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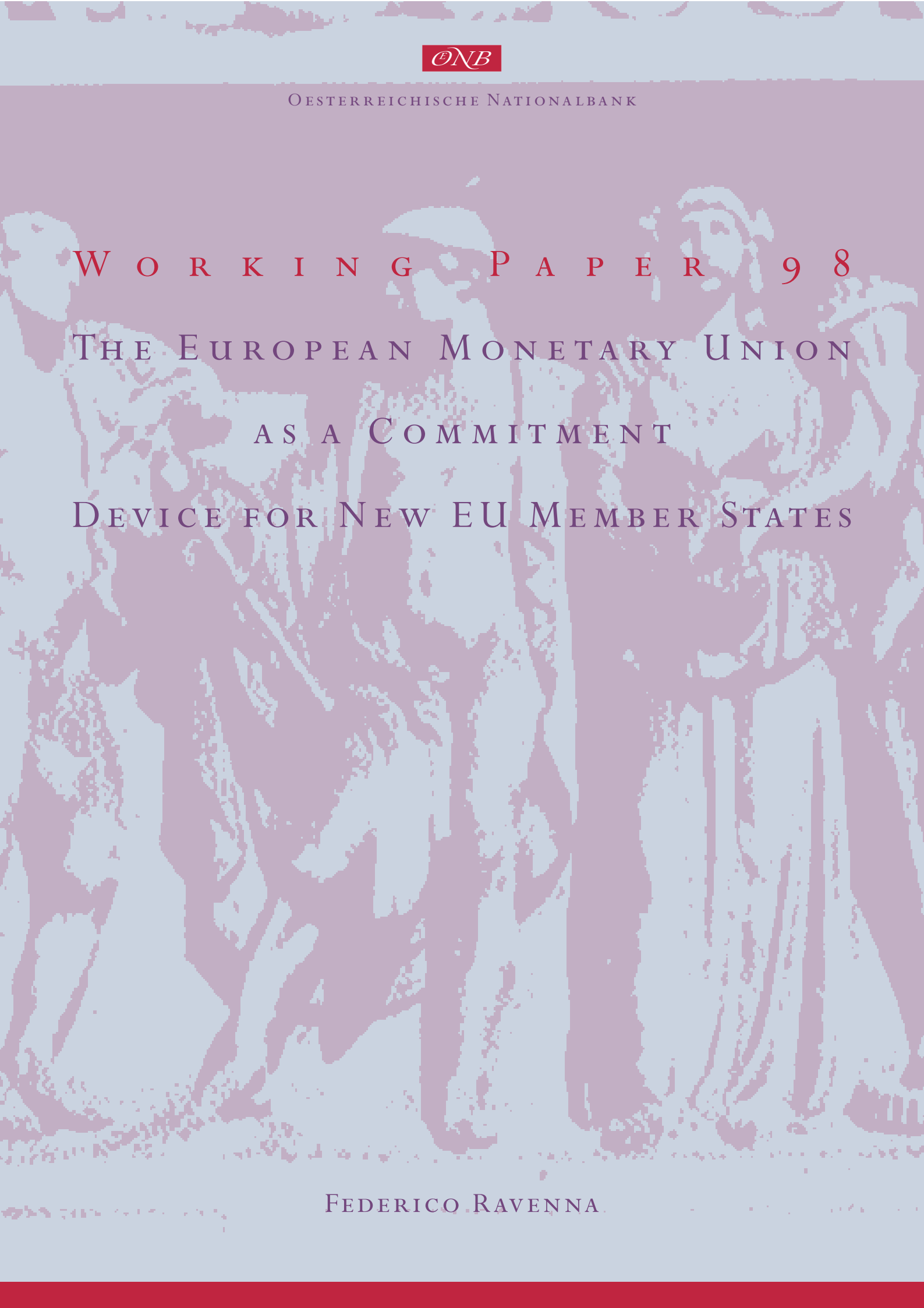

WORKING PAPER 98

THE EUROPEAN MONETARY UNION AS A COMMITMENT DEVICE FOR NEW EU MEMBER STATES

FEDERICO RAVENNA

Statement of Purpose

The Working Paper series of the Oesterreichische Nationalbank is designed to disseminate and to provide a platform for discussion of either work of the staff of the OeNB economists or outside contributors on topics which are of special interest to the OeNB. To ensure the high quality of their content, the contributions are subjected to an international refereeing process. The opinions are strictly those of the authors and do in no way commit the OeNB.

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Editorial

On the occasion of the 65th birthday of Governor Klaus Liebscher and in recognition of his commitment to Austria's participation in European monetary union and to the cause of European integration, the Oesterreichische Nationalbank (OeNB) established a "Klaus Liebscher Award". It will be offered annually as of 2005 for up to two excellent scientific papers on European monetary union and European integration issues. The authors must be less than 35 years old and be citizens from EU member or EU candidate countries. The "Klaus Liebscher Award" is worth EUR 10,000 each.

The winners of the first Award 2005 were Ester Faia and Federico Ravenna. Ester Faia's winning paper is presented in Working Paper 97, while Federico Ravenna's contribution is contained in this Working Paper.

Federico Ravenna shows that the credibility gain from permanently committing to a fixed exchange rate by joining the European Monetary Union can outweigh the loss from giving up independent monetary policy if the domestic monetary authority does not enjoy full credibility. Using a DSGE model, this paper shows that when the central bank enjoys only limited credibility a pegged exchange rate regime yields a lower loss compared to an inflation targeting policy, even if this policy ranking would be reversed in a full-credibility environment. There exists an initial stock of credibility that must be achieved for a policy-maker to adopt inflation targeting over a strict exchange rate targeting regime. Full credibility is not a precondition, but exposure to foreign and financial shocks and high steady state inflation make joining the EMU relatively more attractive for a given level of credibility.

May 12, 2005

The European Monetary Union as a Commitment Device for New EU Member States

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April 2005

Abstract

We show that the credibility gain from permanently committing to a fixed exchange rate by joining the European Monetary Union can outweigh the loss from giving up independent monetary policy if the domestic monetary authority does not enjoy full credibility. Using a DSGE model, this paper shows that when the central bank enjoys only limited credibility a pegged exchange rate regime yields a lower loss compared to an inflation targeting policy, even if this policy ranking would be reversed in a full-credibility environment. There exists an initial stock of credibility that must be achieved for a policy-maker to adopt inflation targeting over a strict exchange rate targeting regime. Full credibility is not a precondition, but exposure to foreign and financial shocks and high steady state inflation make joining the EMU relatively more attractive for a given level of credibility. The theoretical results are consistent with empirical evidence we provide on the relationship between credibility and monetary regimes using a Bank of England survey of 81 central banks.

JEL Classification Numbers: E52; E31; F02; F41.

Keywords: Inflation targeting, Credibilty, Open Economy, Exchange Rate Regimes, Monetary Policy

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1 Introduction

In May 2004 ten central and eastern European countries joined the European Union (EU). Even before gaining full membership, all of these countries announced their plans to join the European Monetary Union (EMU) and adopt the Euro as official currency within four to six years.

Yet most of these countries, and all the largest ones, have become working market economies only since the second half of the 1990s. They have undergone or are still undergoing much structural change, and expect to reap very large productivity gains and to converge to EU standards of living in the next decade. Since new EU member states are under many respects emerging market economies, there seem to be an important role for an independent monetary policy, at least in the short to medium term. In fact, of the new EU member states, only Estonia, Latvia, Lithuania and Malta have already given up monetary policy independence in favor of a hard peg to the Euro. Moreover, many of the economic gains from joining the EU - from having access to a free-trade area to creating a more favorable environment for foreign investors through fiscal and legal harmonization - do not require adopting the Euro as a currency.

What is the gain for new EU member states of joining the Euro currency area so soon? This paper shows that the credibility gain from committing to a fixed exchange rate can be larger than the loss from giving up independent monetary policy. We argue that the incentive to adopt a fixed exchange rate regime, rather than an independent monetary policy, is common to countries whose monetary authority enjoys a limited level of credibility. Joining the EMU as soon as possible can be a desirable policy if it allows a EU member to choose a fully credible fixed exchange rates against other EMU members over a not fully-credible independent monetary policy.

In our analysis we compare a fixed exchange rate to an inflation-targeting instrument rule. For countries engaging in inflation targeting, the primary objective of monetary policy (established by political mandate) is to pursue a quantitative inflation target - keeping the CPI inflation rate within a given band, for example. We first provide evidence on the relationship between alternative monetary policies and credibility. We document that inflation targeting is mostly popular among countries with medium levels of monetary policy credibility, and the least among low-credibility countries. Exchange rate targeting is comparatively more popular in countries with low credibility. We then show that while under full credibility inflation targeting performs better than a hard peg for a given policy objective function, the policy ranking is reversed when the central bank policy attains only limited credibility[1]. For new EU members, the policy of adopting the Euro as official currency offers a clear advantage: the central bank commitment to fixing the exchange rate against the Euro is fully credible. On the other hand, the commitment to an inflation targeting

[1] In perfect credibility DSGE models, while it is possible to show that under certain conditions (very open economy, a high degree of liability dollarization) some exchange rate stability is desirable, *full* exchange rate stability is an optimal policy only under very restrictive assumptions (Devereux, 2004).

policy can only be verified after many months. A central bank willing to commit to a monetary regime but with little reputation may be forced to choose between a credible exchange rate target, and a non-credible inflation target.

Monetary policies are evaluated using a DSGE New-Keynesian model of a small open economy. The model is solved under the assumption of imperfect credibility - the private sector expects the monetary authority to behave according to a policy different from the one effectively adopted. The larger the distance, the least the credibility enjoyed by the policy announced. We can quantify the initial stock of credibility necessary for inflation targeting to perform better than a hard peg for a given policy-maker loss function. Full credibility is not a precondition for a hard peg to perform worse than inflation targeting. Countries more exposed to foreign and financial shocks volatility or with high average inflation need to enjoy a comparatively higher levels of credibility for monetary independence to improve over a fixed exchange rate.

The paper is organized as follows. Section 2 reviews the literature on inflation targeting in emerging markets, and the role of credibility in inflation targeting adoption. Section 3 provides evidence on the relationship between monetary regimes and credibility. Section 4 describes the model. Section 5 discusses the results under full and imperfect credibility. Section 6 concludes

2 Policy Choices in Emerging Markets

While most central banks have price stability as a statutory policy goal, inflation targeting central banks publicly commit to adjust their policy so as to reach a numerical target for the benchmark inflation index at a given horizon; and to explain deviations of inflation from the target when this is not achieved. Svensson (1999) characterizes inflation targeting as *inflation forecast targeting:* monetary policy must be adjusted so that at the targeting horizon inflation is forecast to reach the target. Other policy objectives, such as the employment level or the exchange rate, are subordinated to the inflation objective. Inflation targeting amounts to more that a generic commitment to price stability, and the provision of a nominal anchor for monetary policy. A key ingredient of inflation-targeting monetary regimes is the central bank's transparency on its objective, on the evaluation of the current economic situation, on the steps the central bank expects to take to fulfill the long term inflation goal.

A number of papers have examined what are the preconditions necessary for emerging market economies to adopt inflation targeting. Amato and Gerlach (2002), Masson et al. (1997) and Schaechter et al. (2000) identify as necessary preconditions central bank independence, sound fiscal policy, the need for the economy to be resilient to fluctuations in exchange rate, and the availability of econometric models for the inflation dynamics and monetary transmission mechanism.

The literature on monetary regime choice in less developed countries is vast. Much attention has been devoted to the question of whether inflation targeting is a viable policy for emerging market economies. Eichengreen (2002), Calvo and Mishkin (2003), Mishkin (2004), Amato and Gerlach (2002), Carare et al. (2002) provide an overview of emerging economies characteristics that may make inflation targeting a

comparatively less attractive choice, and can explain the popularity enjoyed by hard pegs. First, most emerging markets are small open economies, and neglect of the exchange rate target may lead to high exchange rate volatility and a strong impact on firms' profitability. Higher pass-through also means that domestic prices react strongly to exchange rate fluctuations. Second, emerging markets' investments are often financed by external borrowing to a large extent, making them very vulnerable to large negative changes in capital inflows (so called 'sudden stops'). If foreign currency borrowing is relatively important in the balance sheets of financial institutions, production firms and the government, the large depreciation following a sudden stop under a floating exchange rate regime can lead to widespread bankruptcies.

