Uncertain potential output: implications for monetary policy in small open economy *

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Abstract

A huge literature analyzes the performance of simple rules in closed-economy models when the policy-maker observes only a noisy measure of the state of the economy. This paper extends the analysis to a small-open economy new keynesian model. Passing from a closed-economy model to an open-economy one, there is another simple policy rule available to the central bank, namely the exchange rate peg. Hence, evaluating the performance of simple rules allows us to assess if the choice of the exchange rate regime depends on the uncertainty about the true state of the economy. Evaluating the conduct of monetary policy in terms of a Taylor rule, this paper shows that not reacting to the exchange rate yields better outcomes in terms of a welfare-based loss function and quantifies for which parameter configuration (in terms of the reaction to the exchange rate and the domestic inflation rate), the fixed exchange rate regime is to be preferred. The analysis is done both with complete and with incomplete information.

Keywords: Small open economy; Exchange rate regime; Monetary policy rules; Uncertainty

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1 Introduction

In most DSGE models, the conduct of a central bank is evaluated according to the variance of inflation and the output gap. In the models which deviate from the workhorse DSGE model, other variables enter the welfare-based loss function, but inflation and the output gap always contribute to welfare in a relevant way. More recently, the new-Keynesian open economy models have provided us with a microfounded, dynamic, stochastic and general equilibrium model such that monetary policy does have real effects. Clarida et al. (2001, 2002) and Galí and Monacelli (2005) highlighted the analogy between a new Keynesian model in closed and in open economy. As pointed out by Galí and Monacelli, however, the derivation of a welfare-based loss function in a small-open economy model is possible only under a particular calibration. Following this *ad hoc* calibration, Galí and Monacelli prove that an exchange rate peg is worse in welfare terms than a floating regime because it limits the possibility of influencing the terms of trade in a way beneficial to domestic consumers. De Paoli (2009) derives a more general welfare criterion for a small-open economy, showing that the optimal policy in a small open economy is not isomorphic to a closed economy and does not prescribe a pure floating exchange rate regime. Domestic inflation targeting, in fact, is optimal only under a particular parameterization, where the unique relevant distortion in the economy is price stickiness.

In this paper I analyze the implications of incomplete information on potential output for the conduct of monetary policy in a small-open economy. This paper will also assess the performance of a fixed versus a floating exchange rate system in the case of complete information and relaxing the latter assumption. The existing literature focuses mainly on the effects of uncertainty in closed economy. Ehrmann and Smets (2003), using a calibrated model of the euro area, show that the loss due to incomplete information about potential output is significant. Since the central bank cannot distinguish between a cost-push shock and a shock to potential output, after a negative cost-push shock, it assigns some probability that a positive supply shock hits the economy. As a consequence, the policy reaction will consist in lowering the interest rate by more than it would otherwise done, leading to a larger response in the output gap and a smaller fall in inflation. Even if imperfect information about the potential output lowers the optimal response in the estimated output gap, Taylor rules perform relatively well when the output gap is optimally estimated. In open economy, incomplete information on the potential output can originate in the domestic economy or abroad, hence there exist more sources of uncertainty that can affect the central bank and the private sector to perfectly know it. To my knowledge, this paper is the first attempt to assess the consequences of uncertain potential output in open economy. Other contributions dealing with uncertainty in open-economy models have focused on other issues. Leitemo and Söderström (2005) analyze the performance and robustness of simple rules for monetary policy in a New-Keynesian open-economy model under exchange rate uncertainty, modeled as deviation from the uncovered interest rate parity, in terms of 1) the formation of exchange rate expectations, 2) varying degrees of risk premium persistence.

