SCCIE WORKING PAPER #04-20
Santa Cruz Center for International Economics
http://sccie.ucsc.edu/

The Euro as a Commitment Device for New European Union Member States

Federico Ravenna*

University of California - Santa Cruz

February 2008

Abstract

We argue a fixed exchange rate can be an optimal choice even if a policymaker could commit to the first-best monetary policy whenever the private sector's believes reflect incomplete information about the policymaker's dependability. This model implies that new EU member states have an incentive to join the Euro area not for its impact on the behaviour of the policymaker, but on the believes of the private sector. Monetary policies are evaluated using a new Keynesian model of a small open economy solved under imperfect policy credibility. We quantify the maximum distance between announced policy and private sector's believes necessary for an independent monetary policy to perform better than a peg when the policymaker can commit to the first best policy. Exposure to foreign and financial shocks make joining the Euro area relatively more attractive for a given level of credibility.

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

Keywords: Monetary union, Credibilty, Small Open Economy, Exchange Rate Regimes, Monetary Policy, Nominal Rigidities

*Address for Correspondence: Department of Economics, University of California, Santa Cruz, CA 95064. Email: fravenna@ucsc.edu. Part of this work was prepared while the author was participating in the ECB Visiting Researcher program. Support from the ECB is gratefully acknowledged. The views expressed in this paper solely reflect those of the author and not necessarily those of the European Central Bank.

1 Introduction

Since May 2004 twelve new member states joined the European Union (EU). Even before gaining full membership, all of these countries announced their plans to adopt the Euro as official currency within four to eight years. As of 2008, within the group of new entrants three countries have joined the Euro currency area, and three more peg their currency to the Euro. Yet most of these countries, and all the largest ones, have become working market economies only since the second half of the 1990s. Since new EU member states are under many respects emerging market economies, there seems to be an important role for a monetary policy independent from industrialized Euro area countries, at least in the short to medium term. As an example, long-term structural changes have caused large real exchange rate appreciations in new EU member states (Ravenna and Natalucci, 2008).

What is the incentive for new EU member states to join the Euro currency area so soon? The case for a fixed exchange rate as an optimal monetary policy was made forcefully by Giavazzi and Pagano (1988), who suggest that a peg can correct the inflationary bias of a monetary policymaker lacking access to a commitment technology. The argument, widely accepted in the literature, rests on the assumption that fixing the exchange rate amounts to the indirect appointment of a precommitted foreign central banker.

This paper shows that a fixed exchange rate can be the optimal choice also for a policymaker with access to a commitment technology, whenever the private sector's believes reflect incomplete information about the policymaker's dependability. Our model implies that irrevocably fixing the exchange rate by joining the Euro area is an optimal choice not because it affects the behaviour of the policymaker, but because it affects the believes of the private sector.

We make our case by embedding in a microfounded DSGE model a mechanism initially suggested by Cukierman and Liviatan (1991). As in Backus and Driffill (1985) and Barro (1986), Cukierman and Liviatan (1991) assume there exists uncertainty about whether the policymaker can commit to the optimal policy ('strong' type policymaker), or whether the time-consistent policy is the only rational expectations equilibrium (the case of a 'weak' type policymaker). Under incomplete information the 'weak' type has an incentive to mimic the 'strong' type, making announced policy objectives only partially credible. If the 'strong' policymaker is allowed to react optimally to expectations, it will choose to deviate from the complete information first best policy, despite having access to the commitment technology.

In the context of a modern DSGE model for business cycle analysis, we show this argument

implies joining the Euro area can be an optimal policy *even if* the policymaker would be able to commit to the first best policy. Since our objective is to discuss the incentives of the policymaker to adopt one particular policy - a fixed exchange rate - we employ some simplifying assumptions. First, we restrict the range of available policies to a family of simple policy rules, which includes a peg. Second, we do not model the private sector's expectations as the endogenous outcome of uncertainty about the policymaker type. Instead, we parameterize the expectations of the private sector, taking them as a primitive of the model. We derive the equilibrium law of motion under the assumption the private sector's expectations are different from the policy announced by the monetary authority. The larger the distance between policy announcements and private sector's believes, the least the credibility enjoyed by the policy.

Our result rests on the following intuition. Let the 'k' type policy be the private sector's expected policy consistent with the believes on policymaker types. Relative to the complete information case, the cost from implementing under incomplete information the first best policy chosen by the 'strong' type can be split into two parts. A first portion of the total cost can be interpreted as the cost of implementing the 'k' type policy conditional on the private sector's expectation that the policymaker is of the 'k' type, relative to the first best policy outcome (the 'policy gap'). The remaining portion of the total cost measures the cost of implementing the first best policy conditional on the expectation that the policymaker is of the 'k' type, relative to the complete information 'k' type policy outcome (the 'implementation gap'). If the loss measured by the policy gap is larger than the loss under a fixed exchange rate, the policy gap can explain the gain from adopting a fixed exchange rate with a shift from the domestic 'k' to the foreign 'strong' policymaker type, as in Giavazzi and Pagano (1988). Still, for a vast range of alternative policymaker types the fixed exchange rate is a dominated equilibrium. The existence of an additional implementation gap under incomplete information can explain the gain from adopting a fixed exchange rate with a shift in private sector's expectations - or, a shift in private sector's believed probability distribution over the policymaker type. Even if the loss measured by the policy gap is smaller than the loss under a fixed exchange rate, the implementation gap can still make a fixed exchange rate the dominant strategy.

Incomplete information about the policymaker type implies that even a 'strong' policymaker will choose to fix the exchange rate if credibility enjoyed by the policy announcement is not high enough. We quantify the level of policy credibility necessary for a fixed exchange rate to be a dominated policy when the policymaker can commit to the first best policy. Countries more exposed to foreign and financial shocks volatility need to enjoy a comparatively higher level of credibility for monetary independence

to improve over a fixed exchange rate.

The paper is organized as follows. Section 2 discusses related literature. Section 3 describes the model. Section 4 presents the results under complete and incomplete information, and the intuition for the existence of a policy gap and an implementation gap in a new Keynesian model with nominal price rigidities. Section 5 concludes. The Appendix contains a detailed description of the model and the parameterization.

2 Related Literature

This paper is related to two areas of research: a body of theoretical research on optimal monetary policy under incomplete information conducted using small-scale monetary models on one hand, and, on the other hand, empirical and theoretical work on the choice of monetary regime in emerging small open economies.

2.1 Optimal Monetary Policy under Incomplete Information

Standard models of discretionary monetary policy imply that the policymaker has an incentive to generate unexpected inflation, resulting in an output expansion. As a result, the equilibrium inflation rate will be higher than socially optimal (Kydland and Prescott, 1977). A commitment technology that enables enforcement of the announced, ex-ante optimal policy, can eliminate the policymaker's inflationary bias[1].

Barro (1986) pointed out that the inflationary bias problem reappears if the policymaker's preferences are not common knowledge. The private sector's uncertainty has been modeled as uncertainty about the objective function of the policymaker (Herrendorf, 1998, Vickers, 1986, Walsh, 2000) or as uncertainty about the policymaker's ability to precommit (Backus and Driffill, 1985, Barro, 1986, Cukierman and Liviatan, 1991). In either case, there exists an incentive for policymakers to behave differently relative to the complete information case, since policymakers' actions also act as signals about their type ('strong' or 'weak', with the 'strong' policymaker being able to enforce the socially optimal policy). As a consequence, 'weak' policymakers may find optimal to mimic the 'strong' policymaker's behaviour. When the policymaker's action cannot reveal her type, incomplete information will affect the private sector's expectations and the equilibrium outcome, even when the 'strong' policymaker is

[1] Other mechanisms to correct the inflationary bias have been proposed, including reputation (Barro and Gordon, 1983), the appointment process (Rogoff, 1985), inflation contracts (Walsh, 1995).

in charge.

While we exploit the intuition of this earlier literature, we use a reduced form approach. Rather than modeling the endogenous forces that lead to the mapping between a probability distribution over policymaker types and expectations in equilibrium, we take private sector's expectations as a primitive of the model. Therefore, we implicitly assume that the private sector's policy believes are the rational expectation conditional on some given probability distribution over the policymaker type in office, and that full information revelation cannot happen. These two assumptions are appropriate for the problem at hand: we do not seek the best response of the 'strong' policymaker to the private sector's believes, but wish to describe how the incentives to adopt a fixed exchange rate (or to join a monetary union) change with the credibility enjoyed by the policy announcement.

Our model also calls for a policymaker that is constrained by a binary choice between a peg and the complete information first best policy (within a family of simple policy rules). Other independent monetary policies may in fact be the best response of the policymaker, and in our model it is possible to determine the 'strong' type best-response strategy for any given level of policy credibility (or, any probability distribution over the potential presence of other policymakers which cannot precommit). In the case of EU member states, the policymaker choice of an independent monetary policy is indeed constrained by the Maastricht criteria, which emphasize price stability.

