Pegging the Exchange Rate to Gain Monetary Policy Credibility*

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Abstract
Central banks that lack credibility often tie their exchange rate to that of a more credible partner in order to “import” credibility. We show in a small open economy model that a central bank that displays “limited credibility” can deliver significant improvements to a social welfare function that contains no role for exchange rate stabilization by maximizing an objective function that places weight on exchange rate stabilization, and thus the central bank with limited credibility will peg their currency to that of a more credible partner. As the central bank’s credibility improves it will place less weight on exchange rate stabilization in its objective function and thus loosen the peg. When the central bank is perfectly credible its objective function and the social welfare function are identical; it places no weight on exchange rate stabilization and allows the currency to freely float. Empirical results using a panel of both developed and developing countries show that as central banks become more independent they tend to allow more currency flexibility.

JEL codes: E50, E30, F40

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1 Introduction

The work of Kydland and Prescott (1977) and Barro and Gordon (1983) highlight the importance of time consistency in policy making. Countries with a weak institutional framework may lack the ability to commit to a future course of monetary policy. In this case optimal monetary policy may be to abandon a floating exchange rate regime and tie the currency with a more credible partner.

Historically this has been the preferred option for many countries. Bordo and Kydland (1995) discuss this practice of pegging one’s currency to gain credibility in terms of the pre-World War 1 gold standard. Bordo (2003) discusses how the development of institutions like strong, independent central banks has been an important precursor to the widespread adoption of floating currencies by many developed countries since the end of the Bretton Woods system. Giavazzi and Pagano (1988) and Giavazzi and Giovannini (1989) discuss how "tieing ones hands" by to pegging the currency to the German Deutsche Mark an important motivation behind the adoption of the European Exchange Rate Mechanism, the precursor to the euro. Similarly, Calderón and Schmidt-Hebbel (2003) discuss the practice of pegging to gain credibility in many Latin American countries, and Mishkin and Calvo (2003) and Husain, Mody, and Rogoff (2005) discuss this practice in many developing and emerging market economies.

This paper will explore this issue of how the lack of central bank credibility can be a motivation to adopt a currency peg. To do this we will calculate optimal monetary policy in a New Keynesian model of a small open economy, as in Gali and Monacelli (2005) or de Paoli (2009). However, unlike these models, the central bank in this small open economy displays limited credibility (also referred to as loose commitment). As in Schaumburg and Tambalotti (2007) and Debortoli and Nunes (2010) the central bank will renege on previous commitments with a certain exogenous probability. This exogenous commitment probability is known by agents in the model, so the solution to the model a Markov-Perfect equilibrium, where agents form expectations based on the fact that the central bank may renege on past
promises, and the central bank takes those expectations into account when deciding optimal policy.

Perfect commitment and perfect discretion are nested as boundary cases in this model of limited credibility, where the probability of commitment is either 1 (perfect commitment) or 0 (discretion). The optimal policy equilibrium can be solved for all values of the commitment probability along the continuum from perfect commitment to full discretion. When the central bank tries to maximize social welfare taking the probability of commitment as given, as the probability of commitment falls, the outcome from optimal monetary policy gets progressively worse. We show that by including exchange rate stability as an extra term in their objective function, the central bank with limited credibility can significantly improve overall social welfare.

Thus this paper formally analyzes the benefits of exchange rate targeting under discretionary monetary policy. In addition, within the limited credibility framework, where the probability of commitment lies on a continuum between 0 and 1, this paper can analyze the link between the degree of commitment and the degree of exchange rate targeting.

This finding is similar to that in Rogoff (1985), who shows that a central bank that practices discretionary policy can significantly improve overall social welfare by maximizing a central bank objective function that places more weight on inflation stability than the overall social welfare function. In the small open economy model in this paper, the central bank with loose commitment can "tie their hands" by including exchange rate stability in their objective function. The fact that the central bank has this modified objective, and the fact that agents know that the central bank has an exchange rate target will affect the Markov-Perfect equilibrium solution to the game between agents and a central bank with loose commitment. The currency peg helps contain agents' inflation expectations following a shock, and thus optimal policy from a central bank with a modified objective function that includes exchange rate stability can result in a significant improvement in overall social welfare, even though exchange rate stability is not part of the social welfare function.
This is not to say that adopting a modified objective function is an optimal outcome. While adopting an exchange rate peg does result in a significant welfare improvement taking the probability of commitment as given, the central bank that can commit can still deliver a better outcome than a less than credible central bank that adopts a currency peg. As discussed by Mishkin and Calvo (2003) the optimal outcome is for the country to develop the institutions to allow the central bank to commit.

In discussing why some countries may have a "fear of floating", Calvo and Reinhart (2002) present a model where a central bank that lacks credibility would find it optimal to adopt a fixed exchange rate. Herrendorf (1997, 1999) discusses adopting a currency peg as an effective communication device by a central bank that practices discretionary policy. By modeling the central bank in this limited credibility framework, in this paper we are able to model how the optimal weight on exchange rate stability is itself a function of the exogenous commitment probability. We show that the optimal exchange rate regime for a central bank that practices discretionary policy is a fixed peg. Under perfect commitment the optimal regime is a floating exchange rate. As the commitment probability moves along the continuum from discretion to perfect commitment, the optimal exchange rate peg gets looser.¹

We then test the model’s prediction that improvements in central bank credibility lead to looser exchange rate pegs. Using central bank independence as a proxy for central bank credibility (see e.g. Cukierman (1992) and Alesina and Summers (1993)) we show in a panel of 96 developed and developing countries from 1998-2010 that improvements in central bank independence lead to increasing exchange rate flexibility.