The third and least controversial hurdle restraining emerging market economies from adopting inflation targeting is the *lack of credibility* of the monetary authority commitment to an announced policy. The main advantage of a floating exchange rate regime - the ability to tailor monetary policy to the domestic economy and the domestic business cycle - is largely lost if the monetary authority enjoys little credibility. Changes in the interest rate will not be effective in influencing firm's pricing decision to meet the inflation target, if firms do not believe the central bank will stick to the announced policy, and will falter in the face of output fluctuations. Imperfect credibility may then require large swings in interest rates for the central bank to achieve the inflation target. It will also force the central bank to adhere strictly to the inflation target, so as not to lose any credibility gained. Emerging market countries - with the notable exception of Chile - adopted inflation targeting in situations of moderate inflation (less than 10%), using an exchange rate target to achieve inflation stabilization first.

Yet inflation targeting was adopted in many countries exactly to *improve the credibility record*, after a history of poor inflation performance. In a new inflation targeting regime initial credibility is low, and is earned over time. The Joint Economic Committee of US Congress states in a report discussing inflation targeting (Saxton, 1997):

> "Experience in several countries indicates that establishing the credibility of inflation targeting arrangements is not easy and occurs only over an extended time frame...It is only after a record of price stability...that credibility develops, implying that inflationary expectations and risk premia of interest rates will disappear slowly over time."

But the experience of inflation targeting countries over time is generally regarded as positive: they have been successful at meeting the targets, lowered the sacrifice ratio, strengthened the effect of forward-looking expectations on inflation, and reaped a credibility gain (Corbo et al., 2001, Bernanke et al., 1999). The question left open is why have OECD countries sustained the initial cost of a low-credibility inflation targeting regime, whereas emerging markets have not found it optimal to follow suit.

The literature that examines the impact of imperfect credibility of inflation targeting regimes within business cycle models has focused on lack of credibility of the *level* of inflation targeted (Fraga et al., 2003, Kumhof, 2001, Weymark, 2002). But

large welfare costs can arise from the imperfect credibility of the central bank *reaction function*. Given a level of steady state inflation, the way the central bank reacts to unexpected shocks can generate excess volatility in inflation and the output gap. Under rational expectations monetary policy can exploit the expectations channel: anticipated future policy actions allow the central bank to achieve its objectives by smaller movements of the policy instrument (Williams, 1999, Svensson, 2003, Perrier and Amano, 2000). If after an inflationary shock the central bank is expected to hesitate in raising interest rates to bring inflation back to target, the monetary policy will have to be much more contractionary than under full credibility. This mechanism, driving our theoretical results, has received only limited attention (see Rabanal, 2003, and Ravenna, 2004, for applications).

3 Credibility and Monetary Policy Regimes

Countries can import credibility for the monetary policy by pegging their exchange rate, thus giving up independent monetary policy altogether. Mahadeva and Stern (2000) report than in the period 1970-1996 39 out of 70 episodes of stable inflation (defined as a period of at least five years when inflation remains within a given range) were achieved through exchange range targeting. The ratio raises to two thirds when excluding episodes where average inflation was above 19.7%. Among developing economies, all of the 14 episodes of stable inflation occurred through exchange rate targeting. Hamann and Prati (2002) look at 51 stabilizations from high inflation and find that exchange rate based stabilizations are more likely to succeed, even after controlling for institutional factors and pre-stabilization level of inflation.

This empirical work suggests that countries with a history of high inflation enjoy little independent monetary policy credibility. On the other hand, there seems to be surprisingly little evidence that resorting to inflation targeting rather than exchange rate anchors is associated with higher credibility of the monetary authority.

Reliance on seigniorage is often interpreted as indicating a lack of credibility of the monetary authority's commitments[2]. Yet in the period 1980-1995 the average reliance on seigniorage in the countries which adopted inflation targeting is similar to the average of all advanced economies (Masson et al., 1997). Hu (2003) using country panel data and quantifying credibility with a measure of the barriers against firing the central bank director and against forcing the central bank to purchase government debt, finds credibility to be insignificantly correlated with the adoption of inflation targeting.

Mishkin and Schmidt-Hebbel (2002) test whether the set of eighteen inflation targeters over the decade 1990-1999 is significantly different from a control group of nine non-inflation targeting advanced economies. The authors show that inflation targeting is significantly correlated only with policy instrument independence, whereas is negatively and insignificantly correlated with statutory and goal independence, and

[2]Seignorage is indeed negatively correlated with Cukierman (1992) measure of central bank independence calculated over the 1980s.

with inflation. In a Probit regression, the paper finds that inflation targeting is significantly and negatively correlated with goal independence.

If we take at face value the possibility that emerging markets lag in adopting inflation targeting because they lack the credibility to implement the policy, it is puzzling that the data do not show a stronger association between credibility of the monetary authority and adoption of inflation targeting. A possible explanation is that the relationship between credibility and inflation targeting is non-linear, and is masked by looking at the full cross-country panel. If inflation targeting is adopted mostly by countries lacking a good credibility record, but can't be implemented unless some initial stock of credibility is available, we should see mostly *medium* credibility countries adopt it.

While a full empirical analysis is beyond the scope of the paper, we offer evidence in favor of this hypothesis using data from a Bank of England 1998 survey among 94 Central Banks (Mahadeva and Stern, 2000). The purpose of the survey was to provide multi-dimensional measurement of institutional characteristics such as independence, accountability, and transparency, operational characteristics such as the nature of economic analyses undertaken by the banks, and policy characteristics such as the relative emphasis placed on managing exchange rates, money, and inflation. The measurement of each characteristic is based on the answers to several questions on a numerical scale. The complementarities among survey questions and the fairly nuanced answers that they allow makes the data very information preserving and is likely to reduce measurement error.

Since we would like to have a measure of credibility that is the least endogenous to inflation targeting, we rule out direct measures of inflation, such as the one used by Cecchetti and Krause (2002). The credibility measure we adopt is constructed as the average of answers to four independence-related questions, weighted in the same way as in the overall independence measure calculated by the authors. The four questions concern target independence, instrument independence, central bank financing of government debt, and the term of office of the governor[3]. While reverse causation is a potential problem of our credibility measure, it is also true that many independent central banks achieved stable inflation without an explicit inflation target. Supporting the use of a independence-based measure, central bank independence and a history of honesty ranked top among ways to establish and maintain credibility in surveys conducted among economists and professional forecasters (Blinder, 2000, Waller and de Haan, 2004). In the Bank of England survey itself independence is ranked as the most important component of the country's monetary framework.

The survey also asks whether a central bank describes its policy regime as 'inflation targeting'. It is often the case that developing countries describe themselves as inflation targeters when in fact they also try to limit exchange rate volatility. Among OECD economies, France and Spain are reported in the survey to consider their policy as partial inflation targeting at a time when they were scheduled to join soon the Euro currency area and were pegging the Deutsche Mark. Therefore we crossed the

[3]We omit the question whether price stability is a statutory objective since the answer is always positive in the case of inflation targeters. The Appendix describes in detail the dataset.

survey data with de-facto exchange rate regime indicators from Reinhart and Rogoff (2002) for the year 1998. This reduced the total sample size to 81 countries. Table 1 reports the list of inflation targeters. For a regime to be a de-facto inflation targeting policy we require the de-facto exchange rate regime to be classified in Rheinart and Rogoff (2002) as a freely floating or managed floating regime. Floating exchange rate regimes with inflation above 40% (labeled 'freely falling') are not considered inflation targeters. All other regimes, from currency unions to narrow moving bands, are considered exchange-rate targeters.

Table 2 shows that the correlation between credibility and inflation targeting is very close to zero. The correlation between credibility and the score recorded for the overall degree of inflation focus of the monetary policy is even negative, while the correlation between credibility and exchange rate targeting is positive and larger. Once we adjust the data for the de-facto regime, the correlation is still low in absolute value, but points in the direction expected. Countries with higher credibility tend to adopt inflation targeting, while lack of credibility is associated with an exchange rate target.

Splitting the sample is very revealing. We separate in Table 3 countries with a very high credibility score ($x \geq 0.9$), from countries with a very low score ($x < 0.7$). The largest group lies in the middle, where 36 countries enjoy a credibility score between 0.7 and 0.9. The survey data shows its limitations: for example, it includes the United States and Ecuador - which dollarized in 2000 and experienced an inflation rate above 40% at the time of the survey - in the same high credibility group. Yet, most alternative indicators of credibility that can be built from the survey yield similar results. What is the relative choice of monetary policy in each subgroup? Table 4 shows that inflation targeting popularity grows with credibility. But most of the increase in inflation targeting diffusion among high-credibility countries rests on the fact that among these countries the proportion of exchange rate-focused monetary policies drops to about 44%. High-credibility countries tend to have independent monetary policies - and inflation targeting is only one of the available options. Conditional on having a floating exchange rate, only 30% of high credibility countries choose to float their exchange rate with an explicit inflation target, against over 45% of medium-credibility countries.

A possible interpretation of this result is that central banks with high credibility do not enjoy much advantage from inflation targeting. It is countries with poor inflation performance and low credibility that benefit from explicitly tying their hands. By the same token, we should observe that among low-credibility countries which do not have an exchange rate focus inflation targeting is the most popular. Quite the opposite: less than 13% of the low-credibility countries adopt inflation targeting.

In the next section we show how a business cycle model with imperfectly credible monetary policy can generate a credibility gap and explain this result. If a country does not enjoy a sufficiently high initial level of credibility, it will find an exchange rate target more attractive than inflation targeting.

4 The Model

The small open economy is described by a monetary business cycle model with nominal rigidities, along the lines of Obstfeld and Rogoff (2000), Devereux (2001, 2003), Devereux and Lane (2001). The economy is exposed to the volatility of foreign variables through exogenous shocks to the terms of trade, the cost of borrowing on the international capital market and the volume of export demand for the home-produced good. As in Monacelli (2004) and Gali and Monacelli (2005) we assume complete pass-through from the foreign to the domestic price of imported goods[4].

The domestic (H) sector produces a consumption-good basket that is both consumed by domestic households and exported to the foreign (F) sector, in exchange for a foreign-produced consumption good. Firms in the home and foreign country set prices in their respective currency and do not discriminate across markets, so that the law of one price holds for each traded good. Domestic firms in the monopolistically competitive production sector can update the price with probability less than one in any period, as in the Calvo (1983) staggered price adjustment model. We allow the monetary authority to set a positive steady state money growth rate, and do not assume steady state price indexation in the production sector.

Households trade on the international capital market a foreign currency denominated bond yielding an exogenous nominal riskless return, and hold a positive amount of the zero-interest domestic nominal asset because of the utility it yields.

4.1 Households and Foreign Sector

There is a continuum of infinitely lived households, indexed by $j \in [0,1]$. Households' preferences are described by the instantaneous utility function:

$$U_t^j = \left\{ [\ln C_t^j] D_t - \frac{\ell {N_t^j}^{1+\eta}}{1+\eta} + \frac{\mu}{1-\frac{1}{\zeta}} \left(\frac{M_t^j}{P_t} \right)^{1-\frac{1}{\zeta}} \right\}$$

where M_t/P_t is real money balances, N_t is the amount of labor service supplied, D_t is an aggregate preferences shifter. C_t is an aggregate consumption index defined over a basket of domestic (C_H) and foreign (C_F) goods:

$$C_t^j = [(1-\gamma)^{\frac{1}{\rho}} (C_{H,t}^j)^{\frac{\rho-1}{\rho}} + \gamma^{\frac{1}{\rho}} (C_{F,t}^j)^{\frac{\rho-1}{\rho}}]^{\frac{\rho}{\rho-1}} \tag{1}$$

with associated price index:

$$P_t = [(1-\gamma)(P_{H,t})^{1-\rho} + \gamma (P_{F,t})^{1-\rho}]^{\frac{1}{1-\rho}} \tag{2}$$

where $P_F = P_F^* e_t$, P_F^* is the exogenously given foreign-currency price of the imported good and e_t is the nominal exchange rate. Intratemporal expenditure minimization implies that:

$$C_{H,t}^j = (1-\gamma)[\frac{P_{H,t}}{P_t}]^{-\rho} C_t^j \quad ; \quad C_{F,t}^j = \gamma [\frac{P_{F,t}}{P_t}]^{-\rho} C_t^j \tag{3}$$

[4] See Devereux and Engel (2003) for implications of incomplete-pass through in business cycle models.

