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CREDIBILITY AND INFLATION TARGETING IN AN EMERGING MARKET: THE CASE OF CHILE

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Resumen

Cuando la autoridad monetaria de un país carece de credibilidad se ve enfrentada a un trade-off mayor entre producto e inflación. Lo anterior plantea desafíos importantes para el diseño y la implementación de un régimen de metas de inflación y para los procesos de estabilización inflacionaria. En este trabajo mostramos como estos desafíos han definido las diferentes fases en el proceso de implementación del régimen de metas de inflación en Chile, y como distintas características del proceso desinflacionario seguido por el país durante los 90s son consistentes con una situación donde la credibilidad en la política no es perfecta.

Abstract

When the monetary authority lacks credibility it faces a larger trade-off between output and inflation. This poses important challenges for the implementation and design of an inflation targeting regime and an inflation stabilization process. In this paper we show how these challenges have determined different implementation phases of an inflation targeting regime in Chile, and how imperfect credibility is consistent with the different features of the disinflationary process followed by Chile during the 90s.

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1 Introduction

During recent years an increasing number of emerging and industrialized economies have started implementing inflation targeting as the framework to guide monetary policy. While this framework has been arguably successful in bringing down inflation, different degrees of credibility and inflation rates at the moment of adoption have determined different implementation strategies. In this paper we address different challenges that credibility poses for the implementation of inflation targeting in emerging markets and for the design of inflation stabilization processes. We also illustrate how credibility may have played a role in the evolution of the monetary policy framework in Chile during the nineties.

When credibility of the monetary authority is imperfect, the response of inflation to a disinflationary shock is slow. We show this result by using a small open economy model with imperfect credibility as in Erceg and Levin (2003). With the model we also show that this slow response of inflation may imply large swings in the real exchange rate and significant output fluctuations. Therefore, the trade-off between inflation stabilization and output volatility –and potentially real exchange volatility– faced by the monetary authority is larger under imperfect credibility.

One possible implication of the previous result is that the lower its credibility the smaller the response of the Central Bank to different shocks. In fact, we show that, as credibility increases, the Central Bank will naturally increase its response to inflation deviations from the target. Another implication of the larger trade-off between inflation stabilization and output volatility is that the design of a desinflationary process may involve a slow convergence of inflation to its long-run level to avoid large output losses.

Alternatively, the Central Bank will try actively to improve its trade-off by gaining credibility. If credibility is affected by deviations of effective inflation from its target, then one way of gaining credibility is managing the exchange rate. In effect, as the inflation target is usually defined with reference to the CPI inflation (which includes tradable goods), a central bank will have incentives to strongly use the exchange rate channel to fulfill its target as in Svensson (1999). This could explain the fact that exchange rate management has been a common feature in emerging markets implementing

inflation targeting. Additionally, lags between the effects of monetary policy changes on inflation through lower expected activity is an additional incentive to use actively the exchange rate to control inflation in the short-run.

We illustrate some differences in the implementation of inflation targeting by showing how the policy responses of inflation-targeting emerging economies to external shocks have differed from those of developed economies with a similar policy frameworks. In particular we show that during the Asian crisis, emerging market economies responded by contracting their monetary stance as opposed to what occurred in developed economies. Among the elements that explain this pro-cyclical response is the lack of credibility in the monetary regime. In fact, we show that behind this policy response there was the fear of a high pass-through from the exchange rate to inflation, usually associated with lack of credibility, and an initially high inflation rate, which could also be associated with lack of credibility.[1]

In the case of Chile, there have been two clear phases in the implementation of the monetary policy regime both in terms of the properties of the inflation target and the monetary policy horizon. In the first phase, when gaining credibility was a key issue, the Central Bank set short-term horizon CPI inflation targets, and actively managed the exchange rate. In the second phase, the Central Bank moved to a fully flexible exchange rate system, with a stationary inflation target, and a monetary policy horizon of two years.

We present some new empirical evidence that shows that the policy rule that describes the behavior of the Central Bank during this second phase became more forward looking and aggressive in fighting both inflation and output deviations from target. We also present empirical evidence on the effects of changes in the inflation target on inflation, output and the real exchange rate during the nineties. In particular, we show that a negative shock to the inflation target (a fall) generated a slow response of inflation and significant losses in output. Also, the real exchange rate appreciated significantly during the disinflationary process.

The paper is organized as follows: The next section describes some

[1] Considerations about balance sheet effects may have also played an important role to explain this response.

facts regarding inflation targeting implementation in emerging and developed economies. In this section we report the main differences in the response of these two sets of economies to the Asian crisis and the US recession in 2001. The third section describes the implementation of the inflation targeting regime in Chile, and the way monetary policy has been conducted. We present some new empirical estimates of the monetary policy rule, and the impulse-response functions to an inflation target shock. In the fourth section we present a small open model with imperfect credibility. The fifth section concludes.

2 Monetary policy in an emerging market economy

Inflation targeting has been introduced as a monetary policy framework that allows certain degree of discretion to the monetary policy authority. It has been argued that it is precisely the fact that it embeds well defined rules and performance goals what make this "constraint discretion" framework effective (see Bernanke et al (1999) and Corbo, Landerretche and Schmidt-Hebbel (2002)).

As opposed to developed countries that have implemented an inflation targeting (IT) framework, emerging market economies usually have introduced it at moments in which inflation rates were far away from their steady state levels (or their desired long run levels of inflation). In fact, from all emerging market economies that have implemented an IT framework up to date, only South Africa exhibited an inflation rate close to its long run goal at the moment of adoption. Average inflation rates for emerging markets at the moment of adopting IT were above 13% compared to less than 4% for developed economies (see Fraga, Goldfajn and Minella (2003)). These differences in inflation rates between emerging and developed economies have implied differences in the strategies within the IT framework.

Most emerging market economies have employed, during the initial phase of IT, some type of exchange rate management.[2] Also, short-term horizons

[2] Mostly in the form of exchange rate bands. Exchange rate market interventions have been also part of the instruments used to control the exchange rate.

for the inflation target have been adopted in the initial stage, with annual inflation targets being commonly used. These special features have been embraced in order to increase credibility in the new regime. More flexible targets, in the form for example of medium-term-horizon inflation targets and flexible exchange rate regimes, that have been usually implemented by developed economy IT countries, have been seen by policy makers as less likely to break down high inflation expectations by policy makers as they could be interpreted as a light compromise of the authority with the inflation target (see for example Massad (2003)).

Controlling the exchange rate has been an essential part in the inflation stabilization process for emerging economies. For these economies, inflation is quite sensible to changes in the exchange rate due to high pass-throughs. Average emerging market economy pass-throughs were close to 33% (being 47% for Latin American economies) while for developed countries were less than 10% (see table 1) during the nineties. These differences could reflect different degrees of openness and also different degrees of credibility associated to bad inflation records.

As gaining credibility has been a crucial element in the implementation of an IT framework, the inflation target horizons for emerging economies have been shorter than those observed in industrial economies. Most of these targets are defined in terms of CPI inflation to ensure well understood and transparent targets. In this context, the exchange rate is a useful instrument to ensure the fulfillment of the annual inflation target. While changes in the monetary policy interest rate translate only gradually into current inflation through lower expected activity, there is a direct effect of the exchange rate in tradable goods prices that could be exploited in the short run in order to fulfill the inflation target. It is clear that a more aggressive monetary policy might help to generate credibility in the inflation target but output losses could also be significant, thereby threatening the legitimacy of the IT regime.

Now, less flexible inflation target regimes, in the form of regimes with short-term inflation goals and less flexible exchange rates, have less flexibility to deal with external negative shocks. With high pass-through coefficients, allowing the exchange rate to depreciate to absorb an external shock is likely

to generate an impact increase in the rate of inflation. As inflation targets are short-run horizon, the increase in inflation could be interpreted as a lack of commitment to reduce inflation and therefore could erode the credibility of the IT regime and could end up de-anchoring inflation expectations (see Massad (2003)).

