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Inflation Targeting and the Role of Exchange Rate Pass-through

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Abstract

The paper presents evidence on the exchange rate pass-through for a set of emerging and developed economies before and after the adoption of Inflation Targeting. We use an ARDL model for a sample of developed and emerging market economies to estimate the short-run and the long-run effects of depreciations on prices. The results support the view of the previous literature that the pass-through is higher for emerging than for developed economies, and that it has decreased after the adoption of Inflation Targeting. This reduction, however, does not mean that the pass-through is no longer existent for developed and emerging market economies, especially when it comes to the long-run. This finding highlights the importance of using dynamic models when dealing with the inflation-depreciation relationship. The results also show the important role of foreign producer costs for the imports pricing behaviour in developed economies, and of inflation stability in emerging markets.

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1. Introduction

Following the mid-1990s currency crisis many emerging market economies have decided to change the focus of their monetary policy from targeting the exchange rate to targeting inflation [Mishkin (2000), Mishkin and Savastano (2001), Eichengreen (2002) and Reyes (2003)]. This option has been analysed by many economists in the past few years, and the general view is that it brings important challenges for their monetary authorities due to imperfect credibility, fiscal dominance, and high pass-through [Mishkin (2000), Mishkin and Savastano (2001), Mishkin and Schmidt-Hebbel (2001), Schmidt-Hebbel and Corvo (2001), Eichengreen (2002), Amato and Gerlach (2002), Minella et al. (2003), Fraga et al. (2003) and Reyes (2003)]. In this paper we look at the importance of the exchange rate pass-through in some emerging and developed economies that adopted Inflation Targeting¹.

The exchange rate pass-through from depreciation to inflation means that changes in imports prices are translated into higher domestic prices. There is a vast literature on this [Dornbusch (1987), Fischer (1989), Klein (1990), Freenstra and Kendal (1994), Goldberg and Knetter (1997), Amitrano et al. (1997) and Campa and Goldberg (2002)], and the importance given to this issue has increased after the advent of Inflation Targeting. Many authors, such as Goldfajn and Werlang (2000), Calvo and Reinhart (2002), Schmidt-Hebbel and Tapia (2002) and Schmidt-Hebbel and Werner (2002), have shown that the pass-through is higher for emerging than for developed economies². The problem of having a high pass-through effect is that it implies a greater difficulty for their attainment of the inflation targets, as noted by Minella et al. (2003) and Fraga et al. (2003).

¹ For a general view on Inflation Targeting regimes, see Bean (1998), Svensson (1999) and Meyer (2002). For an introduction on Inflation Targeting in emerging market economies see Masson et al. (1997) and Mishkin (2000); the latter paper was the first one to specifically focus on this issue.

² The main reason for a higher pass-through effect in emerging market economies lies on the lack of credibility of their monetary authorities, which leads to a general belief among agents that temporary exchange rate shocks are indeed permanent [Eichengreen (2002)].

Various studies have shown that the pass-through effect has decreased in recent years. Taylor (2000), Choudhri and Hakura (2001), Baqueiro et al. (2003) and others, relate the reduction of the pass-through to the lower inflation environment of the last decade that prevents firms from increasing prices. Mishkin and Savastano (2001) and Schmidt-Hebbel and Werner (2002) argue that this decrease was caused by credibility gains of monetary authorities under Inflation Targeting. Campa and Goldberg (2002) see this movement through the change in the composition of the import bundle. Finally, Reyes (2003) and Reyes (2004) suggest that the pass-through has been low in targeter emerging markets because they have been heavily intervening in the foreign exchange market and thus reducing the correlation between inflation and exchange rate.

The objective of this paper is to present new empirical evidence regarding the pass-through effect in a set of emerging and developed economies that adopted Inflation Targeting. We use a dynamic (ARDL) inflation model to test if the pass-through has decreased after the monetary regime change, and if it is higher for the emerging market economies group. It is important to note that the use of an ARDL model allows testing the pass-through effect both in the short-run and in the long-run.

This study contributes to the existing literature in two aspects. First, the analyses found relating the pass-through effect and Inflation Targeting are in general based on very simple econometric models or stylized facts, hence the use of a dynamic model allows checking whether the results of previous studies can survive to a more elaborate econometric investigation³. Secondly, there is no research comparing the pass-through effect for developed and emerging market economies before and after the adoption of the

³ Most of the papers studying the pass-through effect are general, and do not focus specifically on the Inflation Targeting regime [as Goldfajn and Werlang (2000), Taylor (2000), Hausmann et al (2001), Choudhri and Hakura (2001), and others]. The papers that relate the two subjects are either theoretical [as Mishkin (2000), Eichengreen (2002), Fraga et al. (2003), and others] or just look at emerging market economies [as Schmidt-Hebbel and Werner (2002), Reyes (2003), Minella et al. (2003), and others].

targeter regime⁴. Hence, our study provides a more general empirical test of the pass-through problem before and after the adoption of Inflation Targeting, evaluated using a fully-dynamic econometric specification. This evidence sheds light on the empirical relevance of the pass-through for the targeter regime.

We conclude that the pass-through is higher for emerging markets than for developed economies, but the gap between the two has reduced after the adoption of Inflation Targeting. We have also observed that the pass-through effect has decreased in the last decade for both emerging and developed countries. However, the pass-through coefficients, especially in the long-run, still seem to be an issue for the achievement of their inflation targets. This finding highlights the importance of using dynamic models and looking at the long-run behaviour of the variables when dealing with the inflation and exchange rate relationship. The results also show the important role of foreign producer costs for the pass-through in developed economies, and of macroeconomic stability for the emerging markets.

The paper is organized as follows: section 2 briefly discusses the literature on Inflation Targeting in open-economies; section 3 presents the data and the methodology applied; section 4 shows the results of the estimations of the pass-through effect; and section 5 concludes.