C_H and C_F are themselves aggregates of a continuum of imperfectly substitutable goods indexed by $i \in [0,1]$. We assume preferences over the individual goods are defined by a standard CES aggregator, so that the expenditure minimization problem gives the demand schedules:

$$C^j_{H,t}(i) = (\frac{P_{H,t}(i)}{P_{H,t}})^{-\vartheta} C^j_{H,t} \quad ; \quad C^j_{F,t}(i) = (\frac{P_{F,t}(i)}{P_{F,t}})^{-\vartheta} C^j_{F,t} \tag{4}$$

and the aggregate price indices:

$$P_{H,t} = (\int_0^1 P_{H,t}(i)^{1-\vartheta} di)^{\frac{1}{1-\vartheta}} \quad ; \quad P_{F,t} = (\int_0^1 P_{F,t}(i)^{1-\vartheta} di)^{\frac{1}{1-\vartheta}}$$

Households maximize the expected discounted utility flow:

$$U^j = E_0 \sum_{t=0}^{\infty} \beta^t U^j_t(C^j_t, N^j_t, \frac{M^j_t}{P_t}, D_t)$$

subject to eqs. (1), (2), (3), (4) and the budget constraint:

$$P_t C^j_t + M^j_t + e_t v^*_t B^{*j}_t + v_t B^j_t \leq W^j_t N^j_t + M^j_{t-1} + e_t B^{*j}_{t-1} + B^j_{t-1} + \Pi^j_t - \tau_t \tag{5}$$

where v_t (v^*_t) is the price of a zero-coupon riskless bond priced in domestic (foreign) currency, B_t (B^*_t) is the amount of domestic (foreign) asset purchased, W_t is the wage rate, Π^j is the share of profit from the monopolistic firms rebated to the household, and τ is a lump sum government tax.

The optimality conditions for consumption and labor allocation are:

$$\frac{C_{F,t}}{C_{H,t}} = \frac{\gamma}{1-\gamma} \left(\frac{P_{F,t}}{P_{H,t}}\right)^{-\rho} \tag{6}$$

$$MUC_t \frac{W_t}{P_t} = \ell N^{\eta}_t \tag{7}$$

and the marginal utility of consumption is $MUC_t = \frac{D_t}{C_t}$ [5]. The household maximization problem yields as well the money demand equation, not reported here. Since we assume the central bank policy instrument is the nominal interest rate, money demand only establishes the money stock the central bank has to supply in order to achieve the desired level of the nominal interest rate.

The Euler equations for the domestic and foreign bond can be combined to yield the stochastic equivalent of the uncovered interest parity condition:

$$E_{(t)} \left\{ MUC_{t+1} \frac{P_t}{P_{t+1}} \left[\frac{e_{t+1}}{e_t}(1+i^*_t) - (1+i_t) \right] \right\} = 0 \tag{8}$$

[5] Since in the symmetric equilibrium all households' choices are identical we drop the j index.

where $(1+i_t) = v_t^{-1}$ is the gross nominal interest rate and $(1+i_t^*) = v_t^{*^{-1}}$is the interest rate paid by domestic residents to borrow on the international capital market[6]. Foreign households' demand for the home-produced good is also assumed to be price-elastic, and the export demand is given by:

$$C_{H,t}^* = \gamma^* [\frac{P_{H,t}}{E_t P_{F,t}^*}]^{-\rho^*} C_t^* = \gamma^* S_t^{\rho^*} C_t^*$$

where C_t^* is an exogenous stochastic process and $S_t = P_{F,t}/P_{H,t}$ defines the home country terms of trade.

4.2 Firms

The home production sector is made up of a continuum of firms i indexed on the unit interval. Domestic firms produce goods employing labour services supplied by households and a production technology A_t:

$$Y_{H,t}(i) = A_t N_t(i) \tag{9}$$

In every period t, firms adjust their prices with probability $(1-\theta_p)$. This assumption generates the well know time-dependent Calvo (1983) pricing model used in the New Keynesian literature. The problem of the firm setting the price at time t consists of choosing $P_{H,t}(i)$ to maximize

$$E_t \sum_{i=0}^{\infty} (\theta_p \beta)^i \Lambda_{t,t+i} \left[\frac{P_{H,t}(i)}{P_{H,t+i}} Y_{H,t+i}(i) - \frac{MC_{t+i}^N}{P_{H,t+i}} Y_{H,t+i}(i) \right] \tag{10}$$

subject to

$$\begin{aligned} Y_{t,t+i}(i) &= \left[\frac{P_{H,t}(i)}{P_{H,t+i}} \right]^{-\theta} Y_{H,t+i} \\ MC_t^N &= P_{H,t} MC_t = \frac{W_t}{MPL_t} \end{aligned} \tag{11}$$

where MC^N and MC are the nominal and real marginal cost, MPL is the marginal productivity of labor. In (11), $Y_{H,t+i}(i)$ is the demand function for firm's output at time $t+i$, conditional on the price set i periods in advance at time t, $P_{H,t}(i)$. Market clearing ensures that $Y_{H,t+i}(i) = C_t^W(i) = C_{H,t}(i) + C_{H,t}^*(i)$ where $C_{H,t}^*(i) = (\frac{P_{H,t}(i)}{P_{H,t}})^{-\vartheta} C_{H,t}^*$ is foreign demand for good i. The stochastic discount factor between t and $t+i$ is $\beta^i \Lambda_{t,t+i}$. The solution to the optimal pricing problem is given by:

$$P_{H,t}(i) E_t \sum_{i=0}^{\infty} (\theta_p \beta)^i \Lambda_{t,t+i} \left[\frac{P_{H,t}(i)}{P_{H,t+i}} \right]^{1-\theta} Y_{H,t+i} = \frac{\theta}{\theta - 1} E_t \sum_{i=0}^{\infty} (\theta_p \beta)^i \Lambda_{t,t+i} MC_{t+i}^N \left[\frac{P_{H,t}(i)}{P_{H,t+i}} \right]^{1-\theta} Y_{H,t+i}. \tag{12}$$

[6] To ensure stationarity, following Schmitt-Grohe and Uribe (2001) we assume that $i^*$is given by the exogenous world interest rate $\widetilde{i}^*$ plus a premium increasing in the real value of the country's stock of foreign debt: $(1+i_t^*) = (1+\widetilde{i}_t^*) g(-\widetilde{B}_t)$, where $\widetilde{B}_t = \frac{e_t B_t^*}{P_{H,t}}$ and $g(\cdot)$ is a positive, increasing function.

Since we assume a non-zero steady state inflation rate, log-linearization of eq. (12) does not return the standard forward-looking New Keynesian inflation equation (as derived, among others, in Monacelli, 2004). The Appendix provides a detailed derivation.

4.3 Government and central bank behaviour

The government rebates the seigniorage revenues to the households in the form of lump-sum transfers, so that in any time t the government budget is balanced: $-\tau_t = M_t^s - M_{t-1}^s$. In the steady state the central bank follows a constant money growth rate policy. When the economy is away from the steady state, the central bank monetary policy is described by an interest rate rule, where the instrument is a function of the models' state and control variables. A monetary regime is defined by the policy rule L:

$$\begin{aligned} \frac{(1+i_t)}{(1+i_{ss})} &= L(s_t, s_{t-1}) \\ L &= [s^L, \varepsilon_i] \end{aligned}$$

where i_{ss} is the steady state level of the interest rate, s_t is the vector of state and control variables, s^L is the vector parametrizing the policy rule L, and ε_i is a random shock summarising exogenous shifts in monetary policy.

4.4 Market Clearing and Aggregate Equilibrium

The assumptions of symmetric equilibrium and constant return to scale production allow a straightforward derivation of the equilibrium equations for the aggregate economy. Market clearing in the domestic economy requires

$$Y_{H,t} \equiv C_{H,t} + C_{H,t}^* = \int_0^1 A_t N_t(i) di = A_t N_t$$

Since all firms face identical marginal costs, any firm belonging to the fraction $(1-\theta_p)$ resetting the price at t chooses the same new optimal price: $\tilde{P}_{H,t}(i) = \tilde{P}_{H,t}$. The aggregate price index evolves according to:

$$P_{H,t} = \left[\theta_p P_{H,t-1}^{1-\vartheta} + (1-\theta_p)\tilde{P}_{H,t}^{1-\vartheta}\right]^{\frac{1}{1-\vartheta}}$$

The equilibrium in the money market requires $M_t^s = M_t^d$. Each household purchases an equal amount $C_{H,t}^j(i)$ so that $C_{H,t}^j(i) = C_{H,t}(i)$. The quantities purchased of each good i will depend upon the price currently charged, which differs across firms. The labor market clears in every period. Since all households are identical, equilibrium in the domestic asset markets implies $B_t = 0$. Households can borrow from the rest of the world, so that B^* can be non-zero. The evolution of the foreign asset stock can be derived using the households' budget constraints and market clearing conditions.

We assume that the logarithm of the exogenous preference shifter D_t, the technology shock A_t, the world interest rate $\hat{\imath}_t^*$, imports' price $P_{F,t}^*$ and aggregate foreign consumption demand C_t^* follow a first order autoregressive stochastic processes, with the random innovation $\varepsilon_{j,t} \sim N(0, \sigma_j^2)$. The model parametrization is described in the Appendix.

4.5 Solution method

The model is solved by taking a linear approximation around the non-stochastic steady state of the economy equilibrium. We allow the private sector belief of the monetary policy rule L followed by the central bank to be different from the true policy adopted. This methodology lets us examine the equilibrium achieved when the central bank announces *and* enforces a given policy, but the private sector forms expectations according to its own believes of the central bank policy rule. We label 'imperfect credibility' any equilibrium where the private sector expectations are different from the rational expectation solution. The *credibility gap* (the distance between the announced and the believed policy) can be exogenously specified. We assume the only model-inconsistent believes concern the systematic reaction of the monetary authority to the state of the economy.

Let $\tilde{E}_t^L$ indicate the expectation of a variable under the belief that the central bank follows the policy rule L. Write the model in matrix form as

$$0 = \quad E_t(s_{t+1}) + \quad s_t + \quad s_{t-1} + \quad \varepsilon_t \tag{13}$$

where both control and state variables are elements of the vector s_t, and where ε is the vector of i.i.d. innovations to the exogenous stochastic variables. Under the monetary policy rule L_a, the solution of the rational expectations model is:

$$s_t = \quad {}_a s_{t-1} + \quad {}_a \varepsilon_t \tag{14}$$

If the private sector expects the central bank to behave according to the policy rule L_b, expectations are consistent with the rational expectation equilibrium defined by:

$$s_t = \quad {}_b s_{t-1} + \quad {}_b \varepsilon_t \tag{15}$$

The structural model becomes:

$$\begin{aligned} 0 &= \quad \tilde{E}_t^b(s_{t+1}) + \quad s_t + \quad s_{t-1} + \quad \varepsilon_t \\ &= \quad [\ {}_b s_t] + \quad s_t + \quad s_{t-1} + \quad \varepsilon_t \end{aligned} \tag{16}$$

which can be solved yielding a reduced form:

$$s_t = \quad {}_c s_{t-1} + \quad {}_c \varepsilon_t$$

where $\quad {}_c = -(\quad {}_b + \quad)^{-1}$ and $\quad {}_c = -(\quad {}_b + \quad)^{-1}$. Clearly $(\quad {}_a, \quad {}_a) \neq (\quad {}_c, \quad {}_c)$ except when $(\quad {}_b, \quad {}_b) = (\quad {}_a, \quad {}_a)$, in which case we obtain the RE equilibrium. But it is also true that $(\quad {}_b, \quad {}_b) \neq (\quad {}_c, \quad {}_c)$. Over time, the private sector

should be able to learn that it is using a mis-specified model to form expectations. We choose not to include a learning dynamics for two reasons. First, monetary policy regime reforms are usually coordinated between monetary authorities and the government (they usually happen together with an overhaul of the fiscal policy, so as to enhance the credibility of the commitment). Governments often have very high discount rates - they are unlikely to bet on the learning speed of the private sector when evaluating the relative performance of alternative policies[7]. Therefore in our model the monetary authority assumes the private sector assigns probability one to the event "monetary policy will be conducted according to regime L_b". Effectively, we are assuming the policy-maker ranks policies according to a worst-case scenario where his credibility never improves. Second, we are interested in evaluating what is the maximum credibility gap that would still make inflation targeting perform better than exchange rate targeting for a given a policy objective function. Introducing learning dynamics adds an extra layer to the problem which muddles the result: a policy rule may in fact be preferable because it speeds up learning. Even if under full credibility an inflation targeting were optimal, with learning the policy-maker may find optimal to converge to inflation targeting by adopting a sequence of intermediate policies that trade-off the gain from being close to the optimal one with the gain from faster learning.