In addition to the papers mentioned earlier that explored the relationship between central bank credibility and currency pegs in the historical context, Levy Yeyati, Sturzenegger, Devereux and Engel (2003) and Engel (2011) discuss the optimality of a fixed exchange rate regime, but in these models, the central bank can commit. The prevalence of local currency pricing and the violation of the law of one price either diminishes the expenditure switching benefit of a floating currency or imposes a cost in terms of increased price dispersion. Thus the prevalence of local currency pricing may be a possible motivation behind adopting a fixed exchange rate. That channel is not present in this paper. Here we assume producer currency pricing and that the Law of One Price holds at the level of the individual good.⁴

¹Devereux and Engel (2003) and Engel (2011) discuss the optimality of a fixed exchange rate regime, but in these models, the central bank can commit. The prevalence of local currency pricing and the violation of the law of one price either diminishes the expenditure switching benefit of a floating currency or imposes a cost in terms of increased price dispersion. Thus the prevalence of local currency pricing may be a possible motivation behind adopting a fixed exchange rate. That channel is not present in this paper. Here we assume producer currency pricing and that the Law of One Price holds at the level of the individual good.
and Reggio (2010) show that the strength of political institutions is one key factor in explaining exchange rate regime choice. Similarly, Hakura (2005) finds that exchange rate flexibility in emerging market countries has increased over the past decade, and argues that this “learning to float” appears to have involved a strengthening of monetary and financial policy frameworks in many countries.

The rest of this paper is organized as follows. The New Keynesian model of a small open economy with a central bank with loose commitment is presented in section 2. The results from numerical simulations of the model are presented in section 3. Namely, we calculate the optimal weight that the central bank with limited credibility places on exchange rate stability in its objective function, and show that this optimal weight in a decreasing function of the central bank exogenous probability of commitment. Then with impulse response diagrams we show the response of the output gap, inflation, and the exchange rate following a mark-up shock and see how this response depends on the probability of commitment. By targeting the exchange rate, the optimal policy from central bank with loose commitment can produce impulse responses that look similar to those from optimal policy from a central bank with perfect commitment. In section 4 we present evidence from a panel data model that supports the model’s main finding that as central bank credibility increases, the central bank will loosen the exchange rate peg and move towards a floating exchange rate regime. Finally, section 5 concludes with some suggestions for further research.

2 Model

In the model there are two countries, home and foreign. The home country is of size $n$ and the foreign country is of size $1 - n$, as $n \to 0$, the model becomes that of a small open economy. The small open economy is populated by a representative household and a continuum of firms. Firms employ labor to produce a tradable consumption good and set prices according to a Calvo style price setting framework. In the small open economy there
is a central bank that sets policy to maximize the second-order approximation of household welfare. The central bank displays limited credibility. It can commit and honor past promises only with an exogenous probability $\gamma$ and thus in any period it will renge on past promises and reoptimize policy with some exogenous probability $1 - \gamma$.

### 2.1 Households

In the small open home economy, the representative household chooses consumption, $C_t$, and labor effort, $h_t$, to maximize expected lifetime utility given by:

$$\max \sum_{t=0}^{\infty} \beta^t \left[ \ln (C_t) - \frac{H_t^{1+\eta}}{1 + \eta} \right]$$

where $\beta$ is the household’s discount factor and $\eta$ is the inverse of the Frisch labor supply elasticity.

The consumption good is produced in a perfectly competitive final goods sector that simply aggregates home and foreign goods in a CES production function:

$$C_t = \left(1 - \omega\right)^{\frac{1}{\sigma}} \left[ \left( \frac{1}{n} \right)^{\frac{1}{\sigma}} \int_0^1 C_t^H (i) \frac{\sigma - 1}{\sigma} \, di \right]^{\frac{\sigma - 1}{\sigma - 1}} + (\omega)^{\frac{1}{\sigma}} \left[ \left( \frac{1}{1 - n} \right)^{\frac{1}{\sigma}} \int_0^1 C_t^F (j) \frac{\sigma - 1}{\sigma} \, dj \right]^{\frac{\sigma - 1}{\sigma - 1}}$$

where $C_t^H (i)$ is the quantity of goods sold to the home market by home country firm $i \in [0 \ n]$ and $C_t^F (j)$ is the quantity imported into the home market and sold by foreign country firm $j \in (n \ 1]$. $\theta$ is the elasticity of substitution between home and foreign goods, $\sigma$ is the elasticity of substitution between goods from different firms within the same country, and $\omega$ is the steady-state import share.

From the aggregator function in (2), the demand for either the home consumption good from firm $i$ or the foreign consumption good from firm $j$ are given by:
\[ C_t^H (i) = (1 - \omega) \left( \frac{P_t^H (i)}{P_t^H} \right)^{-\sigma} \left( \frac{P_t^H}{P_t} \right)^{-\rho} C_t \]
\[ C_t^F (j) = \omega \left( \frac{P_t^F (j)}{P_t^F} \right)^{-\sigma} \left( \frac{S_t P_t^F}{P_t} \right)^{-\rho} C_t \]

where \( P_t^H (i) \) is the price set by firm \( i \) and \( P_t^F (j) \) is the price set by foreign firm \( j \) (in the foreign currency). The Law of One Price holds, so if the good has a price \( P_t^H (i) \) in the home market, then its price in the foreign market is \( \frac{P_t^H (i)}{S_t} \), where \( S_t \) is the nominal exchange rate in units of the domestic currency per units of the home currency. Thus the various price indices are given by:

\[
P_t^H = \left( \frac{1}{n} \int_0^n P_t^H (i)^{1-\sigma} \, di \right)^{\frac{1}{1-\sigma}}
\]
\[
P_t^F = \left( \frac{1}{1-n} \int_n^1 \left( S_t P_t^F (j) \right)^{1-\sigma} \, dj \right)^{\frac{1}{1-\sigma}}
\]
\[
P_t = \left[ (1 - \omega) \left( P_t^H \right)^{1-\theta} + \omega \left( S_t P_t^F \right)^{1-\theta} \right]^{\frac{1}{1-\theta}}
\]