2. Inflation Targeting in open-economies

The econometric modelling of the Inflation Targeting framework for open-economies normally includes four basic equations: an aggregate demand, or IS-type equation (1), expressing the output gap as a function of its own lags, and the lags of real interest rates and nominal exchange rate; a Phillips curve (2), expressing the rate of inflation as a function of its own lags, and the lags of the output gap and the nominal

⁴ Using an increasing window methodology Reyes (2003) looks at the pass-through for a small set of emerging market economies over a period comprising both targeter and non-targeter monetary policies.

exchange rate; an interest rates rule equation (3), in terms of a Taylor rule; and an exchange rate determination equation (4), expressing the uncovered interest rate parity condition, that would hold in a financially open economy [Bean (1998), Werlang et al. (2000), Ball (2000), Eichengreen (2002), Reyes (2004) and others].

$$y_{t+1} - y^* = \lambda (y_t - y^*) - \beta (i_t - \pi_t) - \delta e_t + \varepsilon_{t+1} \quad (1)$$

$$\pi_{t+1} = \pi_t + \alpha (y_t - y^*) - \omega (e_t - e_{t-1}) + \varepsilon_{t+1} \quad (2)$$

$$i_t = \theta + \gamma (\pi_t - \pi^*) + \lambda (y_t - y^*) + \partial (e_t - e_{t-1}) \quad (3)$$

$$e_t - E(e_{t+1}) = i_t - i^* + \varepsilon_t \quad (4)$$

where y^* is the equilibrium output, π^* is the inflation target, i is the nominal interest rate, e is the nominal exchange rate, and ε is a stochastic error term.

Under the Inflation Targeting framework the monetary authority aims to keep inflation within a predefined band, which requires the adoption of a forward-looking attitude as there is an important lag between the policy decisions and their effect on output and prices. In this sense, the main feature of this monetary policy system is to look at future inflation indicators to decide the current interest rates. The model proposed represents a form of “flexible” Inflation Targeting, as the monetary authority cares not only about inflation but also gives weight on output⁵ [Svensson (1999)].

The model also shows Inflation Targeting as a “target” rule, used to calibrate the use of the monetary policy instruments. The inflation forecast is a natural “intermediate target” in this framework, as it is correlated with the ultimate policy goal but is easier to control and to observe. In this sense, Svensson (1997), Mishkin (2000), Woodford (2000) and Werlang et al. (2000) define Inflation Targeting as Inflation-forecast Targeting, as in such monetary system an econometric model is used to generate conditional forecast paths

⁵ Eichengreen (2002) argues that even when the central bank does not care about output it would be included in the policy reaction function given its importance to future inflation.

for the inflation, from which the central bank chooses one specific path, using a targeting criterion. Eichengreen (2002) argues that “Inflation-forecast” Targeting should be more efficient than formulating policies on an ad-hoc basis, as the central bank will react to all the information that is relevant for the forecast. This kind of policy will also be more credible than the alternatives when the central bank establishes a reputation of accurate forecasting⁶.

Openness exposes the economy to foreign shocks to both commodities and financial markets and introduces additional channels for policy. In a closed-economy the optimal policy would be to target $\pi_{t+2} = \pi^*$, as π_{t+1} is given by current output, which is predetermined and hence could not be controlled. In an open-economy, however, the central bank can hit the target at π_{t+1} by using the exchange rate and thus altering import prices. On the one hand it helps the monetary authority to curb deviations of the inflation from the target in the short-run, but on the other hand it increases output volatility. In addition to this, in an open-economy inflation is subject to movements in the exchange rate, which is the basic idea of the pass-through effect⁷.

The exchange rate pass-through can be defined as the change in local currency domestic prices resulting from 1 percent change in the exchange rate. According to Campa and Goldberg (2002), pass-through studies consider the extent to which exchange rate movements are passed into traded goods prices, versus absorbed in producer profit margins. Most of the studies on this issue focus on changes in import prices following exchange rate movements. Campa and Goldberg (2002) have explained that the basic procedure of this literature is to estimate a local currency imports prices equation that captures movements of the exchange rate, dollar price of imports and domestic demand of

⁶ Kumhof (2001) compared Inflation Targeting with monetary rules with floating exchange rates, and found no definition of which one is superior. He argues that the advantage of the targeter regime is that it offers more discretion to the monetary authority.

⁷ Some authors, such as Ball (2000), advocate the exclusion of short-run exchange rate movements from the inflation target. The main problem with this approach, as discussed by Agenor (2002), is the reduction of the policy’s transparency to the general public.

the destination market (normally real GDP). Ganapolsky and Vilan (2005) observe that this economic literature supports the hypothesis of partial pass-through, which means that only a portion of the exchange rate movements are translated into higher domestic prices⁸.

There is wide recognition in the literature that the pass-through, at the macroeconomic level, is determined mainly by the inflation level, the output gap and the credibility of the monetary authority [Amitrano et al. (1997), Goldfajn and Werlang (2000), Taylor (2000), Choudhri and Hakura (2001), Garcia and Restrepo (2001), Baqueiro et al. (2003) and Reyes (2003)]. The output gap affects the pass-through by reducing the firm's power to increase prices, as increasing sales firms find it easier to pass-through increases in costs to final prices [Goldfajn and Werlang (2000)]. The inflation level affects the persistence of costs changes, which is positively correlated with the pass-through [Taylor (2000)]⁹. This view, as expressed by Campa and Goldberg (2002) is that the pass-through of costs into mark-ups is endogenous to a country's inflation performance, generating a virtuous circle where low inflation variability leads to reduced mark-ups, less inflationary implications of monetary expansions, and continued low mark-ups. Finally, credible monetary authorities are expected to act according to the inflation stability objective, which keeps low inflation expectations even in the advent of a large depreciation.

Considering the impact of exchange rate on prices in an open-economy, a targeter must regularly adjust the domestic interest rate to fight deviations from the inflation targets caused by changes in the nominal exchange rate [Eichengreen (2002), Schmidt-Hebbel and Werner (2002), Berg et al. (2002), Minella et al. (2003), Reyes (2004), Ball and Reyes (2004a), Ball and Reyes (2004b) and Mishkin (2004)]. Agenor (2002) noted that the absence of such adjustments can be in fact destabilizing. According to Hausmann et al.

⁸ For example, Campa and Goldberg (2002) have analysed the pass-through from exchange rate depreciation to imports prices, and have found an average short-run pass-through of 60 percent for OECD countries between 1975 and 1999, and 40 percent for the US. Using a similar methodology Ganapolsky and Vilan (2005) have found a short-run pass-through of 18 percent for the US for the period that spans from 1993M12 to 2004M12.

⁹ The idea that low inflation countries have low exchange rate pass-through is the basic explanation given by Amitrano et al. (1997) for the low pass-through levels seen in Europe after the 1992 depreciations.