Since we adopt an infinite-horizon DSGE model with a stationary law of motion, the private sector's expectations are not fully rational even accounting for the incomplete information. The policymaker's behaviour is observable and does not change over time, yet the private sector never realizes which type is in office. In the Cukierman and Liviatan (1991) framework, the private sector's uncertainty is not resolved because there exists no separating equilibrium for periods t to $t+j$, though from $t+j+1$ up to the finite horizon T it will be optimal for the 'weak' policymaker to change behaviour and reveal its type. Effectively, we are assuming the policymaker ranks policies according to a scenario where policy credibility never improves. This setup is useful since it highlights the incentives of the policymaker in the worst possible case, allowing computation of the maximum gain that a fixed exchange rate can offer. Indeed if the policymaker's target is not perfectly controllable, reputation may take a long time to improve. Including the private sector's learning raises a number of additional issues, discussed in section 5.[2]

The literature has proposed different explanations as to why dependability may differ across

[2] Within a simple reduced-form model for policy analysis, Cukierman (2000) discusses the factors that affect the private sector's speed of learning of the policymaker type.

policymakers, such as the existence of a distribution for dependability within the society where the policymaker is drawn from, or political economy considerations. Monetary policymakers' experience over the decades indicate that the problem of establishing credibility when the policymaker type is not common knowledge is certainly very real. As an example, consider the following excerpt from a US Congress Joint Economic Committee 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."

Finally, our model begs the question of why committing to a peg should be any more credible than committing to the first best policy. Herrendorf (1999) argues that the answer to this question hinges on the easier controllability of the exchange rate relative to other targets. The transparency of a peg resolves the incomplete information problem. Exchange rate bands have also been interpreted as a verifiable system for the policymaker to conduct monetary policy with some degree of independence while making a credible anti-inflationary commitment (Cukierman et al., 2004). 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, for example, an inflation targeting policy can only be verified after many months.

Obviously the result that a fixed exchange rate can be an optimal policy under incomplete information rests on the assumption that no alternative time-consistent policy would yield a lower loss, else the commitment problem would not be relevant. Notice though that in our reduced-form setup the private sector's expectations can also be interpreted as the outcome of incomplete information over the preferences of a policymaker able to precommit.

2.2 Policy Choices in Emerging Markets and Credibility

The literature on monetary regime choice in emerging countries is vast. Amato and Gerlach (2002), Calvo and Mishkin (2003), Devereux, Lane and Xu (2004), Eichengreen (2002), Masson et al. (1997), Mishkin (2004) and Schaechter et al. (2000) provide an overview of emerging economies characteristics that may make an independent monetary policy a comparatively less attractive choice, and can explain the popularity enjoyed by hard pegs.

The least controversial hurdle restraining emerging market economies from adopting independent monetary policies is the *lack of credibility* of the monetary authority's commitment to an announced policy. A policymaker enjoying full credibility can exploit the private sector's expectations of future policy actions to achieve its objectives, resulting in smaller movements of the policy instrument compared to a regime where policy actions are unexpected. 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 to achieve a given inflation path. Herrendorf (1999) provides a model where a peg can be the equilibrium policy regime, by importing credibility for the monetary policy. In complete information DSGE models it can be shown that under certain conditions (exposure to terms of trade shock, a high degree of liability dollarization) some exchange rate stability is desirable. *Full* exchange rate stabilization is an optimal policy only under very restrictive assumptions (Devereux, 2004, Lahiri, Singh and Vegh, 2007). Mendoza (2001) shows that the policy uncertainty caused by lack of credibility of the monetary authority is a very costly distortion, that can be eliminated by adopting a fixed exchange rate.

Empirical work suggests that countries with a history of high inflation enjoy little independent monetary policy credibility and are likely to use an exchange rate peg to anchor inflation expectations. 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 the pre-stabilization level of inflation.

3 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), Gali and Monacelli (2005). 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. This model provides a stylized framework to analyze a small open economy with nominal rigidities, and a parsimonious parameterization of the business cycle shock propagation

mechanism. The qualitative results are robust to the choice of parameters, which are chosen following the new Keynesian open economy literature.

The domestic sector produces a consumption-good basket that is both consumed by domestic households and exported, in exchange for a foreign-produced consumption good. As in Gali and Monacelli (2005) and Monacelli (2004) we assume firms in the home and foreign country set prices in their respective currency, so that the law of one price holds for each traded good[3]. Domestic firms in the monopolistically competitive production sector can reset the price in any period with constant probability, as in the Calvo (1983) staggered price adjustment model. 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.

3.1 Household and Foreign Sector

The preferences of the representative household are described by the utility function:

$$U = E_0 \sum_{t=0}^{\infty} \beta^t \left\{ [\ln C_t] D_t - \frac{\ell N_t^{1+\eta}}{1+\eta} + \frac{\mu}{1-\frac{1}{\zeta}} \left(\frac{M_t}{P_t} \right)^{1-\frac{1}{\zeta}} \right\}$$

where M_t/P_t is real money balances and N_t is the amount of labor services supplied. D_t is a stochastic preference shock that distorts the labor-leisure decision. Hall (1997) defines this shock as a shift in "households' choice between work in the market and time spent in non-market activities", and shows that it can explain a very large share of the volatility in U.S. labor hours. C_t is an aggregate consumption index defined over a basket of domestic (C_H) and foreign (C_F) goods:

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

where $0 \leq \gamma \leq 1$ is the share of the foreign-produced good and $\rho > 0$ is the elasticity of substitution between domestic and foreign goods. The variables P_t, $P_{H,t}$, $P_{F,t}$ indicate the corresponding consumption price indices. The domestic-produced good H and the foreign-produced good F are Dixit-Stiglitz aggregates defined over a continuum of differentiated goods $i \in [0,1]$ with elasticity of substitution ϑ. The imported good aggregate is purchased at the exogenously given foreign-currency price $P^*_{F,t}$.

Let v_t (v_t^*) indicate the price of a zero-coupon riskless bond priced in domestic (foreign) currency,

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

B_t (B_t^*) the amount of domestic (foreign) asset purchased, e_t the nominal exchange rate, W_t the nominal wage, pr_t the share of profit from the monopolistic firms rebated to the household, and τ a lump sum government tax. The household's budget constraint is:

$$P_t C_t + M_t + e_t v_t^* B_t^* + v_t B_t \leq W_t N_t + M_{t-1} + e_t B_{t-1}^* + B_{t-1} + pr_t - \tau_t \tag{2}$$

Foreign households' demand for the home-produced good is price-elastic. While we do not explicitly model the foreign household's consumption choice, export demand for the aggregate basket $C_{H,t}^*$ and for good $i, C_{H,t}^*(i)$, is assumed to be symmetric to the optimal domestic household's choice of $C_{H,t}$, $C_{H,t}(i)$:

$$\begin{aligned} C_{H,t}^*(i) &= (\frac{P_{H,t}(i)}{P_{H,t}})^{-\vartheta} C_{H,t}^* \\ C_{H,t}^* &= \gamma^* [\frac{P_{H,t}}{e_t P_t^*}]^{-\rho^*} C_t^* = \gamma^* S_t^{\rho^*} C_t^* \end{aligned}$$

where C_t^* is the exogenous foreign consumption, $S_t = P_{F,t}/P_{H,t}$ defines the home country terms of trade, and we assume that the share of home-produced imported goods in the rest of the world consumption basket is infinitely small so that $P_t^* = P_{F,t}^*$.

3.2 Firms

A domestic firm produces good i employing labour services supplied by households and an exogenous production technology A_t:

$$Y_{H,t}(i) = A_t N_t(i) \tag{3}$$

In every period t firms adjust their prices with probability $(1 - \theta_p)$. This assumption generates the time-dependent Calvo (1983) pricing model. Given the real marginal cost MC_t^N, equal across all firms, and the aggregate demand schedule $Y_{H,t}(i) = \left[\frac{P_{H,t}(i)}{P_{H,t}}\right]^{-\vartheta} (C_{H,t} + C_{H,t}^*)$, the problem of the firm setting the price at time t consists of choosing $P_{H,t}(i)$ to maximize

$$E_t \sum_{j=0}^{\infty} (\theta_p \beta)^j \Lambda_{t,t+j} \left[\frac{P_{H,t}(i)}{P_{H,t+j}} Y_{H,t+j}(i) - \frac{MC_{t+j}^N}{P_{H,t+j}} Y_{H,t+j}(i) \right] \tag{4}$$

In eq. (4) $Y_{H,t+j}(i)$ is the demand function for firm's output at time $t + j$, conditional on the price set j periods in advance at time t, $P_{H,t}(i)$. $\beta^j \Lambda_{t,t+j}$ is the stochastic discount factor between t

and $t+j$ defined in terms of the home-produced good basket. Since we assume a non-zero steady state inflation rate, log-linearization of the firm's first order condition does not return the standard forward-looking new Keynesian inflation equation (as derived, among others, in Monacelli, 2004). The Appendix provides a detailed derivation.