In addition, the household’s labor supply decision can be expressed as:

\[
H_t^n = \frac{W_t}{P_t} \frac{1}{C_t} (4)
\]

2.1.1 Asset Market Structure

We assume that asset markets are complete both domestically and internationally. Thus agents have access to a complete set of state-contingent securities. This implies that the intertemporal marginal rate of substitution is equalized across countries:

\[
\frac{C_{t+1}}{C_t} \pi_{t+1} = \frac{S_{t+1}}{S_t} \frac{C_{t+1}^s}{C_t^s} \pi_{t+1}^s
\]
where $\pi_{t+1} = \frac{P_{t+1}}{P_{t}}$ is the inflation rate over the next period. The nominal interest rate $i_t$ is simply given by:

$$i_t = \frac{C_{t+1}}{\beta C_t^*} \pi_{t+1} - 1$$

Using this equation and the definition of the real exchange rate, $Q_t = \frac{S_t P_t^*}{P_t}$, it follows that:

$$Q_t = \frac{C_t}{C_t^*}$$

Thus under complete asset markets, the price of the foreign consumption good relative to the home consumption good, $Q_t$, is equal to the marginal utility of foreign consumption divided by the marginal utility of home consumption.

### 2.2 Firms

Home country firm $i \in [0, n]$ produces output with the following production technology:

$$Y_t(i) = h_t(i)$$

where $h_t(i)$ is the labor employed by the firm in period $t$. Market clearing in the labor market requires that the total demand for labor by firms is equal to the supply of labor from households, $\int_0^1 h_t(i) \, di = H_t$. The firm’s marginal cost of production, $MC_t$, is simply equal to the wage rate.

Firms set prices according to a Calvo price setting framework. In period $t$, the firm will be able to change its price in the domestic market with probability $1 - \xi_p$.

Thus if allowed to change their price in period $t$, the firm will set a price to maximize:

$$\max_{P_t(i)} E_t \sum_{\tau=0}^{\infty} \beta^\tau (\xi_p)^\tau \Lambda_{t+\tau} \left( P_t^H(i) - MC_{t+\tau}(i) \right) Y_{t+\tau}(i)$$
where $\Lambda_t$ is the marginal utility of household consumption in period $t$. The firm that is able to change its price in period $t$ will set its price to:

$$
\tilde{P}_t^H (i) = \frac{E_t \sum_{\tau=0}^{\infty} \beta^\tau (\xi_p)^\tau \Lambda_{t+\tau} MC_{t+\tau} (i) Y_{t+\tau} (i)}{E_t \sum_{\tau=0}^{\infty} \beta^\tau (\xi_p)^\tau \Lambda_{t+\tau} Y_{t+\tau} (i)} 
$$

(9)

where $\mu_t$ is the mark-up that the firm charges over expected future marginal cost. This mark-up is stochastic and follows an AR(1) process with a steady state value $\bar{\mu} = \frac{\sigma}{\sigma-1}$.

Firms that can reset prices in period $t$ will all reset to the same level, so $\tilde{P}_t^H (i) = \tilde{P}_t^H$. Substitute this optimal price into the price index $P_t^H = \left( \int_0^1 \left( P_t^H (i) \right)^{1-\sigma} \, di \right)^{\frac{1}{1-\sigma}}$. Since a firm has a probability of $1 - \xi_p$ of being able to change their price, then by the law of large numbers in any period $1 - \xi_p$ percent of firms will reoptimize prices. Thus the price index for domestic traded goods, $P_t^H$, can be written as:

$$
P_t^H = \left( \xi_p \left( P_{t-1}^H \right)^{1-\sigma} + (1 - \xi_p) \left( \tilde{P}_t^H \right)^{1-\sigma} \right)^{\frac{1}{1-\sigma}}
$$

2.2.1 Derivation of New Keynesian Phillips Curve

The firm’s pricing decision in (9), combined with the labor market equilibrium condition in (4) and the asset market equilibrium condition in (7) yields the following derivation for the New Keynesian Phillips Curve that links the output gap, $\tilde{Y}_t$, to the current and future expected rate of inflation for home country production, $\pi_t^H$ and $E_t \left( \pi_{t+1}^H \right)$:

$$
\pi_t^H = \tilde{\mu}_t + \kappa (1 + \eta) \tilde{Y}_t + \beta E_t \left( \pi_{t+1}^H \right) 
$$

(10)

where $\kappa = \frac{(1-\beta \xi_p)(1-\xi_p)}{\xi_p(1+\eta \sigma)}$. The output gap is defined as the log difference between output and output in the flexible price equilibrium. The details of this derivation can be found in the appendix.
2.3 Monetary Policy

The central bank sets monetary policy in order to maximize the second-order approximation of the household’s welfare in (1). As shown in Gali and Monacelli (2005), this model, the maximization of the second-order approximation of welfare is equivalent to the minimization of the quadratic loss function of the output gap and the inflation rate of home country produced goods:

\[
L = \frac{1}{2} E_0 \sum_{t=0}^{\infty} \beta^t \left[ (1 + \eta) \left( \hat{Y}_t \right)^2 + \frac{\sigma}{K} \left( \pi_t^H \right)^2 \right]
\]  
(11)

We assume that the central bank displays imperfect credibility. Policy makers have a commitment technology, but with a certain exogenous probability they may renege on their earlier commitment. This exogenous probability is known by all agents in the model. This framework has been labeled as quasi-commitment or loose-commitment in Schaumburg and Tambalotti (2007), Debortoli and Nunes (2010), Debortoli, Maih, and Nunes (2014), and Dennis (2014). In any given period, the central bank will honor past commitments with probability \( \gamma \) and it will renege on previous commitments and reoptimize with probability \( 1 - \gamma \).