(2001) and Reyes (2003) this adjustment is often also made via international reserves use in the foreign exchange market.

The higher the exchange rate pass-through effect, the greater the level of adjustment of interest rates required to achieve the inflation target following a depreciation episode. As a higher interest rate has a negative effect on output, the greater the pass-through the more costly it is to keep the monetary stability under the targeter regime. In this sense, Calvo (2001), Mishkin and Savastano (2001), Eichengreen (2002) and Fraga et al. (2003) believe the difficulties in managing an Inflation Targeting regime are clearer for emerging market countries, because they are small open-economies, more likely to face currency crisis. Following this argument, the success of their Inflation Targeting regimes depends on the exchange rate movements. This view is in line with the argument of Fraga et al. (2003) and Minella et al. (2003) that, given higher pass-through for emerging market economies, the inflation targets cannot be achieved without a great economic loss following episodes of exchange rate pressure. A possible solution for this problem is the use of international reserves instead of interest rates.

Given this necessity to intervene in the foreign exchange market to curb possible inflationary pressures, a question that may arise is whether the monetary authorities working under an Inflation Targeting regime will exhibit “Fear of Floating” [Calvo and Reinhart (2002)], and will constantly intervene in the exchange rate¹⁰. Eichengreen (2002) observed that in general the exchange rate of targeter countries will adjust to shocks, although the monetary authority will wish to smooth its movement. Inflationary pressures coming from exchange rate shocks will be curbed, so if the exchange rate depreciates the interest rate will be raised. The key-point here is that this response will not prevent the

¹⁰ The main argument of the “Fear of Floating” critique is that many countries that claim to be “free-floaters” are indeed “dirty-floaters”. According to this view the adoption of Inflation Targeting would lead to a pattern of high volatility of interest rates and international reserves, and exchange rate stability. This would be especially true for emerging market economies, due to their higher pass-through level.

exchange rate from adjusting to the new long-run equilibrium level, and that the exchange rate will be much more flexible under this regime than under a peg.

Many economists have shown that the pass-through has reduced in recent years for both developed and emerging market economies. The reasons presented to explain it are often related to the determinants of the pass-through: low inflation level [Amitrano et al. (1997), Taylor (2000), Choudhri and Hakura (2001), Baqueiro et al. (2003), Gagnon and Ihrig (2004) and Bailliw and Fujii (2004)], negative output gap [Garcia and Restrepo (2001) and Fraga et al. (2003)] and credibility gains [Mishkin and Savastano (2001) and Schmidt-Hebbel and Werner (2002)].

Goldberg and Campa (2002) have also found some evidence that lower inflation environments have helped reducing the pass-through effect, but they believe that the main reason for the low levels of pass-through in recent years is related to changes in the composition of import bundles. Another explanation is proposed by Reyes (2003) and Reyes (2004): the pass-through is low because the monetary authorities are intervening in the foreign exchange market, and thus reducing the correlation between inflation and depreciation. Reyes (2004) argues that the pass-through in emerging market economies may not even be lower now than it was a decade ago, but the data will not show the high pass-through because of the interventions.

3. Data and Methodology

In this paper we are interested in answering two basic questions: one, whether the exchange rate pass-through is an important determinant of inflation in the short-run and in the long-run for a set of targeter countries; and two, whether this effect has indeed decreased after the adoption of Inflation Targeting.

A common approach of estimating the pass-through at the macroeconomic level is regressing the accumulated inflation of any given period on the accumulated depreciation

of the same period, with or without other control variables. This is the case of Goldfajn and Werlang (2000), Garcia and Restrepo (2001), and Baqueiro et al. (2003): the first one is based on the regression of the accumulated inflation for any given period on the accumulated depreciation of the previous period plus the lagged values of output gap, inflation, exchange rate misalignment and openness of the economy; the second one regresses the accumulated inflation on the accumulated depreciation and an inflation trend; and the final one is a simple bivariate regression between accumulated inflation and accumulated depreciation. A proposition even simpler is that of Schmidt-Hebbel and Werner (2002), based on a simple analysis of the correlation matrix between inflation and depreciation¹¹.

These approaches are rather static, having problems of both residual autocorrelation and of general dynamic misspecification. The propositions of Garcia and Restrepo (2001) and Baqueiro et al. (2003) also leave aside important variables discussed in the literature, resulting in a possible misspecification bias¹². These models also fail to analyse the impacts of foreign producer costs changes, which is an important variable in much of the previous literature on this issue. Finally the approach of Schmidt-Hebbel and Werner (2002) just analyse the linear relation between the variables, making it not possible to conclude anything about the pass-through level. In addition to this, these approaches fail to look at the long-run impact of exchange rate changes on inflation, although Goldfajn and Werlang (2000) do regress different accumulated periods for comparisons¹³.

¹¹ Reyes (2003) used the approaches of Goldfajn and Werlang (2000), Garcia and Restrepo (2001) and Schmidt-Hebbel and Werner (2002) to estimate the pass-through of Mexico, Brazil and Chile, and concluded that the results are somewhat similar, indicating a decrease in the pass-through level after the adoption of Inflation Targeting.

¹² Baqueiro et al. (2003) acknowledge this problem in their model, and justify it by saying that they are interested in looking at the movements of the pass-through effect through time, if it is decreasing or increasing, and not at the coefficient's value itself, which means that such bias would not be an issue for their conclusions. Even to this end the estimation proposed is problematic, as variables such as the output gap may be influencing the pass-through effect differently through time.

¹³ They estimated models with accumulated inflation in 3, 6, 9, 12 and 24 months, concluding that the pass-through reaches its peak after a 12-month period of the depreciation episode. However, this does not consider a fully dynamic structure of inflation, which would encompass different short-run and long-run impacts.

A comparison of the results of the pass-through estimates using the models of Goldfajn and Werlang (2000), Garcia and Restrepo (2001), and our model is presented in the Appendix. The use of our dynamic model corrects the problems of autocorrelation and heteroskedasticity, and in general also those of ARCH and normality. The R^2 obtained with the dynamic model is also much higher, reinforcing the quality of our model in comparison to the static ones. The lack of a more robust econometric analysis of aggregate pass-through may lead to wrong policy conclusions. This paper constitutes a first step in that direction.