3.3 Government and Monetary Authority

The government rebates the seigniorage revenues to 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. Among the twelve countries that joined the EU since 2004, average HICP inflation was 4.6% in 2004 and 4.4% in 2006 (excluding countries that joined the Euro area). In the model, steady state inflation is set at 5%. 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 S_L:

$$\begin{aligned} \frac{(1+i_t)}{(1+i_{ss})} &= S_L(s_t, s_{t-1})\ \varepsilon_{i,t} \\ L &= [\omega] \end{aligned}$$

where i_{ss} is the steady state level of the interest rate, s_t is the vector of state and control variables, L is the vector of coefficients ω_j parameterizing the policy rule S_L, and $\varepsilon_{i,t}$ is a random shock summarizing exogenous shifts in monetary policy.

4 Monetary Policy Choices under Incomplete Information

4.1 Solution Method with Parameterized Expectations

The model is solved by taking a linear approximation around the non-stochastic steady state. The logarithm of the exogenous preference shock D_t, technology shock A_t, world interest rate $\hat{\imath}_t^*$, imports' price $P_{F,t}^*$ and aggregate foreign consumption demand C_t^* follow a first order autoregressive stochastic process.

We allow the private sector's believes to differ from the monetary policy rule S_L followed by the central bank, and expectations to be formed accordingly. This methodology lets us examine the equilibrium achieved when the central bank announces *and* enforces a given policy, but the private

sector forms expectations reflecting incomplete information about the policymaker type currently in office. Notice that if the private sector's ex-ante probability distribution over policymakers' types is non-degenerate, and the policymaker's actions cannot resolve the uncertainty, the private sector's expected policy could be endogenously derived as the rational expectation conditional on the available information and believes (as in Cukierman and Liviatan, 1991). We label as 'imperfect credibility' any equilibrium where the private sector's expectations are not consistent with the complete information equilibrium. The distance between the policy announcement and the private sector's expected policy is exogenously specified.[4]

Let $\tilde{E}_t^L$ indicate the expectation of a variable conditional on private sector's believes being parameterized by the policy L. Write the model in matrix form as

$$0 = \mathbf{F}E_t(s_{t+1}) + \mathbf{G}s_t + \mathbf{H}s_{t-1} + \mathbf{R}\varepsilon_t \tag{5}$$

where both control and state variables are elements of the vector s_t, and where ε_t is a vector of zero-mean i.i.d. random innovations to the exogenous states. Conditional on policy L_a, the rational expectations equilibrium law of motion can be written as:

$$s_t = \mathbf{\Gamma}_a s_{t-1} + \mathbf{\Lambda}_a \varepsilon_t \tag{6}$$

If the private sector's believes are described by the policy L_b, expectations are consistent with the rational expectations equilibrium defined by:

$$s_t = \mathbf{\Gamma}_b s_{t-1} + \mathbf{\Lambda}_b \varepsilon_t \tag{7}$$

Given policy L_a and believes L_b the model can be written as:

$$\begin{aligned} 0 &= \mathbf{F}\tilde{E}_t^b(s_{t+1}) + \mathbf{G}s_t + \mathbf{H}s_{t-1} + \mathbf{R}\varepsilon_t \\ &= \mathbf{F}\left[\mathbf{\Gamma}_b s_t\right] + \mathbf{G}s_t + \mathbf{H}s_{t-1} + \mathbf{R}\varepsilon_t \end{aligned} \tag{8}$$

The model in eq. (8) can be solved yielding the equilibrium law of motion:

$$s_t = \mathbf{\Gamma}_c s_{t-1} + \mathbf{\Lambda}_c \varepsilon_t$$

[4] In the following we refer to the private sector's 'believes' and 'expected policy' as the same concept, though in a full-blown model the expectation on the policy enforced would be the equilibrium outcome conditional on prior believes.

where $\mathbf{\Gamma}_c = -(\mathbf{F}\mathbf{\Gamma}_b + \mathbf{G})^{-1}\mathbf{H}$ and $\mathbf{\Lambda}_c = -(\mathbf{F}\mathbf{\Gamma}_b + \mathbf{G})^{-1}\mathbf{R}$. Clearly $(\mathbf{\Gamma}_c, \mathbf{\Lambda}_c) \neq (\mathbf{\Gamma}_b, \mathbf{\Lambda}_b)$ except when $(\mathbf{\Gamma}_b, \mathbf{\Lambda}_b) = (\mathbf{\Gamma}_a, \mathbf{\Lambda}_a)$, in which case we obtain the complete information equilibrium. But it is also true that $(\mathbf{\Gamma}_c, \mathbf{\Lambda}_c) \neq (\mathbf{\Gamma}_a, \mathbf{\Lambda}_a)$, implying the monetary authority cannot rely on its policy affecting the shocks' propagation mechanism through its impact on expectations. By assumption, the law of motion is stationary. Therefore the private sector does not update its believes about the policymaker type, and credibility of the policy announcement never improves, regardless of the policy implemented. The implications of this assumption are discussed in section 5.

4.2 Expectations and Policy Performance

This section discusses the ranking of alternative monetary policies as the distance between the policy announcement and the private sector's believes exogenously changes. The performance of alternative policy rules is assessed by assuming the policymaker's objective function depends on domestic producers' price inflation, the consumption gap and the interest rate:

$$Loss = Var[c_t - \widetilde{c}_t] + \lambda_\pi Var[\pi_{H,t}] + \lambda_i Var[i_t] \tag{9}$$

where lower-case variables indicate log-deviations from the steady state, and $\widetilde{c}_t$ is the flexible-price level of consumption conditional on the exogenous states. The objective function (9) can be derived as the limit for $\beta \to 1$ of the quadratic loss function:

$$E_t(1-\beta)\sum_{j=0}^{\infty}\beta^j\left[(c_{t+j} - \widetilde{c}_{t+j})^2 + \lambda_\pi(\pi_{H,t+j})^2 + \lambda_i(i_{t+j})^2\right] \tag{10}$$

Since eq. (10) is not derived from the household's utility function, the policymaker is allowed to have preferences that differ from the representative household. This proves to be useful in our stylized framework, by giving the opportunity to examine the robustness of results to changes in the policymaker's objectives. The objective function (10) reflects the policymaker's concern for distortions that are negatively correlated with the household's welfare. First, since prices cannot be adjusted optimally, firms' average markup fluctuates inefficiently, and the dynamics of aggregate consumption c will deviate from the flexible price level $\widetilde{c}$. Second, 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 producers' price inflation π_H introduces a welfare-reducing distortion.[5] Finally,

[5] Gali and Monacelli (2005) show that in a New Keynesian full pass-through model stabilising producer price inflation

we allow for the possibility that the policymaker may be averse to interest rate volatility. Lowe and Ellis (1997) justify these preferences with concerns about financial market fragility.

The policy-maker loss function (9) includes a consumption gap, to take into account how policy impacts 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 expressed in terms of consumer price inflation π rather than producer price inflation π_H. 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. The policy-maker is assumed to assign equal weights to the policy targets: $\lambda_\pi = 1$ and, when the interest rate target is explicitly included, $\lambda_i = 1$. Unless explicitly stated, we assume $\lambda_i = 0$.

The monetary authority minimizes the loss function (9) choosing a policy within the family of simple (log-linear) policy rules:

$$\bar{i}_t = \omega_\pi \pi_{H,t} + \omega_e \Delta e_t \tag{11}$$

parameterized by $\omega_\pi \in [0, 2]$, $\omega_e \in [0, 1]$, where ω_π and ω_e are the feedback coefficients to producer price inflation π_H and nominal exchange rate depreciation Δe.[6] A policymaker concerned only with the inflation objective will set $\omega_e = 0$. A managed exchange rate float would instead imply $\omega_e > 0$, $\omega_\pi = 0$. The monetary authority also has the option of delegating policy to a foreign policymaker by fixing the exchange rate against the foreign currency. Schmitt-Grohe and Uribe (2004) discuss the performance and determinacy properties of simple policy rules in closed economy new Keynesian models. The welfare implications of similar simple rules in a small open economy are examined in Devereux (2003) and Gali and Monacelli (2005).

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

$$i_t = (1 - \chi)\bar{i}_t + \chi i_{t-1} + \varepsilon_{i,t} \tag{12}$$

is optimal, and that the utility-based welfare criterion to evaluate the cost of sub-optimal 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.

[6] To ensure local uniqueness of the equilibrium for low values of ω_π we assume policies (believes) that place a lower weight on the inflation target also place a higher weight on the exchange rate target. In the following experiments, the relationship between feedback coefficients in policies L is $\omega_\pi = x$, $\omega_e = [\max(x) - x]/2$. For values of ω_π giving a unique equilibrium, the positive weight on Δe_t does not affect qualitatively the results.

where $\chi \in [0, 1)$ is the degree of smoothing and the exogenous shock $\varepsilon_{i,t}$ represents non-systematic movements in monetary policy. A high degree of interest rate smoothing is a recurrent feature of estimated policy feedback rules (Clarida et al., 1998).