The central bank will seek to minimize the loss function in (11) subject to the New Keynesian Phillips Curve in (10). Due to the central bank’s limited commitment, the solution will be the solution to a Markov problem, where agents’ expectation of the next period’s inflation rate depends on whether the central bank will honor or renege on their commitment this period. As we will see in the next section, the fact that the central bank displays this loose commitment means that the value of the loss function \( L \) in this Markov-Perfect equilibrium is higher than it would have been if the central bank could fully commit. The possibility that the central bank may \textit{ex-post} renege on prior commitments lowers \textit{ex-ante} social welfare.

To improve \textit{ex-ante} social welfare and partially make up for the fact that the central bank
display limited commitment, the central bank may ex-ante choose to minimize a different loss function than the social loss function. This alternative loss function is known to all agents in the model and is a way to tie the central bank’s hands and force them to adopt a policy that better mirrors the policy under perfect commitment. This alternative loss function doesn’t actually make the central bank able to commit, it still will renege with the exogenous probability $1 - \gamma$. This is similar to the appointment of a conservative central banker in Rogoff (1985). By minimizing a loss function that is different from the social loss function the central bank that cannot perfectly commit can actually lower the value of the social loss function and partially make up for increased social loss that steams from the fact that the central bank cannot commit.

A potential candidate for the alternative central bank loss function is the following:

$$
\tilde{L} = \frac{1}{2} E_0 \sum_{t=0}^{\infty} \beta^t \left[ (1 + \eta) \left( \hat{Y}_t \right)^2 + \frac{\sigma}{\kappa} \left( \pi^H_t \right)^2 + \phi(\gamma) \left( S_t \right)^2 \right]
$$

(12)

where $S_t$ is the level of the nominal exchange rate and $\phi(\gamma)$ is the weight that the central bank places on nominal exchange rate stabilization in their loss function. From the definition of the real exchange rate we can derive the following condition that links changes in the nominal exchange rate to domestic inflation and changes in the output gap:

$$
\hat{Y}_t - \hat{Y}_{t-1} = \hat{S}_t - \hat{S}_{t-1} - \pi^H_t
$$

(13)

From this condition it is clear that by putting weight on the exchange rate in their objective function, the central bank is introducing history dependence into their objective. As shown by Jensen (2002) and Vestin (2006), this history dependence can mitigate the adverse effects arising from a central bank that cannot commit.

The central bank’s problem now is to minimize the loss function in (12) subject to the Phillips curve in (10) and the equation describing exchange rate determination in (13). Of course, when $\phi(\gamma) = 0$, the central bank’s loss function $\tilde{L}$ is identical to the social loss
function $L$. This weight $\phi(\gamma)$ is written as a function of the central bank’s commitment probability $\gamma$ because, as we shall see in the next section, as $\gamma$ decreases, the value of $\phi$ that enables the central bank to minimize the social loss function increases. When $\gamma$ is high and the central bank has a high commitment probability, $\phi$ is small or even zero, indicating that the central bank places very little weight on nominal exchange rate stability. As $\gamma$ falls and the central bank has greater trouble honoring past commitments, $\phi$ rises. For some small values of $\gamma$, $\phi$ is so high that the optimal policy of the central bank is to adopt a fixed exchange rate. By adopting a fixed exchange rate, the central bank is deciding that since they have such a problem with ex-post commitment, the best way to maximize social welfare is to ex-ante remove themselves from the monetary policy making process.

\section{2.4 Calibration}

The calibrated values of the different parameters in the model are presented in table 1. These parameter values are all taken from either Gali and Monacelli (2005) or de Paoli (2009). The Calvo (1983) price stickiness parameter is set such that firms reset price on average once a year. In the next section we show how the results of the model change under different values of this price stickiness parameter. The subjective discount factor is set such that the steady state annualized real interest rate is about 4%. The inverse of the Frisch labor supply elasticity and the elasticity of substitution between differentiated goods from the same country are both from de Paoli (2009). The unitary elasticity of substitution between home and foreign goods is taken from Gali and Monacelli (2005).

Numerical simulations of the model are calculated in response to home country mark-up shocks. We assume that these shocks follow an AR(1) process with an autoregressive parameter of $\rho = 0.8$. In the next section we show how the results of the model change under different values of this parameter. Since the numerical simulations are calculated with a first-order linearization, assume that these shocks have a standard deviation of 1%.
3 Model Results

In the last section we discussed the intuition behind why a central bank with loose commitment might want to alter their own objective function in order to deliver a better outcome for overall social welfare. Intuitively the $\phi$ parameter that determines the weight that the central bank puts on exchange rate stability should itself be a decreasing function of the central bank’s ability to commit, $\gamma$. First we will calculate the optimal value of $\phi$ from numerical simulations of the model. Then we will plot some impulse responses to show how the central bank adopting a policy that deviates from the social loss function can affect the responses of the output gap, inflation, the exchange rate, and the nominal interest rate following a mark-up shock. Finally we show how the various parameters in the model, like the degree of price stickiness or shock persistence might affect the optimal weight that a quasi-credible central bank places on exchange rate stability.

3.1 The optimal weight on exchange rate stability, $\phi$

Some results from numerical simulations of the model are presented in figure 1. The four plots in the figure are the variance of the output gap, $\hat{Y}_t$, the variance of the inflation rate on home production, $\pi^H_t$, the variance of the nominal exchange rate, $S_t$, and the social loss $L$ from (11). Note that the social loss function is simply a weighted sum of the variances of the output gap and the inflation rate. The figure plots the value of these variance from a Markov-Perfect equilibrium numerical solution to the model under different values of the weight that the central bank places on nominal exchange rate stability in its own objective function, $\phi$, and different values of the limited credibility parameter $\gamma$.