Two examples of the problems that emerging market economies face when dealing with external shocks are illustrated by their responses to the Asian crisis in the period 1997-1998 and the U.S. recession in 2001. Following Céspedes, Goldfajn, Lowe and Valdés (2004), we examine some determinants of real deposit interest rate changes, used as a proxy for monetary policy actions, in those periods. During these two episodes, emerging and developed inflation targeting countries suffered similar reductions in the growth of commercial partners. Additionally, emerging market economies experienced also significant reductions in their terms of trade (see table 2). Nevertheless, during the Asian crisis emerging inflation targeting countries raised interest rates as opposed to what developed economies did. Part of the fear of allowing the exchange rate to depreciate was fear to balance sheets effects due to foreign currency denominated borrowing. Nevertheless, central banks were also reluctant to let the exchange rate to depreciate because of the fear of loosing the nominal anchor of the economy. As can be seen in table 3, emerging IT countries in 1998 raised real interest rates more that 5% with respect to the average real neutral rate. This strategy reported significant gains in inflation as inflation rates fell almost 3% in annual terms between 1998 and 1999. However, they implied significant losses in output (see table 3).

When comparing the policy response of emerging IT economies to the Asian crisis with their responses to the U.S. recession in 2001 is clear that monetary policy was less pro-cyclical (or countercyclical) in this last episode. One reason behind this difference in policy reactions are, as argued by Céspedes, Goldfajn, Lowe and Valdés (2004), initial conditions. By the end of 1997, inflation rates in emerging IT economies were close to 10%, in the transition towards stationary levels of inflation (see table 4). By the end of 2000, inflation rates were in the vicinity of the long run levels with many emerging IT economies already operating under stationary levels of inflation. With

higher levels of credibility established, many emerging market economies were able to pursue a countercyclical monetary policy when dealing with the negative external shock originated by the U.S. recession.[3]

A simple regression analysis is useful to illustrate different policy reactions to external shocks within IT countries during the Asian crisis and the U.S. recession. In particular, we estimate the next relation:

$$\widehat{r}_{ij} = \beta_0 + \beta_1 PT_{ij} + \beta_2 \pi_{0,ij-1} + \beta_3 Y^*_{ij}, \tag{1}$$

where $\widehat{r}_{ij}$ corresponds to the difference between the real deposit interest rate for country i in the period j and the average real deposit interest rate for the 6 years previous to the year j where $j = 1998, 2001$; PT_{ij} is the pass-through coefficient for country i in period j; $\pi_{0,ij-1}$ is the initial level of inflation for country i (or the inflation rate at the end of year 1997 or 2000) and finally, Y^* is the GDP growth of commercial partners.[4]

Our results (see table 5) indicate that the higher (lower) the pass-through the higher the increase (reduction) in real interest rates. To the extent that the higher pass-throughs are the result of lower credibility as it has been argued by some analysts, lower degrees of credibility constraint monetary policy authorities from taking a more countercyclical stance. Also IT countries with higher inflation rates at the moment of the shock were less able to implement countercyclical monetary policy. The GDP growth of commercial partners, which is used to control for the size of the external shock is not found to be significant for the whole sample. If we run these simple regressions using only countries in the transition towards stable rate of inflation (see estimation 5.4), we found that external variables are not significant in explaining the evolution of the real interest rate, only the pass-through is significant to explain monetary policy actions in those periods. The opposite is the case for countries whose IT framework was operating at its *steady state*(see estimation 5.5).[5] This very preliminary evidence indicates that even for IT countries, flexibility to deal with external shocks is only part

[3] See Calderón, Duncan and Schmidt-Hebbel (2003) for a study on the role of credibility in the cyclical properties of macroeconomic policies in emerging economies.

[4] We use a dummy that takes value of 1 for year 2001's observations.

[5] When we control for the dollarization of liabilities problem using the index constructed by Hausmann and Panniza (2002), the results are not significantly affected.

of the possibility set for policy makers once they have reached their steady state level of inflation.

3 Inflation targeting adoption in Chile

3.1 Monetary policy framework evolution

During the period 1991-2003 the Chilean economy grew at an average rate of 5.5% per year. Inflation rates fell from levels close to 30% at the beginning of 1991 to stationary levels of around 3% by the end of the nineties (see figure 1). During this period the Central Bank of Chile (CBC) started to announce an explicit target for inflation that has been credited with providing a sound guide for conducting monetary policy.[6] Nevertheless, the whole monetary policy framework endured significant changes along the way. During a first phase (1991-1999), the macro framework included not only inflation targets but also targets for the current account deficit and a managed exchange rate. During the second phase (2000-to date), the CBC implemented a full-fledged IT regime with inflation as the main policy objective with no others explicit targets.

In September of 1990 the Central Bank of Chile announced the first target range for inflation after being granted independence in 1989. The initial target, a 15-20% target range for December of 1991, was defined for the CPI inflation. The initial inflation target was set over a rather short time horizon and represented a strong commitment to reducing inflation. The short term inflation target reflected the need for generating credibility in the new regime. Previous poor inflation performance that reduced credibility in monetary policy, potentiated a widely spread indexation of the economy and high inflation expectations (see Schmidt-Hebbel and Tapia (2002)). The stabilization process was very gradual in order to avoid high output losses in the context of this widespread indexation and low credibility.

In addition to annual inflation targets, the CBC implemented a target band for the exchange rate during the period 1991-1999 (first phase). The band was perceived as the instrument for achieving the objective of normal

[6] See Corbo (1998) on the effects of IT on the Chilean inflationary dynamics during the nineties.

functioning of the external payments system. The CBC also set targets for the current account deficit. In order to retain the possibility of managing the exchange rate with monetary policy independence, the CBC maintained regulations in the capital account including a non-remunerated reserve requirement for capital inflows. During this period, exchange rate market interventions were conducted in order to sustain the exchange rate band. Nevertheless, significant modifications to the exchange rate band, including adjustments in its width and once-and-for-all realignments, were applied.

Since 2000, Chile operates a flexible inflation targeting regime with the objective of keeping the CPI inflation rate between 2 and 4 percent in a two-year horizon. The move towards a full-fledged IT framework was seen as the natural step after reaching the steady state level of inflation and after establishing "enough" credibility and were, in part, triggered by the macroeconomic outcomes in the aftermath of the Asian crisis. It was after suffering a significant reduction in GDP growth in the period 1998-99 and a substantial fall in the annual inflation rate in 1999, which went from 4.6% in 1998 to 2.3% in 1999, 2% below the inflation target for that year, that the monetary policy authority embarked on a substantial enhancement of its macroeconomic framework. The new main elements were the adoption of a free-floating exchange rate regime, the deepening of the foreign exchange derivative market and the total opening of the capital account (see Morandé (2002) and Céspedes, Goldfajn, Lowe and Valdés (2004)). Additionally, there was a significant increase in transparency with the publication of a regular inflation report and the public release of the minutes of policy meetings.

3.2 Monetary policy rules

The two different phases in the evolution of the monetary policy framework regime in Chile during the nineties have implied differences in policy responses. In order to illustrate these differences we compute monetary policy interest rate rules for two periods. The first one goes from the first quarter of 1991 to the fourth quarter of 1999. The second covers the period

1996.I-2003.IV.[7]

As discussed earlier, during the first phase inflation targets were short-run horizon, there was exchange rate management and also a target for the current account. We capture these features by assuming that the real interest rate (r_t) set by the Central Bank of Chile during the first period of IT was a function of current inflation, output gap, and the current difference between the real exchange rate and its equilibrium level.[8] In particular, we estimate the following relationship:

$$\begin{aligned} r_t &= (1-\theta_0)\,\overline{r} + (1-\theta_0)\,\beta_0\,(\pi_t - \overline{\pi}_t) + (1-\theta_0)\,\gamma_0 y_t \\ &\quad + (1-\theta_0)\,\delta_0 e_t + \theta_0 r_{t-1} + u_t \end{aligned} \tag{2}$$

where π and $\overline{\pi}$ correspond to the inflation rate and the inflation target respectively; y_t corresponds to the output gap; e_t is the real exchange rate misalignment and u_t is a linear combination of prediction errors and policy innovations.[9] As the term u_t could be correlated with actual values of inflation and the output gap, we estimate this relationship using GMM as suggested by Clarida, Galí and Gertler (2000).

The results indicate that the specification of the monetary policy rule in (2) is a good description of monetary policy actions for the period 1991-1999 (see table 6). The estimated coefficients have the expected sign and are in all cases significant. In addition to respond to deviations of inflation from the target, the Central Bank of Chile did respond to deviations of output from its potential value. Additionally, the authority responded actively to the exchange rate. As discussed previously, the CBC also had some current account targeting during the period 1991-1999. In order to test how this could have been reflected in the policy rule, other than through the exchange rate, we included the current account in our estimations. The coefficient associated to the current account balance turned out to be negative and significant indicating that the CBC responded actively to changes in

[7] The two estimations share the period 1996-1999. We do this in order to increase the degrees of freedom for the second period of estimation.

