The Relationship between Exchange Rates and Inflation Targeting Revisited

Sebastián Edwards
University of California at Los Angeles

For decades, the exchange rate was at the center of macroeconomic policy debates in emerging markets. Many countries used the nominal exchange rate to bring down inflation; –others—mostly in Latin America—used the exchange rate to implicitly tax the export sector.[1] Currency crises were common and usually resulted from acute real exchange rate overvaluation. In the 1990s, academics and policymakers debated the merits of alternative exchange rate regimes for emerging economies. Many authors drew on credibility-based theories to argue that developing and transition countries should have hard peg regimes, preferably currency boards or dollarization. One of the main arguments in favor of rigid exchange rate regimes was that emerging economies exhibited a fear of floating.[2] After the currency crashes of the late 1990s and early 2000s, however, a growing number of emerging economies moved away from exchange rate rigidity and adopted a combination of flexible exchange rates and inflation targeting. Because of this move, the exchange rate

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1. Argentina is perhaps the best example of a country that has used the nominal exchange rate to achieve alternative policy objectives. In the 1960s and 1970s, the real exchange rate was deliberately kept at an overvalued level to implicitly tax the agriculture sector (Díaz-Alejandro, 1970). In the early 1980s, the exchange rate was devalued at a slow, predefined rate to bring down inflation; this was the so-called *tablita* episode. In the 1990s, Argentina had a fixed exchange rate and a currency board. For a historical view of Argentina's exchange rate policies, see Della Paolera and Taylor (2003).
2. See Calvo (1999); Calvo and Reinhart (2002).

Monetary Policy under Inflation Targeting, edited by Frederic Mishkin and Klaus Schmidt-Hebbel, Santiago, Chile.

has become less central in economic policy debate in most emerging markets, although it certainly has not disappeared altogether. Indeed, the adoption of inflation targeting has raised a number of important exchange-rate-related questions, many of them new.

This paper addresses three broad policy issues related to inflation targeting and exchange rates. These issues have become increasingly important in analyses on monetary policy in emerging countries.[3] First, I examine the effectiveness of the nominal exchange rate as a shock absorber in inflation-targeting regimes. This issue is related to the extent of the pass-through from the exchange rate to domestic prices. Much of the literature on pass-through misses the important connection between pass-through and the exchange rate's effectiveness as a shock absorber.

Second, I analyze whether the adoption of inflation targeting has had an impact on exchange rate volatility. Many authors point out that since inflation targeting requires some degree of exchange rate flexibility, it necessarily results in higher exchange rate volatility.[4] This, however, is not a very interesting statement. A more useful analysis would separate the effects of inflation targeting, on the one hand, and of a more flexible exchange rate regime, on the other, on exchange rate volatility. This is what I do in section 2 of the paper.

Third, I discuss whether the exchange rate should affect the monetary policy rule in an inflation-targeting regime. This issue remains unresolved from an analytical perspective. At the policy level, very few inflation-targeting central banks openly recognize using the exchange rate as a separate term in their policy rules (that is, Taylor rules). Existing empirical evidence suggests, however, that almost every central bank takes exchange rate behavior into account when undertaking monetary policy.[5]

Much has been written about these three topics, yet recent policy debates miss some of the finer aspects of the problems. In this paper, therefore, I take a new look at the issues. In sections 1 and 2, on pass-through and volatility, I perform comparative empirical analyses for a group of seven countries—two advanced and five emerging—that

3. On inflation targeting, see Bernanke and others (1999); Bernanke (2004); Mishkin and Schmidt-Hebbel (2001); Jonas and Mishkin (2005); Mishkin and Savastano (2001); Corbo and Schmidt-Hebbel (2003); Schmidt-Hebbel and Werner (2002).

4. See Mishkin and Savastano (2001) for a discussion of the requirements for an inflation-targeting regime to work.

5. See the discussion in section 3.

have adopted inflation targeting.[6] In section 3, I discuss the possible role of the exchange rate in determining the monetary policy stance in an inflation-targeting system. Section 4 concludes.

1. The Effectiveness of the Nominal Exchange Rate as a Shock Absorber in Inflation-Targeting Regimes

Economists have long been concerned with the effectiveness of nominal exchange rate changes as shock absorbers. This issue has been related with structuralists' rejection of devaluations and the historical skepticism regarding the benefits of flexible exchange rates. From a policy perspective, this issue can be decomposed into three topics: the effects of nominal exchange rate changes on the real exchange rate; the effects of real exchange rate changes on the external position of a country; and the collateral effects of nominal exchange rate changes on balance sheets and aggregate economic activity.

This section addresses the first topic—namely, the effects of nominal exchange rate changes on real exchange rates—in the context of inflation-targeting regimes. This question is directly related to the issue of the pass-through from exchange rates to domestic prices. Much of the recent literature on the pass-through ignores the question of the exchange rate's effectiveness, focusing instead on the inflationary effects of exchange rate changes. If the inflationary effects of exchange rate changes are large, the authorities will have to implement monetary and fiscal policies that offset the inflationary consequences of exchange rate changes. Historically, pass-through has tended to be large in emerging countries and, in particular, in countries that experience a currency crisis. Borensztein and De Gregorio (1999), for example, examine forty-one countries and find that after one year, 30 percent of a nominal devaluation was passed through to inflation; after two years, the pass-through was a very high 60 percent, on average. They also find that the degree of pass-through was significantly smaller in advanced countries.

A number of recent papers show that the degree of pass-through has declined substantially since the 1990s; particularly telling examples include the United Kingdom and Sweden after their currency crises in

6. I chose these countries for two reasons: I wanted countries representing different regions and different stages of development, and I needed fairly long time series to perform the empirical analysis.

the early 1990s, and Brazil after the 1999 devaluation of the real. Taylor (2000) argues that this lower pass-through was the result of a decline in the level and volatility of inflation. He holds that one of the positive consequences of a strong commitment to price stability is that the extent of pass-through declines significantly, creating a virtuous circle in which lower inflation reduces pass-through, and this, in turn, helps maintain low inflation. Campa and Goldberg (2002) test Taylor's proposition using data on domestic prices of imports for member countries of the Organization for Economic Cooperation and Development (OECD); their results suggest that monetary conditions are only mildly related to the degree of pass-through. Gagnon and Ihrig (2004) use a sample of advanced nations to analyze this issue; they conclude that the decline in the pass-through is related to changes in monetary policy procedures and, in particular, the adoption of inflation targeting.

1.1 Two Notions of Pass-Through

Most authors argue—either implicitly or explicitly—that a decline in the degree of pass-through is a positive development; after all, a lower pass-through will reduce inflationary pressures from abroad. This inflation-centered view is too simplistic, however, and it tends to ignore the role of relative prices and the real exchange rate.[7]

Once relative prices are introduced into the analysis, it is clear that the pass-through problem not only affects inflation, but is also related to the effectiveness of the nominal exchange rate as a shock absorber. In this context, it is important to make a distinction between the pass-through of exchange rate changes into the price of nontradabales and into the domestic price of tradables. While a high pass-through into nontradables will reduce the nominal exchange rate's effectiveness, a high pass-through into tradables will enhance it.

To illustrate this point, I use the standard definition of the real exchange rate, ρ, as the (domestic) relative price of tradable to nontradable goods:

$$\rho = \frac{P_T}{P_N}, \tag{1}$$

7. Edwards and Levy-Yeyati (2005) analyze the effectiveness of alternative exchange rate regimes in accommodating external shocks. For the exchange rate to act as a shock absorber, changes in the nominal exchange rate must be translated into real exchange rate changes. See also Hochreiter and Siklos (2002).

where P_T is the domestic price of tradables and P_N is the price of nontradables. For the nominal exchange rate to be an effective shock absorber—under either an adjustable or a flexible exchange rate regime—a depreciation of the nominal exchange rate (E) will have to generate an increase in ρ; if this happens, the change in ρ will help generate an expenditure switching effect. Traditional models ensure this result through three assumptions: (1) the law of one price holds for tradables;[8] (2) P_N is the result of the clearing conditions in the nontradables market; and (3) economic authorities pursue tight monetary and fiscal policies and nominal wages do not adjust automatically as a result of the nominal depreciation. The first two assumptions are summarized in equations (2a) and (2b):

$$P_T = EP_T^*; \tag{2a}$$

$$N^S\left(\frac{W}{P_N}\right) = N^D(\rho, A), \tag{2b}$$

where E is the nominal exchange rate (an increase in E is a nominal depreciation); P_T* is the international price of tradables; N^S and N^D are the supply and demand for nontradables, W is nominal wages, and A is absorption. Absorption is affected by fiscal policy and monetary policy; both expansive fiscal and monetary will result in a higher A.