Let the enforced monetary policy be described by policy L_a. Private sector expectations are consistent with policy L_b. Given the model parameterization (including values for χ and σ_{ε_i}), the best-performing policy within the family of instrument rules in eqs. (11) and (12) is:

$$L^* = [\omega_\pi = 2, \omega_e = 0]$$

Under complete information $L_b = L_a$, and private sector's expectations are consistent with the monetary authority's announcement. In this case, as the weight ω_π on the inflation target in the policy rule gets smaller, policy performance monotonically worsens.

To measure the impact of incomplete information *conditional* on the monetary authority using the complete-information first best policy L^*, we evaluate the loss function (9) in the case of imperfect credibility. Assume $L_a = L^*$ and private sector's expectations are formed according to $L_b \neq L_a$, where L_b indicates policy believes ranging from $L_b^{low} = [\omega_\pi \to 0, \omega_e = 1]$ to $L_b^{high} = L^*$. As the private sector's uncertainty over the policymaker type decreases, and correspondingly the credibility of the central bank announced policy improves, the coefficient ω_π in the expected policy L_b increases towards the true value of 2 and ω_e decreases towards the true value of 0. When credibility is low and $L_b = L_b^{low}$ the private sector expects the policymaker to put only a small weight on producer price inflation deviations from the target. In other words, the monetary authority is not believed to react with an aggressive contractionary policy to inflationary shocks.

Figure 1a shows the policymaker's loss under complete and incomplete information for the family of instrument rules in eqs. (11) and (12). In the complete information case, the policy enjoys full credibility, and figure 1a plots the loss corresponding to any policy $L_a \in [L_b^{low}, L_b^{high}]$ where for each policy the private sector's believes are correct: $L_b = L_a$. In the case of incomplete information about the policymaker type, figure 1a plots the loss for a single policy, $L_a = L^*$, as a function of private sector's believes $L_b \in [L_b^{low}, L_b^{high}]$. Contrary to the complete information case, the plot evaluates outcomes not as a function of the policy enforced, but as a function of the private sector's believes. When the distance between L_a and L_b is not too large, for given believes L_b the performance of the policymaker enforcing $L_a = L_b$ or $L_a = L^*$ is very close. That is, conditional on believes, the policymaker is paying little or no penalty for using a policy which is more inflation-averse relative to expectations. As

the distance between L_a and L_b increases, the unexpected component of the policymaker's behaviour generates large losses.

The surface in figure 1a represents the loss achieved under a fixed exchange rate regime, where L_a is given by:

$$L^{fix} = [\omega_\pi = 0, \omega_e \to \infty]$$

For a country that pegs its exchange rate by joining the Euro currency area, the policy enjoys full credibility thanks to the common knowledge of the commitment mechanism, and $L_b = L^{fix}$. The monetary authority complies with the announced policy under either regime L^* or L^{fix}- but may enjoy less than full credibility when conducting an independent monetary policy, implying $L_b \neq L_a$. Even for a country that pegs its exchange rate without giving up its national currency, as in the case of Euro area members, many authors have argued a fixed exchange rate regime enjoys a credibility advantage thanks to the transparency of the commitment, which can be verified on a daily basis. Given this advantage, the monetary authority will prefer an (imperfectly credible) independent monetary policy only if it yields a loss no larger than a more credible exchange rate peg.

For any model parameterization, it is possible to compute the maximum distance between announced policy and private sector's believes necessary for an independent monetary policy to perform better than a peg. Given our choice of parameters, figure 1a shows that for L_b approximately equal to $[\omega_\pi = 0.35, \omega_e = 0.85]$ the two policies yield the same loss. Therefore, even for a substantial distance between the enforced policy and private sector's believes, the policymaker will find the fixed exchange rate regime L^{fix} a dominated monetary regime. As believes get further away from the announced policy, the penalty paid by the policymaker for enforcing policy $L_a = L^*$ through movements in the interest rate that are not predicted by the private sector gets very large.

If the policymaker's objective function (10) is defined in terms of consumer price inflation π, rather than producer price inflation π_H, the penalty resulting from using a policy which is more inflation-averse relative to expectations increases, as showed in figure 1b. This is because the variability of the exchange rate, which now enters the objective function trough π, grows rapidly with the distance between L_a and L_b. As a consequence, the maximum distance between policy and believes necessary for an independent monetary policy to be preferable to an exchange rate peg falls.

4.3 The Cost of Uncertainty over Policymaker Type

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 in the imperfect credibility equilibrium by incomplete information about the policymaker type. This loss can be read as the sum of two terms:

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

The first term $[L_b|L_b - L_a|L_a]$ is the *policy gap*. This is the loss relative to policy L_a for any enforced policy $L_b \in [L_b^{low}, L_b^{high}]$ when the private sector's believes are correct. It represents the cost associated with employing a policy that performs worse than L_a under complete information.

But the loss from the policymaker enforcing the worse policy L_b conditional on an expected policy L_b is only a portion of the 'credibility gap' $L_a|L_b - L_a|L_a$ arising from incomplete information. Holding fixed the believes L_b assume the policymaker 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 law of motion for private sector's expectations is constant, and all that changes is the policy actually implemented. In other words, the 'credibility gap' does not arise only from the private sector holding expectations of a worse policy, but also from the policymaker enforcing policy L_a to achieve a desired level of the instrument i_t in response to equilibrium movements in the target variables, despite the private sector's believes. Figure 2 plots the loss $L_b|L_b$ for each enforced policy L_b, and the loss $L_a|L_b$ for a single enforced policy $L_a = L^*$ as a function of expectations L_b. Policy L^* results in the complete-information first best outcome. Given a parameterization for the private sector's expected policy L_b, L^* need not be the best response of the policymaker, since policies which are dominated under complete information may be optimal under incomplete information if they reduce the distance between L_a and L_b, and with it the 'implementation gap'.

The existence of a 'policy gap' echoes the traditional argument made by Giavazzi and Pagano (1988) for a peg being an optimal policy choice: the policymaker can choose between a credible external anchor, and achieve loss given by L^{fix}, or an independent monetary policy L_a where for some reason - lack of a commitment mechanism in the case of these authors - there exist an external constraint to the best possible performance, and the first best outcome cannot be achieved. This argument is reminiscent of the dilemma faced by the policymaker in Kydland and Prescott (1977): there exists a first best policy

under commitment, but the policy is optimal only conditional on private sector's expectations being consistent with the announcement. If the policymaker can renege on the announcement, in equilibrium the private sector will adjusts its expectations. In this case, the best possible performance is achieved by the time-consistent policy.

Under complete information, there may be a vast range of policies L_a for which the peg is a dominated choice. The full credibility loss plot in figure 2 shows that for values of ω_π larger than 0.2 the independent policy performs better than a fixed exchange rate. The choice faced by the policymaker under incomplete information is different: choose between a credible external anchor, and achieve loss given by L^{fix}, or implement the first best policy conditional on private sector's expectations that policy L_b is being implemented. Fighting against expectations generates a large 'implementation gap', and makes the L^* policy a poor choice. In fact, for a large range of expectations L_b a peg improves on enforcing policy L^*. The optimality of a peg depends not on the policymaker inability to choose the first best policy, but on the inability to influence expectations. As policy credibility improves, the implementation gap narrows rapidly.

The intuition for the existence of a sizeable implementation gap can be illustrated by looking at the impulse response function to an annualized 1% expansionary policy shock to ε_{i_t} (Figure 3). Consider the rational expectations equilibrium given policies $L_a = [\omega_\pi = 2,\ \omega_e = 0.1]$ and $L_b = [\omega_\pi = 0.4,\ \omega_e = 0.9]$. The policy rule L_b implies the decrease in i_t below the steady state value following the initial expansionary shock is smaller than under policy L_a. Conditional on L_b, the monetary authority responds more aggressively to the nominal exchange rate depreciation, which fully adjusts each period and on impact has a larger movement than producer price inflation.

In the imperfect credibility equilibrium, given the state of the economy and enforced policy L_a, the interest rate i_t is lower than predicted by the private sector, which forms expectations conditional on L_b. Effectively, in the believes of the private sector the movement in i_t is interpreted as the outcome of a larger initial expansionary shock. In addition, conditional on L_b firms increase the price by a larger amount then they would conditional on L_a since they expect inflation will trigger smaller future interest rate hike by the monetary authority, which would curb future demand. Given $\tilde{E}_t^b \pi_{H,t+1}$ and $\tilde{E}_t^b i_{t+1}$ domestic inflation will be higher relative to the case of a fully credible policy L_a *and* relative to the case of a fully credible policy L_b. Since an increase in π_H requires a drop in the average markup, the larger drop also leads to a larger 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 results in the 'implementation gap' loss.