Using the small-open economy DSGE model developed in the recent literature, I assume that potential output is unobservable for the central bank and the private sector that share the same incomplete information set and estimate the state of the economy through Kalman filtering. The small-open economy can be summarized in a linear-quadratic setup and this allows me to assess the effects of uncertain potential output following the methodology in Svensson and Woodford (2003) and Ehrmann and Smets (2003). In closed economy models, the presence of noisy information is often a rationale for cautious policies[1]. Does this principle extend to the open-economy models? Among the simple rules available in open economy, there is of course the possibility of pegging the exchange rate. Hence, should a central bank with incomplete information tie his hands? The main results of the paper are two. First of all, the Taylor rule that performs better does not include a term in the exchange rate. Second, both under complete and incomplete information, there exists a parameter combination in the policy coefficients such that the exchange rate peg performs well or better than an independent monetary policy.

One of the simple rules available to the central bank in open economy is the exchange rate peg. This paper analyzes if the presence of incomplete information about potential output motivates to adopt a fixed exchange rate regime. Giavazzi and Pagano (1988) shows that fixed exchange rate dominates the other alternative policies because an *inflation-prone* country

[1] See, for example, Ehrmann and Smets (2003) and several contributions by Orphanides.

can borrow credibility from a central bank who credibly aims at stabilizing prices. To that extent, "tying central bank's hands" allows to reach a stable inflation. Soffritti and Zanetti (2007) find mixed evidence about the desirability of fixing the exchange rate: time-consistent monetary policy leads to a lower loss than a policy that fixes the exchange rate, but the exchange rate peg is preferable when the policymaker maximizes the agent's utility. More recently, Ravenna (2011) shows that 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 beliefs are not consistent with the central bank's dependability.

The paper is organized as follows. Section 2 describes briefly the log-linearised version of the small-open economy model. In section 3 the information structure is modeled, while section 4 discusses how the monetary policy is conducted. Section 5 provides a numerical evaluation of monetary policy rules under complete and incomplete information. Section 6 concludes, while and appendix shows the main ingredients of the model that had been presented in log-linear terms in section 2.

2 The model

The small open economy is modeled following Galí and Monacelli (2005) and De Paoli (2009). The baseline framework consists of a small open economy DSGE model with complete asset markets, monopolistic competition in production and sticky prices à la Calvo. There is complete pass-through and monetary frictions are absent by considering a cashless economy. The law of one price holds, but home bias in private consumption leads to deviations from purchasing power parity. Since the model is analogous to the small open economy version present in De Paoli, I will present the relevant log-linearised equilibrium relationships, before focusing on the main contribution of the paper about the signal-extraction problem in open economy. Throughout the paper, I denote with an asterisk all the variables referred to the world economy. The equilibrium relationships are a IS schedule, a new Keynesian Phillips curve and the uncovered interest parity respectively.

The IS schedule reads as

$$y_t = E_t y_{t+1} - (B+\lambda A) E_t c^*_{t+1} + (B+\lambda A) c^*_t + E_t \left(g_{t+1} - g_t\right) - \frac{A(1-\lambda)}{\rho} \left(r_t - E_t \pi_{H,t+1}\right) \tag{1}$$

where y_t is real output and $\pi_{H,t}$ stands for domestic inflation rate. In the IS there are two shocks: c^*_t denotes foreign consumption, while g_t indicates government spending. r_t is the interest rate, λ is a parameter indicating the degree of home bias, A and B depend on structural parameters[2], and ρ^{-1} is the intertemporal elasticity of substitution.

The new Keynesian Phillps curve is expressed in terms of domestic inflation

$$\pi_{H,t} = \beta E_t \pi_{H,t+1} + \kappa \left(\eta \left(y_t - y^T_t\right) + (1-\lambda)^{-1} \left(q_t - q^T_t\right) + u_t\right) \tag{2}$$

In (2) β is the discount factor, η^{-1} denotes the Frisch elasticity of labor supply, y^T_t is the output target for optimal monetary policy and κ denotes the Phillips' curve slope. As shown by previous contributions, policy targets usually do not correspond to the flexible price allocation. More in detail, y^T_t is generally different from the flexible price allocation for output y^{flex}_t[3]. Another consequence of being in small open economy is that Phillips curve is also affected by the difference between the real exchange rate q_t and its target value q^T_t. Finally, the term u_t is a function of the distance between real output and the output arising under the flexible price allocation, and of the difference between the real exchange rate and its level under the flexible price allocation[4]. Even if it is not evident in (2) and (1), there are two other shocks affecting the dynamics of the model through the definition of target variables and the variables arising under the flexible price allocation: a