In this setting, and assuming that the international price of tradables does not change,

$$\frac{d\log\rho}{d\log E} = 1 - \left(\alpha_1 + \alpha_2\frac{d\log W}{d\log E} + \alpha_3\frac{d\log A}{d\log E}\right). \tag{3}$$

where $\alpha_1 = \eta/(\eta - \varepsilon)$, $\alpha_2 = -\varepsilon/(\eta - \varepsilon)$, $\alpha_3 = \phi/(\eta - \varepsilon)$, and $\eta \geq 0$, $\varepsilon \leq 0$, $\phi \geq 0$ are elasticities. According to the traditional monetary model, the pass-through from the exchange rate to the domestic price of tradables will be unitary, and the pass-through to the domestic price of nontradables will depend on wage rate behavior and absorption policies. Under the classical case, $d\log W = d\log A = 0$, and the pass-through to P_N will be equal to $0 < (1 - \alpha_1) \leq 1$. A nominal depreciation will result in a real exchange rate depreciation—that is, $(d\log\rho)/(d\log E) > 0$—and the nominal exchange rate will play a role as a shock absorber.

8. This assumption is often referred to as producer-currency pricing.

The assumptions of the traditional monetarist model do not necessarily hold in the real world, however. Indeed, in the presence an automatic backward-looking wage indexation mechanism, the pass-through to the price of nontradables will be equal to one, and $(d\log\rho)/(d\log E) = 0$. Moreover, if the monetary authorities have low credibility and labor unions expect inflationary pressures in the future, then $(d\log W)/(d\log E) > 0$, and the effectiveness of the nominal exchange rate as a shock absorber will decline, as shown in Edwards (1998).

A number of analysts question the validity of the law of one price for tradables (equation 2a), even in small economies. If export firms have some monopolistic power, they will set prices in a way that maximize profits. In this case, they will price to market—that is, they will not alter their domestic prices in a particular market in proportion to exchange rate changes.[9] The easiest way to visualize this is to consider the optimal pricing strategy for a monopoly operating in country *j*. Equation (2a) for the domestic price of tradables is replaced with the following:

$$P_T^j = \mu \mathrm{MC}^j \,, \tag{2c}$$

where μ is the markup; and MC is the marginal cost of operating in country *j* (in domestic currency), which depends on production costs, the cost of transportation, and distribution costs. The markup depends on the price elasticity of demand for T in country j (ϑ) and is given by $\mu = \vartheta \,/\, (1+\vartheta)$, where $\vartheta < 0$. The elasticity, in turn, depends on a number of variables, including income growth and the degree of price instability in the economy. Under most circumstances, a change in the nominal exchange rate will not be translated into a one-for-one change in the domestic price of tradables, for two reasons. First, MC does not necessarily remain constant when E changes. Second, the mark-up is affected when the exchange rate depreciates; indeed, it is likely to decline.[10] This means that the magnitude of the pass-through from exchange rate to the price of tradables is likely to be less than one. When the pass-through into importable goods is zero, the market is said to be characterized by local currency pricing.

Although the framework developed here could be made more complex (by assuming that nontradables use tradable inputs, for example), the main points would still be valid. In particular, once the role of the real exchange rate is explicitly introduced into the analysis, it is important to distinguish between two notions of exchange rate

9. See Atkenson and Burstein (2005) for a recent survey and results.
10. This is the case under many forms of the demand curve.

pass-through: pass-through into nontradables and pass-through into tradables. From a policy perspective, pass-through coefficients for tradables and nontradables should be different, with the pass-through for tradable goods being higher than that for nontradables.

In this section, I use data from seven inflation-targeting countries to investigate whether the adoption of this monetary policy regime affected the magnitude of the pass-through; see table 1 for a list of countries and the date when inflation targeting was enacted. One of the main objectives of this analysis is to investigate whether the adoption of inflation targeting has altered the effectiveness of nominal exchange rates as shock absorbers. As pointed out above, this would be the case if the pass-through from exchange rates to nontradable prices has declined or if the pass-through to tradables goods has increased (or, at least, has not declined).

Table 1. Selected Inflation-Targeting Countries

Country	*Start date of inflation-targeting regime*
Australia	April 1993
Brazil	June 1999
Canada	February 1991
Chile	June 1991, June 1994
Israel	December 1991
Korea	January 1998
Mexico	January 1999

Source: Corresponding central bank's monetary policy reports and press releases; IMF research papers.

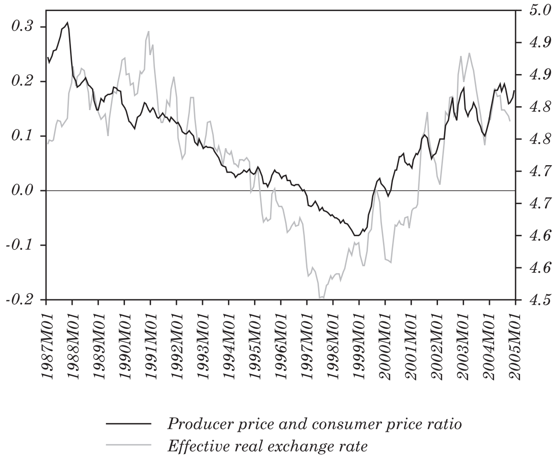
1.2 Empirical Model

An empirical analysis of the pass-through that focuses on inflation and the real exchange rate must consider the way in which changes in nominal exchange rates affect the domestic prices of nontradable and tradable goods. Most countries, however, have important data limitations, especially with regard to nontradables prices. Data limitations are most severe in emerging countries, where long series of domestic prices of importable goods are rarely available.[11] I therefore use the CPI index as a proxy for the domestic price of nontradables (P_N) and the PPI as a proxy

11. In the International Monetary Fund's *International Financial Statistics* (IFS), unit import prices for industrialized countries are expressed in domestic currency. For most emerging countries, however, they are expressed in U.S. dollars.

for the domestic price of tradables (P_T). This means that I am using the PPI-to-CPI ratio as a proxy for the real exchange rate in equation (1). This provides a fairly good proxy for the (effective) real exchange rate in many countries, as illustrated in figure 1 for the case of Chile.

Figure 1. Effective and Proxied Real Exchange Rates: Chile[a]



Source: IMF, International Financial Statistics.
a. The proxy used for the real exchange rate is the ratio of the producer price index to the consumer price index.

Most empirical studies on pass-through estimate variants of the following equation (Campa and Goldberg, 2002; Gagnon and Ihrig, 2004):

$$\begin{aligned}\Delta \log P_t &= \beta_0 + \beta_1 \Delta \log E_t + \sum \beta_{2i} \mathbf{x}_{it} \\ &\quad + \beta_3 \Delta \log P_t^* + \beta_4 \Delta \log P_{t-1} + \omega_t,\end{aligned} \tag{4}$$

where P_t is a price index (of either importable, tradable, or nontradable goods), E is the nominal exchange rate, P^* is the an index of foreign prices, the betas are parameters to be estimated, $\mathbf{x}_{it}$ is a vector of other controls expected to capture changes in the markup, and ω_t is an error term with standard characteristics. The short-run pass-through is given by β_1, and the long term pass-through is $\beta_1/(1-\beta_4)$.[12]

12. Campa and Goldberg (2002) use the sum of four lagged coefficients of the change in the exchange rate to compute the long-run pass-through. Most other authors also follow this distributed-lags approach.

Many analysts impose the constraint $\beta_1 = \beta_3$. In this paper, however, I consider the more general case, and I allow for different coefficients for the nominal exchange rate and international prices.[13]

From an empirical perspective, the question of interest is whether the coefficients β_1 and β_4 experience a structural change at (approximately) the time of the adoption of inflation targeting. I investigate this by adding two interactive terms to equation (4), so the equation I actually estimate is

$$\begin{aligned}\Delta \log P_t &= \beta_0 + \beta_1 \Delta \log E_t + \sum \beta_{2i} \mathbf{x}_{it} + \beta_3 \Delta \log P_t^* + \beta_4 \Delta \log P_{t-1} \\ &\quad + \beta_5 \Delta \log E_t \cdot \mathrm{DIT} + \beta_6 \Delta \log P_{t-1} \cdot \mathrm{DIT} + \omega_t,\end{aligned} \tag{4a}$$

where DIT is a dummy variable that takes the value of one since (approximately) the time inflation targeting is adopted, and zero otherwise. The short-term pass-through in the post-inflation-targeting period is $\beta_1 + \beta_5$. In contrast with other studies, in equation (4a) I allow the coefficient of lagged $\Delta \log P$ in the post-inflation-targeting period to be different from the pre-inflation-targeting coefficient. This is important for two reasons: first, it allows me to investigate whether a more inflationary-focused policy reduces inflationary inertia, as argued by Taylor (2000). Second, it provides an alternative channel through which the long-run pass-through may decline. Indeed, since the long-run pass-through in the post-inflation-targeting period is $(\beta_1 + \beta_5)/[1 - (\beta_4 + \beta_6)]$, it could be lower than the pre-inflation-targeting coefficient because either β_5 or β_6 may be significantly negative in equation (4a).