5 Credibility and Policy Performance

This section discusses the implication for ranking of alternative monetary policies as the credibility gap changes. The performance of alternative policy rules is assessed by assuming the policy-maker objective function depends on deviations from the steady state levels of domestic producers' price inflation, the consumption gap and interest rates:

$$Loss = \lambda_c Var[c_t - \widetilde{c}_t] + \lambda_\pi Var[\pi_{H,t}] + \lambda_i Var[i_t] \tag{17}$$

where $\widetilde{c}$ is the flexible-price level of consumption. Unless explicitly stated, we will assume $\lambda_i = 0$. Ranking policies using the household utility function would require solving for a second order approximation to the equilibrium, and is not feasible since the solution method under imperfect credibility relies on a first-order approximation. The policy objective in eq. (17) assumes that the monetary authority aims at replicating the flexible-price equilibrium. Since prices cannot be adjusted optimally, individual firms' markups are heterogeneous, and the dynamics of aggregate consumption c will deviate from the flexible price level $\widetilde{c}$. In addition, the existence of the nominal rigidity implies that inflation is costly because it generates dispersion in relative prices. Foreign goods are uniformly priced, therefore only domestic inflation π_H introduces a welfare-reducing distortion. Gali and Monacelli (2005) show that in a New Keynesian full pass-through model stabilising producer price inflation is optimal, and that the utility-based welfare criterion to evaluate the cost of sub-optimal

[7] Unless they have available a clear way of signalling the committment, such as entry into the EU signalled the committemnt to join the European Monetary Union for member states.

policies can be written as a function of the output gap and domestic price inflation volatility. This result hinges on a number of restrictive assumption which are not met in our model. Benigno and Benigno (2003) prove that in general the flexible price equilibrium is not welfare-maximizing because of the expenditure switching effect of the terms of trade in an open economy[8]

The policy-maker loss function includes a consumption gap, to take into account how policy impacts on the composition of the domestic and foreign good basket entering the household utility function. Using the domestic output gap does not alter qualitatively the results. We also examine the case of a policy objective (17) expressed in terms of consumer price inflation π rather than producer price inflation. Inflation targeting countries usually choose a measure of core CPI inflation as the policy target for ease of communication and transparency. A large literature (Devereux and Engel, 2003, Sutherland, 2005) shows that if pass-through is less than complete, exchange rate fluctuations have a direct impact on welfare. Including CPI inflation implicitly introduces the exchange rate volatility in the policy objective. Finally, we allow for the possibility that the policy objective may include interest rate volatility. Lowe and Ellis (1997) justify such policy-maker preferences with institutional reasons and concerns about financial market fragility. The policy-maker is assumed to assign equal weights to the policy targets: $\lambda_\pi = \lambda_c = 1$ and, when the interest rate target is explicitly included, $\lambda_i = 1$.

Inflation targeting has been alternatively modeled as an instrument rule where a measure of inflation or expected inflation enters the policy-maker feedback rule (an *inflation-targeting instrument rule*: see McCallum and Nelson, 2004), or as the minimization of a loss function increasing in the deviation between the target variables and the target levels (an *optimal targeting rule* Svensson, 1999). In some simple models, the two approaches are equivalent (Gali, 2002, Eichengreen, 2002). In general, a targeting rule will be implemented by a policy equation where the interest rate is a function of all state variables, so an instrument rule where the interest rate is a function of inflation only will be suboptimal, even if the central banker's loss function depends exclusively on inflation.

We model inflation targeting as an instrument rule, as in Devereux (2003) and Parrado and Velasco (2002). One advantage of this approach is that optimal targeting rules can be very sensitive to the micro-structure of the model, and therefore less robust. Simple rules instead seem to perform reasonably well in a variety of models (Williams, 1999). Moreover, simple rules are easier to monitor for private agents, and this increases the central bank's ability to credibly commit to a strategy.

The monetary authority follows the instrument rule:

$$\frac{\left(1+\overline{i}_t\right)}{\left(1+i^{ss}\right)} = \left(\frac{1+\pi_{H,t}}{1+\pi_{H,SS}}\right)^{\omega_\pi} \left(\frac{\Delta e_t}{\Delta e_{SS}}\right)^{\omega_e} \tag{18}$$

where ω_π, $\omega_e \geq 0$ are the feedback coefficients to domestic inflation and nominal exchange rate depreciation. Strict inflation targeting would require $\omega_e = 0$. A man-

[8] Walsh (2003) and Woodford (2003) discuss the implications for welfare of nominal price rigidities in the New Keynesian model. Clarida et al. (2001) extends the results to an open economy model.

aged exchange rate float would instead imply $\omega_e > 0$, $\omega_\pi = 0$. The larger ω_e, the more the policy regime will approximate a fixed exchange rate regime. The welfare implications of domestic inflation targeting rules are examined by Devereux (2003), Gali and Monacelli (2005) and Parrado and Velasco (2002). Targeting π_H is a appropriate given the policy objective (17) is expressed in terms of producer price inflation. Including CPI inflation in eq. (18) would also blur the comparison across regimes, since the model implies $\pi_t = (1-\gamma)\pi_{H,t} + \gamma(\Delta e_t + \pi^*_{F,t})$ and a CPI target would allow exchange rate movements to affect policy beyond the explicit exchange rate target $\Delta e_t / \Delta e_{SS}$.

We assume the policy-maker adjusts the interest rate only gradually to the target rate $\bar{i}_t$:

$$(1 + i_{t,t+1}) = \left[\left(1 + \bar{i}_{t,t+1}\right)\right]^{(1-\chi)} \left[(1 + i_{t-1,t})\right]^{\chi} \varepsilon_{i,t} \tag{19}$$

where $\chi \in [0, 1)$ is the degree of smoothing and the exogenous shock $\varepsilon_{i,t}$ represents non-systematic, unexpected movements in monetary policy, arising for example from policy mistakes. A high degree of interest rate smoothing is a recurrent feature of estimated policy feedback rules (Clarida et al., 1998). Woodford (2003) finds that optimal monetary policy rules in the closed economy New Keynesian setting are associated with large policy inertia, even for $\lambda_i = 0$.

Let the inflation targeting regime adopted by the central bank be described by:

$$L_a = [\omega_\pi = 2, \omega_e = 0.1, \chi = 0.8, \varepsilon_i]$$

Under full credibility, private sector expectations are consistent with the model:

$$L_b = L_a$$

What are the consequences of imperfect credibility? Our thought experiment consists in the announcement of a policy change from a fixed exchange rate regime to the inflation targeting regime L_a. Assume private sector expectations are formed according to $L_b \neq L_a$, where L_b indicates policy believes ranging from $L_b^{low} = [\omega_\pi = 0.1, \omega_e = 1]$ to $L_b^{high} = L_a$. The credibility gap is given by the distance between the vectors L_a and L_b. As the credibility of the central bank improves, ω_e decreases towards the true value of 0.1 and ω_π contemporaneously increases towards the true value of 2 [9]. The value χ is fixed at 0.8, and the distribution of ε_i is known. When credibility is low and $L_b = L_b^{low}$ the private sector expects the central bank to heavily manage the exchange rate, and to put only a small weight on producer price inflation deviations from the target. In other words, the central bank is not believed to react with an aggressive contractionary policy as the inflation rate deviates from the announced target, nor to subordinate the exchange rate to the inflation rate target.

Figure 1a shows the policy-maker loss as a function of the believed policy $L_b \in [L_b^{low}, L_b^{high}]$. The surface in the figure represents the loss achieved under a fixed exchange rate regime. The monetary authority complies with the announced policy

[9] We allow for a positive level of ω_e in the inflation targeting regime, to account for the fact that emerging small open economies may be concerned with smoothing the volatility of the nominal exchange rate, and that inflation targeting regimes do not filter out completely the impact of exchange rate movements in their definition of target inflation rate (tipycally a measure of 'core inflation').

under either regime - but may enjoy less than full credibility in the inflation targeting regime if $L_b \neq L_a$. The advantage of an exchange rate targeting lies in the transparency of the commitment: it can be verified on a daily basis. In the case of a currency union, reneging on the commitment carries a very high political cost. Given this advantage, the central bank will choose an (imperfectly credible) inflation targeting policy if it yields a loss no larger than an exchange rate peg. What is the initial stock of credibility necessary for this to happen? The figure shows that for L_b approximately equal to $[\omega_\pi = 0.35, \omega_e = 0.95]$ the two policies yield the same loss. Even given a substantial credibility gap, the policy-maker will find inflation targeting a better monetary regime. But as the credibility gap increases, a fixed exchange rate regime guarantees a lower loss. For $L_b = L_b^{low}$, the inflation targeting regime nearly doubles the loss of the exchange rate peg.

If the policy-maker target is defined in terms of consumer price inflation, rather than producer price inflation, the cost of the credibility gap increases, as the variability of the exchange rate which now enters the objective function increases rapidly with the credibility gap. For the lowest level of credibility, targeting π_H implies an excess loss of about 100% relative to the fixed exchange rate regime. If the objective function includes CPI rather than PPI inflation the value of the excess loss rises to over 300%. As a consequence, the initial stock of credibility necessary for inflation targeting to yield a loss lower than an exchange rate peg rises.

5.1 The Credibility Gap

To illustrate the cost of the credibility gap, figure 1 also displays the loss as L_a varies in the range $[L_b^{low}, L_b^{high}]$ under full credibility. Figure 2 reproduces figure 1b and shows how to interpret the cost from the credibility gap. Let $L_a|L_b$ indicate the loss associated with policy L_a conditional on believes L_b. Define the *credibility gap* as the loss $L_a|L_b - L_a|L_a$ generated by imperfect credibility. This loss can be read as the sum of two terms:

$$L_a|L_b - L_a|L_a \;\; = \;\; [L_b|L_b - L_a|L_a] + [L_a|L_b - L_b|L_b]$$

The first term $[L_b|L_b - L_a|L_a]$ is the *policy gap*. This is the loss that the policy-maker faces if the private sector believes policy is described by $L = L_b$ and monetary policy is conducted according to the expectations. It represents the cost associated with employing a policy that performs worse than L_a. But the cost of imperfect credibility does not only correspond to the policy-maker being forced to use the worse policy L_b conditional on an expected policy L_b. Holding fixed the believes L_b assume the policy-maker could adopt any other policy. The extra loss generated by implementing policy L_a rather than policy L_b is the *implementation gap* and is equal to $[L_a|L_b - L_b|L_b]$. The monetary authority faces this cost only because is trying to implement a policy different from the expected one - it has to 'fight' wrong expectations by the private sector. As L_a changes, the mapping between the state variables and the private sector expectations is constant, and all that changes is the policy actually implemented. In other words, the credibility gap does not simply originates in the private sector holding expectations of a worse policy, but also in

the policy-maker acting to achieve a desired equilibrium movement in the target variables despite the private sector believes. Under imperfect credibility, the policy-maker should choose policies that perform well conditional on the true private sector expectations, rather than conditional on model-consistent expectations. For given expectations, the policy ranking faced by the monetary authority may differ.

The inflation targeting policy L_a performs well under full credibility, but carries a very high implementation cost for low levels of credibility, making an exchange rate peg a more attractive option. From figure 1 it is clear that the implementation gap narrows rapidly as credibility improves, and with a producer price inflation objective function goes to zero already for $L_b = [\omega_\pi = 1, \omega_e = 0.6]$. Including π_H in the loss function (17) rather than CPI inflation implies that the implementation gap diminishes considerably, dropping by about 50% for $L_b = L_b^{low}$. Intuitively, imperfect credibility raises the volatility of the nominal exchange rate, so that compared to the full credibility case the excess volatility of π is larger than that of π_H.

The intuition for the cost of a credibility gap can be illustrated by looking at the impulse response function to an annualized 1% expansionary policy shock to i_t (Figure 3). Consider the policies $L_a = [\omega_\pi = 2,\ \omega_e = 0.1]$ and $L_b = [\omega_\pi = 0.4,\ \omega_e = 0.9]$. Under full credibility, the policy L_b will generate a larger increase in inflation and output, a standard result in a New Keynesian model. Firms increase the price by a larger amount if this will trigger a smaller future interest rate hike by the monetary authority. Since under L_b the central bank responds to the nominal exchange rate depreciation by tightening monetary policy, the decrease in i_t below the steady state value following the initial expansionary shock is smaller than under policy L_a. With imperfect credibility, policy L_a implies the central bank response to the exchange rate depreciation is much more muted. Therefore, given the state of the economy i_t is lower than it would be conditional on L_b. Effectively, in the believes of the private sector this translates into a larger initial expansionary shock. Given $\tilde{E}_t^b \pi_{H,t+1}$ and $\tilde{E}_t^b i_{t+1}$ domestic inflation will be higher than it would be under a fully credible policy L_b. Domestic inflation depends on $\tilde{E}_t^b mc_{t+k}$ for $k = 1, 2...$ and these expectations are built conditional on the monetary policy shock being more expansionary than it really is, leading to a larger increase in domestic prices.

Conditional on L_a the domestic inflation increase nearly doubles under imperfect credibility. Since an increase in π_H requires a drop in the average markup, the larger drop also leads to a large increase in output and consumption. Because this increase is all due to the nominal rigidity, it fully translates into an (inefficient) consumption gap. This mechanism, present in varying degrees depending on the shock considered, leads to the larger volatility in consumption gap and inflation and to the loss observed in Figure 1.