Two more elaborated approaches found in the previous literature were carried out by Minella et al. (2003) and Reyes (2003). The first one comprises on estimating a cointegrated Vector Autoregression (VAR) model, in which the endogenous variables are exchange rate, output, inflation, interest rates, and EMBI+ (to capture financial instability). The second one is based on Carstens and Werner (1999) Vector Error Correction model (VECM) of inflation, wages costs, depreciation, controlled prices inflation and money creation by the monetary authority. Carstens and Werner (1999) were interested in showing that the Mexican inflation was caused by shocks other than monetary ones; Reyes (2003) used their model to estimate the pass-through effect.

Hausmann et al. (2001) have also used a cointegration analysis of inflation and exchange rate. They have based their model on the studies of De Brouwer and Ericsson (1995) and Garces Diaz (1999) that estimated a mark-up model, in the line of those discussed by Campa and Goldberg (2002), but using as independent variable headline inflation instead of import prices. Hausmann et al. (2001) have looked at the pass-through for a large set of countries using monthly data for 1990 to 1999, but have not addressed the Inflation Targeting issue, nor tested for a trend of lower exchange rate pass-through. In addition to this, their short-run analysis of the pass-through represents the accumulated

pass-through over a 12-months period, thus not really indicating what the short-run effect is.

The problem with cointegration analysis on this issue is that this procedure requires large sample periods to make reasonable inferences, which means that given the short time elapsed since the adoption of Inflation Targeting, especially when it comes to emerging market economies¹⁴, the sample cannot be properly divided in two periods - before and after the policy change - and instead it must be used as a single sample, making comparisons difficult¹⁵.

We build on this literature and propose an Autoregressive Distributed-lag model (ARDL) of inflation that includes the exchange rate depreciation, the inflation persistence and the output growth. The use of the ARDL model is justified by the fact that it makes it possible to easily analyse the pass-through both in the short-run and in the long-run¹⁶, the latter being defined as the static equilibrium solution, an approach advocated by Banerjee et al. (1986). Another advantage is the consistency and efficiency of estimates in the presence of endogenous regressors. Finally, the use of the ARDL model yields consistent estimates of the coefficients irrespective of whether the underlying regressors are I(1) or I(0), which makes it unnecessary to test for unit-roots [Pesaran et al. (1999)]. The model takes the form of equation (5).

$$\pi_t = \beta_0 + \sum_{k=1}^n \beta_{1k} \pi_{t-k} + \sum_{k=0}^n \beta_{2k} \Delta y_{t-k} + \sum_{k=0}^n \beta_{3k} \Delta e_{t-k} + \varepsilon_t \quad (5)$$

¹⁴ The developed economies have adopted Inflation Targeting at the beginning of the 1990s, while the emerging market economies started adopting it at the end of the decade. In addition to this, for some countries, as Brazil for example, there is lack of valid observations before the adoption of Inflation Targeting because of very high and volatile inflation levels that negatively affect the robustness of the results.

¹⁵ The sample used by Minella et al. (2003) comprises the period that spans from 1994M9 to 2002M12 for Brazil; and the sample used by Reyes (2003) comprises the period that spans from 1997M1 to 2002M12 for Brazil and Chile, and 1997M1 to 2001M12 for Mexico. Minella et al. (2003) have tried to split the sample but given the shortage in observations the standard deviations were too high.

¹⁶ In order to capture the correct long-run pass-through, special attention was paid to the selection of the number of lags of the variables involved. In this sense a general-to-specific approach starting from 12 lags was used.

Where π is the inflation rate, Δy is the output growth, Δe is the change of the nominal exchange rate, and ϵ is a stochastic error term. The pass-through effect is defined as the coefficient of the lagged exchange rate depreciation.

The short-run effect is the increase in prices following a depreciation episode that happened in no more than one lagged month. The long-run effect, or static solution, corresponds to the expected value after all the dynamic adjustment has taken place. We can think of the coefficients as short and long-run multipliers.

The model is quite simple, and basically follows the literature on exchange rate pass-through at the macroeconomic level discussed before. The idea is straightforward: today's inflation is determined by the past inflation, the output growth, the exchange rate depreciation and a shock. In other terms, it is a backward looking inflation equation in which the exchange rate term plays an important role. We have opted to use output growth instead of output gap when estimating the model in order to avoid using ad-hoc de-trending processes that might eliminate information from the data. As the literature enforces the role of output gap and not output growth we have estimated the model using both variables. The results were remarkably similar, and we have opted to show here just the output growth one¹⁷.

We have also extended this specification by adding two variables that could potentially influence the model's results. The first one is wage costs, given its important role in price-formation. If this variable proves to be important in the determination of the inflation rate, and it is excluded from the model, then the effect of exchange rate depreciation on prices may be overestimated. The second variable is dollar price of imports, as it is the main variable used in the micro-founded literature to capture the impact of changes in foreign producer costs on the local currency price of imports [Campa and Goldberg (2002), Bailliw and Fujii (2004), Ganapolsky and Vilan (2005), and others]. The

¹⁷ The output gap was constructed by de-trending output using the HP-Filter. The HP trend was calculated with a smoothing parameter of 14400 as is standard for monthly observations. We have also tested a linear trend instead of the HP-filtered one.

idea behind the inclusion of this variable is that the price of imports in local currency depends basically on the price in foreign currency and the exchange rate, thus controlling for changes in the foreign producer costs allows isolating the exchange rate effect.

The problem with these variables is that although they were available for the developed economies in our sample, they were not for most of the emerging market economies. The alternative specifications in which wage costs and dollar price of imports were included were tested for countries whose data was available, and are also shown here. In general, we have seen that the model is robust to the inclusion of the wage costs variable. The dollar price of imports, on the other hand, has proved to be an important variable for developed economies, but not for the emerging markets.

Monthly data was collected for 8 targeter countries that may be divided into two groups: the first one comprises developed economies (Canada, United Kingdom and Sweden), and the second one is composed of emerging market economies (Brazil, Czech Republic, Mexico, South Africa and South Korea). The period of estimation corresponds to the interval that spans from 1981M1 to 2004M12 for the developed economies, and 1995M1 to 2004M12 for the emerging market economies. The shorter period of the former countries is in order to exclude hyperinflation data that may negatively affect the results¹⁸.