Estimating equation (4a) presents several challenges. The most important has to do with potential endogeneity problems: $\Delta \log E$ may not be exogenous, and it may be correlated with the error term. In principle, there are several ways to deal with this issue, but none of these methods is particular satisfactory in practice. For example, simultaneous equations methods, such as two-stage least squares or generalized method of moments, are limited by the difficulty of finding good instruments for $\Delta \log E$. However, in the vast majority of countries with floating exchange rates, most exogenous variables are not highly correlated with changes in the nominal exchange rate.[14] In the case of structural vector autoregressions (VARs),

13. Some studies, such as Gagnon and Ihring (2004), analyze how different monetary regimes affect the extent of pass-through.

14. This difficulty was first pointed out by Meese and Rogoff (1983).

identification conditions require making unconvincing assumptions about the timing of the effects of the exchange rate on prices. For these reasons, most recent studies on pass-through, including Campa and Goldberg (2002) and Gagnon and Ihrig (2004), rely on least squares methods. An additional challenge in estimating equation (4a) is that many countries do not have data on the (possible) determinant of the markup or the additional controls, **x**.

1.3 Data and Empirical Results

To estimate equation (4a), I use quarterly data for the period 1985–2005 for two advanced and five emerging countries that adopted inflation targeting at some point in the last fifteen years (see table 1).[15] Chile adopted inflation targeting in an evolutionary fashion, so table 1 provides two adoption dates: 1991, when an inflation target range was first announced, and 1994, when a specific inflation rate was adopted as a target.[16] Unless otherwise indicated, the results reported in this section were obtained using mid-1994 date as the launch date for inflation targeting in Chile. The results were similar using the 1991 launch date.

I estimated two equations for each country: one for the rate of change of the CPI (which, as mentioned, is a proxy for nontradables inflation) and one for the rate of change of the PPI (a proxy for domestic tradables inflation). All data are expressed as quarterly percentage changes. The exchange rate is the effective (multilateral) exchange rate, defined as the domestic price of a basket of currencies. Thus, an increase in E is a (multilateral) nominal depreciation.[17] To the extent that it takes time for the public to understand a new policy regime, the structural change in the pass-through coefficients will not be instantaneous, but rather will take place some quarters after the new policy is adopted. In the estimation of equation (4a), I considered alternative lags for DIT; most of the results reported in table 2 are for four lags. The rate of change of the U.S. producer price index was used as a proxy for world inflation. In the basic results reported in table 2, I follow Gagnon and Ihrig (2004) and do not include the additional controls, **x**. See, however, the discussion below.

15. The time period was slightly shorter in some countries.

16. Another relevant date is March 2000, when the first Monetary Policy Report was published.

17. For the majority of countries, I took the multilateral effective exchange rate from the IFS. For countries for which the IFS does not provide the effective rate, I constructed a multilateral exchange rate index.

Table 2. SURE Estimates: Exchange Pass-through, Selected Countries[a]

	Australia		*Brazil*		*Canada*		*Chile*	
Explanatory variable	*CPI*	*PPI*	*CPI*	*PPI*	*CPI*	*PPI*	*CPI*	*PPI*
dlog E	0.054	0.070	0.719	0.759	0.039	0.085	0.137	0.207
	(2.34)	(1.31)	(24.76)	(22.30)	(0.79)	(0.79)	(2.88)	(2.08)
dlog P^*	0.184	0.481	0.117	0.404	0.128	0.070	0.028	0.254
	(3.13)	(3.65)	(0.22)	(1.66)	(2.69)	(0.66)	(0.26)	(1.10)
dlog P_{-1}	0.548	0.060	0.300	0.284	0.499	0.404	0.355	0.194
	(4.09)	(0.30)	(10.38)	(8.67)	(3.99)	(1.83)	(3.43)	(1.77)
Constant	0.006	0.011	0.011	–0.013	0.004	0.003	0.003	0.016
	(2.27)	(2.51)	(0.55)	(0.54)	(2.75)	(1.24)	(3.88)	(1.66)
DIT* dlog E	–0.057	–0.054	–0.663	–0.524	–0.066	0.032	–0.132	–0.162
	(1.55)	(0.60)	(4.95)	(3.28)	(1.20)	(0.28)	(2.27)	(1.32)
DIT* dlog P_{-1}	–0.344	–0.011	0.866	0.379	–0.488	–0.054	–0.090	–0.120
	(1.76)	(0.05)	(1.51)	(1.41)	(2.77)	(0.19)	(0.79)	(0.66)
Summary statistic								
R^2	0.467	0.234	0.974	0.964	0.349	0.220	0.667	0.169
Durbin-Watson.	2.11	2.17	2.39	2.41	2.14	2.06	2.13	1.74
Determinant residual covariance	–	4.85e–9	–	4.13e–6	–	1.49e–9	–	3.73e–8

Table 2. (continued)

	Israel		Korea		Mexico	
Explanatory variable	*CPI*	*PPI*	*CPI*	*PPI*	*CPI*	*PPI*
dlog E	0.624	0.627	0.020	0.055	0.191	0.246
	(12.18)	(5.95)	(1.20)	(2.10)	(4.85)	(5.98)
dlog P^*	0.017	0.202	0.006	0.137	0.184	0.313
	(0.18)	(1.54)	(0.07)	(0.88)	(0.64)	(1.29)
dlog P_{-1}	0.132	0.121	0.200	0.213	0.635	0.584
	(2.84)	(2.92)	(2.07)	(2.15)	(10.49)	(10.06)
Constant	0.024	0.018	0.013	0.003	0.026	0.021
	(4.78)	(4.33)	(4.59)	(0.94)	(1.96)	(1.79)
DIT* dlog E	−0.427	−0.430	−0.031	−0.063	−0.176	−0.053
	(5.23)	(6.42)	(0.43)	(0.77)	(1.05)	(0.31)
DIT* dlog P_{-1}	0.120	−0.064	−0.097	−0.039	−0.454	−0.362
	(0.92)	(0.54)	(0.43)	(0.51)	(2.02)	(1.74)
Summary statistic						
R^2	0.866	0.880	0.210	0.110	0.793	0.790
Durbin-Watson.	2.46	2.10	2.15	2.32	2.31	2.37
Determinant residual covariance	–	2.98e−8	–	7.19e−9	–	5.23e−8

Source: Author's elaboration.

a. Quarterly data from 1986:1 to 2005:1, except for Chile, which is 1988:1 to 2005:1. E is nominal effective exchange rate, P^* is the U.S. producer price index, P_{-1} is one lag of domestic producer or consumer price index, and DIT is a dummy for periods with inflation targeting. Absolute value of t statistics is reported in parentheses.

Since, for each country, the errors in the CPI and PPI equations are likely to be correlated, I estimated the two equations for each country simultaneously, using Zellner's seemingly unrelated regressions (SURE) procedure.[18] The results obtained are presented in table 2. Table 3 presents a summary of the pass-through coefficients in the pre-inflation-targeting and post-inflation-targeting periods. The main results may be summarized as follows.

—The pre-inflation-targeting short-term pass-through coefficient in the CPI equation is positive in all countries. It is significantly so in six out of the seven countries; the only exception is Canada, whose coefficient is positive but not significant.[19] However, the estimated coefficients show a significant degree of variability across countries. The pre-inflation-targeting short-term pass-through coefficient into nontradable prices (CPI) ranges from a low of 0.020 in Korea to a very high 0.719 in Brazil. A simple inspection at these estimates suggests that the CPI pass-through coefficient has historically been much higher in countries with a tradition of high and chronic inflation (such as Brazil), than in countries with traditional price stability (such as Korea).

—The short term pass-through coefficient in the PPI (or tradables) equation is significantly positive in six out of the seven countries. There is also a significant variability across countries.

—The point estimate of the pre-inflation-targeting short term pass-through coefficient is higher for tradables (PPI) than for nontradables (CPI) in all countries.

—In the pre-inflation-targeting period, the long-run point estimate for the PPI pass-through is higher than for the CPI pass-through in most countries.

—The estimated coefficient of ($d\log E \cdot \mathrm{DIT}$) is negative in all cases. It is significantly so in most cases. This indicates that the short-run pass-through declined in every country in the sample following the adoption of inflation targeting. Moreover, in most cases the decline was larger in the CPI (or nontradables) equation than in the PPI equation, indicating that the short-run effectiveness of the nominal exchange rate rose.

—The decline in the short-run CPI pass-through in the post-IT period was particularly dramatic in the case of Brazil, where the short-run coefficient declined from 0.719 to 0.056. Chile, Israel, and Mexico

18. All equations also include a time trend and, in the case of Brazil, two dummy variables for the 1989 and 1999 currency crises.

19. In the analysis that follows, I consider coefficients with a p value of 20 percent or less to be significant. In most cases, however, the p values are less than 5 percent.