Note first that for any given value of $\phi$, the variances of the output gap and the inflation rate, and hence the social loss function are strictly decreasing functions of the central bank’s ability to commit $\gamma$. A central bank that is better able to commit will deliver lower variability in both the output gap and the inflation rate, and hence a lower value of the social loss
function. The values of the social loss function under different values of the commitment probability $\gamma$ are summarized in table 2. When the central bank does not place any weight on exchange rate stabilization in their loss function, social loss under optimal policy with perfect credibility, $\gamma = 1$, is 0.47. When $\gamma = 0.7$, the value of the social loss function rises to 0.94, and when $\gamma = 0.3$ it rises to 2.21. When $\gamma = 0$ and the central bank is fully discretionary, the value of the social loss function is 3.74.

In the case of perfect credibility, $\gamma = 1$, the value of the social loss function is monotonically increasing in the weight that the central bank puts on exchange rate stability in their own loss function, and thus when $\gamma = 1$, the central bank’s optimal choice of $\phi = 0$. When $\gamma = 0.7$, the value of the social loss function is initially decreasing in $\phi$, and the social loss function is minimized when $\phi = 1.46$. By placing a small amount of weight on exchange rate stability in their own loss function, the central bank is able to lower the value of the social loss function to 0.87. When $\gamma = 0.6$, this optimal value of $\phi$ rises to 3.46. When $\gamma = 0.5$ the optimal value rises to 6.86. When $\gamma = 0.4$ it rises to 13.81. When $\gamma = 0.3$ the optimal value of $\phi$ is 36.76 and the central bank has nearly completely tied their own hands and adopted a fixed exchange rate. By sacrificing their monetary independence, the central bank with limited credibility parameter $\gamma = 0.3$ is able to lower the social loss from 2.21 to 1.04.

One way to read the results in table 2 is to say that for a low enough value of the exogenous commitment probability $\gamma$, the central bank is "committing" to maintain a fixed exchange rate. Of course in this limited credibility model, the central bank’s commitment probability is fixed. For a high enough value of $\phi$ in its objective function, the central bank really only cares about exchange rate stability. Suppose that in the previous period it promised to maintain a fixed exchange rate, and with probability $1 - \gamma$ it is allowed to reoptimize this period. Since it only really cares about exchange rate stability, it will still maintain a fixed exchange rate. So even though the central bank was able to renge on past promises and reoptimize, it will appear as if past commitments were honored. For a high enough weight on the exchange rate in the loss function, it doesn’t matter whether the
central bank honors past promises or reneges, it will always choose the same thing. Hence, all functions under different values of $\gamma$ will converge as $\phi \to \infty$ in figure 1.

### 3.2 Impulse Responses

The responses of the output gap, inflation, the nominal exchange rate, and the nominal interest rate following a mark-up shock are presented in figure 2. The blue line in each figure is the response when the central bank has perfect credibility, $\gamma = 1$. The red line in each figure is the response when the central bank has limited credibility and places no weight on exchange rate stabilization in their loss function, $\phi = 0$. In the left-hand column in the figure, the probability of commitment is low, $\gamma = 0.3$. In the middle column of responses, $\gamma = 0.5$, and in the right-hand column, $\gamma = 0.7$. The green line in each figure represents the impulse response when the central bank is putting some weight on exchange rate stabilization in their objective function, and this weight is chosen to minimize the social loss function taking the probability of commitment, $\gamma$, as given. Thus in the left-hand column, the weight on exchange rate stabilization in the central bank’s objective function $\phi = 36.76$. In the middle column $\phi = 6.86$, and in the right-hand column $\phi = 1.46.$

The responses show that when the central bank with perfect credibility responds optimally to the mark-up shock, there is a fall in the output gap, an increase in inflation, and an appreciation in the nominal exchange rate. When the central bank has limited credibility these responses are amplified. Equilibrium in this limited credibility model is solved as a Markov-Perfect equilibrium. Agents know that the central bank has limited credibility and it likely to reneg on past commitments. This means that following a shock, inflation expectations rise by more than they would have under perfect commitment. Knowing that this will happen, the central bank that takes its limited credibility as given is forced to tighten monetary policy by more than they would have under perfect commitment.

If the central bank takes its limited credibility as given and minimizes the social loss function by placing some weight on stabilizing the nominal exchange rate, the central bank
is not forced to tighten monetary policy by near as much and still keep inflation under control. In the green line in the figure the bank does not tighten monetary policy as much following the mark-up shock and thus there is less fall in the output gap and less exchange rate appreciation than there would have been if the central bank with limited credibility did not target the exchange rate. The figure shows that in the case of the central bank with low credibility, \( \gamma = 0.3 \), the bank’s optimal policy is to nearly completely tie their own hands and adopt a fixed exchange rate. In this case, since the foreign interest rate remains constant, the central bank would maintain a constant nominal interest rate. Under this policy the central bank with limited credibility is able to keep inflation expectations and inflation in check.

However, adopting a fixed exchange rate is not without costs. As shown in table 2, the value of the social loss under the fixed exchange rate regime is 1.05 compared to that under the optimal policy from a central bank that can commit of 0.47. As shown in figure 2, the central bank with limited credibility that chooses to fix the nominal interest rate cannot change the nominal interest rate. The central bank that can commit is able to lower the interest rate in the immediate aftermath of the shock and then increase it. The central bank with limited credibility is able to markedly improve their outcome by fixing the nominal exchange rate, but by holding the nominal interest rate constant, they lose a key instrument of monetary policy and so are still worse off than optimal policy under full commitment.

### 3.3 The role of price stickiness or shock persistence

The results from numerical simulations of the model to find the optimal value of \( \phi \) in the central bank’s objective function in versions of the model with varying degrees of price stickiness is presented in figure 3. This figure has the same layout as in the benchmark figure 1 presented earlier, except here the level of central bank credibility is held fixed at \( \gamma = 0.5 \) throughout and we are varying the Calvo price stickiness parameter \( \alpha \) from 0.7 to 0.8.
Of course, the numerical results where $\alpha = 0.75$ in figure 3 corresponds to the numerical results where $\gamma = 0.5$ in figure 1. When $\alpha = 0.75$ and $\gamma = 0.5$, the optimal weight on exchange rate stabilization in the central bank’s objective function is $\phi = 6.86$. However, the figure shows that when $\alpha$ increases and prices become stickier, the optimal weight $\phi$ increases.