[8] From 1985 up to 1999, the Central Bank of Chile conducted monetary policy using a short-term interest rate indexed to the CPI inflation.

[9] A positive value for e implies that the exchange rate undervalued with respect to its equilibrium level.

the current account. In particular, increases in the current account deficit beyond the target level triggered increases in the interest rate in order to cool down domestic expenditure.

Estimations for the policy reaction function in (2) when we include in the sample the period 2000-2003, yield poor results. Most coefficients become insignificant and/or have the wrong sign. This may reflect the change in the IT framework starting in 1999 discussed previously. In order to account for this change in the IT framework, we estimate the following policy reaction function:

$$r_t = (1-\theta_1)\,\overline{r} + (1-\theta_1)\,\beta_1\,(\pi_{t+4} - \overline{\pi}_{t+4}) + (1-\theta_1)\,\gamma_1 y_t + \theta_1 r_{t-1} + u_t \quad (3)$$

The estimations of this last policy rule indicate that in the full-fledged inflation targeting phase, the monetary authority has become more forward looking in terms of inflation. As opposed to the previous phase, the evidence indicates that the CBC is willing to allow deviation of current inflation from the inflation target as long as it does not have impact on future inflation. Additionally, both β_1 and γ_1, the coefficients associated to inflation and output respectively, have increased compare to the interest rate rule for the previous IT phase. This stronger response of the interest rate to inflation and output deviations is consistent with a central bank that takes advantage of an improved trade-off between inflation and output, possibly as a consequence of higher credibility or improved commitment to control inflation as in Clarida, Galí and Gertler (1999). Finally, the relative response of inflation deviations to output gap has fallen from two to one indicating that in the full-fledged inflation targeting phase, output loss considerations have increased as the stabilization of inflation has been achieved.

3.3 The role of inflation targets

As has been discussed by some analysts, during the convergence to low stationary inflation, it is likely that inflation targets will be reduced each year taking into account the state of the economy. In fact, slow and gradual convergence to the long run inflation target is one characteristic of the disinflation process in Chile. Schmidt-Hebbel and Werner (2002), for example, show that Chile had the longest transition period (thirty-six quarters) amongst

three Latin American inflation targeters (Chile, Mexico and Brazil), and exhibits a longer transition period than those observed for a control group including mostly developed inflation targeters. In this section we analyze empirically the effects of innovations to the inflation target for the Chilean economy using a structural VAR analysis. The VAR is estimated using monthly data from January 1991 up to December 1999.

First, we assume that the dynamic behavior of vector y_t of economic variables is governed by the following structural model

$$y_t = \sum_{i=0}^{l} B_i y_{t-i} + \varepsilon_t \tag{4}$$

where ε_t, the vector of structural disturbances, is serially uncorrelated and var(ε_t)=Γ, a diagonal matrix whose elements correspond to the variances of the structural shocks. Therefore, we are assuming that the structural shocks do not have a common cause. Moreover, we assume that ε_t can not be directly observed. A problem that arises from the system (1) is that it can contain many unknown parameters. Following Blanchard and Watson (1986), we impose no restrictions, other than the lag length, on B_i for $i > 0$. Therefore, we concentrate on modeling contemporaneous relationships.

The system in (1) can be rewritten to obtain the reduced form to be used in the econometric estimation

$$y_t = \sum_{i=1}^{l} C_i y_{t-i} + u_t \tag{5}$$

where $C_i = (I - B_0)^{-1} B_i$ and $u_t = (I - B_0)^{-1} e_t$. Moreover, using this last relation between the structural disturbances and the reduced form residuals we can show that $\Sigma = (I - B_0)^{-1}\Gamma(I - B_0)^{-1}$. Where $\Sigma = var(u_t)$. Once we have computed values for Σ from the unrestricted estimation of the system (2), we can proceed to obtain the structural parameters contained in B_0 and the covariance matrix Γ by maximum likelihood estimation. Note that there are $n(n+1)$ free parameters in $(I - B_0)^{-1}\Gamma(I - B_0)^{-1}$ to be estimated and since Σ contains $n(n+1)/2$ parameters, we need at least $n(n+1)/2$ restrictions to identify the system. If we normalize the n diagonal elements of $(I - B_0)$ to 1's, we must impose at least $n(n-1)/2$ restrictions on $(I - B_0)$ to identify the system.

The identification scheme used in this work follows Bernanke (1986) and Kim and Roubini (2000). The data vector is $\{i^*, tot, y, \pi, \overline{\pi}, i, e\}$, where i^* represents the world interest rate proxied by the Federal Funds Rate in the U.S., y is output growth, π is the CPI inflation, $\overline{\pi}$ is the CPI inflation target, i is the domestic interest rate and finally, e is the real exchange rate expressed as units of local currency per U.S. dollars.

In order to obtain identification we have imposed a series of contemporaneous conditions on matrix B_0. The world interest rate is assumed to be exogenous to any other variable innovation. The terms of trade are assumed to respond contemporaneously only to the world interest rate. We also assume that economic activity is not affected contemporaneously by any variable in the system. This assumption can be justified by inertia, adjustment costs and planning delays in this low frequency. Inflation is assumed to respond within the period only to innovations in output. The inflation target does not respond contemporaneously to any domestic variable other than the exchange rate and it is affected contemporaneously by shocks to the external variables in the system.[10] Domestic interest rates are assumed to respond contemporaneously to changes in the world interest rate, the terms of trade and the inflation target. Given the asset price nature of the exchange rate, we assume that this variable can react contemporaneously to all the other variables in the system.

In Figure 2 we present the estimated impulse response functions for a one standard deviation shock to the inflation target.[11] The first result emerging from this empirical analysis is that the domestic interest rate increases when the inflation target is reduced, as expected. Output decreases in the process while the real exchange rate appreciates significantly. Inflation falls slowly and converges to the inflation target only after eight months (see figure 3). In the next section we will present a model for a small open economy in which credibility issues, as in Erceg and Levin (2003), play a crucial role in the transmission of shocks to the inflation target. We will explore under which specifications a model with imperfect credibility can replicate the dynamic response of inflation, output and the real exchange rate presented in this

[10] Valdés (1998) identifies the effects of monetary policy shocks in Chile by assuming that the inflation target is endogenous.

[11] One-standard deviation error bands are obtained from Montecarlo simulations.

section without relying on indexation or backward looking behavior.

4 A small open economy model with imperfect credibility

In this section we present a small open economy model with imperfect information/credibility. The model is presented in its log-linear version –variable $\widehat{z}$ represents the log deviation of Z with respect to its steady-state value.[12] The main characteristics of the model are the following: (i) Domestic households consume two types of goods, Home and Foreign, and provide labor in a competitive market. (ii) Firms producing different varieties of Home goods have monopoly power and set prices a-la Calvo. (iii) The central bank defines a target for CPI inflation and implements its monetary policy by following a simple rule for the interest rate.

As in Erceg and Levin (2003) we introduce imperfect credibility by assuming that private agents have rational expectations but do not have access to complete information regarding the process behind the inflation target. Therefore, in order to make inference about the future path of inflation target, private agents must solve a signal extraction problem.

In what follows, we denote by $\widetilde{\mathbb{E}}_t x_{t+1}$ the rational forecast of variable x_{t+1} given all information available to private agents at time t. Total consumption, $\widehat{c}_t$, is determined by the usual Euler equation:

$$\widehat{c}_t = -\sigma \widetilde{\mathbb{E}}_t \left(\widehat{i}_{t+1} - \widehat{\pi}_{t+1} \right) + \widetilde{\mathbb{E}}_t \widehat{c}_{t+1} \tag{6}$$

where $\widetilde{\mathbb{E}}_t \left(\widehat{i}_{t+1} - \widehat{\pi}_{t+1} \right)$ corresponds to the ex-ante real interest rate. The parameter σ corresponds to the intertemporal elasticity of substitution. From the optimal resetting price of domestic firms we obtain the following expression for Home goods inflation:

$$\widehat{\pi}_{H,t} = \lambda \widehat{mc}_t + \lambda \frac{1-\gamma}{\gamma} \widehat{q}_t + \beta \widetilde{\mathbb{E}}_t \widehat{\pi}_{H,t+1} \tag{7}$$

where $\widehat{mc}_t$ corresponds to the real marginal cost, $\widehat{q}_t$ is the real exchange rate defined as the relative price of Foreign goods to the price of the consumption

[12] A full derivation of the model is presented in Céspedes and Soto (2004).

bundle, and β and γ correspond to the discount factor and the share of Home goods in the consumption basket respectively The real marginal cost depends on output and consumption, and it is given by $\widehat{mc}_t = (v-1)\,\widehat{y}_t + \left(\frac{1}{\sigma}\right)\widehat{c}_t - v\widehat{a}_t$. Here $\widehat{a}_t$ represents a productivity shock faced by domestic producers, and v is the elasticity of labor disutility.