Table 3. Short- and Long-Run Exchange Rate Pass-through, Selected Countries[a]

	CPI equations				*PPI equations*			
	Short-run pass-thorough		*Long-run pass-thorough*		*Short-run pass-thorough*		*Long-run pass-thorough*	
Country	*Pre-IT*	*Post-IT*	*Pre-IT*	*Post-IT*	*Pre-IT*	*Post-IT*	*Pre-IT*	*Post-IT*
Australia	0.054	0.000	0.120	0.000	0.070	0.070	0.070	0.070
Brazil	0.719	0.056	1.027	—	0.759	0.235	1.060	0.697
Canada	0.039[a]	0.000	0.078[a]	0.000	0.085	0.085[a]	0.143[a]	0.143
Chile	0.137	0.005	0.212	0.008	0.207	0.045	0.257	0.056
Israel	0.624	0.197	0.718	—	0.627	0.197	0.713	0.224
Korea	0.020	0.020	0.025	0.025	0.055	0.055	0.070	0.070
Mexico	0.191	0.015	0.523	0.018	0.246	0.246	0.591	0.316

Source: Author's elaboration, based on estimations reported in table 2.
a. Quarterly data from 1986:1 to 2005:1.

also display a major reduction in the pass-through coefficient. At the other extreme, the change in the degree of CPI (or nontradables) pass-through in Korea is not statistically significant, as the CPI pass-through was already very low when inflation targeting was adopted (0.020).

—The pre-inflation-targeting period was characterized by a considerable degree of inflation inertia in most countries, measured by the coefficient of lagged $\Delta \log P$ (see table 2). In most cases, however, inertia was higher for CPI (or nontradables) inflation than for PPI (or tradables) inflation.

—The estimated coefficients of ($\Delta \log P_{-1} \cdot \text{DIT}$) are negative in the vast majority of the countries, with the exception of Brazil for both definitions of inflation and Israel for CPI. The estimated coefficient for ($\Delta \log P_{-1} \cdot \text{DIT}$) is negative and statistically significant for Australia (CPI), Canada (CPI), and Mexico (CPI and PPI), indicating that inflation inertia declined significantly after those countries adopted inflation targeting.

—The post-inflation-targeting long-run pass-through depends on the behavior of both ($\Delta \log P_{-1} \cdot \text{DIT}$) and ($\Delta \log E \cdot \text{DIT}$). As table 3 shows, the long-run pass-through coefficient declined in the post-inflation-targeting period in most countries in the sample (see table 3). This is the case for both the CPI (or nontradables) and the PPI (or tradables) pass-through coefficients.

To explore whether the differences in the pass-through coefficients for the CPI (nontradables) and PPI (tradables) equations reported in tables 2 and 3 are statistically significant, I computed Wald chi-squared statistics to test for cross-equation restrictions. The results are reported in table 4. The null hypothesis that the pass-through coefficients in the CPI and PPI equations are equal is rejected at conventional levels in four of the seven countries.[20] In Brazil, the null hypothesis was rejected both in the short- and long-run in the pre- inflation-targeting period, but it is only rejected in the short-run in the post- inflation-targeting period. Finally, I also tested the joint hypothesis that the short- and long-run pass-through coefficients were equal in both the pre- and post-inflation-targeting periods. The results (which are available on request) indicate that the null hypothesis is rejected for Brazil, Canada, and Mexico.

The estimates reported in table 2 include few controls. To check for the robustness of the results and, in particular, to check for possible omitted variables bias, I also estimated equation (4a) with

20. In most cases, the rejection is not across all time runs and time periods.

Table 4. Wald Tests for Cross-Equation Restrictions[a]

	Short-Run		*Long-Run*	
Country	*Pre-inflation-targeting*	*Post-inflation-targeting*	*Pre-inflation-targeting*	*Post-inflation-targeting*
Australia	0.078	0.131	0.209	0.132
	(0.78)	(0.72)	(0.65)	(0.72)
Brazil	4.240*	3.966*	6.216*	0.543
	(0.04)	(0.04)	(0.01)	(0.46)
Canada	0.189	11.189**	0.085	8.219*
	(0.66)	(0.01)	(0.77)	(0.00)
Chile	0.721	0.251	0.140	0.214
	(0.39)	(0.61)	(0.71)	(0.64)
Israel	0.007	0.010	0.025	0.523
	(0.93)	(0.87)	(0.87)	(0.46)
Korea	3.466**	0.030	2.840**	0.051
	(0.05)	(0.91)	(0.09)	(0.92)
Mexico	23.523*	14.846*	3.824*	6.235*
	(0.00)	(0.00)	(0.05)	(0.01)

Source: Author's elaboration, based on estimations reported in table 2 and 3.
* statistically significant at the 5 percent level.
** statistically significant at the 10 percent level.
a. The test statistics are chi-squared with one degree of freedom. The null hypothesis is that the pass-through coefficients in the CPI and PPI equations are equal in each country. *P* values are reported in parentheses.

the following controls: deviations of GDP from a stochastic trend, lagged one or two periods (in some regressions this variable was also interacted with the nominal depreciation); deviations of U.S. GDP, lagged one or two periods; the change in the degree of volatility of inflation, lagged one or two periods (in some regressions this variable was also interacted with the nominal depreciation); and a time trend. The results are very similar to those presented in table 2 and confirm that most countries display breakpoints in the short-run pass-through, the degree of inertia, and the long-run pass-through coefficient.[21]

1.4 Further Results and Comments on Chile's Experience

Chile has been a pioneer in the implementation of inflation targeting in emerging economies. The country suffered high and chronic inflation for decades. Starting in the 1940s, inflation increased significantly and became a major political and economic problem, and repeated efforts to quell it proved unsuccessful (Meller, 1996). Pazos (1972) refers to Chile as the premier case of an economy in which inflation tended to perpetuate itself. Numerous scholars have analyzed the historical behavior of inflation in Chile, concluding that fiscal largesse, low Central Bank credibility, and widespread indexation practices (for both wages and the nominal exchange rate) were behind Chile's historical high rates of inflation. In the 1990s, however, Chile's monetary policy underwent important changes: the Central bank was granted independence, and it formally adopted an inflation-targeting approach (Corbo, 1998; Schmidt-Hebbel and Tapia, 2002; Morandé, 2002). Since then, inflation has declined significantly; it has not been considerably different from world inflation in the last few years.

The results presented in tables 2 and 3 tend to confirm this story: after adopting inflation targeting in the early 1990s, Chile experienced a decline in the degree of pass-through, in the case of both CPI and PPI inflation (see also De Gregorio and Tokman, 2004). This section provides additional results on Chile that shed further light on the relation between inflation and exchange rates. Table 5 presents new estimates for equation (4a) for CPI (or nontradables) and PPI (or tradables) inflation using three stages least squares (3SLS), which deals with the potential endogeneity of exchange rate changes.[22] Although

21. Results are available on request.

22. I used the following instruments: lagged first difference in the U.S. CPI, the commodity price index, and first difference of the U.S. PPI.

the point estimates are somewhat different, the overall results tend to confirm the conclusions reached above. The 3SLS estimations generally show that the degree of both CPI and PPI pass-through declined in the post-inflation-targeting period. Interestingly, and in contrast with the cases of Australia, Canada and Mexico, I find no evidence of a decline in the degree of inflationary inertia in Chile in the post-inflation-targeting period. Moreover, the level of inertia in Chile is similar for CPI and PPI inflation. From a comparative perspective, however, inflationary inertia is not higher in Chile than in countries with a long tradition of price stability, such as Australia and Canada (see table 2).

Table 5. 3SLS Estimates: Exchange Rate Pass-Through, Chile

Explanatory variable	*CPI*	*PPI*
dlog E_{-1}	0.228	0.530
	(1.55)	(2.21)
dlog P_{-1}	0.375	0.281
	(2.53)	(1.62)
dlog P^*	−0.035	0.213
	(0.26)	(0.72)
C	0.024	0.000
	(1.69)	(0.00)
DIT* dlog E	−0.214	−0.446
	(1.47)	(2.00)
DIT* dlog P_{-1}	−0.105	−0.189
	(0.62)	(0.70)
Summary statistic		
R^2	0.647	0.056
Durbin-Watson	2.05	1.72
Determinant residual covariance	4.31e−0.8	

Source: Author's elaboration.
a. Quarterly data from 1988:1 to 2005:2. E is nominal effective exchange rate, P^* is the U.S. producer price index, P_{-1} is one lag of domestic producer or consumer price index, and DIT is dummy for periods with inflation targeting. Instruments are the lagged first difference of the U.S. CPI, the first difference of commodity price index, and the first difference of the U.S. PPI. Absolute value of t statistics is reported in parentheses.

2. Inflation Targeting and Exchange Rate Volatility: Some Empirical Tests

As a number of authors point out, a floating exchange rate system is a requirement for a well-functioning inflation-targeting regime (Mishkin and Savastano, 2001).[23] In a world of capital mobility, independent monetary policy cannot coexist with a pegged exchange rate regime—this is the so-called impossibility of the holy trinity. This connection between inflation targeting and floating exchange rates has led some analysts to argue that one of the costs of inflation targeting is increased exchange rate volatility. De Gregorio, Tokman, and Valdés (2005) discuss this issue in the Chilean context; they show that (nominal) exchange rate volatility has not been higher in Chile than in other countries with floating exchange rates.