As far as the other terms in the central bank’s objective function in (12), the weight on the square of the output gap is unchanged when $\alpha$ increases, and the weight on the square of inflation decreases when $\alpha$ increases. So given that the weight on the output gap is unchanged, the weight on inflation decreases, and the weight on the nominal exchange rate increases as $\alpha$ increases, as prices become stickier, the central bank with limited credibility will favor a stricter exchange rate peg. Since sticky prices are the means through which monetary policy has a real effect in this New Keynesian model, as prices become stickier, the central bank’s lack of credibility becomes more of a problem. In this case, the central bank will be more inclined to tie their hands and adopt a fixed exchange rate.

Similarly, the results from the same numerical simulations to find an optimal $\phi$ in versions of the model with varying degrees of mark-up shock persistence is presented in figure 4. Here the level of central bank credibility is held fixed at $\gamma = 0.5$ and the Calvo price stickiness parameter is held fixed at $\alpha = 0.75$ and the shock persistence parameter varies from 0.7 to 0.9.

The numerical results when the persistence parameter $\rho = 0.8$ in figure 4 corresponds to the numerical results where $\gamma = 0.5$ in figure 1 and where $\alpha = 0.75$ in figure 3. The figure shows that as the persistence parameter $\rho$ increases the optimal value of $\phi$ increases. As far as the other terms in the central bank’s objective function in (12), both the weight on the square of the output gap and the weight on the square of inflation are unchanged when the persistence parameter $\rho$ increases. Thus as mark-up shocks become more persistent, the central bank with limited credibility will favor a stricter exchange rate peg.
4 Empirical

The model in the previous section shows how a central bank that cannot fully commit to future actions can improve their monetary policy outcome by choosing to peg the nominal exchange rate to that of a more credible partner. In this section we show empirical evidence that as a central bank gains credibility, it tends to loosen any currency pegs and adopt a floating exchange rate.

4.1 Empirical model, variables, and data

To establish this empirical link between central bank credibility and a floating exchange rate, we will estimate a panel data model with an index of exchange rate flexibility as the dependent variable and a proxy for central bank credibility as the independent variable.

An index of whether a country has a fixed or floating exchange rate is from Ilzetzki, Reinhart, and Reinhart (2008). This index varies from (1) - "no separate legal tender" to (13) - "freely floating" and in between covers varying degrees of exchange rate pegs. The exact definitions for each of the 13 index values are found in the appendix. We use annual data from 96 countries over 13 years, from 1998-2010. The full list of countries can be found in the appendix.

As a proxy for central bank credibility we use the index of central bank independence from Dincer and Eichengreen (2013). Central bank independence has been used as a proxy for central bank credibility and institutional quality from as early as Cukierman (1992) and Alesina and Summers (1993). Blinder (2000) reports that a vast majority of both central bank governors and academic economists cited central bank independence as one of the most important factors behind central bank credibility.

As control variables in this panel data regression we add trade openness (the sum of exports and imports divided by GDP), the inflation rate in the previous year, the GDP growth rate in the previous year, and an indicator variable equal to one if a country has
adopted inflation targeting.

4.2 Empirical Results

The results from this panel data regression of exchange rate flexibility on central bank independence is presented in tables 3 and 4. Table 3 presents the results from the panel that includes all 96 countries, table 4 presents the results for the subsample of 75 developing and emerging market countries.

Table 3 shows that when cross-section fixed effects are not included in the panel data regression, there is a strong negative correlation between central bank independence and exchange rate flexibility. This suggests that there is a strong negative correlation between the two in the cross-section. The Euro Area countries in the sample drive this negative correlation. These are countries with a very independent central bank that score a 1 on the fixed-floating index. This strong negative cross-sectional correlation disappears in the sub-panel of only developing and emerging market countries.

Including cross-section fixed effects controls for the cross-sectional correlation between central bank credibility and the index of exchange rate flexibility. The coefficient of central bank independence is now positive and significant, indicating that when central bank independence improves in year \( t - 1 \), holding all else equal, the index of exchange rate flexibility will shift towards floating in year \( t \).

The table shows that this fact holds throughout the various regression specifications with cross-section fixed effects. This link between increases in central bank independence and increased exchange rate flexibility is especially true when we control for whether or not a country has adopted inflation targeting. It also holds whether we include one or two lags of central bank independence. When we include two lags, the sum of the coefficients on the two lags is significantly positive. The coefficient on trade openness is positive and significant, indicating that holding all else equal, as a country becomes more open the central bank allows more flexibility in the exchange rate. The lagged values of the inflation rate or the
GDP growth rate do not have an effect on the degree of exchange rate flexibility.

Table 4 shows that these same results hold not just for the full panel of 96 countries but for the sub-panel of 75 developing and emerging market countries. Thus in both developed and developing counties, when central bank independence improves in year $t-1$, holding all else equal, the index of exchange rate flexibility shifts towards floating in year $t$.

5 Summary and Conclusion

Historically, the lack of central bank credibility has been a motivation to adopt a currency peg. This paper sought to model this motivation in a small open economy where the central bank cannot perfectly commit to a future course of policy. In the model the central bank has limited credibility, with some exogenous probability it will renege on its previous promises and re-optimize. The limited credibility of the central bank imposes a welfare cost on society. Inflation and inflation expectations are not well anchored if agents assume that the central bank will renege on past promises. In this case, the social welfare is actually improved by assigning the central bank to minimize a loss function which is different from the social loss function. By including a term for nominal exchange rate stabilization in their loss function, even though the social loss does not contain a role for exchange rate stabilization, the central bank with limited credibility can communicate their commitment to keeping inflation low and stable, and thus inflation expectations remain anchored. The central bank with limited credibility can deliver a significant welfare improvement by adopting an objective function that contains a role for exchange rate stabilization. This paper conducted numerical simulations to find the optimal weight on the exchange rate. For a central bank that can perfectly commit, this optimal weight is 0, and thus optimal policy is a floating currency. For a central bank that practices discretionary policy, the optimal policy is to adopt a fixed exchange rate.