Output is demand determined in the short run and depends on the real exchange rate, domestic consumption, and foreign demand for Home goods, $\widehat{c}^*_{H,t}$,

$$\widehat{y}_t = \eta\theta\frac{1-\gamma}{\gamma}\widehat{q}_t + \eta\widehat{c}_t + (1-\eta)\,\widehat{c}^*_{H,t} \tag{8}$$

The parameter θ corresponds to the elasticity of intratemporal substitution in consumption between Home and Foreign goods, and η is the ratio of domestic consumption of Home goods to domestic output.

The nominal exchange rate is determined by the uncovered interest rate parity condition,

$$\widehat{i}_{t+1} = \widehat{i}^*_{t+1} + \widetilde{\mathbb{E}}_t\Delta\widehat{e}_{t+1} + \varphi_{t+1}, \tag{9}$$

where φ_{t+1} is the risk premium faced by domestic households. We assume this premium depends on the net foreign position of the economy: $\varphi_t = \mu\widehat{b}^*_t$, where the law of motion for $\widehat{b}^*_t$ is given by,

$$\widehat{b}^*_{t+1} = \frac{1}{\beta}\widehat{i}^*_t + \frac{1+\mu}{\beta}\widehat{b}^*_t - \phi\widehat{c}_t + \chi\widehat{q}_t + \alpha\phi c^*_{H,t} - \Delta\widehat{p}^*_t, \tag{10}$$

and where $\alpha = C^*_H/C^*_F$ is the steady state ratio of foreign consumption of Home goods relative to domestic consumption of Foreign goods, $\phi = \frac{C^*_F}{(1+i^*_t)b^*}$, and $\chi = \phi\left(\theta - \frac{\alpha}{\gamma}\right)$. Finally, CPI inflation is a linear combination of Home goods inflation, the nominal devaluation of the exchange rate, and foreign inflation,

$$\widehat{\pi}_t = \gamma\widehat{\pi}_{H,t} + (1-\gamma)\,(\Delta\widehat{e}_t + \Delta\widehat{p}^*_t) \tag{11}$$

4.1 Monetary policy

The central bank conducts its monetary policy by using the nominal interest rate as its instrument. It follows a simple rule where the interest rate is raised whenever output is above its long run level (steady state output), and when

inflation is above its target, $\widehat{\pi}_t^{\intercal}$:[13]

$$\bar{\imath}_{t+1} = \omega_\pi \left(\widehat{\pi}_t - \widehat{\pi}_t^{\intercal}\right) + \omega_y \widehat{y}_t \tag{12}$$

We assume the central bank does not adjust the monetary policy instantaneously in response to a shock. Instead, we assume the interest rate follows a partial adjustment process:

$$\widehat{i}_{t+1} = \rho \widehat{i}_t + (1-\rho)\, \bar{\imath}_{t+1} \tag{13}$$

This assumption is consistent with wide empirical evidence regarding the process the interest rate followed in various countries and in particular is relevant to the Chilean case as shown in section 3.2.

4.2 Inflation target and imperfect credibility

One way of modelling imperfect credibility is to assume that private agents have imperfect information regarding the process governing the evolution of the inflation target. Remember that current inflation depends on the expectation of private agents respect to the future evolution of a set of exogenous variables, and the future behavior of the central bank. Therefore, if privates agent do not know the process that underlies the inflation target, they will not be able to correctly forecast the future behavior of the central bank.

As in Erceg and Levin (2003), we assume that the inflation target has two components: a persistent component , $\widehat{\pi}_{P,t}^{\intercal}$, and a transitory component, $\widehat{\pi}_{T,t}^{\intercal}$:

$$\widehat{\pi}_t^{\intercal} = \widehat{\pi}_{P,t}^{\intercal} + \widehat{\pi}_{T,t}^{\intercal} \tag{14}$$

We assume that $\widehat{\pi}_{T,t}^{\intercal}$ is a white noise, and that the persistent component of the inflation target follows an AR(1) process with autoregressive coefficient ρ_π:

$$\widehat{\pi}_{P,t}^{\intercal} = \rho_\pi \widehat{\pi}_{P,t-1}^{\intercal} + \zeta_t \tag{15}$$

where ζ_t is also a white noise process and represents an innovation to the persistent component of the inflation target. We assume that $E\left(\widehat{\pi}_{T,t}^{\intercal} \zeta_s\right) = 0$ $\forall t, s$.

[13] The inflation target corresponds to deviations of the inflation target with respect to its steady state value, which we have assumed zero.

Private agents observe the inflation target, $\widehat{\pi}_t^{\intercal}$, but they do not observe either its persistent nor its transitory components. In other words, whenever the monetary authority announces a new target for inflation, private agents do not know if this new target will remain over time –which would be the case if the new target corresponds to an innovation to the persistent component–, or if it will be reverted after a few periods –in case the new target corresponds to an innovation to the transitory component.

Following Erceg and Levin (2003) we assume private agents use the Kalman filter to obtain an estimate of the persistent component of the inflation target and to forecast future inflation targets. Then, we have that

$$\widetilde{\mathbb{E}}_t \widehat{\pi}_{P,t}^{\intercal} = \rho_\pi \widetilde{\mathbb{E}}_{t-1} \widehat{\pi}_{P,t-1}^{\intercal} + \frac{k_g}{\rho_\pi} \left(\widehat{\pi}_t^{\intercal} - \widetilde{\mathbb{E}}_{t-1} \widehat{\pi}_t^{\intercal} \right) \tag{16}$$

Using the Kalman filter gives the optimal forecast of an unobservable state, given the signal. In our case, the unobservable state corresponds to the persistent component of the inflation target, while the signal equation is (14).

4.3 Parametrization and solution

The model is parameterized using some parameters in the literature and some figures consistent with the features of the Chilean economy for quarterly data. In particular, we assume that the proportion of Home goods in the consumption bundle in the steady state is 0.6. The ratio between the stock of net foreign liabilities and output is assumed to be 2, which is consistent with the actual net foreign position of Chile (50% of GDP by the end of 2003). The probability that firms change prices is $\delta = 0.75$ which implies that firms reset prices every four periods on average. The parameter μ, which defines the sensibility of the risk premium to changes in the net foreign position is set to be 0.05. This number implies that an increase in the net foreign asset position of the economy by 10% reduces the risk premium by 50 basis points.

The discount factor β is set to be 0.99 and the elasticity of labor disutility v equal to 2. The values for intratemporal and intertemporal elasticity of substitution are $\theta = 1$ and $\sigma = 0.5$, respectively. These values are consistent with recent estimates for Chile made by Duncan (2003). Finally, we assume

the persistent component of the inflation target process is very persistent, with $\rho_\pi = 0.99$. In other words, despite the fact that the inflation target eventually returns back to its steady state, it takes several periods for this convergency to occur.

To solve the model we make use of the block exogenous structure of the model and utilize the Anderson and Moore algorithm. Collard and Dellas (2004) present a detailed description on a more general way of solving this type of forward looking model with imperfect information and learning.

4.4 Effects of an inflation target shock

We simulate the effects of a negative shock to the persistent component of the inflation target –a "disinflation" shock–under two alternative policy rules. The baseline policy rule is a Taylor rule where the parameters that define the response to deviation of inflation and output from target are: $\omega_\pi = 1.5$, and $\omega_y = 0.5$. The alternative rule is one where the central bank is much more aggressive in its response to deviations of inflation from the target. For this alternative rule we assume $\omega_\pi = 6$.