The estimations were carried out in two sub-periods, before and after Inflation Targeting. Considering that the developed economies adopted the new regime at the beginning of the 1990s, and the emerging market economies at the end of the 1990s, we may roughly say that we are analysing the pass-through 10 years before and 10 years after Inflation Targeting for the developed economies, and 5 years before and 5 years after for the emerging markets. It will vary according to the actual date of the regime change for each country. These dates can be seen in the Appendix II.

¹⁸ The use of a longer period for Brazil and Mexico leads to misspecification problems. We opted to exclude this period of the others emerging market economies in order to make comparisons between them more appropriate.

Data was obtained from the IMF International Financial Statistics database. The inflation rate is the rate of growth of Consumer Price Index. Exchange rate depreciation data is the change of the national currency per unit of dollar (average of the month). A positive variation means depreciation of the national currency, and a negative one means appreciation. As a proxy of monthly output growth we have used the rate of growth of the Industrial Production Index. Wage costs and dollar price of imports are the changes in the series of wage cost index and unit value of imports (dollars). All the data is in logarithms, and was transformed in 12-months accumulated data to avoid seasonality effects¹⁹.

4. Results

We estimated the ARDL model by OLS, using a general to specific approach to determine the lag length of the variables. It is important to note that negative and insignificant coefficients mean minor or no importance of the exchange rate pass-through on prices. The results of the estimates of the short-run and long-run pass-through effect using the basic specification - equation (5) - are shown in Table 1²⁰.

Canada's results show stability of the pass-through in both periods, as the changes in the coefficients are within the standard errors: in the short-run, in both periods, 1 percent depreciation would lead to approximately 0.05 percent inflation; at the same time there is no indication of a long-run pass-through. For Sweden we have found only insignificant coefficients in the two periods. UK's results before the regime change are insignificant. After Inflation Targeting there is a significant, but low, long-run effect, in which 1 percent depreciation would lead to 0.05 percent inflation.

¹⁹ The problem of using monthly year-to-year data is the high autocorrelation observed. The use of appropriate lags length helps solving the problem, although some persistence in shocks may affect the results. For robustness purposes we also obtained the results using monthly data, and they were very similar and did not change any conclusion. The problem with the monthly data is the strong seasonality effect plus its great irregularity. We have opted to report here just the results of the 12-months accumulated data.

²⁰ See Appendix for specification tests.

Brazil had the higher pass-through both in the short-run and in the long-run before the adoption of the new regime, and the coefficients show that 1 percent exchange rate depreciation would generate about 0.17 percent inflation in the short-run, and 1.16 percent in the long-run²¹. After the policy change, the short-run coefficient found was much lower, showing that 1 percent exchange rate depreciation would lead to just 0.04 percent inflation in the short-run. Although the long-run one remained high, it is no longer significant.

The Czech Republic had, before the adoption of Inflation Targeting, a high and significant short-run pass-through coefficient and an insignificant long-run one. These coefficients were followed by a lower, positive and significant short-run pass-through, and a high, positive and significant long-run one. The coefficients show that 1 percent depreciation would be followed by 0.02 percent increase inflation in the short-run and approximately 0.34 percent in the long run. It means that although the pass-through seems to have reduced a lot in the short-run it remained quite important for the attainment of the inflation targets for that country in the long-run.

Mexico had the second highest long-run pass-through before Inflation Targeting, with positive and significant coefficients: 1 percent depreciation would lead to 0.03 percent inflation in the short-run, and 1.05 percent in the long-run, which shows, as in the Brazilian case, a complete pass-through in the long-run. As for Brazil this result can be explained by a pegged exchange rate regime that was in place before the adoption of Inflation Targeting, and served as an anchor for firm's pricing decisions. After the regime change both coefficients were found to have lowered, but the long-run pass-through remained very high: 1 percent exchange rate depreciation would lead to about 0.31 percent inflation in the long-run.

²¹ The reason for such a high short-run pass-through for Brazil before Inflation Targeting is probably linked to the dollar-pegged exchange rate regime of the period between 1995M3 and 1999M2 that was basically used to drive inflation closer to international levels, after more than a decade of very high and unstable inflation. The peg served as a nominal anchor for national price-setting behaviour during this disinflation period, almost as a full-dollarization. In this sense the results show that the inflation in the long-run basically follows the exchange rate movements.

South Africa's results show an important decrease in long-run pass-through, but also indicate a persistence of a positive and significant short-run coefficient after the change of the monetary policy. Before Inflation Targeting, 1 percent exchange rate depreciation would generate 0.03 percent inflation in the short-run, and 0.30 percent in the long-run. After the regime change, 1 percent depreciation would generate 0.05 percent inflation in the short-run (but statistically not different from the 0.03 percent inflation found for the previous period), but just 0.09 percent in the long-run.

Finally, South Korea's results show an important change in the short-run pass-through level in the two periods of the analysis, as 1 percent depreciation would lead to 0.06 percent inflation in the short-run before Inflation Targeting and 0.03 percent after. The long-run pass-through, however, has increased, and after the regime change 1 percent depreciation would lead to 0.06 percent inflation in the long-run.

The general conclusion for the developed economies is that the pass-through is either very low or non-existent, thus not being a major issue for their monetary policy conduction. With respect to emerging market economies, with few exceptions the coefficients found are positive and statistically significant, showing a picture of high pass-through, especially before the regime change. After Inflation Targeting the pass-through seems to have dropped consistently for all of them. It is interesting to notice, however, that although the pass-through has decreased it remained quite high for the emerging market countries in comparison to the developed ones.

Table 2 reports the results of the pass-through estimates controlling for wage costs changes. The results are very similar to those obtained with the basic specification, with the only exception being Mexico's long-run pass-through before Inflation Targeting, that although quite high was no longer statistically significant. It is indeed fair to believe that the model is robust to the inclusion of wage costs.

Table 3 presents the results of the estimates controlling for dollar price of imports. As discussed before, this variable should capture the importance of foreign producer costs for the imports price determination. In a different way from the inclusion of wage costs the results of the pass-through coefficients do change when dollar price of imports are included in the model.

The point here is that the conclusions reached with the basic specification - equation (5) - are only no longer valid for the developed economies, as although the pass-through coefficients found for the emerging market countries did change it was within the standard errors, so we cannot statistically guarantee that they are indeed different. The pass-through estimates for developed economies, however, are considerably different. We can observe that once changes in the dollar price of imports are taken into account, exchange rate movements seem to have a strong positive and significant effect on inflation for these countries.