In this model, limited credibility had a specific meaning. It meant the probability that
the central bank will honor past commitments. In technical terms, it is the probability that previous inflation expectations appear as a constraint in the central bank’s maximization problem. The central bank still has the same underlying preferences and discount factor as the rest of society.

In many historical cases of a central bank that lacks credibility, the central bank or monetary authority actually has different preferences from the rest of society. This is most clearly illustrated when monetary policy is in the hands of an elected politician. Here one could say that the elected politician has a different discount factor or places a different weight on output in the output/inflation trade-off that society at large, and may try to stimulate the economy in the short run in order to win an upcoming election, at the cost of higher inflation in the long-run, after the election. Historically, this type of monetary arrangement has led to high and variable inflation, and many countries have been forced to adopt currency pegs, currency boards, or complete dollarization in order to control inflation arising from a monetary authority with different preferences than society at large. That channel is not included in this model. Here the central bank can’t commit but its preferences are the same as the rest of society. An interesting direction for further research would be to see how the motivation to peg the currency can also depend on the central bank’s preferences. This paper shows that limited credibility can be a motivation, what about a monetary authority that is less patient than the rest of society. Would the impatient central banker have the same motivation to tie their hands?
References


A Appendix

A.1 Model

A.1.1 Derivation of New Keynesian Phillips Curve

As presented in the text, the optimal price for a firm that can change their price, $P^H_t$, is given by:

$$P^H_t = \mu_t \frac{E_t \sum_{\tau=0}^{\infty} \beta^\tau (\xi_p)^\tau \Lambda_{t+\tau} M C_{t+\tau} (i) Y_{t+\tau} (i)}{E_t \sum_{\tau=0}^{\infty} \beta^\tau (\xi_p)^\tau \Lambda_{t+\tau} Y_{t+\tau} (i)}$$

Furthermore, the expression for the evolution of the home goods price index is:

$$P^H_t Y_t = \frac{1}{n} \int_{0}^{\pi} P^H_t (i) Y_t (i) \, di$$

$$P^H_t = \left( \xi_p \left( P^H_{t-1} \right)^{1-\sigma} + (1 - \xi_p) \left( P^H_t \right)^{1-\sigma} \right)^{\frac{1}{1-\sigma}}$$

The linearized form of these two expressions is given by:

$$\hat{P}^H_t = \hat{\mu}_t + (1 - \beta \xi_p) \left( M \hat{C}_t (i) \right) + \beta \xi_p E_t \left( \hat{P}^H_{t+1} \right)$$

$$\hat{P}^H_t = \xi_p \left( \hat{P}^H_{t-1} \right) + (1 - \xi_p) \hat{P}^H_t$$

Furthermore note that the linearization of the price index can be rewritten as $\hat{P}^H_t = \hat{P}^H_t + \frac{\xi_p (1+\eta \sigma)}{(1-\xi_p)} \pi^H_t$ and $E_t \left( \hat{P}^H_{t+1} \right) = E_t \left( \hat{P}^H_{t+1} \right) + \frac{\xi_p (1+\eta \sigma)}{(1-\xi_p)} E_t (\pi^H_{t+1})$. After a few substitutions, the New Keynesian Phillips Curve equation is given by:

$$\pi^H_t = \hat{\mu}_t + \frac{(1 - \beta \xi_p) (1 - \xi_p)}{\xi_p (1 + \eta \sigma)} \left( M \hat{C}_t - \hat{P}^H_t \right) + \beta E_t (\pi^H_{t+1})$$

Recall that $\hat{P}_t = (1 - \omega) \hat{P}^H_t + \omega \left( \hat{S}_t + \hat{P}^F_t \right)$, $\hat{Q}_t = \hat{S}_t + \hat{P}^F_t - \hat{P}_t$, $M \hat{C}_t = \hat{W}_t$, and from
the household’s labor supply decision \( \eta \hat{H}_t + \hat{C}_t = \hat{W}_t - \hat{P}_t \), then we can write the NKPC as:

\[
\pi^H_t = \mu_t + \left( \frac{1 - \xi_p}{\xi_p (1 + \eta \sigma)} \right) \left( \eta \hat{H}_t + \hat{C}_t + \frac{\omega}{1 - \omega} \hat{Q}_t \right) + \beta E_t (\pi^H_{t+1})
\]

Recall that \( \hat{Y}_t = \hat{H}_t + \sigma \hat{P}^H_t - \sigma \int_0^1 \hat{P}^H_t (i) di, \hat{Q}_t = \hat{C}_t - \hat{C}_t^* \) and \( Y_t = C^H_t + C^F_t \). After substituting the demand functions for home country consumption of home goods, \( C^H_t \), and foreign country consumption of home goods, \( C^F_t \) this last expression can be written as:

\[
\begin{align*}
\pi^H_t &= \mu_t + \left( \frac{1 - \xi_p}{\xi_p (1 + \eta \sigma)} \right) \left( \eta \hat{Y}_t - \sigma \hat{P}^H_t + \sigma \int_0^1 \hat{P}^H_t (i) di \right) + \hat{C}_t + \frac{\omega}{1 - \omega} \hat{Q}_t + \beta E_t (\pi^H_{t+1}) \\
\pi^H_t &= \mu_t + \left( \frac{1 - \xi_p}{\xi_p (1 + \eta \sigma)} \right) \left( \eta \hat{Y}_t + \hat{C}_t + \frac{\omega}{1 - \omega} \hat{Q}_t \right) + \beta E_t (\pi^H_{t+1})
\end{align*}
\]

\[
Y_t = \left( \frac{P^H_t}{P_t} \right)^{-\theta} \left[ (1 - \omega) C_t + \omega \left( \frac{1}{Q_t} \right)^{-\theta} C^*_t \right]
\]