Notice that in general the 'implementation gap' may be positive or negative. The intuition for why in our example with Calvo pricing we obtain a positive implementation gap, or a worsening of performance relative to the 'policy gap' loss, can be explained as follows. Suppose the policymaker enforced a policy such that inflation volatility were exactly the same as under complete information, but the private sector expected a less inflation-averse policy. WLOG, set the policymaker target for inflation variance at zero. To achieve this target, in the face of inflationary shocks the enforced policy must be more contractionary than under complete information, resulting in a higher volatility of domestic producers' markups, and thus in a larger volatility of the consumption gap. This is because under complete information zero-inflation volatility implies markups are constant at the steady state level. But as firms choose prices based on wrong expectations of future movement in markups, the monetary authority must contract current demand until the point where the expected discounted sum of markups is zero, and domestic inflation does not move. The incorrect believes unlock the relationship between constant markups and zero inflation following an inflationary shock that exists in the rational expectations equilibrium. If the policymaker places some weight on the consumption gap, incomplete information generates an 'implementation gap' since for given inflation variance the consumption gap volatility is larger relative to the complete information case.

This intuition extends to the case analyzed in figures 1 and 2. Under complete information, a fixed exchange rate policy results in higher loss by shifting the burden of relative price adjustment on P_H, generating larger movements in domestic inflation and mark-ups over the business cycle. Since domestic prices cannot adjust in every period, while the exchange rate is perfectly flexible, policies stabilizing domestic prices rather than the exchange rate are welfare enhancing in most small open economy models with Calvo pricing. The implementation gap generates an additional cost for a policymaker trying to stabilize domestic prices more than expected. Given reasonable parameterizations, incomplete information can thus reverse the policy ranking observed under rational expectations.

4.4 Interest Rate Smoothing

The policy rule (12) 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 policymaker's loss for $\lambda_i = 0$ and $\lambda_i = 1$. The loss from implementing policy L^* is lower than in a fixed exchange rate regime for values of ω_π larger than 0.4. The credibility gap loss increases, but the

maximum distance between announced policy and private sector's believes necessary for an independent monetary policy to perform better than a peg does not increase proportionally, since the performance of a fixed exchange rate regime worsens when $\lambda_i = 1$.

4.5 The Degree of Openness and Exposure to Financial Volatility

Two widely studied vulnerabilities of small open economies are exposure to foreign shocks and to financial instability. We examine how these issues bear on the policymaker's optimal choice under incomplete information.

First, 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 $\gamma = 0.2$. This implies the economy steady state ratio of imports to total consumption gets smaller. Table 1 shows the implications for the objective function under a number of believed policies L_b when the policymaker enforces $L_a = L^*$. As the policy enforced and private sector's policy believes L_b get closer, the ratio between the loss under L^* and under the exchange rate peg drops faster below 100% when $\gamma = 0.2$. For a more closed economy an independent monetary policy becomes an attractive option for lower levels of credibility. This result does not hinge on a smaller 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 an independent monetary policy 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 2 asks what is the relative importance of financial shocks. To this end, we compare the relative performance of a peg and of an independent monetary policy under incomplete information in the case all exogenous shocks have positive variance, and in the case all shocks but ε_{i_t} and ι_t^* have zero variance - implying all the volatility in the economy is caused by relative money supply adjustments. Movements in ε_{i_t} 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 when part of the exogenous variability in the model is eliminated. This though does not imply that the credibility gap will decrease in relative terms. In fact, the loss from an independent monetary policy under incomplete information relative to an exchange rate peg increases, and so does the implementation gap. In countries where the volatility of financial shocks is relatively important for the business cycle, the attractiveness of a peg increases for low levels of policy credibility.

5 Conclusions

New member states that recently entered the European Union plan to join the Euro area within a few years, despite large structural differences still existing against current Euro area members.

A widely accepted argument in the optimal monetary policy literature suggests that joining a monetary union, and fixing the exchange rate, can improve welfare if the policymaker lacks access to a commitment technology, since this policy amounts to the indirect appointment of a precommitted foreign central banker. This paper argues that a peg can be the optimal choice even if a policymaker has access to a commitment technology, whenever the private sector's believes reflect incomplete information about the policymaker's dependability.

We embed in a DSGE model of a small open economy a mechanism suggested by Cukierman and Liviatan (1991) by solving for the equilibrium conditional on exogenously parameterized private sector's expectations for the policymaker's preferences. The private sector's believes can be self-fulfilling, since a policymaker may find adopting a fixed exchange rate regime optimal despite the fact that it could commit to the policy which is the first best under complete information. We show that the cost of the private sector's incomplete information when the policymaker implements the first best policy can be substantial, and reflects partly the loss that would obtain implementing a dominated policy conditional on correct private sector's believes (the policy gap), and partly the loss of implementing the first best policy *despite* the private sector's expectations of a dominated policy (the implementation gap). In this framework, good policy outcomes depend more on how the central bank policy is *perceived* by the private sector than on what policy is *actually* implemented.

Our model explains the choice to join the Euro area with its impact not on the policymaker's behaviour, but on the believes of the private sector. It also provides an argument to explain the popularity enjoyed by pegged exchange rate regimes, despite the recurring crises associated with this monetary policy. We quantify the maximum distance between announced policy and private sector's believes necessary for an independent monetary policy to perform better than a peg. Countries more exposed to foreign and financial shocks volatility need to enjoy a comparatively higher level of credibility for monetary independence to improve over a fixed exchange rate.

We suggest three directions for future work that deserve further investigation. First, while the qualitative results we obtain are robust to the choice of parameters, a quantitative evaluation of the cost from incomplete information would call for a less stylized model, where the role of non-traded goods, investment, slow capital and labor adjustment would play an important role. Second,

we chose to parameterize exogenously the policymaker preferences to gain a better intuition for the mechanism at work in the economy. Ranking policies using the household utility function would be appropriate when using a less stylized model. Third, we assumed the policymaker ranks policies according to a worst-case scenario where policy credibility never improves. This let us find what is the maximum distance between policy announcements and believes that would still allow independent monetary policy to perform better than a peg. An open question is the role played by the private sector's learning dynamics, the subject of a rapidly growing literature. Allowing for the private sector's believes over the policymaker type to be optimally updated adds an extra layer to the policy choice problem: a policy rule may in fact be preferable because it speeds up learning (as in Wieland, 2000). In an environment where the private sector can update its priors, it will be optimal to converge to the complete information first-best policy by adopting a sequence of intermediate policies that trade off the gain from performing well at time t with the gain from faster learning at future dates. Depending on the speed of learning and the policymaker's horizon, it is certainly feasible for an independent monetary policy to dominate a peg even under incomplete information.

References

[1] Amato, J. and Gerlach, S., (2002), 'Inflation targeting in emerging market and transition economies: lessons after a decade', *European Economic Review* 46: 781-791.

[2] Ascari, G., (2004), "Staggered Prices and Trend Inflation: Some Nuisances", *Review of Economic Dynamics,* 7: 642:677.

[3] Backus, D. and Driffill, J, (1985), 'Rational expectations and policy credibility following a change in regime', *Review of Economic Studies* 52: 211-221.

[4] Barro, R., (1986), 'Reputation in a model of monetary policy with incomplete information', *Journal of Monetary Economics* 17: 3-20.

[5] - , and Gordon, (1983), 'Rules, discretion and reputation in a model of monetary policy', *Journal of Monetary Economics*, July.

[6] Benigno, G. and Benigno, L., (2003), 'Price Stability in open economies', *Review of Economic Studies* 70: 743-764.

[7] Bernanke, B., Laubach, T., Mishkin, F. and Posen, A., (1999), *Inflation Targeting: Lessons from the International Experience*, Princeton: Princeton University Press.

[8] Calvo, G., (1983), 'Staggered prices in a utility-maximizing framework', *Journal of Monetary Economics* 12: 383-98.

[9] Calvo, G. and Mishkin, F., (2003), 'The mirage of exchange rate regimes for emerging market countries', *Journal of Economic Perspectives,* 17(4): 99-118.

[10] Clarida, R., Gali, J. and Gertler, Mark, (1998), 'Monetary policy in practice: some international evidence', *European Economic Review* 42: 1033-1067.

[11] Cukierman, A., (2000), 'Establishing a reputation for dependability by means of inflation targets', *Economics of Governance* 1: 53-76.

[12] - and Liviatan, N., (1991), 'Optimal accommodation by strong policymakers under incomplete information', *Journal of Monetary Economics* 27: 99-127.

[13] - , Spiegel, Y. and Leiderman, L., (2004), 'The choice of exchange rate bands: balancing credibility and flexibility', *Journal of International Economics* 62: 379-408.

[14] Devereux, M., (2001), 'Monetary policy, exchange rate flexibility and exchange rate pass-through', in Revisiting the Case for Flexible Exchange Rate, Bank of Canada.

[15] - (2003), 'A macroeconomic analysis of EU accession under alternative monetary policies', *Journal of Common Market studies*, 41(5): 941-64.

[16] - (2004), 'Should the Exchange Rate be a Shock Absorber?', *Journal of International Economics* 62: 359-377.

[17] Devereux, M. and Engel, C., (2003), 'Monetary Policy in an Open Economy Revisited: Price Setting and Exchange Rate Flexibility', *Review of Economic Studies* 70: 765-783.

[18] Devereux, M., Lane, P. and Xu, J., (2004), 'Exchange rates and monetary policy in emerging market economies', IIIS Discussion Paper 36.

[19] Eichengreen, B., (2002), 'Can emerging markets float? Should they inflation target?', mimeo, University of California - Berkeley.