The credibility gap does not necessarily work against the central bank objectives. Table 5 shows that there are instances in which if $L_b \neq L_a$ the objective function loss improves. If the central bank could convince the private sector that it will follow the policy L_b whereas the true policy is L_a - implying a higher degree of exchange rate management - the loss would improve by 35%. Unfortunately this policy is not time-consistent and is not a rational expectations equilibrium: it implies the central

bank can cheat on the private sector in perpetuity. The table illustrates a very well known result in the optimal policy literature: if the central bank could follow a time-inconsistent policy, it could achieve a higher welfare. In the present case, it is advantageous to smooth exchange rate fluctuations without letting the private sector know the true central bank aversion to a volatile exchange rate.

5.1.1 Interest Rate Smoothing

The policy rule (19) assumes interest rate smoothing in the behaviour of the monetary authority, but in figure 1 the cost of interest rate fluctuations did not enter the objective function. Accounting explicitly for the cost of interest rate volatility does not alter substantially the results. Figure 2b compares the credibility gap for $\lambda_i = 0$ and $\lambda_i = 1$. The loss from inflation targeting is lower than in a fixed exchange rate regime for values of ω_π larger than 0.4. The credibility gap increases, but the initial stock of credibility necessary to implement inflation targeting does not increase proportionally, since the performance of a fixed exchange rate regime worsens when $\lambda_i = 1$. Since any movement in the foreign interest rate has to be mirrored by the domestic interest rate, the loss will necessarily be larger as λ_i increases.

5.1.2 Steady State Inflation

Most developing countries experience average inflation rates larger than industrialized economies. The steady state inflation level has a considerable impact on the loss from a credibility gap. Figure 4a compares the loss under a steady state with full price stability against the standard case considered so far of a positive annualized 6% steady state inflation rate. While many emerging markets experience far higher inflation rates, the Calvo pricing framework we adopt is inadequate to model high-inflation economies (see Ascari, 2004). Nevertheless this comparison gives interesting indications as to the impact of steady state inflation on the adoption of inflation targeting under imperfect credibility.

A zero steady state inflation reduces the loss relative to the full credibility case for every policy belief L_b, and proportionally more for very low levels of credibility. At the same time the loss associated with a pegged exchange rates barely moves. The net result is that the initial stock of credibility necessary to implement inflation targeting is reduced. In the case of the loss function defined in terms of PPI inflation, given *any* belief L_b inflation targeting yields a lower loss than a credible exchange rate peg. This result does not hold for a loss function defined in terms of CPI inflation: the volatility of the exchange rate remains very high for low levels of credibility, so the drop in consumption gap volatility gives a smaller percentage contribution to the total loss decrease.

When steady state inflation is positive, π_H is not only a function of future expected real marginal costs - it depends also negatively on output. Whenever a shock generates a positive correlation between output and domestic inflation, π_H increases comparatively less, so that the systematic portion of monetary policy implies a smaller interest rate reaction, leading to larger output movements in equilibrium. Under im-

perfect credibility, this transmission channel is amplified, and implies large swings in the consumption gap.

5.2 The Degree of Openness and Exposure to Financial Volatility

Two widely studied vulnerabilities of small open developing economies are the exposure to foreign shocks and to financial instability. We examine how these issues bear on the relative attractiveness of inflation targeting under imperfect credibility.

We assume that the domestic basket bias in the consumption aggregate, which is equal to steady state share of imports over domestic output, drops from $\gamma = 0.4$ to $\gamma = 0.2$. Table 6 shows the implications for the objective function under a number of believed policies L_b. The ratio of the inflation targeting loss conditional on believes L_b and of the exchange rate peg drops faster below 100% when $\gamma = 0.2$. For a more closed economy inflation targeting becomes an attractive option for lower levels of credibility. But this result does not depend on a smaller loss from the credibility gap. In fact the implementation gap $[L_a|L_b - L_b|L_b]$ expressed as a multiple of the full credibility policy $L_b|L_b$ increases for a more closed economy. The incentive to adopt inflation targeting comes from the very poor performance of the fixed exchange rate regime. Stabilizing the exchange rate in a more closed economy leads to movement in the policy rate that increase the volatility of the consumption gap.

Table 7 asks what is the relative importance of financial shocks. We set all exogenous variables to their steady state values, except for ε_i and ι_t^*. All the volatility in the economy is caused by relative money supply adjustment. Movements in ε_i and ι_t^* can also be interpreted as changes in risk and country premia for borrowing on the international financial market. Obviously the absolute level of volatility is reduced, since we have eliminated part of the exogenous variability in the model. This though does not imply that the credibility gap will decrease. In fact, the loss under an imperfectly credible inflation target relative to an exchange rate peg increases, and so does the implementation gap. For the lowest level of credibility, the loss under inflation targeting increases from 232% to over 300% of the loss under an exchange rate peg. In countries where the volatility of shocks on the financial markets is relatively important for the business cycle, the attractiveness of inflation targeting under imperfect credibility diminishes.

5.3 Targeting Horizons

The distance between the policy coefficients defining the instrument rules L_a and L_b does not offer a clear measure of the credibility gap. A possible credibility metric is the distance between the targeting horizon implied by L_a and the one implied by the private sector believes about the policy rule.

To formalize this concept, we need to specify what is a 'targeting horizon' when the central bank uses an inflation targeting instrument rule. We define the *targeting horizon* as the number of quarters it takes for domestic inflation to drop below 0.1% after an initial unexpected expansionary monetary shock of 1% (annualized rates). While taking as numerical target for domestic inflation a figure of one tenth

of the initial policy shock may seem arbitrary, any other target would give similar (relative) results. In a linear model, impulse responses to a shock of any size scale proportionally.

Figure 4b displays the targeting horizon corresponding to the range of rules considered in L_b. Policy rule L_a implies a targeting horizon between 3 and 4 quarters, while the rule L_b with the lowest feedback coefficient to inflation gives a targeting horizon of about 2.3 years. This means that in the case considered in Figure 1, the inflation targeting loss drops below the loss associated with a strict exchange rate target as soon as the private sector believes the targeting horizon to be approximately smaller than 6.5 quarters (5.5 in the case of the CPI loss function). In other words, if the private sector believes the targeting horizon to be more than 85% longer than announced (60% in the case of the CPI loss function), the central bank will find that a credible hard peg - such as joining a currency area and giving up monetary sovereignty - is a more desirable policy.

6 Conclusions

New EU member states plan to join the EMU and give up monetary policy independence by the end of the decade, despite large structural differences still existing against current EMU members' economies. Most of these countries, and all the largest ones, have become working market economies only since the second half of the 1990s, have undergone or are still undergoing much structural change, expect to reap very large productivity gains and to converge to EU standards of living in the next decade.

This paper shows that the credibility gain obtained by joining the EMU and thus credibly adopting a fixed exchange rates against other EMU members can be larger than the loss from the narrowing of the monetary policy choice set.

Solving a small open economy model with staggered price adjustment under the assumption of imperfect credibility we obtain two results. First, a country needs an initial stock of credibility for inflation targeting to lower the policy-maker loss relative to an exchange rate peg. The result rests on the assumption that a fixed exchange rate enjoys full credibility, as would be the case for new EU member states joining the Euro currency area, while an inflation targeting regime may be perceived as being less aggressive towards inflation than it actually is. We show that the initial stock of credibility is lower if the monetary authority loss function is defined in terms of producer rather than consumer price inflation, and for lower levels of steady state inflation. The cost from the credibility gap can be substantial, and originates partly from the private sector expectations behaving according to a different policy (the policy gap), and partly from the cost of implementing a policy despite the mistaken private sector expectations (the implementation gap).

Second, the loss from the credibility gap becomes larger for more open economies and when financial shocks account for a larger share of the volatility driving the business cycle. These results imply that, under imperfect credibility, vulnerability to financial and foreign volatility impacts a small open economy business cycle through an additional channel, and increases the gain from joining the EMU.

Finally, we report new empirical evidence on the relationship between monetary policy and central bank's credibility consistent with the theory's prediction. Exchange rate targeting is more popular with medium and low-credibility countries. Inflation targeting has been adopted in disproportionate numbers by countries enjoying a medium level of credibility, while it is relatively less popular among countries with a very high or very low level of credibility.

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7 Appendix

7.1 Data

The data used to build the credibility index measure is taken from a survey of 81 national monetary institutions collected by the Bank of England. The survey data is described in Mahadeva, L. and Sterne, G., (2000), 'Monetary Frameworks in a Global Context', Bank of England. Original data can be downloaded at the Bank of England website.

The credibility measure is a weighted average of the answers given to the five questions contained in Table A.5 of the survey:

Table A.5: Independence Scores	**Wt**
Independence score (weighted total)	**6.5**
1. Statutory/legal objectives focus on price stability?	1
2. Target Independence	1
3. Instrument independence	2
4. Central Bank financing of government deficit	2
5. Term of Office of Governor	0.5

The answers are given on a scale ranging from zero to one. For reasons described in the main text, the answer to the first question is omitted in building the average independence score used as a measure of credibility. An answer equal to 1 in questions 2 to 5 will therefore result in an independence score of 1.

The correlation indices in table 2 for the scores "Credibility, policy regime described as inflation targeting" and "Credibility, policy regime described as exchange rate targeting" are computed using the numerical value reported in the survey in the answers to question 1 in Table A.2 and A.4:

Table A.2 Exchange rate focus	**Wt**
Weighted Total	**4**
1. Regime Described as Exchange rate targeting?	1
3. Degree to which the exchange rate is fixed ?	1
2. Rank of objectives?	1
4. Degree to which exchange rate prevails in policy conflicts?	1

Table A.4 Inflation focus	
Weighted Total	**4**
1. Regime Described as inflation targeting?	1
3. Specific target/monitoring range published now?	1
2. Rank of objectives?	1
4. Inflation prevails in policy conflicts?	1

De facto classification for monetary policy regimes is obtained from Reinhart, Carmen M. and Kenneth S. Rogoff (2002), 'The Modern History of Exchange Rate Arrangements: A Reinterpretation', NBER Working Paper w8963. A country is classified as an exchange rate targeter if its policy regime falls among one of the following de facto regimes: moving band that is narrower or equal to +/- 2%; de facto crawling band that is narrower or equal to +/- 5%; pre-announced crawling band that is wider or equal to +/- 2%; de facto crawling band that is narrower or equal to +/- 2%; de facto crawling peg; pre-announced crawling band that is narrower or equal to +/- 2%; pre-announced crawling peg; de facto peg; pre-announced horizontal band that is narrower or equal to +/- 2%; pre-announced peg or currency board arrangement; no separate legal tender. These regimes correspond to category 1 to 11 of the 14 categories used in the classification. A country is not classified as an exchange rate targeter if its policy regime falls among one of the following de facto regimes: freely falling, freely floating, managed floating.

In building tables 1 to 4, a country is considered a 'de facto inflation targeter' if it describes its regime as inflation targeting in Table A.4 of the Bank of England survey and at the same

time is not classified as a de facto exchange rate targeter. Some countries describe themselves as 'partial inflation targeters'. Of these group, only Slovakia is not a de facto exchange rate targeter, and officially describes itself as an implicit inflation targeter (Nell, 2004). Since it announces a yearly target for the inflation rate, it has been classified among inflation targeters. Ecuador and Kyrgyz are classified as 'freely falling' regimes in 1998, with inflation rates above 40%. They are not counted among inflation targeters even if their monetary policy did not have an exchange rate anchor in 1998. Singapore moved to Managed Floating at the very end of 1998, and it is counted among the 'exchange rate targeting' countries.

The last year for which the de facto monetary policy regime classification is available in the Reinhart and Rogoff (2002) dataset is 2001. At that time, among the countries included in the survey Chile, Korea, Poland, South Africa and Poland had joined the de facto inflation targeters group. Among the countries for which the Bank of England survey results are unavailable, Brazil, Colombia and Philippines had joined the de facto inflation targeters group.

The data used for building tables 1 to 4 in the paper are available at the author's homepage http://ic.ucsc.edu/~fravenna/home.

7.2 Parametrization

The model parametrization follows closely the recent examples of New Keynesian models with complete pass through in Monacelli (2004) and Gali and Monacelli (2005). Devereux (2001, 2003), Devereux and Lane (2001) and Natalucci and Ravenna (2003), provide references to empirical studies from which some of the parameters used in the International Business Cycle literature are drawn.