Before discussing the results, it is important to note that a negative shock to the persistent component of the inflation target could be interpreted as a very persistent contractionary monetary shock. Therefore, even under perfect credibility, and since prices are sticky, the shock has short-run real effects.

We also report the results under two different assumptions regarding the learning process. In one case we assume that $kg = 0.15$. This figure is close to the one reported by Erceg and Levin and implies that half of a given change in the persistent component of the inflation target is incorporated into the expectations after a year. We denote the results for this case as *imperfect information* –or imperfect credibility. The second case corresponds to a situation of *perfect information* –or perfect credibility.

Figures 4 and 5 present the impulse response functions to the shock under the base line policy rule. Notice first that the shock produces a reduction in both Home goods and CPI inflation. The fall in CPI inflation, however, is larger since the shock also implies a nominal appreciation of the exchange rate.

Under perfect credibility the negative short-run response of CPI and Home goods inflation is larger than the change in inflation target. Therefore, there is a sort of overshooting of inflation. With imperfect credibility, since the perceived change in the inflation target is much smaller –in the short-run– than the actual change in the target, Home goods producers adjust their prices by less and the fall in inflation is smaller and converges only gradually towards the target as private agents learn about the policy shock. There is, however, also an overshooting and inflation converges to its long run level from below.

To understand why inflation (CPI and Home goods inflation) tends to fall by more than the change in the target it is necessary to analyze the evolution of output and marginal costs. Under both perfect and imperfect information the shock produces a contraction in output which reduces the marginal cost. The shock also induces a nominal and a real appreciation of the exchange rate. The real appreciation has a direct impact on the marginal cost and, therefore, on Home goods inflation. However, the real appreciation also induces an expenditure switching from Home goods towards Foreign goods. This effect reduces output and further lowers the marginal cost.

Under perfect information, however, private agents correctly anticipate a more persistent movement in the interest rate. Then, the initial appreciation of the exchange rate –nominal and real– is larger and the expenditure switching effect is stronger with full information.

Figures 6 and 7 present the impulse-responses to the inflation target shock under the alternative policy rule where the central bank follows a more aggressive policy in response of inflation deviations from the target. Under this policy rule there is still an overreaction of both CPI and Home goods inflation in response to the shock –the overreaction is immediate under perfect information and occurs with a delay under imperfect information. However, inflation under perfect information in this case is much closer to the target than under the baseline rule. Under imperfect information the initial gap between Home goods inflation and the target is still large.

If we compare the response of output with perfect and imperfect information we observe that the former is much stronger under this alternative rule than under the baseline rule. Under the alternative rule the central

bank induces a much stronger monetary contraction in order to keep inflation close to the target. However, since the inflation target is not completely credible and inflation moves slowly towards its new target, the central bank has to raise the interest rate by more than under perfect credibility. Both, the stronger monetary contraction and the slow response of inflation, produce a much larger appreciation of the exchange rate, a stronger expenditure switching effect, and a larger contraction in output.

4.5 Imperfect credibility and sacrifice ratio

In the presence of imperfect credibility, the central bank faces a less favorable trade-off between inflation stabilization around its target and output volatility. Figure 8 present the sacrifice ratio –output loss in percentage point for each percentage point reduction in inflation– for various assumptions regarding the learning process and under the two alternative policy rules we analyzed previously.

From the figure it is clear that the more information the public has about the process underlying the inflation target –a higher kg– the lower the sacrifice ratio.[14] What is more interesting is that the tougher rule has a higher sacrifice ratio with respect to the baseline Taylor rule when credibility is low. However, as credibility increases the sacrifice ratio of the alternative rule becomes lower than the corresponding Taylor rule sacrifice ratio.

It is important to notice that in our model, credibility is not a function of deviations of inflation from its target. If that were the case, then the central bank would face the following dilemma: to improve its trade-off between inflation and output it has to gain credibility. However, if credibility depends on deviations of inflation from target then it will have to play tougher and allow large output volatility. Alternatively, a central bank that is committed to a disinflationary process but is reluctant to confront the large output cost that such a process would entail, would follow a much more gradual disinflation path. In terms of our model, the size of each shock to the inflation target would be smaller and probably more spread out in time.

[14] Given our modelling strategy, a higer kg implies a faster learning, conditional on having a persistent shock to the inflation target.

5 Conclusions

In this paper we argue that in the presence of imperfect credibility, a central bank faces a larger trade-off between inflation stabilization and output stabilization. With imperfect credibility, a deflationary shock –a negative shock to the inflation target– lowers domestic inflation gradually but it produces an immediate appreciation of the nominal exchange rate. Thus, the real exchange rate appreciates and the contractive effect of the deflationary shock on output is amplified. To minimize the contractionary effect of such a shock, the Central Bank should react in a milder way to deviations of inflation from target. However, this would imply a volatile inflation.

This trade-off between output and inflation stabilization is considerably diminished when the Central Bank can credibly reduce its inflation target in a persistent way. In such case, domestic agent adjust their prices quickly, taking into account the new inflation target and its future trajectory, and domestic inflation falls *pari-pasu* with the target. As a consequence, the real exchange rate appreciates by less than under imperfect credibility and the contractionary effect of the deflationary shock is smaller.

Our theoretical results are consistent with the empirical evidence for Chile. The results of the VAR model show that a transitory shock to the inflation target appreciates the real exchange rate, reduces the output gap, and also lowers inflation. However, the response of inflation to the shock is delayed by up to two quarters. Another piece of evidence shows that the policy rule that characterize the actions of the Central Bank of Chile has changed over time, becoming more aggressive towards inflation by the end of the nineties. This result could also be explained in the context of out theoretical framework. We would argue that by the mid nineties, after the IT regime had been in place for several years, the Central Bank of Chile had gained enough credibility to move towards a more aggressive regime, responding in a stronger fashion to deviations of inflation from its target.

For future reasearch there are still several issues to be studied regarding inflation targeting in emerging economies. For example, in our model economy we assumed that the inflation target set by the authority was completely exogenous. However, some empirical evidence for the case of Chile shows that the inflation target during the disinflationary process was in fact

endogenous. Modelling inflation targeting as an endogenous variable could open additional trade-offs between output and inflation stabilization.

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Figure 1: Chile: effective inflation and inflation target