[2]More in detail,

$$A \equiv \frac{\rho\theta\lambda(2-\lambda) + (1-\lambda)^2}{1-\lambda}$$
$$B \equiv \frac{\lambda(1-\lambda) - \rho\theta\lambda(2-\lambda)}{1-\lambda}$$

[3]As shown in Benigno and Woodford (2005), monetary policy should mimic the flexible price allocation only if the steady-state level of production is inefficient and there are no mark-up fluctuations.

[4]Please refer to the appendix or to De Paoli (2009) for the exact formulae.

mark-up shock μ_t and a productivity shock ε_t. All shocks are assumed to be first-order autoregressive and below I will define their statistical properties.

The loss function used to evaluate the conduct of the central bank is given by the following quadratic function that reflects the second-order Taylor expansion of the utility function:

$$\mathcal{L}_t = \frac{1}{2} E_t \sum_{t=0}^{\infty} \beta^t \left[\Phi_y \left(y_t - y_t^T \right)^2 + \Phi_q \left(q_t - q_t^T \right)^2 + \Phi_\pi \pi_{H,t}^2 \right] \tag{3}$$

The welfare loss (3) includes distortions arising from the presence of price stickiness and monopolistic competition. These distortions justify the presence of the terms in $y_t - y_t^T$ and in $\pi_{H,t}$. Being in open economy, there is a third term the central bank should consider, namely the difference $q_t - q^T$, that is the result of the imperfect substitutability between domestic and foreign goods which determines a terms of trade externality. As a consequence, the policymaker tries to influence the terms of trade in favor of domestic consumers.

Complete risk sharing and the small open economy aggregate demand jointly determine the following relationship between output and the real exchange rate (both in deviations from their respective targets):

$$y_t - y_t^T = \left(q_t - q_t^T \right) \left(\frac{1 + l}{\rho(1 - \lambda)} \right) + \chi_t \tag{4}$$

with l depending on the structural parameters and χ_t function of the structural shocks[5]. The solution strategy involves to plug (4) into (2) and (3) so as to express the loss function in terms of output and domestic inflation (as a deviation from their targets) on one hand, and the new Keynesian Phillips curve only in terms of two jump variables, y_t and $\pi_{H,t}$, and the exogenous variables, on the other hand. Under the assumption of complete international financial markets, the uncovered interest parity condition must hold and the expected variation of the exchange rate between t and $t+1$ is related to the interest rate differential:

$$r_t - r_t^* = E_t \Delta e_{t+1} \tag{5}$$

[5]Please refer to the Appendix for the exact expressions.

3 Information structure

The model is solved with complete information and with incomplete information. When solving the incomplete information case, I assume that potential output is unobservable. Being in a small open economy model, the potential output $\overline{y}_t$ will be affected by domestic and foreign variables[6],

$$\overline{y}_t = -\frac{(1-\lambda)^{-1}}{\eta + \frac{\Omega}{1-\lambda}} + \left(\frac{\Omega}{1-\lambda} - \rho\right) c_t^* + \frac{\Omega g_t}{(1-\lambda)\left(\eta + \frac{\Omega}{1-\lambda}\right)} + \left(\frac{1+\eta}{\eta + \frac{\Omega}{1-\lambda}}\right) \varepsilon_t \tag{6}$$