[20] Gali, Jordi and Monacelli, T., (2005), 'Monetary policy and exchange rate volatility in a small open economy', *Review of Economic Studies* 72(3).

[21] Giavazzi, F. and Pagano, M, (1988), 'The advantage of tying one's hands', *European Economic Review* 32: 1055-1083.

[22] Hall, R. (1997), "Macroeconomic Fluctuations and the Allocation of Time", *Journal of Labor Economics*, 15, S223–S249.

[23] Hamann, A., and Prati, A., (2002), 'Why do many disinflations fail?', IMF Working Paper 02-228.

[24] Herrendorf, B., (1998), 'Inflation targeting as a way of precommitment', *Oxford Economic Papers* 50: 431-488.

[25] - , (1999), 'Transparency, reputation and credibility under floating and pegged exchange rates', *Journal of International Economics* 49: 31-50.

[26] Kydland, F. and Prescott, E., (1977), 'Rules rather than discretion: the inconsistency of optimal plans', *Journal of Political Economy*, June.

[27] Lowe, P. and Ellis, L., (1997), 'The smoothing of Official interest rates', in Lowe, P., ed., *Monetary Policy and Inflation Targeting Perceptions: Proceedings of a Conference*, Sydney, Reserve Bank of Australia.

[28] Mahadeva, L. and Sterne, G., (2000), *Monetary Frameworks in a Global Context*, Bank of England

[29] Masson, P., Savastano, M. and Sharma, S., (1997), 'The scope for inflation targeting in developing countries', IMF Working Paper 97/130.

[30] McCallum, Bennett and Nelson, Edward, (2004), 'Targeting vs. Instrument Rules for Monetary Policy', NBER Working Paper 10612.

[31] Mendoza, E., (2001), 'The Benefits of Dollarization when Stabilization Policy Lacks Credibility and Financial Markets are Imperfect', *Journal of Money, Credit and Banking* 33: 176-198.

[32] Mishkin, F., (2004), 'Can inflation targeting work in emerging market countries?', NBER Working Paper 10646

[33] Monacelli, T., (2004), 'Into the Mussa Puzzle: Monetary Policy Regimes and the Real Exchange Rate in a Small Open Economy', *Journal of International Econmics* 62: 192-217.

[34] Obstfeld, M. and Rogoff, K., (2000), 'New directions for stochastic open economy models', *Journal of International Economics*, 50(1): 117-53.

[35] Parrado, E., and Velasco, A., (2002), 'Alternative monetary rules in the open economy: a welfare based approach', in Norman Loayza and Raimundo Soto, eds.: *Inflation Targeting: Design, Performance, Challenges*, Santiago, Chile, Central Bank of Chile.

[36] Ravenna, F., and Natalucci, F., (2008), 'Monetary Policy Choice in Emerging Markets: the Case of High Productivity Growth', *Journal of Money, Credit and Banking*, forthcoming.

[37] Rogoff, K., (1985), 'The optimal commitment to an intermediate monetary target', *Quarterly Journal of Economics* 100: 1056-1070.

[38] Saxton, J., (1997), *Lessons from Inflation Targeting Experience - A Joint Economic Committee Report*, Joint Economic Commitee, United States Congress.

[39] Schaechter, A., Stone, M. and Zelmer, M., (2000), 'Adopting inflation targeting: practical issues for emerging market countries', IMF Occasional Paper 202.

[40] Schmitt-Grohe, S. and Uribe, M., (2001), 'Stabilization policy and the costs of dollarization', *Journal of Money, Credit, and Banking* 33: 482-509.

[41] - , (2004), 'Optimal Fiscal and Monetary Policy Under Sticky Prices', *Journal of Economic Theory* 114: 198-230.

[42] Sutherland, A., (2005), 'Incomplete Pass-Through and the Welfare Effects of Exchange Rate Variability', *Journal of International Economics* 65: 375-399.

[43] Vickers, J., (1986), 'Signalling in a model of monetary policy with incomplete information', *Oxford Economic Papers* 38: 443-455.

[44] Walsh, C., (1995), 'Optimal contracts for central bankers', *American Economic Review* 85: 150-167.

[45] - , (2000), 'Market discipline and monetary policy', *Oxford Economic Papers* 52: 249-271.

[46] Wieland, V., (2000), 'Learning-by-doing and the value of optimal experimentation', *Journal of Economic Dynamics and Control* 24, 501-534.

6 Appendix

6.1 Model Equilibrium Conditions

Household The solution to the household decision problem gives the following first order conditions (FOCs):

$$\frac{C_{F,t}}{C_{H,t}} = \frac{\gamma}{1-\gamma}\left(\frac{P_{F,t}}{P_{H,t}}\right)^{-\rho} \tag{13}$$

$$MUC_t \frac{W_t}{P_t} = \ell N_t^{\eta} \tag{14}$$

$$MUC_t = \beta E_t\left\{MUC_{t+1}\left(1+i_t\right)\frac{P_t}{P_{t+1}}\right\} \tag{15}$$

$$0 = E_t\left\{MUC_{t+1}\frac{P_t}{P_{t+1}}\left[\frac{e_{t+1}}{e_t}(1+i_t^*)-(1+i_t)\right]\right\} \tag{16}$$

where $MUC_t = \frac{D_t}{C_t}$ is the marginal utility of consumption, $(1+i_t) = v_t^{-1}$ 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.[7]

Firms Cost minimization for the domestic production sector implies:

$$MC_t^N = P_{H,t}MC_t = \frac{W_t}{MPL_t} \tag{17}$$

where MC^N and MC are the nominal and real marginal cost, MPL is the marginal productivity of labor. The FOC for the firm's profit maximization problem in eq. (4) is:

$$P_{H,t}(i)E_t\sum_{j=0}^{\infty}(\theta_p\beta)^j\Lambda_{t,t+j}\left[\frac{P_{H,t}(i)}{P_{H,t+j}}\right]^{1-\vartheta}Y_{H,t+j} = \frac{\vartheta}{\vartheta-1}E_t\sum_{j=0}^{\infty}(\theta_p\beta)^j\Lambda_{t,t+j}MC_{t+j}^N\left[\frac{P_{H,t}(i)}{P_{H,t+j}}\right]^{1-\vartheta}Y_{H,t+j}. \tag{18}$$

[7] Following Schmitt-Grohe and Uribe (2001) , the nominal interest rate at which households can borrow internationally is given by the exogenous world interest rate $\tilde{\imath}^*$ plus a premium, which is assumed to be increasing in the real value of the country's stock of foreign debt:

$$(1+i_t^*) = (1+\tilde{i}_t^*)g(-B_{H,t})$$

where $B_{H,t} = \frac{e_t B_t^*}{P_{H,t}}$ and $g(\cdot)$ is a positive, increasing function. This ensures the stationarity of the model. The endogenous risk premium is parameterized so that for a 10 percent increase in the ratio of net foreign debt to steady-state GDP, the interest rate at which domestic agents can borrow abroad increases by 0.4 percent, a conservative figure for emerging markets.

Write eq. (18) as:

$$P_{H,t}(i) = \frac{\hat{G}_t}{\hat{H}_t},$$

where

$$\hat{G}_t = \mu MUC_{H,t} MC_t^N P_{H,t}^{\vartheta-1} Y_{H,t} + E_t \theta_p \beta \hat{G}_{t+1} \tag{19}$$

$$\hat{H}_t = MUC_{H,t} P_{H,t}^{\vartheta-1} Y_{H,t} + E_t \theta_p \beta \hat{H}_{t+1}. \tag{20}$$

and $MUC_{H,t} = MUC_t \frac{P_{H,t}}{P_t}$ is the marginal utility of consumption in terms of the home-produced good. Let $\mu = \frac{\vartheta}{\vartheta-1}$ be the flexible-price equilibrium markup. Divide $\hat{G}_t$ by $P_{H,t}^{\vartheta}$ and $\hat{H}_t$ by $P_{H,t}^{\vartheta-1}$ to obtain:

$$\tilde{G}_t \equiv \frac{\hat{G}_t}{P_{H,t}^{\vartheta}} = \mu MUC_{H,t} \frac{MC_t^N}{P_{H,t}} Y_{H,t} + E_t \theta_p \beta \frac{\hat{G}_{t+1}}{P_{H,t+1}^{\vartheta}} \frac{P_{H,t+1}^{\vartheta}}{P_{H,t}^{\vartheta}} = \mu MUC_{H,t} MC_t Y_{H,t} + E_t \theta_p \beta \tilde{G}_{t+1} (\Pi_{H,t+1})^{\vartheta} \tag{21}$$

$$\tilde{H}_t \equiv \frac{\hat{H}_t}{P_{H,t}^{\vartheta-1}} = MUC_{H,t} Y_{H,t} + E_t \theta_p \beta \frac{\hat{H}_{t+1}}{P_{H,t+1}^{\vartheta-1}} \frac{P_{H,t+1}^{\vartheta-1}}{P_{H,t}^{\vartheta-1}} = MUC_{H,t} Y_{H,t} + E_t \theta_p \beta \tilde{H}_{t+1} (\Pi_{H,t+1})^{\vartheta-1} \tag{22}$$

where Π_H is the steady state domestic good basket gross inflation rate. Since we assume constant terms of trade, in a steady state with flexible exchange rates PPI and CPI inflation will be identical, and equal to the money growth rate. If we assume the foreign price index P_F^* grows at the same rate, the nominal exchange rate is also constant. Using:

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

the law of motion for the aggregate price index is:

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

In a steady state with positive inflation $\widetilde{G}$ and $\widetilde{H}$ are given by:

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

where Π_H is the PPI steady state inflation rate. Then:

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

The steady state price index gives

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

Solving the system of two equations in the two variables MC and $\frac{\widetilde{G}}{\widetilde{H}}$ gives:

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

See Ascari (2004) for a derivation of the log-linear inflation equation in a closed economy.