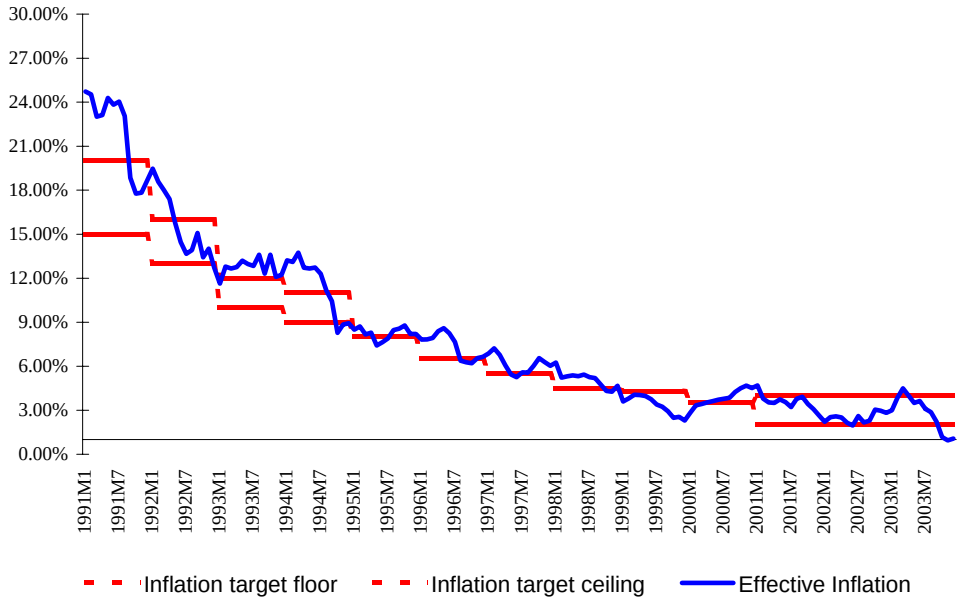

Figure 2: Impulse-responses to an inflation target shock

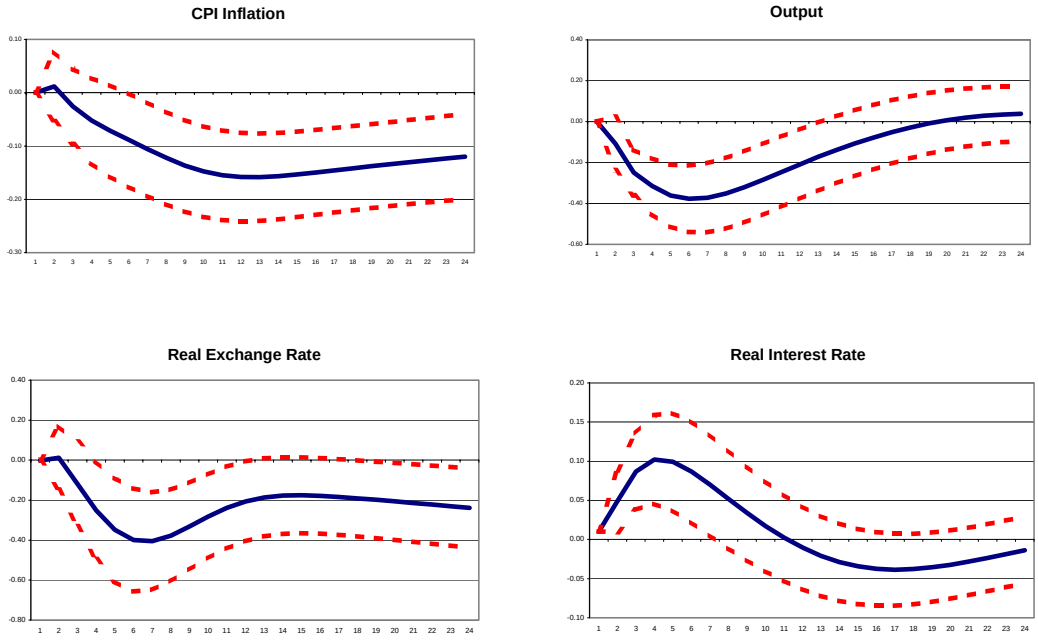

Figure 3: CPI inflation and inflation target responses to an inflation target shock

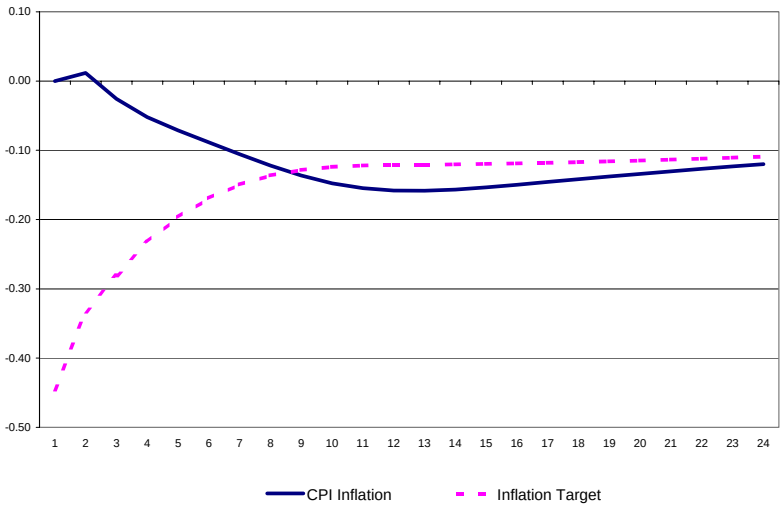

Figure 4: Impulse-response functions to an inflation target shock (baseline policy rule)

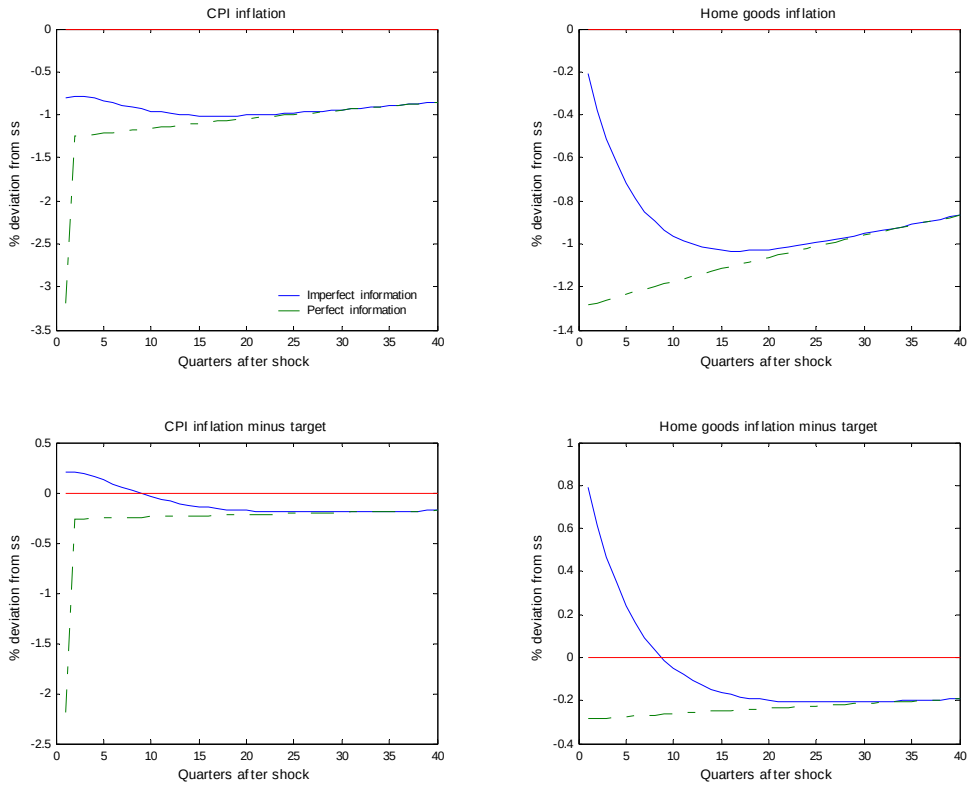

Figure 5: Impulse-response functions to an inflation target shock (baseline policy rule)

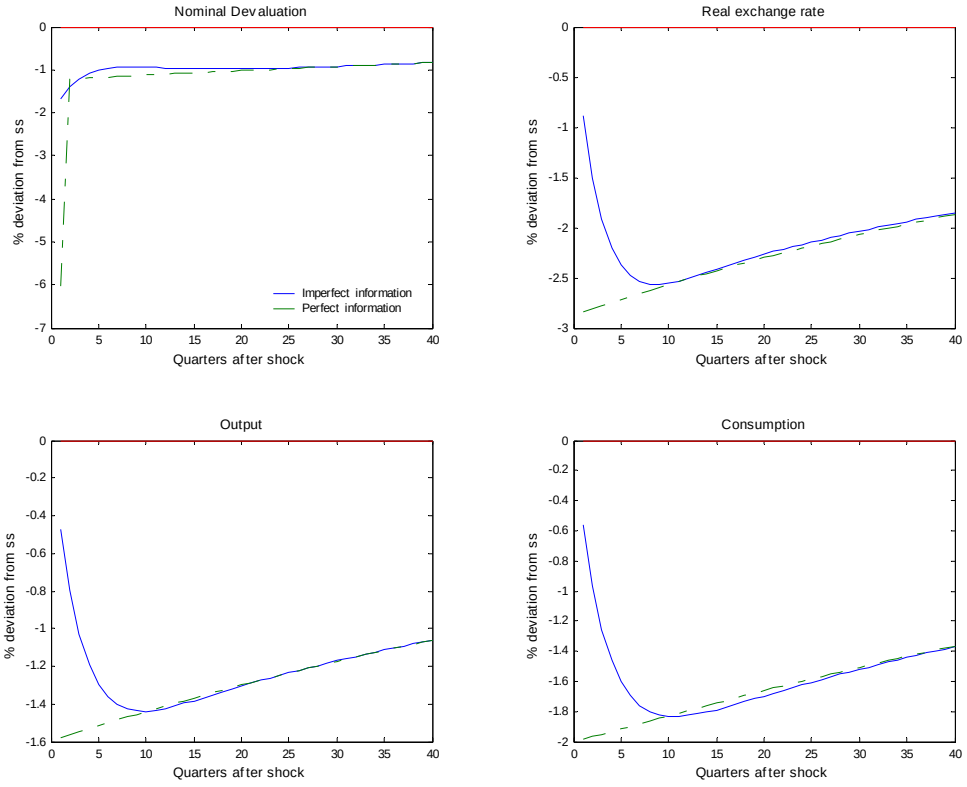

Figure 6: Impulse-response functions to an inflation target shock (alternative policy rule)