In the households' preferences, the discount rate β is set to 0.99 and the elasticity of substitution between home and foreign consumption baskets ρ is set to 1. We assume a labour supply elasticity equal to $1/2$, implying the parameter η is equal to 2. Using a labour supply elasticity as large as 2 or as small as $1/3$ did not alter qualitatively the results. The probability of price adjustment $(1-\theta_p)$ in the firm maximization problem is assumed equal to 0.25, implying an average price duration of four quarters. The elasticity of substitution between goods ϑ is equal to 11. As a consequence, the flexible-price markup is equal to 10%. Gali and Monacelli (2005) choose a higher value, but since we assume a positive rate of money growth rate and no indexation to steady state inflation, the steady state mark-up in our model is larger than the flexible-price one. The home-goods bias γ is equal in steady state to the ratio between imports and domestic output. We take as a model small open economy Canada, and parametrize γ to the Canadian import/output ratio, approximately equal to 0.4. World demand for the home-produced good is assumed to be less price-elastic than domestic demand, and we choose a foreign price-elasticity of demand $\rho^* = 0.5$. The value γ^* does not affect the loglinearized solution, since in steady state we let the amount of exports to be endogenously determined so as to normalize the terms of trade to 1.

In the log-linearized model, the exogenous stochastic processes for the preference shifter, the technology shock, the world interest rate, the imports' price and the aggregate foreign

consumption demand follow an AR(1) specification:

$$\begin{aligned} d_t &= \rho_d d_{t-1} + \varepsilon_{d,t} \\ a_t &= \rho_a a_{t-1} + \varepsilon_{a,t} \\ i_t^* &= \rho_{i^*} i_{t-1}^* + \varepsilon_{i^*,t} \\ p_{F,t}^* &= \rho_p p_{F,t-1}^* + \varepsilon_{p,t} \\ c_t^* &= \rho_c c_{t-1}^* + \varepsilon_{c,t} \end{aligned}$$

The technology shock process is parametrized following Gali and Monacelli (2005), who estimate a first order autoregression for HP-filtered (log) labour productivity in Canada over the sample 1963:1 2002:4 and find $\rho_a = 0.66$ and $\sigma_a = 0.0071$. Over the same period, they estimate the parameters for the foreign consumption demand using HP filtered U.S. (log) GDP to be $\rho_d = 0.86$ and $\sigma_d = 0.0078$. Over the last decade, the share of total Canadian export demand going to the U.S averaged approximately 80%. To parametrize the process for the world interest rate we use data on the U.S. 3-month T-Bill quarterly yield, and estimate over the sample 1963:1 2002:4 $\rho_{i^*} = 0.95$ and $\sigma_{i^*} = 0.0021$. The stochastic process for the imported good price level is estimated using data for the Canadian Laspeyres fixed weight price index for imports from the U.S., 1992:1 to 2000:2. Estimation results in $\rho_p = 0.89$ and $\sigma_p = 0.015$. Following Monacelli (2004) the standard deviation of the preference shock σ_d is set to 0.011 and the autocorrelation parameter is set to $\rho_d = 0.9$. We assume the domestic policy innovation ε_i is an i.i.d. shock with $\sigma_i = 0.0015$.

The model is log-linearized around a zero-net foreign asset steady state. The steady state money growth rate, equal to the steady state inflation, is equal to 6% in the baseline parametrization.

7.3 Inflation Equation

We can write (12)

$$P_t(i) = \frac{G_t}{H_t},$$

where

$$G_t = \frac{(G_t/H_t)^{1-\theta}}{MUC_t}\hat{G}_t \tag{20}$$

$$H_t = \frac{(G_t/H_t)^{1-\theta}}{MUC_t}\hat{H}_t, \tag{21}$$

and

$$\hat{G}_t = \mu MUC_t MC_t^N P_{H,t}^{\theta-1} Y_{H,t} + E_t \theta_p \beta \hat{G}_{t+1} \tag{22}$$

$$\hat{H}_t = MUC_t P_{H,t}^{\theta-1} Y_{H,t} + E_t \theta_p \beta \hat{H}_{t+1}. \tag{23}$$

Let $\mu = \frac{\theta}{\theta-1}$ be the flexible-price equilibrium markup. Divide $\hat{G}_t$ by $P_{H,t}^{\theta}$ and $\hat{H}_t$ by

$P_{H,t}^{\theta-1}$:

$$\tilde{G}_t \equiv \frac{\hat{G}_t}{P_{H,t}^{\theta}} = \mu MUC_t \frac{MC_t^N}{P_t} Y_{H,t} + E_t \theta_p \beta \frac{\hat{G}_{t+1}}{P_{H,t+1}^{\theta}} \frac{P_{H,t+1}^{\theta}}{P_{H,t}^{\theta}} = \mu MUC_t MC_t Y_{H,t} + E_t \theta_p \beta \tilde{G}_{t+1} (1+\pi_{H,t+1})^{\theta} \tag{24}$$

$$\tilde{H}_t \equiv \frac{\hat{H}_t}{P_{H,t}^{\theta-1}} = MUC_t Y_{H,t} + E_t \theta_p \beta \frac{\hat{H}_{t+1}}{P_{H,t+1}^{\theta-1}} \frac{P_{H,t+1}^{\theta-1}}{P_{H,t}^{\theta-1}} = MUC_t Y_t + E_t \theta_p \beta \tilde{H}_{t+1}^{\theta-1} (1+\pi_{H,t+1})^{\theta-1} \tag{25}$$

Using:

$$P_{H,t}(i) = \frac{G_t}{H_t} = \frac{\hat{G}_t}{\hat{H}_t} = \frac{\hat{G}_t / P_{H,t}^{\theta}}{\hat{H}_t / P_{H,t}^{\theta}} = \frac{\tilde{G}_t P_{H,t}}{\tilde{H}_t}.$$

the law of motion for the aggregate price index is:

$$\begin{aligned} P_{H,t}^{1-\theta} &= \theta_p P_{H,t-1}^{1-\theta} + (1-\theta_p) P_{H,t}(i)^{1-\theta} = \theta_p P_{H,t-1}^{1-\theta} + (1-\theta_p) \left[\frac{\hat{G}_t}{\hat{H}_t} \right]^{1-\theta} \\ [(1+\pi_{H,t})]^{1-\theta} &= \theta_p + (1-\theta_p) \left[\frac{P_{H,t}(i)}{P_{H,t-1}} \right]^{1-\theta} = \theta_p + (1-\theta_p) \left[\frac{\tilde{G}_t}{\tilde{H}_t} (1+\pi_{H,t}) \right]^{1-\theta} \end{aligned}$$

7.3.1 Loglinearization of Pricing Equation: non-zero steady state money growth rate and inflation

In the non-zero-inflation steady state G and H are given by:

$$\begin{aligned} G &= \frac{1}{(1-\theta_p \beta \Pi_H^{\theta})} MUC * Y_H * \mu * MC \\ H &= \frac{1}{(1-\theta_p \beta \Pi_H^{\theta-1})} MUC * Y_H \end{aligned}$$

where Π_H is the steady state inflation rate, also equal to the steady state money growth rate. Note that if we assume the foreign price index P_F^* grows at the same steady state rate, it is also true that $\Pi = \Pi_H$ and the nominal exchange rate is constant. Then:

$$\frac{G}{H} = \mu * MC * \frac{(1-\theta_p \beta \Pi^{\theta-1})}{(1-\theta_p \beta \Pi^{\theta})}$$

The steady state price index gives

$$(\Pi)^{1-\theta} = \theta_p + (1-\theta_p) \left(\frac{G}{H} \Pi \right)^{1-\theta}$$

Solving the system of two equations in the two variables MC and G/H gives:

$$\begin{aligned} \frac{G}{H} &= \left[\frac{(1-\theta_p)}{(1-\theta_p \Pi^{\theta-1})} \right]^{\frac{1}{\theta-1}} \\ MC &= \frac{1}{\mu} \left[\frac{\Pi^{1-\theta} - \theta_p}{1-\theta_p} \right]^{\frac{1}{1-\theta}} \frac{1}{\Pi} \frac{(1-\theta_p \beta \Pi^{\theta})}{(1-\theta_p \beta \Pi^{\theta-1})} \end{aligned}$$

Loglinearizing around the non-stochastic steady state with unitary terms of trade level and zero net foreign asset:

$$\begin{aligned} g_t &= (1-\theta_p\beta\Pi^{\theta})(muc_t + mc_t + y_{H,t}) + \Pi^{\theta}\theta_p\beta E_t(g_{t+1} + \theta\pi_{H,t+1}) \\ h_t &= (1-\theta_p\beta\Pi^{\theta-1})(muc_t + y_{H,t}) + \Pi^{\theta-1}\theta_p\beta E_t[h_{t+1} + (\theta-1)\pi_{h,t+1}] \\ \pi_{H,t} &= \frac{(1-\theta_p)}{\theta_p}\left[\frac{G}{H}\Pi\right]^{1-\theta}(g_t - h_t) \\ &= \frac{(1-\theta_p\Pi^{\theta-1})}{\theta_p\Pi^{\theta-1}}(g_t - h_t) \end{aligned}$$

Then substituting $(g_t - h_t)$ in the inflation definition, obtain:

$$\begin{aligned} \pi_{H,t} &= (1-\theta_p\Pi^{\theta-1})(1-\theta_p\beta\Pi^{\theta})\frac{1}{\theta_p\Pi^{\theta-1}}[mc_t] \\ &\quad +(1-\theta_p\Pi^{\theta-1})(1-\Pi)\frac{1}{\theta_p\beta\Pi^{\theta-1}}(muc_t + y_{H,t}) \\ &\quad +\Pi\beta E_t\pi_{H,t+1} + (1-\theta_p\Pi^{\theta-1})(1-\Pi)\frac{1}{\theta_p\Pi^{\theta-1}}\beta E_t h_{t+1} \end{aligned} \tag{26}$$

where lower-case letters indicate log-deviations of a variable from the steady state. See Ascari (2004) for a derivation of the equation in a closed economy.

Inflation Targeters in 1998			
Monetary Policy	De Facto Inflation Targeting	Inflation Targeting but de facto Exchange Rate Targeting	Inflation Targeting, inflation above 40%
	Albania Australia Canada Czech Republic Mexico New Zealand Slovakia* Sweden UK	Armenia Botswana Chile Croatia* Finland* France* Israel Jamaica Mongolia Poland Spain* Uganda* Ukraine*	Ecuador* Kyrgyz*
Update: 2001 Inflation Targeters	Chile Korea Poland South Africa Thailand		
2001 Inflation Targeters Not Included in Survey	Brazil Colombia Philippines		

Table 1: Inflation targeting countries in 1998. Data from the 1998 Bank of England Survey and the de-facto exchange rate regime classification in Rheinart and Rogoff (2002). Countries are not considered exchange rate targeters unless their de-facto exchange rate regime is classified as freely floating or managed floating. Freely falling countries are countries with average inflation rate higher then 40%. An asterisk indicates that the central bank describes its regime as a *partial* inflation targeting regime.

Credibility and Monetary Policy Choices in 1998: Correlations across 81 countries

Credibility, policy regime described as Inflation Targeting	0.05
Credibility, policy regime described as Exchange Rate Targeting	0.12
Credibility, Inflation Focus	-0.02
Credibility, de facto Exchange Rate Targeting	**-0.14**
Credibility, de facto Inflation Targeting	**0.16**

Table 2: Correlation coefficient between declared or de-facto policy regime, and credibility measure constructed from central bank independence scores reported in the Bank of England 1998 survey.

Credibility and Monetary Policy Choices in 1998

Credibility Index Sample Size	High Credibility 18	Medium Credibility 36	Low Credibility 27
Inflation Targeting	Canada Czech Republic Sweden	Australia Mexico New Zealand Slovakia UK	Albania
Non inflation Targeting Floating Exchange Rate	Ecuador Germany Japan Kyrgyz Switzerland Thailand USA	Georgia Malta Moldova Romania Russia South Africa	Ghana Indonesia Kenya Korea Nigeria Norway Zambia
Exchange Rate targeting	Chile Denmark Finland Ireland Italy Latvia Netherlands Singapore	Argentina Armenia Belgium Bosnia Herz. Bulgaria China Croatia Cyprus Estonia France Greece Hong Kong Hungary India Jordan Kazakhstan Lithuania Macedonia Malaysia Peru Poland Portugal Slovenia Spain Uganda	Austria Botswana East. Caribbean Egypt Guyana Iceland Israel Jamaica Kuwait Lebanon Mauritius Mongolia Sri Lanka Tanzania Turkey Turkmenistan Ukraine Uruguay West African states

Table 3: De facto policy regimes in countries ranked according to the credibility index. High Credibility countries have a credibility index $x > 0.9$. Low credibility countries have credibility index $x < 0.7$. Medium credibility countries score $x \in (0.9, 0.7)$.

De Facto Monetary Regimes in 1998: Who Chose Inflation Targeting?

Credibility Index	High Credibility	Medium Credibility	Low Credibility
Sample Size	18	36	27
Inflation Targeting	16.70%	13.90%	3.70%
Exchange Rate Targeting	44.40%	69.40%	70.40%
Percentage of Floating Exchange Rate Countries which Adopted Inflation Targeting	**30.00%**	**45.45%**	**12.50%**
Percentage of countries with statutory focus on price stability	80.60%	49.30%	69.40%

Table 4: De-facto monetary policy regimes as a percentage of the sample size across subsamples of countries enjoying different levels of monetary policy credibility.