Before the regime change, for Canada 1 percent depreciation would generate 0.08 percent inflation in the short-run and about 0.11 percent in the long-run. After the figures would be 0.02 percent and 0.18 percent, indicating that on the one hand the short-run pass-through has dropped a lot, but on the other hand the long-run one has increased. For Sweden, 1 percent depreciation before Inflation Targeting would lead to 0.04 percent in the short-run and 0.42 percent in the long-run. After the regime change 1 percent depreciation would generate 0.12 percent inflation in the short-run and 0.29 percent in the long-run, showing a strong reduction in the long-run pass-through, but an increase in the short-run one. Finally for the UK, the figures before Inflation Targeting are not significant; after, 1 percent depreciation leads to 0.05 percent in the short-run and 0.06 percent in the long-run²².

²² These figures are very similar to those found by Hausmann et al. (2001) for the period 1990 to 1999, which basically represents a period of targeter monetary system for these economies, but also includes a short period of non-targeter regime. They have found a long-run exchange rate pass-through of 0.19 percent for Canada, 0.29 percent for Sweden and 0.06 percent for the UK. Another study that indicates that our results are in the right direction is the one of Campa

The results obtained for developed economies controlling for dollar price of imports are similar, to some extent, to those found for emerging market economies with the basic model. They show that the pass-through is indeed existent for these economies, but suggest some reduction. However, this reduction, as we have seen for emerging markets before, depends on the time horizon analysed.

Table 4 presents the exchange rate pass-through coefficients estimated including to the basic model both wage costs and dollar price of imports. The results are similar to those obtained when just dollar price of imports are included in the model, and shall not be discussed here.

Our results show that the exchange rate pass-through for developed economies seems to be best described by an analysis based on foreign producer costs. It means that in these countries the imports pricing behaviour depends mainly on the costs confronting the importer, suggesting a reduced role of the monetary policy in altering the pass-through level. On the other hand in emerging markets there is some strong evidence of a link between the inflation environment and the exchange rate pass-through, as proposed by Taylor (2000), Choudhri and Hakura (2001), Bailliw and Fujii (2004), Gagnon and Ihrig (2004), and others. The reason for this may be related to a history of high inflation volatility that may have changed the agent's perception of costs changes, and thus the pass-through of costs into mark-ups. These results are in line with the findings of Campa and Goldberg (2002) that have argued that inflation variability is more important to explain the pass-through for emerging market economies than for developed economies.

In conclusion, the estimates presented in this section give some support to the evidence of the literature that the pass-through from depreciation to inflation is higher for emerging markets than for developed economies [Goldfajn and Werlang (2000), Calvo and

and Goldberg (2002) that have found a pass-through of 60 percent in the short-run and 75 percent in the long-run for these countries between 1975 and 1999 in respect to imports prices. Given the level of openness of these economies the pass-through we have found for headline inflation seems plausible. A control for openness could prove to be beneficial, but it is not available for monthly data.

Reinhart (2000), Schmidt-Hebbel and Tapia (2002), Schmidt-Hebbel and Werner (2002), Minella et al. (2003) and Fraga et al. (2003)], but also show that after the regime change this gap may have been closed. There is also some support to the view that the pass-through has decreased in recent years for both developed and emerging market economies [Amitrano et al. (1997), Taylor (2000), Mishkin and Schmidt-Hebbel (2001), Baqueiro et al. (2003), and others]. The results complement the existing literature by showing that the reduction in the pass-through is not as strong as suggested, and that it depends on the time horizon analysed: although it has reduced the long-run effect has remained an issue for most economies.

The reduction of the pass-through after the adoption of Inflation Targeting may be a benign effect of the monetary policy change. As seen before, the literature on this issue acknowledges the importance of the inflation environment, the output gap and the credibility of the monetary authorities, in determining the pass-through level. It means that when inflation is lowered and stabilized, the economy is lined-up with its potential growth, and the monetary policy gains credibility, the pass-through will face a decrease [Reyes (2004)]. However, from the results presented above, these arguments should be taken with caution.

5. Conclusion

In this paper we have presented evidence on the exchange rate pass-through for a set of developed and emerging market economies, before and after the adoption of the Inflation Targeting framework. Our results show that the pass-through has decreased after the regime change for both developed and emerging market economies. This reduction, however, depends on the time horizon analysed, as if the short-run pass-through seems to have dropped consistently for most of the countries, the long-run effect still seems to be an issue for the conduct of monetary policy. This evidence highlights the importance of using

dynamic models and looking at the long-run behaviour of the variables when dealing with the inflation-depreciation relationship.

Nonetheless, we have found evidence on the importance of foreign producer costs for the pass-through in developed economies, and of macroeconomic stability for emerging markets. The basic specification tested, excluding imports prices in foreign currency, seems to be a reasonable approximation to the pass-through effect in emerging markets. On the other hand foreign producer costs seem to influence considerably the local currency price of imports in developed economies. This result suggests a different price-setting behaviour among these countries, probably driven by different perception of the agents of costs changes, leading to again a different approach towards mark-ups.

In general, our results support recent evidence on a lower pass-through effect after the adoption of Inflation Targeting. It also complements this literature with evidence from short-run and long-run effects, showing the importance of a dynamic specification of this phenomenon. In this case, we have shown that the pass-through may be a problem for most economies seeking an inflation target. We have also found that inflation stability seems to be an important feature when explaining the pass-through effect for emerging markets, whereas foreign producer costs seems to have a greater influence for developed economies.

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Table 1: Pass-through estimates

	Before Inflation Targeting		After Inflation Targeting	
	Short-run	Long-run	Short-run	Long-run
Canada	0.053** (0.022)	-0.118 (0.216)	0.051* (0.028)	0.007 (0.019)
Sweden	0.007 (0.006)	0.076 (0.053)	0.006 (0.011)	0.067 (0.050)
UK	0.006 (0.005)	0.097 (0.085)	0.010 (0.012)	0.052** (0.018)
Brazil	0.174* (0.091)	1.161** (0.050)	0.036** (0.015)	0.888 (1.324)
Czech Republic	0.089** (0.030)	-0.024 (0.060)	0.037** (0.007)	0.341** (0.069)
Mexico	0.027** (0.013)	1.053** (0.273)	0.011* (0.006)	0.314* (0.184)
South Africa	0.030** (0.009)	0.303* (0.164)	0.051** (0.020)	0.085** (0.020)
South Korea	0.063** (0.017)	-0.047 (0.055)	0.030** (0.010)	0.062** (0.019)

Notes: ** indicates significance at the 5% confidence level and * indicates significance at the 10% confidence level. The numbers in parenthesis are the std. errors. The model passed all the usual diagnostic tests.