where $\Omega \equiv \left(\frac{\theta\lambda}{1-\lambda} + \theta\lambda + \frac{1-\lambda}{\rho}\right)^{-1}$. As equation (6) shows, in open economy, the policy-maker should take into account a wider number of shocks to estimate potential output. By incomplete information I mean a case in which the central bank and the private sector do not observe potential output. Since potential output depends on the foreign consumption, the demand shock and the productivity shock, when it is unobservable, the central bank and the private sector face a signal extraction problem in trying to distinguish which shock is hitting the economy. Differently from the closed-economy counterpart, the signal extraction problem arises also in estimating the demand shock: in the IS equation (1) there are both demand and foreign consumption shock which are undistinguishable in real time. This result is directly related to the small open economy that I am analyzing: the demand shock can be perfectly estimated, in fact, when shocks to foreign consumption are absent or when we consider a closed-economy version of the model. In the latter case, all the foreign variables cancel out and we come back to the same problem faced by Ehrmann and Smets (2003), where unobservable potential output determines a signal extraction problem in distinguishing cost-push shocks from potential output shocks, while demand shock is perfectly estimated[7].

4 Monetary policy

In this section I discuss the ranking of alternative monetary policies with complete and incomplete information. The performance of alternative policy

[6] See Appendix for details.

[7] In the closed-economy counterpart, also the loss function is unaffected by foreign variables (see De Paoli (2009) and the Appendix.

rules is assessed by assuming that the monetary authority minimizes the loss function (3) choosing a policy within the family of simple linear policy rules:

$$i_t = \omega_\pi \pi_{H,t} + \omega_x x_t + \omega_e \Delta e_t \tag{7}$$

The reaction to domestic inflation and the variation of the exchange rate are related: $\omega_\pi \in [0, 2]$ and $\omega_e \in [0, 1]$. Following Ravenna (2011), $\omega_e = [\max(\omega_\pi) - \omega_\pi]/2$, hence policies that place a lower weight on the inßation target also place a higher weight on the exchange rate target[8]. When $\omega_\pi \to 0$, the central bank's monetary policy regime is close to a managed exchange rate float. Finally, a central bank has the possibility of delegating national monetary policy to a foreign central bank by fixing the exchange rate against the foreign currency. The latter policy scenario corresponds to $\omega_\pi = 0$, $\omega_e = \infty$.

Under the calibration shown in Table 1, the model is solved with complete and incomplete information.

Table 1: Calibration used for the quantitative analysis

Parameter	Description	Numerical Value
ρ	Consumption risk aversion	1
θ	Elasticity of substitution (domestic vs foreign)	3
λ	Degree of openness	0.4
η^{-1}	Frisch elasticity of labor supply	1/0.47
σ	Elasticity of substitution across the differentiated products	10
β	Discount factor	0.99
α	Price stickiness	0.66
$\overline{\mu} = (1-\lambda)^{-1}$	Markup in the steady state	1.51
$sdv(\varepsilon)$	Standard deviation of productivity shock	0.0071
$sdv(g)$	Standard deviation of demand shock	0.0062
$sdv(\mu)$	Standard deviation of markup shock	0.0013
$sdv(c^*)$	Standard deviation of foreign consumption shock	0.0129
$sdv(r^*)$	Standard deviation of foreign interest rate	0.01379
ρ_ε	Autocorrelation of productivity shock	0.66
ρ_{c^*}	Autocorrelation of foreign consumption	0.66
ρ_g	Autocorrelation of demand shock	0.94
ρ_μ	Autocorrelation of markup shock	0.99
ρ_{r^*}	Autocorrelation of foreign interest rate	0.8

[8] This parameterization of policy coefficients ensures local uniqueness of the equilibrium. The two policy coefficients are inversely related: $\omega_e = \frac{2-\omega_\pi}{2}$.

5 Policy performance under complete and incomplete information

The policy rule (7) is modeled in a way that the central bank can be more or less interested in targeting the domestic inflation rate rather than the variation in the nominal exchange rate. The performance of the central bank, therefore, will depend on how it reacts to the output gap, domestic inflation and the variation of exchange rate, and on the information set available. The noisier the observation of domestic inflation, output and the exchange rate, the higher the loss function. However, among the possible combinations of ω_π and ω_e in (7), there is one that makes loss function independent of the information set available. This combination is the exchange rate peg, which corresponds to a pair $\omega_\pi = 0, \omega_e = \infty$. A country that pegs its exchange rate ties its hands and relinquishes the conduct of monetary policy to the foreign counterpart. The monetary authority will prefer an independent monetary policy only if, notwithstanding the incomplete information set available, it yields a loss no larger than an exchange rate peg.