The way in which the adoption of inflation targeting affects exchange rate volatility is an important policy issue, yet recent debates do not address it appropriately. Many analysts compare exchange rate volatility under inflation targeting with volatility under a pegged or administered exchange rate regime. This is not an adequate comparison. Policy evaluation requires separating the selection of the exchange rate regime and the adoption of inflation targeting. The correct question is whether the adoption of inflation targeting increases exchange rate volatility, controlling for the exchange rate regime. Moreover, most volatility analyses are based on comparisons of unconditional volatility measures across countries, or across time in the same country.

In this section, I use two approaches to address these issues. First, I analyze whether the adoption of inflation targeting affects conditional exchange rate volatility in countries that have had a floating exchange rate for a prolonged period, such as Australia and Canada. Second, I estimate regressions that control for the exchange rate regime. The analysis uses monthly data and focuses on the seven countries in table 1. Conceptually, conditioning for the exchange rate regime makes it possible to determine whether inflation targeting alone raises exchange rate volatility. For example, Australia and Canada both have a long tradition of floating rates. Comparing their conditional volatility before and after the implementation of inflation targeting provides information on the effects of the new policy regime on exchange rate behavior.

2.1 The Data and the Empirical Model

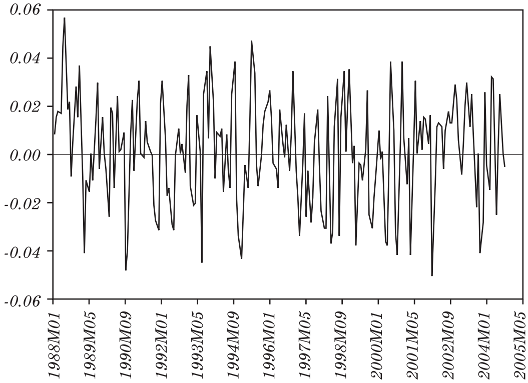
Figure 2 displays data on exchange rate volatility, measured as the monthly difference in the log of the nominal effective exchange

23. The authorities do not need to abstain completely from intervention in the foreign exchange market. See the discussion in section 3 of this paper.

rate for the countries in the sample for January 1988 to January 2005. The figure clearly captures the degree of instability—including crises—faced by some of the countries in the period under study. The figure also shows that instability varied significantly in most of the countries.

Figure 2. Exchange Rate Volatility in the Sample Countries[a]

Australia



Brazil

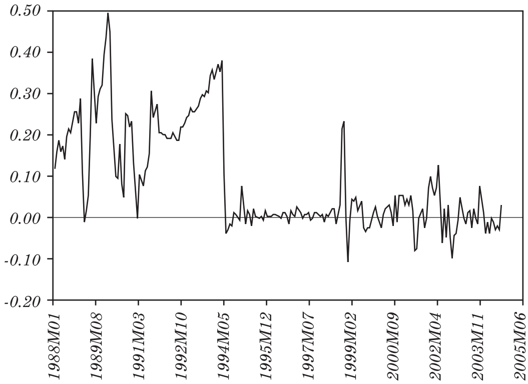
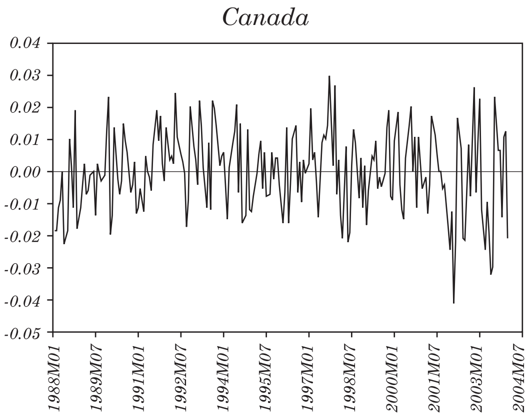
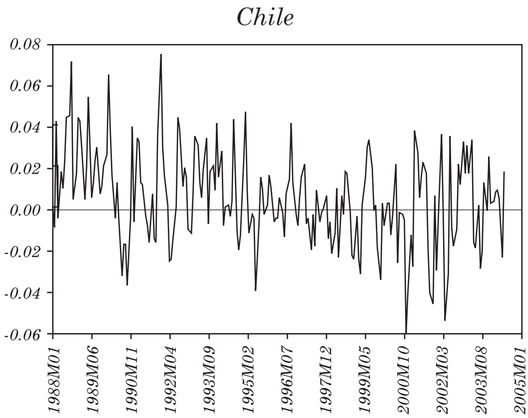


Figure 2. (continued)





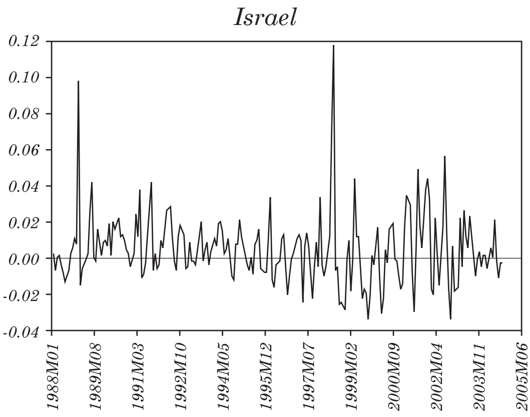
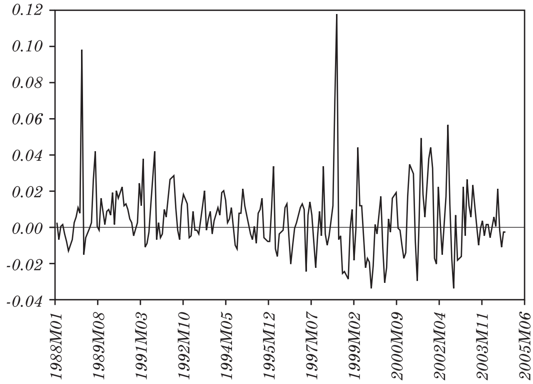
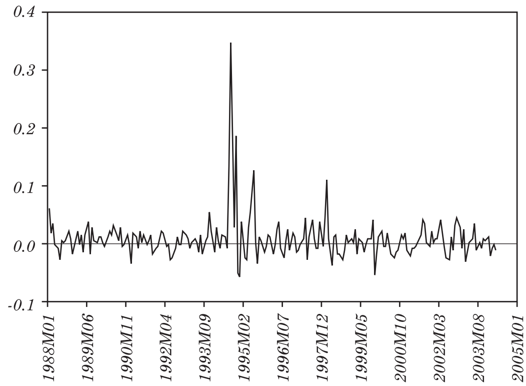


Figure 2. (continued)

Korea



Mexico



Source: Author's elaboration, basedd on data from IMF, International Financial Statistics.
a. Exchange rate volatility is measured as the monthly difference in the log of the nominal effective exchange rate in each country from January 1988 to January 2005.

The changing degree of exchange rate volatility illustrated in figure 2 suggests that, during this period, exchange rate volatility can be explained by models in the generalized autoregressive conditional heteroskedastic (GARCH) tradition. Most GARCH-based empirical work on exchange rate volatility tends to ignore the potential role of alternative monetary regimes, both in the mean and conditional variance equations. Consider the following GARCH model of nominal exchange rates in a particular country:

$$\Delta \log E_t = \theta + \sum \phi_j z_{t-j} + \psi_t \ ; \tag{5}$$

$$\sigma_t^2 = \alpha_1 + \alpha_2 \psi_{t-1} + \sum \gamma_i \sigma_{t-i}^2 + \sum \delta_i y_{t-i} \ , \tag{6}$$

where, as before, E is the nominal effective exchange rate; z is a variable that affects changes in the exchange rate and may include lagged values of $\Delta\log E$, as well as other domestic or international variables; and ψ_t represents innovations to exchange rate changes, with zero mean and conditional variance σ_t^2. In equation (6), y_t, is a variable, other than past squared innovations or lagged forecast variance, that helps explain exchange rate volatility.

This section reports the results from estimating models based on equations (5) and (6) using monthly data for the seven countries in the sample. The time period is January 1988 through January 2005, with the exception of Brazil, for which the period is June 1994 to January 2005.[24] My main objective is to investigate whether the adoption of an inflation-targeting operating procedure for monetary policy affects exchange rate volatility. I am also interested in exploring whether the adoption of a floating exchange rate regime has an effect on volatility. I therefore included two dummy variables as y_t in the conditional variance equation (equation 6): DIT, which takes the value of one if the country has implemented an inflation-targeting regime, and FLOAT, which takes the value of one if the country has a floating exchange rate regime. The variable FLOAT is based on information from a number of sources, including Levy-Yeyati and Sturzenegger (2003), Reinhart and Rogoff (2004), and the IMF. The means equation (equation 5) also includes a time trend and, for Mexico and Korea, dummy variables for their major currency crises.[25]

2.2 Results

In the first step of the analysis, I used ordinary least squares to estimate several versions of equation (5) for the seven countries in the sample.[26] The analysis of the residuals clearly showed the presence of

24. Inflation in Brazil experienced a structural break around mid-1994, when the real plan was adopted.

25. Some of the estimates also include the floating regime dummy in the means equation. Its inclusion does not affect the results, however.