Market Clearing The resource constraint in the domestic production sector is given by

$$Y_{H,t} = \int_0^1 A_t N_t(i)di = A_t N_t = (C_{H,t} + C^*_{H,t}) \int_0^1 \left[\frac{P_{H,t}(i)}{P_{H,t}}\right]^{-\vartheta} di \tag{23}$$

The trade balance, expressed in units of good H, can be written as

$$NX_{H,t} = C^*_{H,t} - \frac{e_t P^*_{F,t}}{P_{H,t}} C_{F,t} \tag{24}$$

Assuming that domestic bonds are in zero net supply, the current account (in nominal terms) reads as

$$e_t B^*_t = \left(1 + i^*_{t-1}\right) e_t B^*_{t-1} + P_{H,t} NX_{H,t} \tag{25}$$

6.2 Parameterization

The model parameterization follows closely Monacelli (2004) and Gali and Monacelli (2005). 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 $1/3$ does 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 parameterize 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 model is log-linearized around a zero-net foreign asset steady state. 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 in logs:

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

where $\varepsilon_{j,t}$ is normally distributed with variance $\sigma^2_{\varepsilon_j}$. The technology shock innovation volatility is parameterized 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, these authors estimate the parameters for the foreign consumption demand using HP filtered U.S. (log) GDP to be $\rho_c = 0.86$ and $\sigma_c = 0.0078$. This is a reasonable approximation for the case of Canada, where the average share of total exports going to the U.S averaged around 80% in the last 15 years. To parameterize 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 2002:4. 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 $\sigma_i = 0.0015$, a low value that reflects the evidence on the small role played by non-systematic monetary policy in business cycle fluctuations in a number of countries.

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 1: Loss for selected values of believed policy L_b. Loss weights: $\lambda_{\pi_H} = 1$, $\lambda_i = 0$. Relative loss is ratio of loss for policy $L_a|L_b$ (where $L_a = L^*$ is the enforced policy) and fixed exchange rate. Implementation gap is measured by the 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 2: Loss for selected values of believed policy L_b. Loss weights: $\lambda_{\pi_H} = 1$, $\lambda_i = 0$. Relative loss is ratio of loss for policy $L_a|L_b$ (where $L_a = L^*$ is the enforced policy) and fixed exchange rate. Implementation gap is measured by the ratio $[L_a|L_b - L_b|L_b]/[L_b|L_b]$.

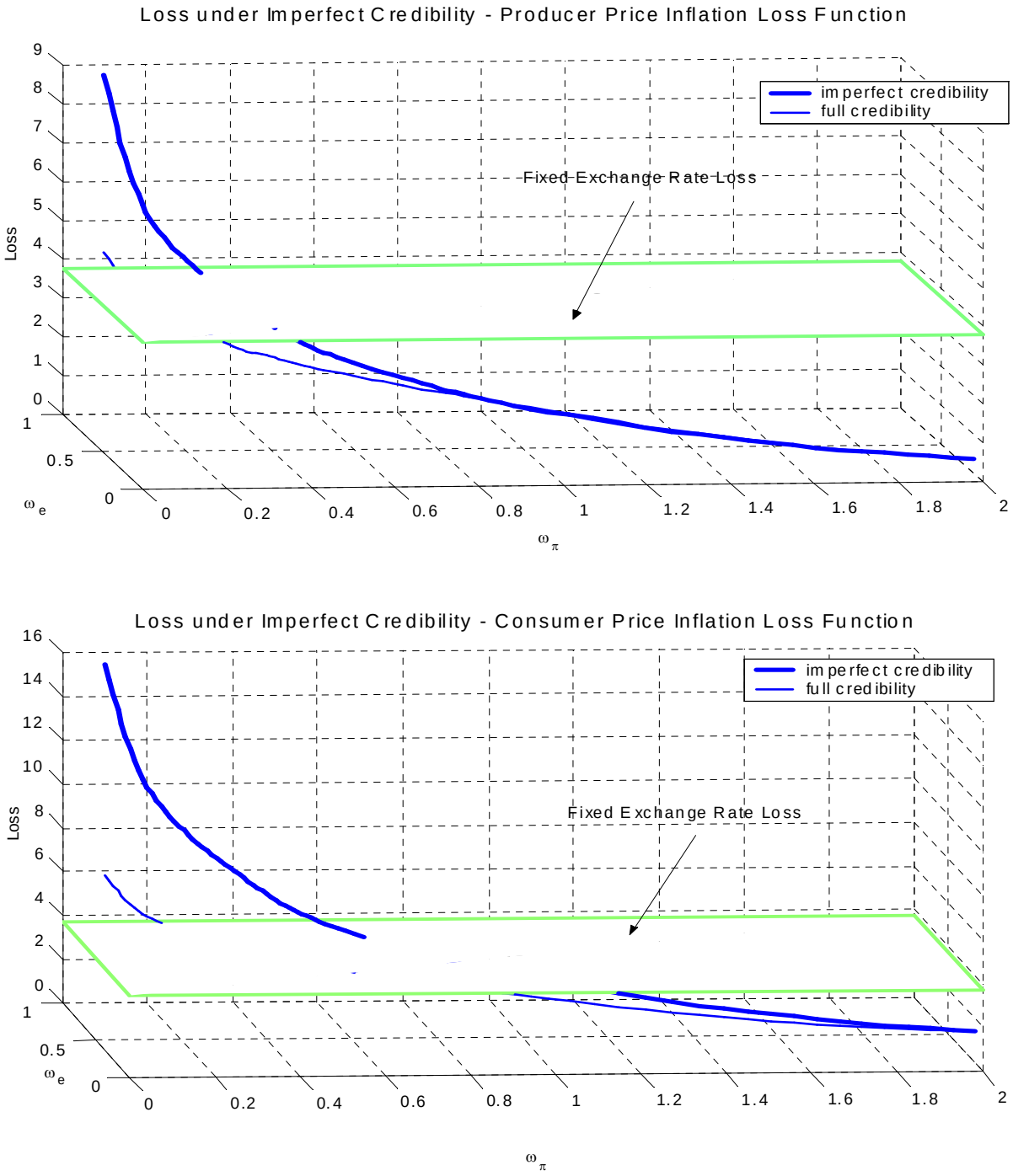
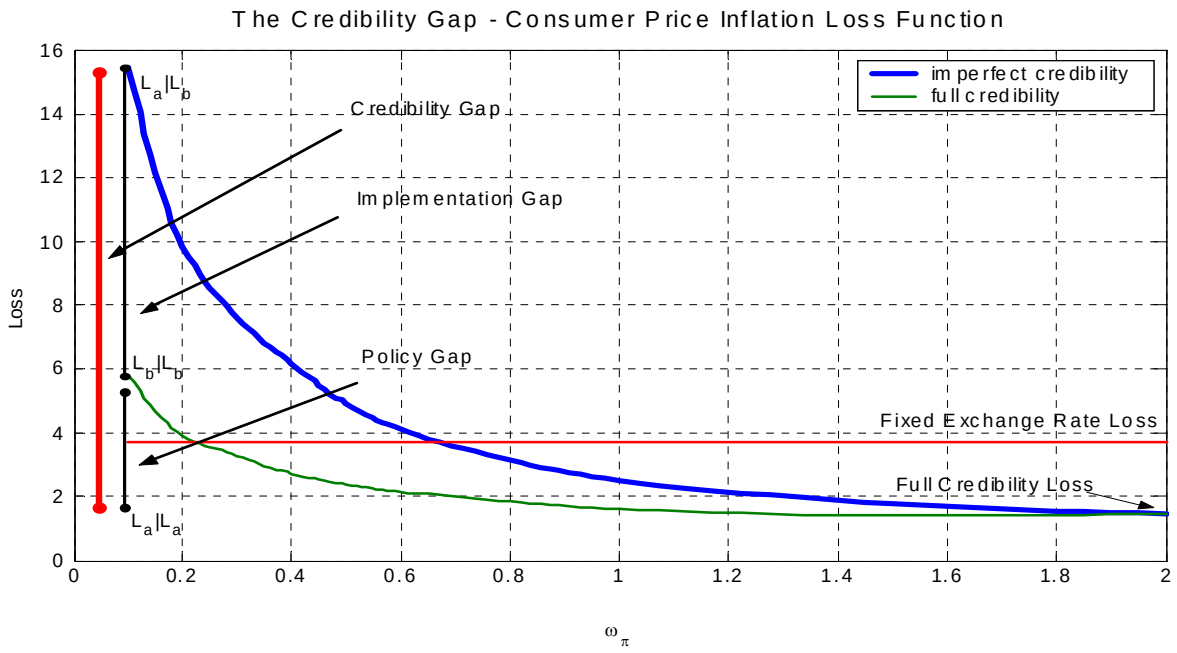