The Gain from Inconsistent Believes

	Loss
$L_b = [\omega_\pi = 2, \omega_e = 0.1]$, $L_a = [\omega_\pi = 2, \omega_e = 0.5]$	0.25
$L_a = L_b = [\omega_\pi = 2, \omega_e = 0.1]$	0.39

Table 5: Loss for believed policy equal to L_b and true policy equal to L_a.

Loss Under Imperfect Credibility - The Degree of Openness

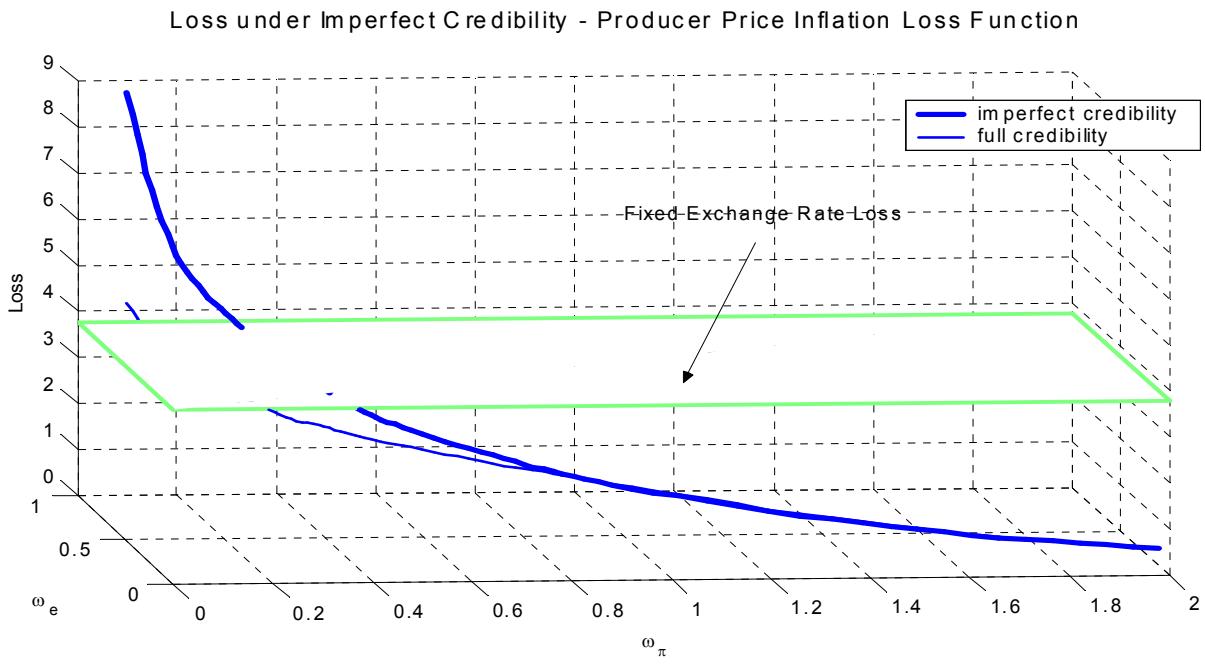
Degree of Openness	Gamma = 0.4			Gamma = 0.2		
Believed Policy L_b	Loss	Loss relative to Fixed Exchange Rate	Implementation Gap	Loss	Loss relative to Fixed Exchange Rate	Implementation Gap
Fixed Exchange Rate	3.76			7.66		
$Omega_P$= 0.1 $Omega_e$ = 1	8.74	**232.45%**	**208.66%**	15.57	**203.28%**	**305.40%**
$Omega_P$= 0.2 $Omega_e$ = 1	5.19	**138.03%**	**185.09%**	9.40	**122.69%**	**255.61%**
$Omega_P$= 0.3 $Omega_e$ = 0.95	3.92	**104.26%**	**166.63%**	7.04	**91.90%**	**213.19%**
$Omega_P$= 0.4 $Omega_e$ = 0.9	3.14	**83.51%**	**168.55%**	5.15	**67.27%**	**176.93%**
$Omega_P$= 0.5 $Omega_e$ = 0.85	2.33	**61.97%**	**142.32%**	4.23	**55.23%**	**161.04%**
$Omega_P$= 0.6 $Omega_e$ = 0.8	1.86	**49.47%**	**129.69%**	3.10	**40.47%**	**133.35%**
$Omega_P$= 0.8 $Omega_e$ = 0.7	1.3	**34.57%**	**112.63%**	2.15	**28.08%**	**114.24%**

Table 6: Loss for selected values of believed policy L_b. Annual steady state inflation is 6%. Loss weights: $\lambda_{\pi_H} = 1$, $\lambda_c = 1$, $\lambda_i = 0$. Relative loss computed as ratio of loss for policy $L_a|L_b$ (where L_a is true policy) and fixed exchange rate. Implementation gap is ratio $[L_a|L_b - L_b|L_b]/L_b|L_b$.

Loss Under Imperfect Credibility - Exposure to Financial Shocks

	All Shocks			Only Policy Shocks		
Believed Policy L_b	Loss	Loss relative to Fixed Exchange Rate	Implementation Gap	Loss	Loss relative to Fixed Exchange Rate	Implementation Gap
Fixed Exchange Rate	3.76			2.79		
$Omega_P$= 0.1 $Omega_e$ = 1	8.74	**232.45%**	**208.66%**	8.54	**305.90%**	**250.93%**
$Omega_P$= 0.2 $Omega_e$ = 1	5.19	**138.03%**	**185.09%**	4.99	**178.82%**	**250.37%**
$Omega_P$= 0.3 $Omega_e$ = 0.95	3.92	**104.26%**	**166.63%**	3.67	**131.48%**	**237.89%**
$Omega_P$= 0.4 $Omega_e$ = 0.9	3.14	**83.51%**	**168.55%**	2.73	**97.89%**	**228.14%**
$Omega_P$= 0.5 $Omega_e$ = 0.85	2.33	**61.97%**	**142.32%**	1.94	**69.64%**	**184.05%**

Table 7: Loss for selected values of believed policy L_b. Annual steady state inflation is 6%. Loss weights: $\lambda_{\pi_H} = 1$, $\lambda_c = 1$, $\lambda_i = 0$. Relative loss computed as ratio of loss for policy $L_a|L_b$ (where L_a is true policy) and fixed exchange rate. Implementation gap is ratio $[L_a|L_b - L_b|L_b]/L_b|L_b$.



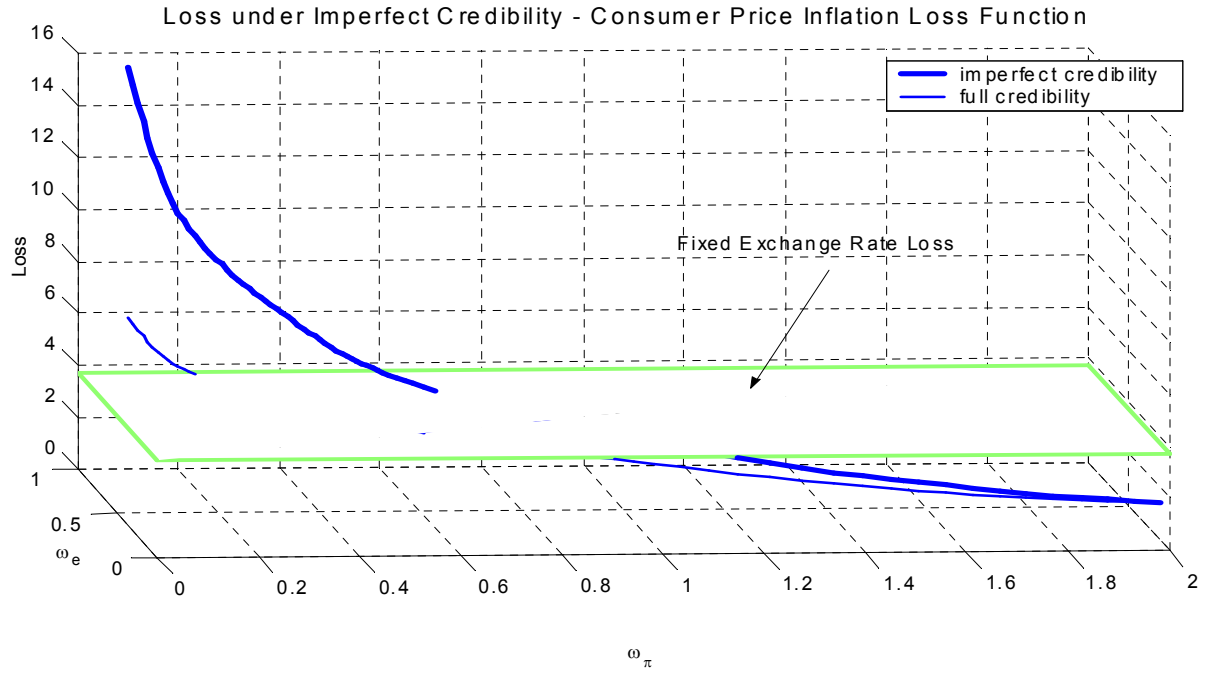
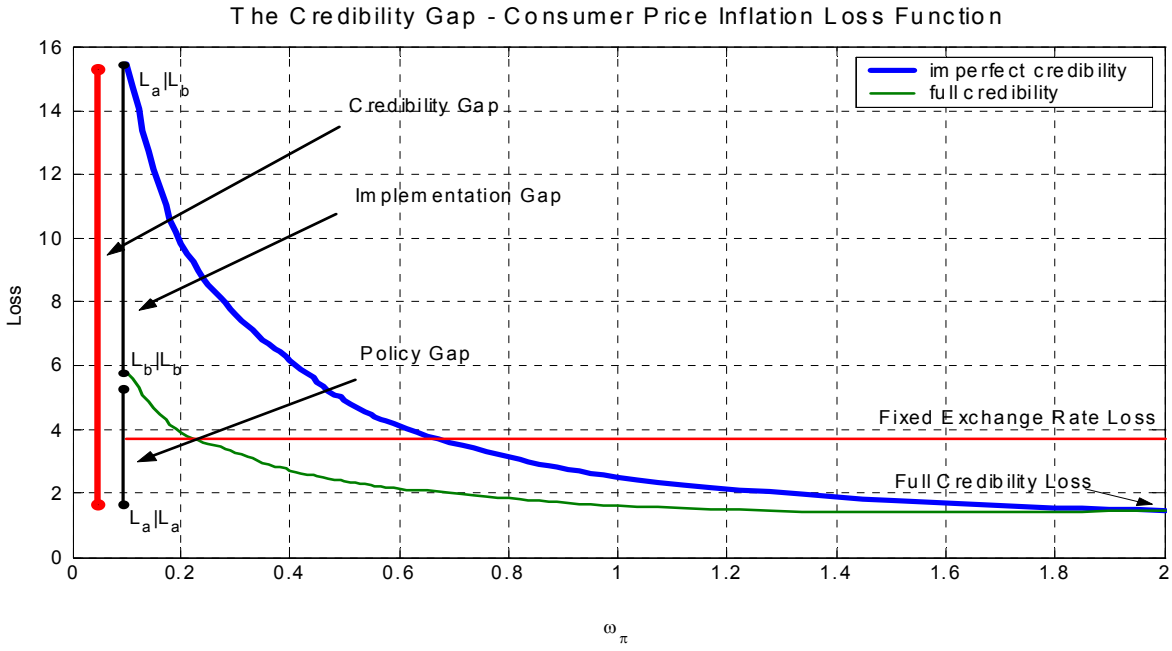


Figure 1: Loss for believed policy L_b varying linearly in the range $L_b^{low} = [\omega_\pi = 0.1, \omega_e = 1]$ to L_b^{high} equal to true policy $L_a = [\omega_\pi = 2, \omega_e = 0.1]$, and $\chi = 0.8$. Annual steady state inflation is 6%. Panel A: Loss weights: $\lambda_{\pi_H} = 1$, $\lambda_c = 1$, $\lambda_i = 0$. Panel B: Loss weights: $\lambda_{\pi_{CPI}} = 1$, $\lambda_c = 1$, $\lambda_i = 0$.