26. As is customary, a preliminary step consists of analyzing stationarity. I used both country-specific and panel techniques.

conditional heteroskedasticity. Engle's Lagrange multiplier (LM) test rejected the null hypothesis of absence of ARCH for every country. In the second step, I identified the order of the GARCH process for each of the countries, and I verified stability. Finally, I estimated the system of equations (5) and (6). The dummy variables for inflation targeting (DIT) and a floating regime (FLOAT) were lagged one period in all cases, although the results were not affected significantly when I used alternative lag structures (including no lags). If the adoption of inflation targeting has indeed resulted in increased nominal effective exchange rate instability, as some critics argue, then the estimated coefficient of DIT would be significantly positive. If floating rates increase exchange rate volatility, as one would expect under most circumstances, then the estimated coefficient of FLOAT would be significantly positive. I did not include the FLOAT variable when estimating the conditional variance equations for Australia and Canada, since both of these countries have had a floating regime since the mid-1970s.

The results are provided in table 6. I only report the order of the GARCH process and the estimated coefficients of DIT and FLOAT. The main results may be summarized as follows. First, the estimated coefficient of the inflation targeting dummy, DIT, is positive and very small in three of the countries—namely, Australia, Canada, and Korea—but it is not significantly different from zero in any of these cases. This indicates that the adoption of inflation targeting did not increase nominal multilateral exchange rate volatility (at least in this sample).

Second, the estimated coefficient of the inflation targeting dummy, DIT, is significantly negative in Brazil, Chile (for both equations), and Israel, and it is negative (but not significant) in Mexico. In the case of Chile, the degree of significance of DIT is higher (in absolute terms) when 1994 is considered as the beginning of the inflation-targeting period. When the FLOAT variable is excluded, the coefficient of DIT becomes positive (but insignificant) in the conditional variance equations for Chile and Brazil. These results suggest that, after controlling for the exchange rate regime, the adoption of inflation targeting has tended to reduce conditional volatility in some countries. The most likely reason for this is that inflation targeting is a transparent and predictable monetary framework that tends to reduce unexpected shocks or news.

Finally, the estimated coefficient of the FLOAT variable is positive in the five equations in which it was included. Moreover, it is significantly positive in three of the five equations—for Brazil, Chile, and Israel.

Table 6. GARCH Estimates: Inflation Targeting, Exchange Rate Regime, and Nominal Exchange Rate Volatility, Selected Countries[a]

Country	*DIT*	*FLOAT*	*DW*	R^2
Australia (1,1)	6.36e–06	–	1.96	0.10
	(0.96)	–		
Brazil (2,2)	–0.001	0.0008	1.97	0.25
	(4.16)	(2.55)		
Canada (1,1)	6.73e–06	–	1.89	0.04
	(0.66)	–		
Chile (1,1)[b]	–7.48e–06	1.71e–07	1.96	0.18
	(1.70)	(3.57)		
Chile (1,1)[c]	–1.57e–05	2.54e–05	1.94	0.22
	(4.20)	(5.97)		
Israel (1,1)	–3.71e–04	3.94e–04	2.30	0.05
	(5.44)	(3.92)		
Korea (1,0)	0.002	0.002	1.73	0.10
	(0.94)	(0.95)		
Mexico (1,1)	–3.67e–04	2.1e–04	2.50	0.14
	(1.06)	(0.63)		

Source: Author's elaboration.
a. Monthly data from January 1988 to January 2005. DIT is a dummy for periods with inflation targeting, and FLOAT is a dummy for periods with floating exchange rate. Absolute value of z statistics is reported in parentheses.
b. Inflation targeting assumed to start in June 1991.
c. Inflation targeting assumed to start in June 1994.

The results reported in table 6 are for standard GARCH models. In this setting, the nominal exchange rate reacts in the same way to positive and negative shocks. As a number of authors argue, however, the nominal exchange rate may react asymmetrically to positive and negative shocks. To analyze whether this possibility would affect the main results discussed above, I estimated a series of threshold and exponential GARCH models for the seven countries in the sample. Although I find some evidence of asymmetric responses, the main conclusions on the DIT and FLOAT coefficients discussed above still hold: there is no evidence that, once one controls for the exchange rate regime, the volatility of nominal (multilateral) exchange rates increased following the adoption of inflation targeting.

The results presented above are for nominal multilateral exchange rates. To analyze whether the adoption of inflation targeting affected real effective exchange rate volatility, I estimated equations (5) and (6) for the four countries with monthly data on real effective exchange rates (namely, Australia, Canada, Chile, and Israel). The results, which are reported in table 7, tend to confirm those obtained for nominal multilateral exchange rate volatility. There is no evidence that the adoption of inflation targeting increased real effective exchange rate volatility. In fact, the evidence indicates that the opposite occurred in Chile and Israel; in both of these countries the coefficient of DIT is negative, with a *z* statistic in excess of 1.2 (in absolute terms). As in table 6, these estimates suggest that the adoption of a floating regime increased real exchange rate volatility: the estimated coefficients of the FLOAT dummy are significantly positive

Table 7. GARCH Estimates: Inflation Targeting, Exchange Rate Regime, and Real Exchange Rate Volatility, Selected Countries[a]

Country	*Mean equation*	*GARCH*	*DIT*	*FLOAT*	*DW*	R^2
Australia	AR(2)	(1,1)	−1.77e−06	–	1.96	0.07
			(0.52)	–		
Canada	AR(3)	(1,3)	−3.67e−05	–	2.03	0.04
			(1.11)	–		
Chile[b]	AR(1)	(2,2)	−8.39e−06	2.50e−06	1.87	0.05
			(1.27)	(4.02)		
Chile[c]	AR(1)	(2,2)	−2.35e−05	4.66e−05	1.89	0.10
			(2.57)	(4.22)		
Israel	AR(1)	(2,2)	−3.47e−05	7.05e−05	1.89	0.09
			(1.43)	(1.75)		

Source: Author's elaboration.
a. Monthly data from January 1988 to January 2005. DIT is a dummy for periods with inflation targeting, and FLOAT is a dummy for periods with floating exchange rate. Absolute value of *z* statistics is reported in parentheses.
b. Inflation targeting assumed to start on June, 1991.
c. Inflation targeting assumed to start on June, 1994.

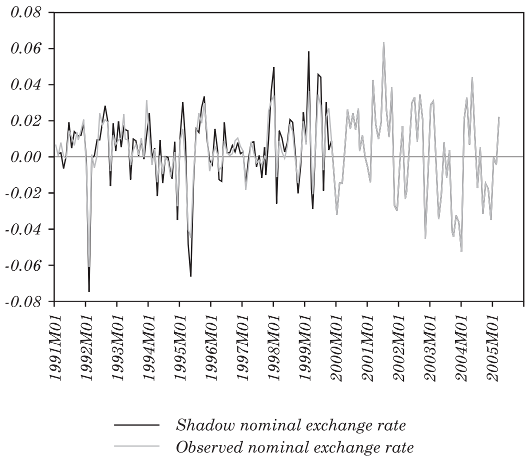
2.3 Extensions for the Case of Chile

The results reported above span a period in which most—but not all—of the countries in the sample underwent important changes in their exchange rate regime. Chile is a case in point.[27] During this

27. This also applies to Mexico, which had a band until late 1994, and Israel, which had a widening crawling band into the 2000s. Korea had a managed exchange rate until 1998; Brazil had a managed rate until 1999.

period, the country evolved from an exchange rate band of varying width to a flexible exchange rate. The extent of exchange rate volatility during the band period may have been limited by the existence of the band itself, even if the actual exchange rate never hit the bands. If this is the case, the results for the emerging countries (though not for Australia or Canada) in table 6 maybe misleading. To address this issue, I used data on Chile's shadow nominal exchange rate—or the exchange rate that would have prevailed in the absence of the bands—to analyze exchange rate volatility in the period 1991–2004. The data on the shadow exchange rate were taken from Edwards and Rigobon (2005). This shadow rate was computed using an iterative procedure based on the behavior of the actual rate, the bands, and the fundamentals. Figure 3 presents the evolution of the monthly change of the nominal observed and nominal shadow exchange rate for the Chilean peso relative to the U.S. dollar.

Figure 3: Monthly Changes in Observed and Shadow Nominal Exchange Rate



Source: Edwards and Rigobon (2005).

The estimation of the conditional variance equation for the shadow exchange rate yielded the following results: the point estimate for the inflation targeting dummy, DIT, was –2.36E–05, with a *z* statistic of –0.406. The point estimate for the floating exchange rate dummy, FLOAT, was 0.00004, with a *z* statistic of 1.620.[28] These results, then, confirm those reported in the preceding subsection. Even when a shadow exchange rate is used, there is no evidence suggesting that the adoption of inflation targeting increased nominal exchange rate volatility; there is, however, some evidence that the move from a band to a floating regime did have a small positive effect on volatility.