Figure 1: Full credibility: loss for enforced policy L_a equal to believes L_b for L_b varying linearly in the range $[L_b^{low}, L_b^{high}]$ where $L_b^{low} = [\omega_\pi \to 0, \omega_e = 1]$ and $L_b^{high} = [\omega_\pi = 2, \omega_e = 0]$. L_b^{high} is the complete information first best policy. Imperfect credibility: loss for enforced policy $L_a = L_b^{high}$ and believes L_b varying linearly in the range $[L_b^{low}, L_b^{high}]$. Panel A: Loss weights: $\lambda_{\pi_H} = 1$, $\lambda_i = 0$. Panel B: Loss weights: $\lambda_\pi = 1$, $\lambda_i = 0$. Surface shows fixed exchange rate loss.



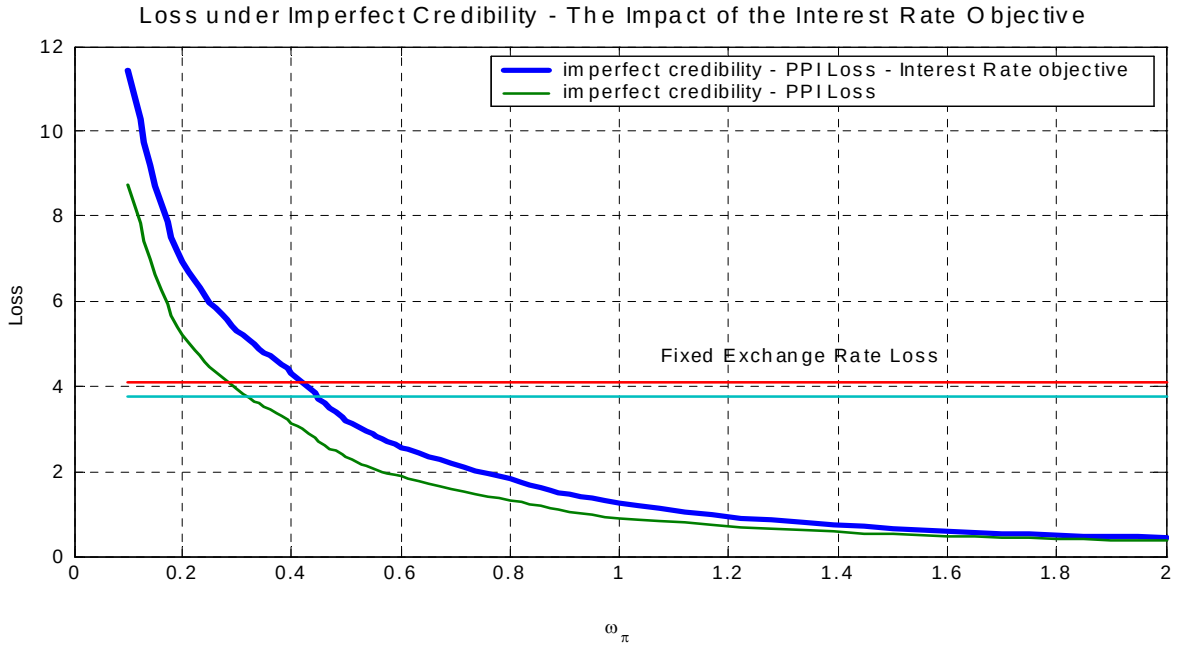


Figure 2: Full credibility: loss for enforced policy L_a equal to believes L_b for L_b varying linearly in the range $[L_b^{low}, L_b^{high}]$ where $L_b^{low} = [\omega_\pi \to 0, \omega_e = 1]$ and $L_b^{high} = [\omega_\pi = 2, \omega_e = 0]$. L_b^{high} is the complete information first best policy. Imperfect credibility: loss for enforced policy $L_a = L_b^{high}$ and believes L_b varying linearly in the range $[L_b^{low}, L_b^{high}]$. Panel A: Loss weights: $\lambda_\pi = 1$, $\lambda_i = 0$. Panel B: Compares loss for $\lambda_{\pi_H} = 1$, $\lambda_i = 0$ with loss for $\lambda_{\pi_H} = 1$, $\lambda_i = 1$. Straight lines show fixed exchange rate loss. Variation in ω_e not shown.

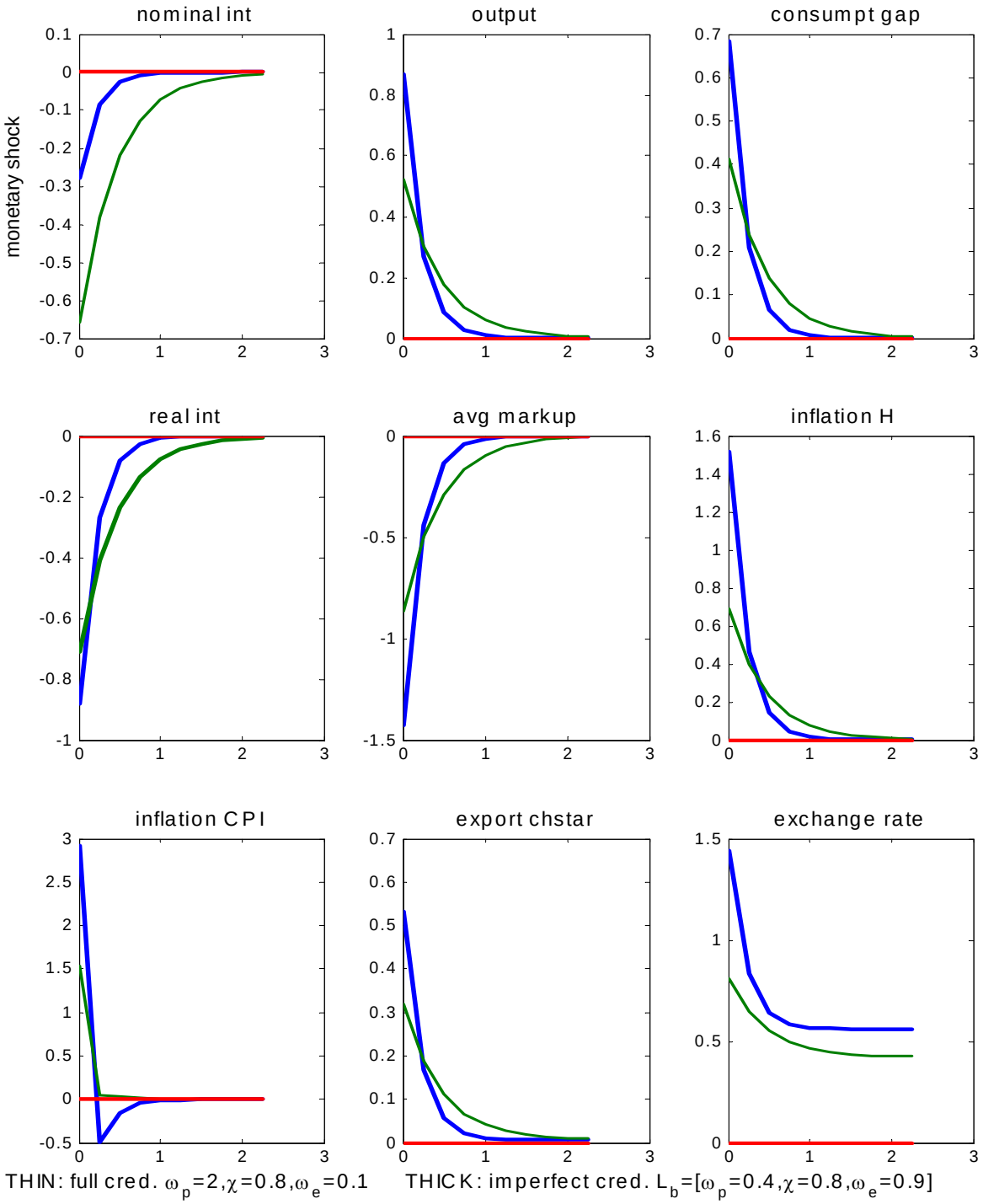


Figure 3: Impulse response function to an unanticipated annualized 1% drop in the nominal interest rate i_t. True policy $L_a = [\omega_\pi = 2,\ \omega_e = 0.1]$. Under imperfect credibility, private sector expects policy $L_b = [\omega_\pi = 0.4,\ \omega_e = 0.9]$. Time is measured in years. Deviations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