Table 2: Pass-through estimates including wage costs

	Before Inflation Targeting		After Inflation Targeting	
	Short-run	Long-run	Short-run	Long-run
Canada	0.039* (0.023)	0.001 (0.103)	0.068** (0.029)	0.004 (0.049)
Sweden	0.005 (0.006)	0.048 (0.052)	0.009 (0.011)	0.081 (0.075)
UK	0.006 (0.004)	0.069 (0.053)	0.018** (0.007)	0.048** (0.020)
Mexico	0.028 (0.019)	0.618 (0.684)	0.017** (0.007)	0.480** (0.234)
South Korea	0.049** (0.013)	-0.134 (0.075)	0.036** (0.010)	0.073** (0.028)

Notes: ** indicates significance at the 5% confidence level and * indicates significance at the 10% confidence level. The numbers in parenthesis are the std. errors. The model passed all the usual diagnostic tests.

Table 3: Pass-through estimates including dollar price of imports

	Before Inflation Targeting		After Inflation Targeting	
	Short-run	Long-run	Short-run	Long-run
Canada	0.084** (0.022)	0.110* (0.070)	0.019** (0.009)	0.180* (0.104)
Sweden	0.043** (0.012)	0.415** (0.147)	0.120** (0.024)	0.290** (0.121)
UK	0.016 (0.023)	0.194 (0.253)	0.054** (0.015)	0.057* (0.031)
Brazil	0.210* (0.117)	0.736** (0.300)	0.020** (0.004)	1.176 (1.697)
South Korea	0.118** (0.045)	-0.085* (0.048)	0.039** (0.005)	0.111** (0.022)

Notes: ** indicates significance at the 5% confidence level and * indicates significance at the 10% confidence level. The numbers in parenthesis are the std. errors. The model passed all the usual diagnostic tests.

Table 4: Pass-through estimates including wage costs and dollar price of imports

	Before Inflation Targeting		After Inflation Targeting	
	Short-run	Long-run	Short-run	Long-run
Canada	0.057** (0.022)	0.086 (0.070)	0.016* (0.008)	0.122* (0.072)
Sweden	0.045** (0.019)	0.376** (0.092)	0.119** (0.024)	0.287** (0.125)
UK	0.011 (0.014)	0.124 (0.150)	0.003 (0.005)	0.022 (0.039)
South Korea	0.053** (0.016)	-0.033 (0.073)	0.040** (0.009)	0.081** (0.015)

Notes: ** indicates significance at the 5% confidence level and * indicates significance at the 10% confidence level. The numbers in parenthesis are the std. errors. The model passed all the usual diagnostic tests.

Appendix I – Comparison of 3 pass-through models

Canada	Goldfajn and Werlang (2000)		Garcia and Restrepo (2001)		ARDL Model			
	Before IT	After IT	Before IT	After IT	Before IT		After IT	
Coefficient	0.029 (0.170)	-0.066** (0.001)	0.050 (0.145)	-0.003 (0.870)	0.041** (0.040)	-0.023 (0.404)	0.051* (0.068)	0.007 (0.949)
R ²	0.058	0.094	N/A	N/A	0.855		0.907	
AR	35.77** (0.000)	116.1** (0.000)	2.750** (0.026)	0.461 (0.861)	0.366 (0.867)		0.791 (0.596)	
ARCH	9.629** (0.000)	39.09** (0.000)	1.050 (0.398)	1.247 (0.281)	0.570 (0.722)		0.282 (0.960)	
Normality	8.649** (0.013)	42.68** (0.000)	0.752 (0.687)	114.3** (0.000)	0.770 (0.000)		51.69** (0.000)	
Hetero	1.238 (0.230)	2.632** (0.010)	1.750 (0.150)	1.822 (0.127)	1.500 (0.150)		0.643 (0.873)	
UK	Goldfajn and Werlang (2000)		Garcia and Restrepo (2001)		ARDL Model			
	Before IT	After IT	Before IT	After IT	Before IT		After IT	
Coefficient	-0.018 (0.422)	0.039** (0.000)	0.032* (0.071)	-0.024 (0.149)	-0.008** (0.024)	-0.117* (0.060)	0.010 (0.401)	0.052** (0.004)
R ²	0.117	0.203	N/A	N/A	0.972		0.921	
AR	136.4* (0.000)	99.97** (0.000)	4.835** (0.000)	2.650** (0.013)	0.789 (0.581)		0.493 (0.839)	
ARCH	23.58* (0.000)	23.49** (0.000)	0.174 (0.983)	2.316** (0.030)	0.456 (0.838)		1.218 (0.298)	
Normality	19.99* (0.000)	3.093 (0.213)	18.34** (0.000)	4.256 (0.119)	6.112** (0.047)		4.786* (0.092)	
Hetero	0.913 (0.511)	1.739* (0.095)	1.098 (0.363)	1.900 (0.114)	0.787 (0.694)		0.775 (0.785)	
Sweden	Goldfajn and Werlang (2000)		Garcia and Restrepo (2001)		ARDL Model			
	Before IT	After IT	Before IT	After IT	Before IT		After IT	
Coefficient	0.066** (0.051)	0.035** (0.000)	-0.029 (0.226)	0.011 (0.487)	-0.005 (0.532)	-0.292 (0.718)	0.006 (0.598)	0.067 (0.183)
R ²	0.086	0.130	N/A	N/A	0.922		0.918	
AR	180.9** (0.000)	184.6** (0.000)	1.229 (0.303)	3.793** (0.001)	0.850 (0.535)		0.597 (0.757)	
ARCH	21.40** (0.000)	29.35** (0.000)	1.392 (0.228)	1.441 (0.195)	1.152 (0.341)		0.795 (0.593)	
Normality	6.548** (0.038)	3.827 (0.148)	21.151** (0.000)	42.51** (0.000)	50.45** (0.000)		58.31** (0.000)	
Hetero	1.558 (0.154)	2.950** (0.005)	0.816 (0.519)	4.084** (0.004)	1.584 (0.150)		2.022** (0.011)	