3. Central Bank Policy and the Exchange Rate under an Inflation-Targeting Policy Regime

Should inflation-targeting central banks intervene in the foreign exchange market? If so, should the intervention be sterilized, where the resulting changes in monetary aggregates are offset through operations involving domestic securities, or nonsterilized, where monetary aggregates are affected?[29] These complex questions have moved to the center of the policy debate in many inflation-targeting countries, especially in Latin America. In this section, I discuss the issue of whether inflation-targeting central banks should explicitly consider the exchange rate in their monetary rule.[30] This question is related to a number of important (and controversial) policy issues, including the costs of real exchange rate misalignment and fear of floating.[31]

3.1 The Issues

From a technical perspective, the discussion of the relation between central bank policy and the exchange rate may be framed in terms of the form of the Taylor rule in a small open economy. Taylor himself poses the problem as follows: "How should the instruments of monetary policy (the interest rate or a monetary aggregate) *react to the exchange rate*?" (Taylor, 2001, p. 263, emphasis added). To address this question formally, consider the following equation:[32]

28. This estimation uses the DIT_{1994} dummy.

29. Questions do not end here, however. For example, if intervention is sterilized, what type of domestic securities should be used in the sterilization? Should purchases and sales of foreign exchange be conducted in the spot or forward market?

30. It is not my intention to provide a comprehensive survey of central bank intervention. The literature is voluminous and country specific, and it continues to grow. See, for example, Domínguez and Frankel (1993); Taylor (2004); Kearns and Rigobon (2005); Neely (2001); Sarno and Taylor (2001). For an excellent analysis of different central bank policies, including Chile, see Tapia and Tokman (2004).

31. On fear of floating, see Calvo and Reinhart (2002).

32. This is the precise equation presented by Taylor in his discussion on the subject.

$$i_t = f\pi_t + gy_t + h_0 e_t + h_1 e_{t-1}, \tag{7}$$

where i_t is the short-term interest rate used by the central bank as a policy tool; π_t is the deviation of the inflation rate from its target level (possibly zero); y_t is the deviation of real GDP from potential real GDP (often called the output gap); e_t is the log of the real exchange rate in year t;[33] and f and g are the traditional Taylor rule coefficients. Finally, h_0 and h_1 are the coefficients of the current and lagged log of the real exchange rates in the expanded Taylor rule, and they are the main interest of this discussion. If $h_0 = h_1 = 0$, then exchange rate developments should not be incorporated in the policy rule, and the Taylor rule reverts to its traditional form.

In principle, the optimal monetary policy rule in a small open economy—that is, the policy that maximizes the authorities' objective function—could conceivably be one in which both h_0 and h_1 are different from zero. Interestingly, if $h_0 > 0$ and $h_0 = -h_1$, then the rule implies that monetary policy should react to changes in the (real) exchange rate. The formulation in equation (7) does not imply that the monetary authorities should defend a certain level of the exchange rate, even when h_0 and h_1 are different from zero. If the optimal policy calls for intervention (that is, for h_0 and h_1 different than zero) and if the monetary authorities follow this policy, a casual observer may conclude that the country in question is subject to fear of floating. This would be an incorrect inference, however, as the country in question would be practicing optimal flotation.

To fully answer this question, it is necessary to specify the policymaker's objective (or loss) function and the model that best captures the functioning of the economy. Most authors assume that the goal of policymakers is to minimize a loss function that combines deviations of GDP (or GDP growth) from trend and deviations of inflation from its target:[34]

$$L = (\pi_t - \hat{\pi}) + \lambda(y_t - \hat{y}), \tag{8}$$

where $\lambda > 0$ and where $\hat{\pi}$ is the inflation target, $\hat{y}$ is potential output, and $(y_t - \hat{y})$ is the output gap. In this case, the exchange rate will

33. In this formulation, an increase in e denotes a real exchange rate appreciation.

34. Medina and Valdés (2002) develop a model in which the authorities also target the current account. They show that the optimal reaction function is significantly different from traditional Taylor rules.

play a role in the monetary policy rule if changes in e (or, in some models, changes in the nominal exchange rate) affect inflation or the output gap (or both). To the extent that the pass-through coefficient is different from zero, exchange rate changes will affect actual inflation—that is, $\partial\pi/\partial e > 0$. If (some) changes in the real exchange rate reflect misalignment, they will affect the output gap. Under these circumstances, the optimal policy will take into account the way in which exchange rate developments affect the two components of the loss function. What is unclear, however, is whether the exchange rate should have an independent role in the monetary policy rule (equation 8). If the authorities have modeled the economy correctly (and, in doing so, have incorporated the effects of e on π and y), there is no need to include an exchange rate term in equation (8). De Gregorio, Tokman, and Valdés (2005) make this point forcefully in their discussion of Chile. If, however, there is a lagged response of both inflation and output to exchange rate changes, the central bank may want to preempt their effect by adjusting the policy stance when the exchange rate change occurs, rather than when its effects on π and y are manifested.

Whether a preemptive strategy is preferable to waiting until π and y begin to reflect the effects of a change in e is, in the final analysis, an empirical issue. Moreover, it is a country-specific issue; the main characteristics of a particular economy—including its inflation dynamics, the size of the pass-through coefficient, and different elasticities—will determine the extent to which macroeconomic volatility (that is, deviations of inflation and growth from targets and trends) is lower when h_0 and h_1 are different from zero.

3.2 A Selective Review of the Literature

Most analytical discussions on inflation targeting implicitly assume that $h_0 = h_1 = 0$, without actually inquiring how the incorporation of e into the policy rule will be affect welfare and macroeconomic performance. Furthermore, most discussions on inflation targeting in the mainstream literature tend to ignore open-economy issues. In the important book, *The Inflation-Targeting Debate,* edited by Ben S. Bernanke and Michael Woodford (2005), the index has no entry for devaluation or pass-through and only one entry for exchange rate. This last corresponds to the paper by Jonas and Mishkin (2005) on inflation targerting in transition economies. Most of the other papers in the volume do not include explicit discussions on exchange rate behavior when addressing monetary policy issues. Exceptions include Cecchetti and Kim (2005), who develop a section on an open economy, but do not ask formally whether h_0 or h_1 should be equal to zero. King (2005) briefly notes that although the United Kingdom experienced a sharp currency appreciation (in excess of 20 percent), this did not alter the effectiveness of the inflation-targeting-based policy. Finally, Caballero and Krishnamurthy (2005) develop a model of an open economy where the exchange rate plays an important role during a sudden stop; the exchange rate does play an important role in determining optimal monetary policy in their setting.

Woodford (2003) provides firm analytical underpinnings for interest-rate-based monetary policy, yet he does not deal explicitly with exchange rates. The index has no entries for exchange rate(s), devaluation, or pass-through and only one entry for open economy. No open-economy model is presented, and the discussions on optimal policy rule do not consider the (potential) role of open-economy variables.[35]

The pioneering book by Bernanke and others (1999) includes interesting discussions on the role of exchange rates in monetary policy implementation in a number of countries. Canada, for example, explicitly uses a monetary conditions index (MCI) that includes the exchange rate.[36] However, the chapter on design and implementation (chapter 3) does not discuss at the analytical level whether exchange rate considerations should be explicitly incorporated into the policy rule in an inflation-targeting setting. In the chapter on Australia, Israel, and Spain, the authors discuss how Israel and Spain gradually relaxed exchange rate bands when they adopted inflation targeting, and they explain that in both of these countries the authorities decided "not to respond to short-term exchange rate fluctuations" when making monetary policy decisions (Bernanke and others, 1999, p. 205).

Mishkin and Savastano (2001) provide one of the most complete discussions on the issue. They convincingly argue that the discussion on macroeconomic stability in Latin America is not related to the selection of the exchange rate regime. The issue, rather, is how to create an institutional framework for conducting credible monetary

35. To be fair, one could interpret the discussion in section 2.1 of chapter 7, on cost-push shocks, as including shocks stemming from exchange rate depreciation.

36. New Zealand also adopted an MCI in the late 1990s.

policy, and they consider that inflation targeting provides such a framework. Mishkin and Savastano develop a model in which optimality implies a Taylor rule of the following form:

$$i_t = \pi_t + b_1 (\pi - \pi^*) + b_2 y_t + b_3 e_t, \tag{9}$$

where e_t is the log of the real exchange rate, expressed as deviations from its equilibrium value. The authors make a very important point:

> "In Latin America exchange rate fluctuations are likely to have a bigger effect on aggregate demand and aggregate supply (because the pass-through may be larger)... [This] indicates that the weight of the exchange rate in the modified Taylor-rule, b_3, may be relatively large. However, this is in no way inconsistent with inflation targeting." (Mishkin and Savastano, 2001, p. 434).