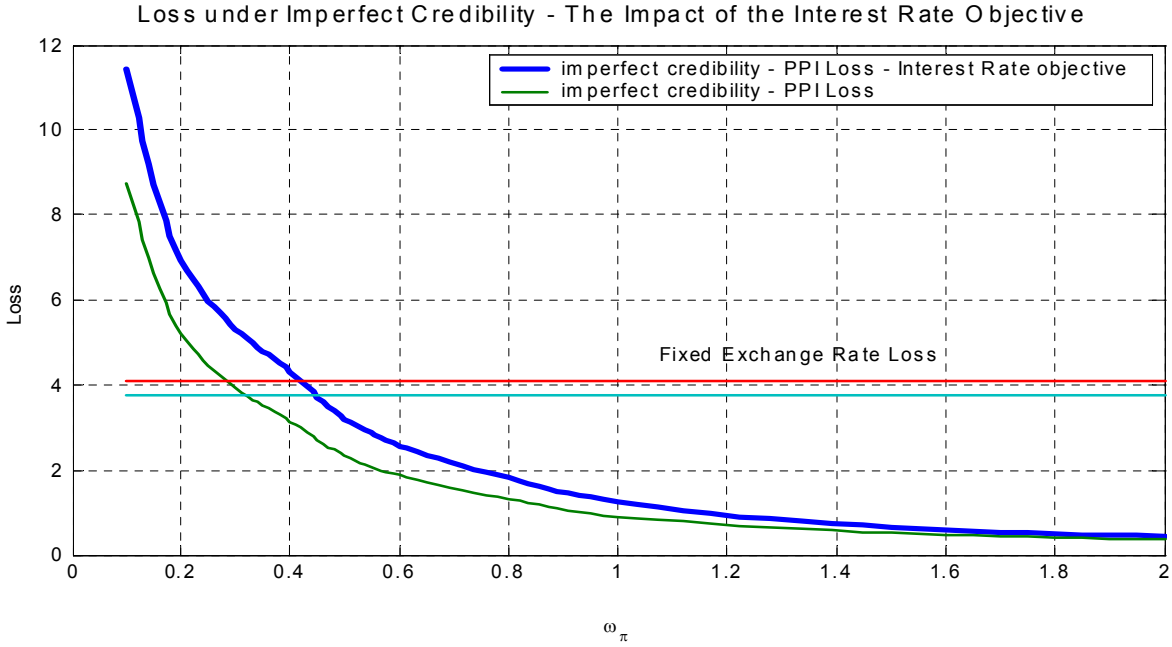


Figure 2: Loss for believed policy L_b varying linearly in the range $L_b^{low} = [\omega_\pi = 0.1, \omega_e = 1]$ to L_b^{high} equal to true policy $L_a = [\omega_\pi = 2, \omega_e = 0.1]$, and $\chi = 0.8$. Annual steady state inflation is 6%. Panel A: Loss weights: $\lambda_{\pi_{CPI}} = 1$, $\lambda_c = 1$, $\lambda_i = 0$. Panel B: compares loss for $\lambda_{\pi_H} = 1$, $\lambda_c = 1$, $\lambda_i = 0$ with loss for $\lambda_{\pi_H} = 1$, $\lambda_c = 1$, $\lambda_i = 1$. Straight lines show fixed exchange rate loss. Variation in ω_e not shown.

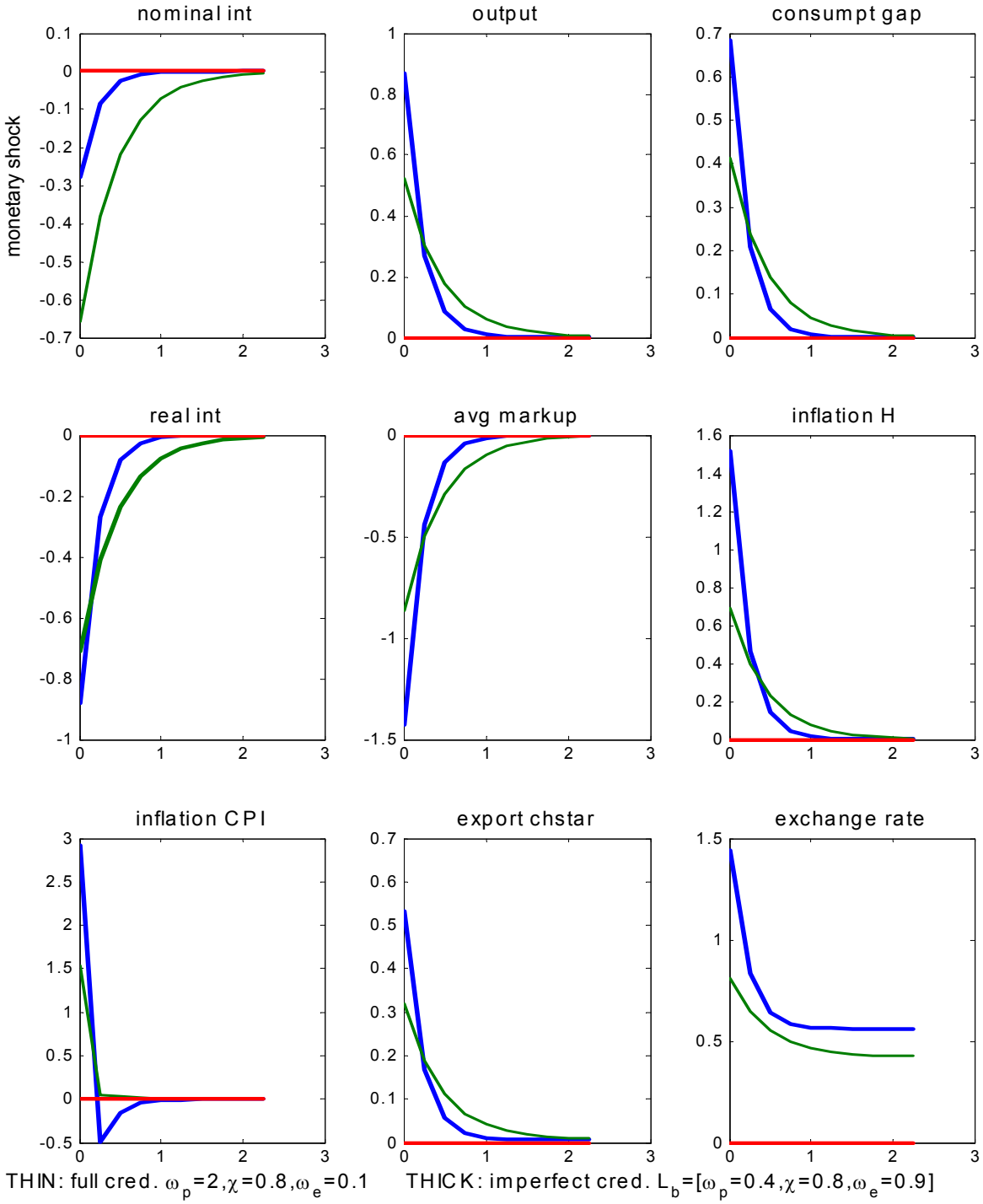


Figure 3: Impulse response function to an unanticipated annualized 1% drop in the nominal interest rate i_t. True policy $L_a = [\omega_\pi = 2,\ \omega_e = 0.1]$. Under imperfect credibility, private sector expects policy $L_b = [\omega_\pi = 0.4,\ \omega_e = 0.9]$. Time is measured in years. Deviations are in percentage terms.

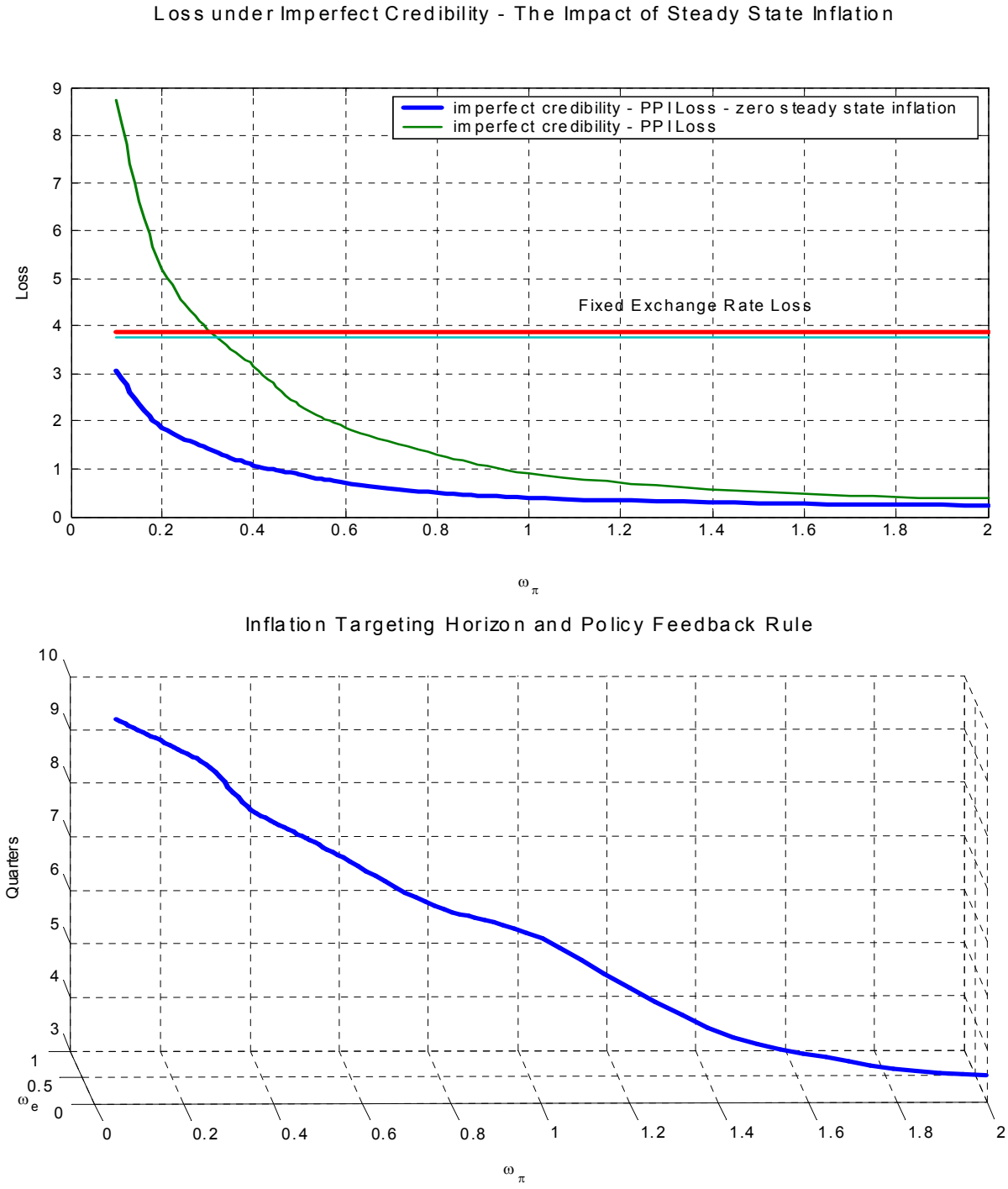


Figure 4: Panel A: Loss for believed policy L_b varying linearly in the range $L_b^{low} = [\omega_\pi = 0.1, \omega_e = 1]$ to L_b^{high} equal to true policy $L_a = [\omega_\pi = 2, \omega_e = 0.1]$, and $\chi = 0.8$. Annual steady state inflation is 0%. Loss weights: $\lambda_{\pi_H} = 1$, $\lambda_c = 1$, $\lambda_i = 0$. Straight lines show fixed exchange rate loss. Variation in ω_e not shown. Panel B:Inflation Targering Horizon for policy L varying linearly in the range $L^{low} = [\omega_\pi = 0.1, \omega_e = 1]$ to $L^{high} = [\omega_\pi = 2, \omega_e = 0.1]$ under full credibility. The targeting horizon is the number of quarters it takes for π_H to revert to 0.1% above the steady state after an unanticipated 1% expansionary policy shock.

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1) vergriffen (out of print)
2) In abgeänderter Form erschienen in Berichte und Studien Nr. 4/1990, S 74 ff
3) In abgeänderter Form erschienen in Berichte und Studien Nr. 4/1991, S 44 ff
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June 7, 2004	Markus Knell, Helmut Stix	88	Three Decades of Money Demand Studies. Some Differences and Remarkable Similarities
August 27, 2004	Martin Schneider, Martin Spitzer	89	Forecasting Austrian GDP using the generalized dynamic factor model
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Oktober 4, 2004	Gabriel Moser, Fabio Rumler, Johann Scharler	91	Forecasting Austrian Inflation
November 3, 2004	Michael D. Bordo, Josef Christl, Harold James, Christian Just	92	Exchange Rate Regimes Past, Present and Future
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Decembert 31, 2004	Harald Grech	94	What Do German Short-Term Interest Rates Tell Us About Future Inflation?
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May 12, 2005	Federico Ravenna	98	The European Monetary Union as a Commitment Device for New EU Member States