Czech Rep.	Goldfajn and Werlang (2000)		Garcia and Restrepo (2001)		ARDL Model			
	Before IT	After IT	Before IT	After IT	Before IT		After IT	
Coefficient	-0.003 (0.870)	0.122** (0.000)	-0.002 (0.977)	-0.010 (0.699)	0.089** (0.008)	-0.024 (0.699)	0.037** (0.000)	0.314** (0.000)
R ²	0.220	0.411	N/A	N/A	0.931		0.980	
AR	8.990** (0.000)	43.22** (0.000)	0.273 (0.845)	0.543 (0.743)	0.637 (0.604)		1.256 (0.290)	
ARCH	2.004 (0.140)	15.71** (0.000)	0.147 (0.931)	1.084 (0.377)	0.100 (0.958)		0.267 (0.929)	
Normality	0.696 (0.706)	13.40** (0.001)	21.58** (0.000)	92.93** (0.000)	0.921 (0.631)		32.13** (0.000)	
Hetero	0.972 (0.483)	6.351** (0.000)	0.656 (0.627)	1.895 (0.120)	N/A		1.151 (0.113)	
S. Korea	Goldfajn and Werlang (2000)		Garcia and Restrepo (2001)		ARDL Model			
	Before IT	After IT	Before IT	After IT	Before IT		After IT	
Coefficient	0.018 (0.272)	0.091** (0.000)	0.047** (0.000)	0.065** (0.001)	0.063** (0.003)	-0.047 (0.391)	0.030** (0.006)	0.062** (0.002)
R ²	0.146	0.822	N/A	N/A	0.933		0.954	
AR	4.457** (0.012)	35.454** (0.000)	1.465 (0.243)	2.993** (0.016)	0.576 (0.643)		0.824 (0.534)	
ARCH	0.080 (0.970)	5.115** (0.001)	1.306 (0.292)	0.627 (0.680)	0.112 (0.951)		0.198 (0.962)	
Normality	2.179 (0.337)	0.236 (0.889)	0.044 (0.978)	9.625** (0.008)	3.535 (0.171)		4.685* (0.095)	
Hetero	8.788** (0.000)	1.214 (0.304)	4.681** (0.005)	3.741** (0.017)	0.256 (0.983)		0.301 (0.993)	
Mexico	Goldfajn and Werlang (2000)		Garcia and Restrepo (2001)		ARDL Model			
	Before IT	After IT	Before IT	After IT	Before IT		After IT	
Coefficient	0.290* (0.000)	0.117* (0.030)	0.080 (0.059)	0.001 (0.980)	0.027** (0.050)	1.053* (0.000)	0.011* (0.060)	0.364** (0.081)
R ²	0.716	0.511	N/A	N/A	0.998		0.995	
AR	8.486* (0.000)	17.56* (0.000)	18.365* (0.000)	5.743* (0.000)	1.109 (0.373)		0.453 (0.809)	
ARCH	0.997 (0.423)	14.311* (0.000)	27.245* (0.000)	1.554 (0.187)	0.482 (0.745)		1.255 (0.296)	
Normality	7.345* (0.025)	8.742* (0.013)	24.873* (0.000)	20.21* (0.000)	3.460 (0.177)		2.915 (0.233)	
Hetero	1.406 (0.230)	2.269* (0.035)	7.846* (0.000)	4.225* (0.001)	29.604 (0.588)		1.588 (0.134)	

Brazil	Goldfajn and Werlang (2000)		Garcia and Restrepo (2001)		ARDL Model			
	Before IT	After IT	Before IT	After IT	Before IT		After IT	
Coefficient	0.979** (0.000)	0.021 (0.359)	0.379** (0.006)	0.001 (0.928)	0.174* (0.069)	1.161** (0.000)	0.036** (0.024)	0.888 (0.505)
R ²	0.981	0.108	N/A	N/A	0.999		0.983	
AR	5.419** (0.002)	98.45** (0.000)	12.54** (0.000)	8.565** (0.000)	1.187 (0.354)		0.855 (0.518)	
ARCH	0.077 (0.989)	72.59** (0.000)	2.372** (0.070)	2.877** (0.022)	0.286 (0.882)		0.648 (0.664)	
Normality	64.85** (0.000)	11.23** (0.000)	7.552** (0.023)	31.17** (0.000)	10.08** (0.009)		0.011 (0.994)	
Hetero	12.91** (0.000)	2.297** (0.033)	14.23** (0.000)	1.129 (0.312)	N/A		1.253 (0.273)	

S. Africa	Goldfajn and Werlang (2000)		Garcia and Restrepo (2001)		ARDL Model			
	Before IT	After IT	Before IT	After IT	Before IT		After IT	
Coefficient	0.053 (0.115)	0.033** (0.055)	0.054** (0.047)	0.009 (0.595)	0.030** (0.002)	0.303* (0.070)	0.051** (0.014)	0.085** (0.000)
R ²	0.119	0.363	N/A	N/A	0.953		0.984	
AR	100.7** (0.000)	43.65** (0.000)	3.292** (0.017)	4.812** (0.002)	0.562 (0.692)		1.946 (0.121)	
ARCH	43.13** (0.000)	4.804** (0.003)	0.805 (0.528)	2.896** (0.031)	0.130 (0.971)		0.524 (0.719)	
Normality	2.535 (0.282)	6.892** (0.032)	0.563 (0.755)	0.585 (0.747)	10.76** (0.005)		0.146 (0.930)	
Hetero	2.565** (0.021)	1.022 (0.434)	1.858 (0.132)	0.643 (0.634)	1.108 (0.378)		0.691 (0.810)	

Notes: ** indicates significance at the 5% confidence level and * indicates significance at the 10% confidence level. The numbers in parenthesis are the p-values. Goldfajn and Werlang (2000) show the 12-months accumulated pass-through effect; Garcia and Restrepo (2001) show the short-run one; and the ARDL model shows the short-run (first coefficients) and the long-run effects (second coefficients).

Appendix II - Date of adoption of the Inflation Targeting regime

Countries	Adoption of Inflation Targeting
Canada	Feb - 1991
United Kingdom	Oct - 1992
Sweden	Jan - 1993
Czech Republic	Jan - 1998
South Korea	Jan - 1998
Mexico	Jan - 1999
Brazil	Jun - 1999
South Africa	Feb - 2000