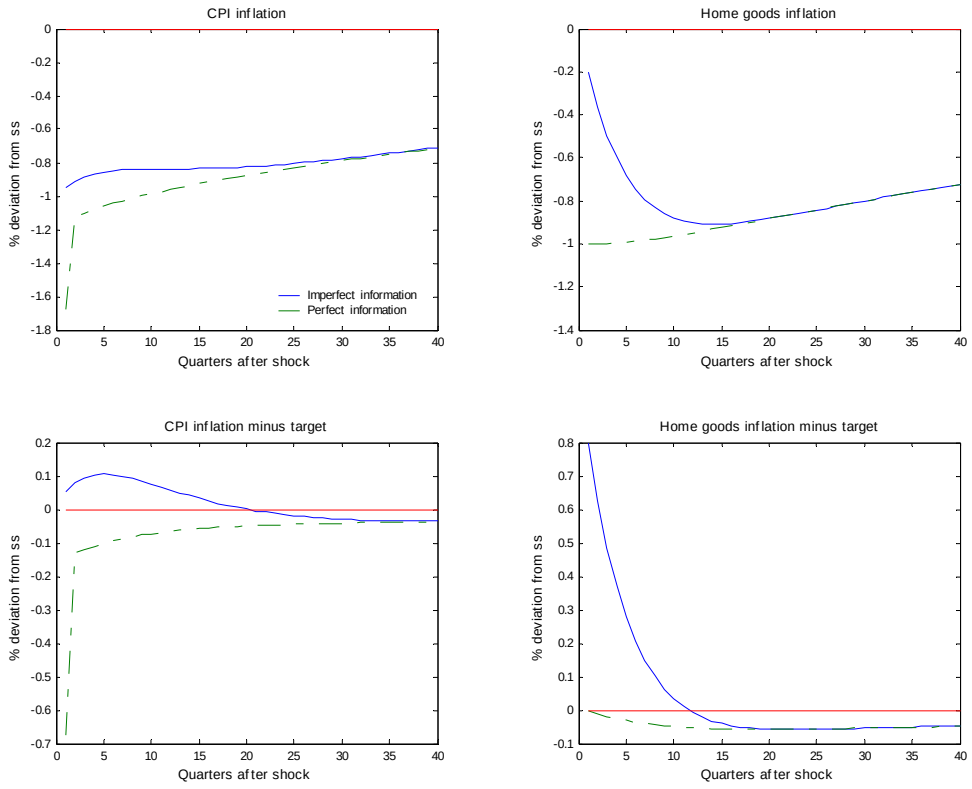

Figure 7: Impulse-response functions to an inflation target shock (alternative policy rule)

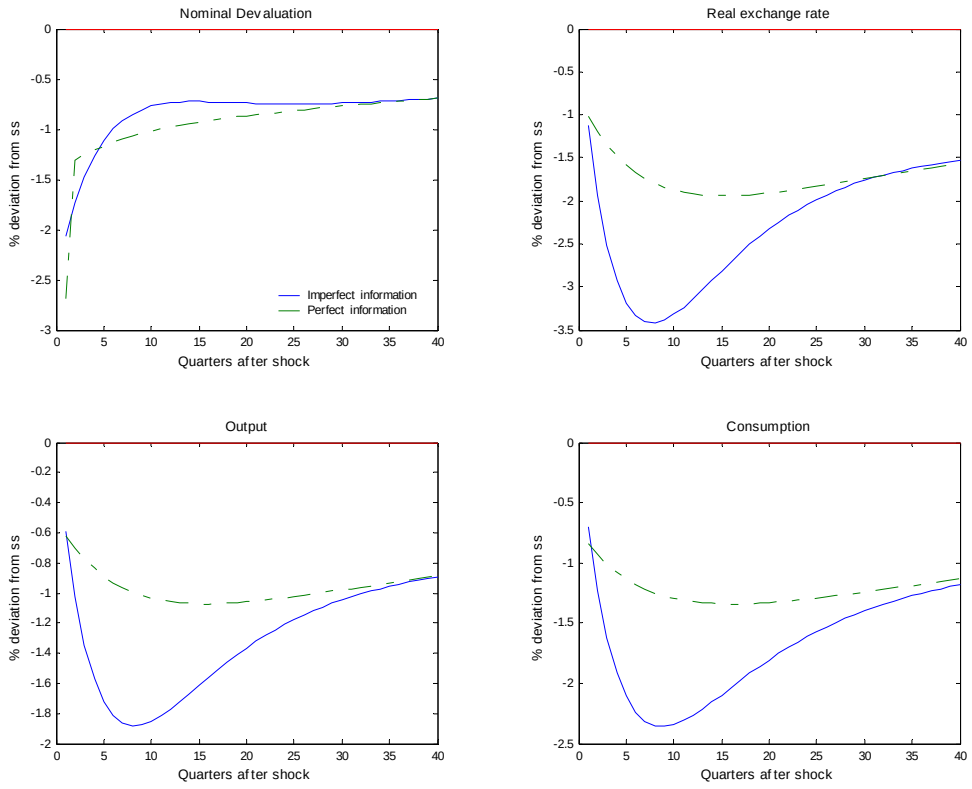

Figure 8: Sacrifice ratio and credibility

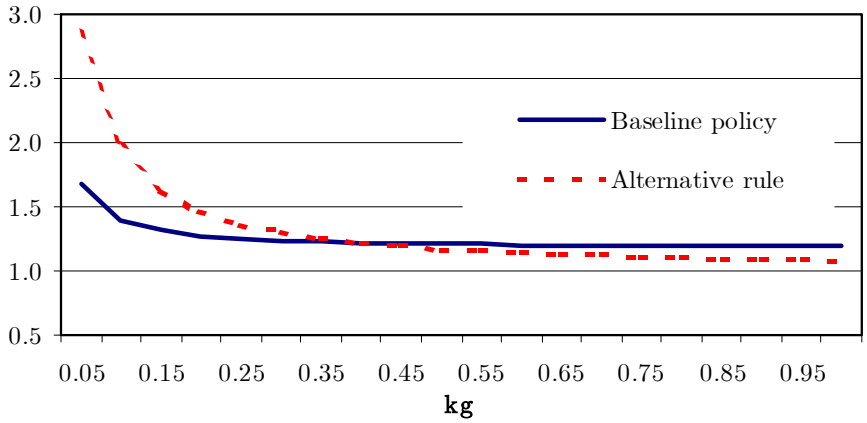

Table 1
Pass-through coefficients during the nineties

Emerging Market Economies	
Brazil	0.81
Chile	0.35
Colombia	0.38
Czech Republic	0.02
Hungary	0.48
Israel	0.16
Korea	0.18
Mexico	0.58
Peru	0.22
Poland	0.62
South Africa	0.11
Thailand	0.03
Developed Economies	
Australia	0.21
Canada	0.07
Iceland	
New Zealand	0.07
Norway	0.09
Sweden	0.14
Switzerland	0.02
United Kingdom	0.03
Average Emerging Market Economies	0.33
Average Developed Economies	0.09
Average Latin American Economies	0.47
Average Non Asian Emerging Market Economies	0.30

Source: Hausmann, Panniza, Stein (2002)