When \( \theta = 1 \), this reduces to (after linearization):

\[
\hat{Y}_t = \frac{\omega}{1 - \omega} \hat{Q}_t + \hat{C}_t
\]

Thus the New Keynesian Phillips Curve can be written as:

\[
\pi^H_t = \mu_t + \left( \frac{1 - \xi_p}{\xi_p (1 + \eta \sigma)} \right) \left( 1 + \eta \right) \hat{Y}_t + \beta E_t (\pi^H_{t+1})
\]

### A.2 Countries in the Estimation

The 96 countries, 21 developed and 75 developing and emerging markets, in the panel data regressions are:

Developed countries: Australia, Austria, Belgium, Canada, Germany, Spain, Finland, France, UK, Greece, Ireland, Italy, Japan, Korea, Luxembourg, Netherlands, Norway, New
Zealand, Portugal, Sweden, USA

Developing countries: Angola, Albania, Argentina, Armenia, Azerbaijan, Bulgaria, Bahamas, Bosnia, Belarus, Belize, Barbados, Bhutan, Botswana, Chile, China, Colombia, Czech Republic, Estonia, Fiji, Georgia, Guyana, Croatia, Hungary, Iceland, Indonesia, India, Israel, Jamaica, Jordan, Kenya, Kyrgyzstan, Cambodia, Laos, Sri Lanka, Lesotho, Lithuania, Latvia, Moldova, Maldives, Mexico, Macedonia, Mongolia, Mozambique, Mauritius, Malawi, Malaysia, Namibia, Nigeria, Oman, Peru, Philippines, Papua New Guinea, Poland, Romania, Russia, Saudi Arabia, Singapore, Solomon Islands, Sierra Leone, El Salvador, Seychelles, Syria, Thailand, Trinidad and Tobago, Tunisia, Turkey, Tanzania, UAE, Uganda, Venezuela, Vanuatu, Samoa, Yemen, South Africa, Zambia
Table 1: Model parameter values.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
<th>Explanation</th>
</tr>
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<td>$\alpha$</td>
<td>0.75</td>
<td>Percent of firms that cannot change price in a given period</td>
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<td>$\beta$</td>
<td>0.99</td>
<td>Subjective discount factor</td>
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<td>$\eta$</td>
<td>0.47</td>
<td>Inverse of the Frisch elasticity</td>
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<tr>
<td>$\sigma$</td>
<td>10</td>
<td>Elasticity of substitution among differentiated goods from same country</td>
</tr>
<tr>
<td>$\theta$</td>
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<td>Elasticity of substitution between home and foreign goods</td>
</tr>
<tr>
<td>$\kappa$</td>
<td>0.015</td>
<td>$\frac{(1-\beta \xi_p)(1-\xi_p)}{\xi_p(1+\eta \sigma)}$</td>
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Table 2: Welfare loss under optimal policy for different values of the commitment probability parameter, and under the situation where the central bank places weight on the exchange rate in their objective function, the optimal weight on exchange rate stabilization.

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Table 3: Results from a panel data regression of an index of currency flexibility on central bank independence. Results from the full sample of 96 countries.

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<th>(4)</th>
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<th>(6)</th>
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<td>Ind(t-1)</td>
<td>1.332*</td>
<td>1.649**</td>
<td>0.978</td>
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<td>-4.609**</td>
<td>-0.032</td>
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<td>0.689</td>
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<td></td>
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<td></td>
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<td>3.277</td>
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<td>0.987</td>
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Notes: Standard errors in parenthesis. * denotes significance at the 10% level, ** denotes significance at the 5% level.
Table 4: Results from a panel data regression of an index of currency flexibility on central bank independence. Results from a sample of 75 emerging market and developing economies.

<table>
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Notes: Standard errors in parenthesis. * denotes significance at the 10% level, ** denotes significance at the 5% level
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<td>Pre announced horizontal band that is narrower than or equal to +/-2%</td>
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<tr>
<td>4</td>
<td>De facto peg</td>
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<td>Pre announced crawling peg</td>
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<td>Pre announced crawling band that is narrower than or equal to +/-2%</td>
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<tr>
<td>11</td>
<td>Moving band that is narrower than or equal to +/-2% (i.e., allows for both appreciation and depreciation over time)</td>
</tr>
<tr>
<td>12</td>
<td>Managed floating</td>
</tr>
<tr>
<td>13</td>
<td>Freely floating</td>
</tr>
</tbody>
</table>
Figure 1: Variances of the output gap, inflation, the nominal exchange rate, and the social loss function as a function of the weight that the planner places on nominal exchange rate stability in their objective function. Shown as the probability of commitment parameter varies from 0.3 (blue line) to 0.7 (green line).
Figure 2: Responses of the output gap, the inflation rate, and the nominal exchange rate to a positive cost-push shock. Blue line is from the model with perfect credibility, red line is from the model where the probability of commitment is only $\gamma$, green line is from the model where the probability of commitment is $\gamma$ but the central bank places the optimal weight on the exchange rate in their objective function. In the left-hand column $\gamma = 0.3$, in the middle column $\gamma = 0.5$, and in the right-hand column $\gamma = 0.7$. 
Figure 3: Variances of the output gap, inflation, the nominal exchange rate, and the social loss function as a function of the weight that the planner places on nominal exchange rate stability in their objective function. Shown as the Calvo price stickiness parameter varies from 0.7 (blue line) to 0.8 (green line).
Figure 4: Variances of the output gap, inflation, the nominal exchange rate, and the social loss function as a function of the weight that the planner places on nominal exchange rate stability in their objective function. Shown as the AR(1) persistence parameter of the cost-push shock process varies from 0.7 (blue line) to 0.9 (green line).