Ball (1999), Obstfeld and Rogoff (1995), and Svensson (2000) argue that adding the exchange rate as an additional variable in equations like equation (7) will result in more stable macroeconomic outcomes. A simulation exercise undertaken by Svensson (1999, 2000) finds that the optimal values of the exchange rate coefficients are $h_0 = -0.45$ and $h_1 = 0.45$. Ball's (1999) analysis suggests that macroeconomic instability will be reduced if $h_0 = -0.37$ and $h_1 = 0.17$. These results, however, are model specific, and they will change for different parameterizations.

Taylor (2002) reviews nineteen models developed to analyze inflation and monetary issues. Of these, only five assume that the exchange rate affects aggregate demand, and only six assume that exchange rate changes are a factor in the process of price determination. This illustrates quite starkly that many influential researchers continue to think in terms of closed-economy monetary models.

Whether h_0 and h_1 should indeed be different from zero is ultimately a country-specific empirical question that should be dealt with by analyzing country-specific evidence—based on both historical data and simulation exercises. After much reflection, I find it difficult to disagree with Taylor (2001) when he expresses some skepticism on the general merits of adding the exchange rate into the interest rate equation, for at least two reasons. First, as pointed out earlier, in properly specified models, the exchange rate already plays an indirect role through its effect on π_t and y_t; second, adding the exchange rate (or any other asset price, for that matter) into the

Taylor rule is likely to add considerable volatility to monetary policy. This conclusion is similar to that of Mishkin and Schmidt-Hebbel (2001), who provide an extensive discussion on the subject. They find that when implementing policy, central banks should consider the effects of exchange rate fluctuations on inflation and the output gap, but they should not consider an independent role for e_t. As they state, “targeting an exchange rate is likely to worsen the performance of monetary policy.”

3.3 What Do Inflation-Targeting Central Banks Actually Do?

The above discussion clearly indicates that the issue of whether monetary policy should react to the exchange rate is not fully resolved. At the analytical level, the answer is likely to depend on each country’s structural characteristics and the authorities’ loss function. The vast majority of central banks, however, do not openly recognize that they explicitly take exchange rate developments into account when conducting monetary policy. If pressed, most inflation-targeting central bankers would go so far as to say that exchange rate changes play a role in monetary policy because they tend to affect inflation, but they would be reluctant to acknowledge that the exchange rate plays a direct role in the monetary policy rule itself. That is, in terms of equation (7), the vast majority of inflation-targeting central bankers would say that in their policy rules, $h_0 = h_1 = 0$.

As every student of monetary policy knows, however, what central banks say they do often diverges from what they actually do. Mohanty and Klau (2005) estimate monetary policy reaction functions (that is, Taylor rules) for thirteen emerging and transition economies; they find that the real exchange rate coefficient was significant in eleven of them.[37] This provides strong indication that, contrary to what they state, most inflation-targeting central banks take central bank developments into account when determining their monetary policy stance. Table 8 presents a list of the countries with the estimated short- and long-term coefficients in the estimated Taylor rule reaction functions.[38]

37. Hammermann (2005) also estimates central bank reaction functions to analyze whether the exchange rate plays a role.

38. The coefficients in table 7 have positive signs, since in this paper a higher exchange rate represents depreciation. In the Mohanty and Klau (2005) paper, a higher rate represents appreciation, and the coefficients are negative.

Table 8. Interest Rate Response to Changes in Real Exchange Rate[a]

Country	*Short-term*	*Long-term*
India	0.18	0.60
Korea	0.29	0.67
Philippines	0.09	0.13
Taiwan	0.03	0.18
Thailand	0.31	0.74
Brazil	0.10	0.36
Chile	0.00	0.00
Mexico	0.79	1.58
Peru	0.38	2.71
Czech Republic	–0.03	–0.19
Hungary	0.15	0.60
Poland	0.05	0.20
South Africa	0.12	6.00

Source: Mohanty and Klau (2005).
a. Obtained from estimated Taylor rule equations.

The case of Chile is particularly interesting. According to Mohanty and Klau's (2005) base estimates, Chile's Taylor rule may be expressed as follows (t statistics are in parentheses):

$$i_t = \underset{(0.25)}{0.32} + \underset{(4.87)}{0.97\pi_t} + \underset{(1.25)}{0.32y_t} + \underset{(2.78)}{0.35\Delta xr_t} - \underset{(-2.40)}{0.35\Delta xr_{t-1}} + \underset{(4.03)}{0.32i_{t-1}},$$

where Δxr is the change in the real exchange rate. The data are quarterly, and the time period covered is from 1992 to 2002. What is particularly interesting about the Chilean case is that the effect of (real) exchange rate changes on central bank policy appears to last only one quarter. Indeed, the sum of the coefficients for Δxr_t and Δxr_{t-1} add up to zero.

As the results summarized in table 8 show, there is a wide range of values for both the short- and long-run estimated coefficients of the real exchange rate in these Taylor rule reaction functions. (The short run is defined as the sum of the coefficients of Δxr_t and Δxr_{t-1}; the long run is the sum of these two coefficients divided by one minus the coefficient of y_{t-1}). Short-run coefficients, for example, range from a relatively high 0.79 for Mexico all the way to zero for Chile; long-run coefficients show an even larger dispersion.[39] To examine why monetary policy appears to have been more susceptible to exchange rate changes in some countries than others, I estimated a number of cross-country regressions. The dependent variable is the short-run exchange rate coefficient reported in table 8. The following controls were used: average inflation, 1990–95; standard deviation of quarterly inflation, 1990–95; standard deviation of the real exchange rate, 1990–95; degree of openness of the economy, measured as imports plus exports over GDP; length of time the country has had floating rates; and number of years since inflation targeting was adopted. The results obtained for these six univariate regressions are presented in table 9. Since I only have thirteen observations, I made no attempt to run a multivariate regression with all the regressors. Despite the extremely small sample, the results reported in table 9 are interesting and suggestive. Countries with a history of higher inflation seem to have a higher coefficient for Δxr in their Taylor rules. Also, countries that have historically had a more volatile (real) exchange rate seem to attach a higher coefficient to the exchange rate in their monetary rule. When both variables are included in a bivariate regression their coefficient are still positive and continue to have a relatively high level of significance.

4. Concluding Remarks

The exchange rate is one of the most important macroeconomic variables in emerging and transition economies. It affects inflation, exports, imports, and economic activity. For decades the vast majority of emerging countries had rigid exchange rate regimes—either pegs (adjustable or hard) or a managed rate. This, however, has changed in the last few years, when an increasingly large number of countries have adopted flexible exchange rate regimes. This move away from exchange rate rigidity has occurred while many countries have embraced inflation targeting as a way of conducting monetary policy. The conjunction of inflation targeting and flexible rates has brought a host of new policy issues to the center of the discussion, including issues related to the role of the exchange rate in monetary policy, volatility, and the relation between exchange rate changes and inflation.

39. In the case of long-run coefficients, most of the very high values are the result of a very low estimate for the lagged interest rate. This may be biasing the long-run estimates.

Table 9. Exchange Rate Coefficient in Taylor Rule Equations and Country Characteristics[a]

Explanatory variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Average inflation	0.015					
	(1.74)***					
Std. deviation inflation		0.010				
		(0.71)				
Std. deviation real exchange rate			0.040			
			(1.78)***			
Trade openness				−0.001		
				(0.64)		
Time with floating regime					−0.000	
					(0.11)	
Years since inflation targeting adopted						0.005
						(0.26)
Constant	0.037	0.140	−0.031	0.276	0.207	0.170
	(0.35)	(1.51)	(0.23)	(1.86)	(1.17)	(1.73)
No. observations	13	13	13	13	13	13
R^2	0.22	0.04	0.22	0.04	0.00	0.01

Source: Author's elaboration.
* Statistically significant at the 1 percent level.
** Statistically significant at the 5 percent level.
*** Statistically significant at the 10 percent level.
a. Estimated using ordinary least squares. Absolute value of t statistics is reported in parentheses.

In this paper, I have addressed three of these issues: the relation between the pass-through and the effectiveness of nominal exchange rates in inflation-targeting regimes; the effects of inflation targeting on exchange rate volatility; and the role (or potential role) of exchange rate changes on the monetary rule in inflation-targeting countries. The main findings from this analysis may be summarized as follows. First, countries that have adopted inflation targeting have experienced a decline in the pass-through from exchange rate changes to inflation. In many of the countries in the sample, this decline in the pass-through has been different for CPI and PPI inflation. There is no evidence, however, of changes in the degree of effectiveness of the nominal exchange rate as a shock absorber. Second, the adoption of inflation-targeting monetary policy procedures has not resulted in an increase in nominal or real exchange rate volatility. However, the adoption of a floating exchange rate regime increased the degree of volatility of exchange rates in three out of five countries. Finally, there is some evidence that inflation-targeting countries with a history of high and unstable inflation tend to explicitly take developments in the nominal exchange rate into account when conducting monetary policy.

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