Table 2
Monetary Policy and External Shocks: Asian Crisis and US Recession

	Real Interest Rate		Terms of Trade Change		GDP growth commercial partners	
	1998	2001	1998	2001	1998	2001
Emerging Market Economies						
Brazil	8.5	-6.1	-1.8	5.6	-1.9	-2.8
Chile	5.8	-1.9	-4.7	-13.7	-2.6	-2.8
Colombia	12.9	-1.6	-8.7	-5.4	-1.4	-2.4
Czech Republic	2.3	-3.0	5.5	0.8	-0.4	-2.6
Hungary	4.6	-0.8	1.5	-0.3	0.1	-2.5
Israel	2.3	-0.3	2.0	-2.1	-1.6	-3.4
Korea	4.6	-4.7	-4.0	-4.4	-3.4	-4.6
Mexico	-1.5	3.4	-6.9	-2.9	-0.4	-3.4
Peru	11.2	1.1	-13.9	-2.8	-1.5	-2.9
Poland	4.2	4.1	3.3	1.7	-0.2	-2.0
South Africa	5.8	-4.3	-2.1	1.7	-1.4	-2.2
Thailand	-4.2	-4.5	-5.9	-9.4	-3.8	-4.7
Developed Economies						
Australia	0.3	-2.2	-2.9	3.2	-4.5	-3.4
Canada	2.0	-0.3	-3.5	-1.0	-0.6	-3.4
Iceland	-2.6	-4.7	7.7	2.0	-0.5	-2.0
New Zealand	0.5	-3.7	1.3	6.8	-2.3	-3.9
Norway	3.7	5.0	-11.1	-5.4	-0.3	-2.5
Sweden	-0.5	-1.8	-0.7	-1.9	-1.2	-2.8
Switzerland	-0.4	0.2	1.3	-2.0	-0.9	-3.0
United Kingdom	0.4		1.9	0.5	-0.9	-3.2
Average Emerging Market Economies	4.7	-1.6	-3.0	-2.6	-1.5	-3.0
Average Developed Economies	0.4	-1.1	-0.8	0.3	-1.4	-3.0
Average Latin American Economies	7.4	-1.0	-7.2	-3.8	-1.6	-2.8
Average Non Asian Emerging Market Economies	4.1	-2.0	-3.3	-3.2	-1.8	-3.2

The real interet rate corresponds to the real deposit interest rate minus the average real interest rate for the previous 6 years.

Table 3
Macroeconomic Performance: Asian Crisis and US Recession

	GDP Growth				Inflation			
	1998	1999	2001	2002	1998	1999	2001	2002
Emerging Market Economies								
Brazil	-2.1	-1.4	-2.0	-1.4	1.7	8.9	7.7	12.5
Chile	-4.5	-8.5	-2.2	-3.4	4.7	2.3	2.6	2.8
Colombia	-3.5	-8.3	-1.2	-1.0	16.7	9.2	7.6	7.0
Czech Republic	-2.9	-1.4	0.8	-0.3	6.8	2.6	4.1	0.5
Hungary	6.0	5.3	0.8	0.5	10.3	11.2	6.8	4.8
Israel	-2.2	-3.4	-6.1	-5.9	8.6	1.3	-4.7	6.5
Korea	-14.2	2.3	-1.9	1.3	4.0	1.4	2.8	3.7
Mexico	1.9	0.5	-3.6	-2.6	18.6	12.3	4.4	5.7
Peru	-4.9	-3.4	-4.5	0.1	6.0	3.7	-0.1	1.5
Poland	2.7	2.0	-4.3	-3.9	8.5	9.8	3.7	0.7
South Africa	-0.6	0.6	0.1	1.0	8.7	2.5	4.1	14.3
Thailand	-17.9	-3.0	-1.6	1.7	4.3	0.7	0.8	1.6
Developed Economies								
Australia	2.3	1.4	-1.6	-0.3	1.6	1.8	3.1	3.0
Canada	2.3	3.7	-2.0	-0.4	1.0	2.6	0.7	3.9
Iceland	4.0	2.6	-1.1	-4.3	1.3	5.6	8.6	2.0
New Zealand	-2.6	1.5	-1.0	0.7	0.4	0.5	1.8	2.7
Norway	-1.4	-1.9	-1.1	-2.4	2.3	2.8	2.1	2.8
Sweden	2.5	3.5	-1.9	-0.7	-1.2	1.3	2.7	2.1
Switzerland	2.0	0.5	-0.4	-1.2	-0.1	1.6	0.3	0.9
United Kingdom	1.2	1.0	-0.9	-1.4	2.7	1.8	0.7	2.9
Average Emerging Market Economies	-3.5	-1.6	-2.1	-1.2	8.2	5.5	3.3	5.1
Average Developed Economies	1.3	1.5	-1.3	-1.3	1.0	2.2	2.5	2.5
Average Latin American Economies	-2.6	-4.2	-2.7	-1.7	9.5	7.3	4.4	5.9
Average Non Asian Emerging Market Economies	-5.3	-1.4	-2.1	-0.8	7.6	4.9	3.1	4.8

GDP growth correponds to GDP growth in each year minus the average GDP growth for the previous 6 years.

Table 4
Initial Conditions: Asian Crisis and US Recession

	Inflation		Inflation Target		Real Exchange Rate Change	
	1997	2000	1998	2001	1998	2001
Emerging Market Economies						
Brazil	5.2	6.0		4.0	2.3	17.7
Chile	6.0	4.5	4.5	3.0	1.7	9.7
Colombia	17.7	8.7	16.0	8.0	4.8	0.1
Czech Republic	10.0	-4.7	6.0	3.0	-7.6	-5.3
Hungary	18.4	10.1		7.0	0.8	-7.4
Israel	7.0	0.0	8.5	3.5	3.0	6.7
Korea	6.6	3.2	9.0	2.5	34.5	5.5
Mexico	15.7	8.9	15.0	6.5	-1.9	-7.6
Peru	6.5	3.7	8.3	3.0		
Poland	13.2	8.6	9.0	6.1	-4.8	-12.0
South Africa	6.5	7.3		4.5	10.4	13.2
Thailand	7.6	1.4		1.8	18.4	3.9
Developed Economies						
Australia	-0.2	5.8	2.5	2.5	12.9	3.7
Canada	0.8	3.2	2.0	2.0	4.7	0.8
Iceland	1.5	4.2		3.5	-2.7	13.7
New Zealand	0.8	4.0	1.5	1.5	16.8	2.0
Norway	2.3	3.0	2.5	2.5	2.9	-3.5
Sweden	1.6	1.0	2.0	2.0	2.9	8.6
Switzerland	0.3	1.5		1.0	-1.3	-2.8
United Kingdom	3.6	2.9	2.5	2.5	-5.9	1.9
Average Emerging Market Economies	10.0	4.8	9.5	4.4	5.6	2.2
Average Developed Economies	1.3	3.2	2.2	2.2	3.8	3.1
Average Latin American Economies	10.2	6.4	11.0	4.9	1.7	5.0
Average Non Asian Emerging Market Economies	9.6	4.5	9.5	4.1	8.8	2.6

Table 5
Monetary Policy Actions: Asian Crisis and US Recession

Dependent variable: Real deposit interest rate	(5.1)	(5.2)	(5.3)	(5.4)	(5.5)
Pass-through	0.078 (0.02)***		0.073 (0.02)***	0.077 (0.03)**	0.031 (0.06)
Initial inflation		0.268 (0.15)*			
GDP growth commercial partners			0.425 (0.46)	-0.197 (0.98)	0.923 (0.49)*
Dummy 2001	-0.042 (0.01)***	-0.039 (0.01)***	-0.036 (0.01)**	-0.051 (0.02)**	-0.018 (0.02)
Constant	0.014 (0.01)	0.012 (0.01)	0.022 (0.01)**	0.016 (0.02)	0.026 (0.01)**
No. Observations	37	39	37	18	19
R^2	0.41	0.33	0.42	0.34	0.41

*** significant at 1% level, ** significant at 5% level, * significant at 10% level.
Robust standard errors in parenthesis.

Table 6
Monetary Policy Rules: Chile 1991-2003

Dependent variable: Monetary policy real interest rate	(6.1)	(6.2)	(6.3)	(6.4)	(6.5)
θ_0	0.51 (0.09)***	0.99 (0.07)***	0.65 (0.04)***		
β_0	0.83 (0.13)***	9.20 (52.12)	0.39 (0.10)***		
γ_0	0.40 (0.09)***	-4.08 (38.73)	0.44 (0.11)***		
δ_0	0.14 (0.07)*	-59.56 (351.19)	0.28 (0.07)***		
λ_0			-0.25 (0.07)***		
θ_1				0.63 (0.07)***	0.94 (0.09)***
β_1				1.22 (0.46)**	-5.73 (9.97)
γ_1				1.15 (0.19)***	0.35 (1.60)
Period	1991.1-1999.4	1991.1-2003.4	1991.1-1999.4	1996.1-2003.4	1991.1-2003.4
R^2	0.95	0.35	0.95	0.95	0.86
J-statistic	0.13	0.22	0.19	0.14	0.11

*** significant at 1% level, ** significant at 5% level, * significant at 10% level.
GMM estimation. Standard errors in parenthesis.

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