It is possible to find the parameters configuration in the interest rate rule such that a peg performs better than an independent. Figure 1 shows the policymaker's loss under complete information for the family rules in equation (7) and if the central bank pegs the exchange rate. From the figure it emerges that the best policy combination is $[\omega_\pi = 2, \omega_e = 0]$, while for $[\omega_\pi = 1, \omega_e = 0.5]$ the Taylor rule and the peg regime yield the same loss. For most of the values of ω_π and ω_e, the central bank will find the fixed exchange rate regime a dominated monetary regime and in the case of a Taylor rule that does not react to movements in the exchange rate, the loss function reaches its minimum value. For values of $\omega_e > 0.6$ fixing the exchange rate regime yields a lower loss. With the aim of evaluating the performance of different policy rules *vis-à-vis* the exchange rate peg, in figure 2 I repeat the same analysis done in figure 1, but with incomplete information. As in the complete information case, loss is increasing in the weight attached to the exchange rate stabilization versus the inflation rate. Differently from the baseline case of complete information, however, there are more combinations of $[\omega_\pi, \omega_e]$ which guarantee that the exchange rate peg performs better than a policy rule that responds also to the inflation rate. For values of ω_π approximatively smaller than 0.4, welfare loss is lower under an exchange rate peg.

This analysis provides a rationale for assessing if the central bank should react to the exchange rate. First, both under complete and incomplete information, the simple policy rule which attains a lower loss is a Taylor rule reacting to the output gap and domestic inflation respectively. Second, hybrid policy rules which react also to the exchange rate, may worsen the welfare loss. To understand what determines this path, Table 2 and 3 report business cycle properties of key variables under alternative policy regimes with complete and incomplete information respectively.

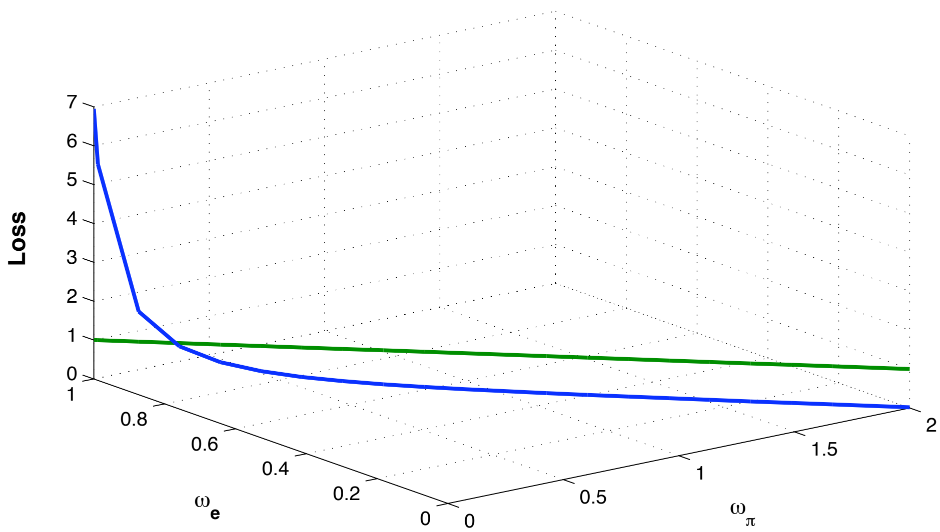

Figure 1: Loss function varying ω_π and ω_e and with a fixed exchange rate regime in the complete information case. Losses are computed as fraction of fixed exchange rate loss.

As a robustness check, I simulate the model, under complete and incomplete information, varying the intertemporal and the intratemporal elasticity of substitution (ρ andθ respectively). As shown in Galí and Monacelli (2005), when $\rho\theta = 1$, the income and substitution effects offset each other and, as a consequence, international relative price movements do not have expenditure switching implications. On the other hand, the higher is the

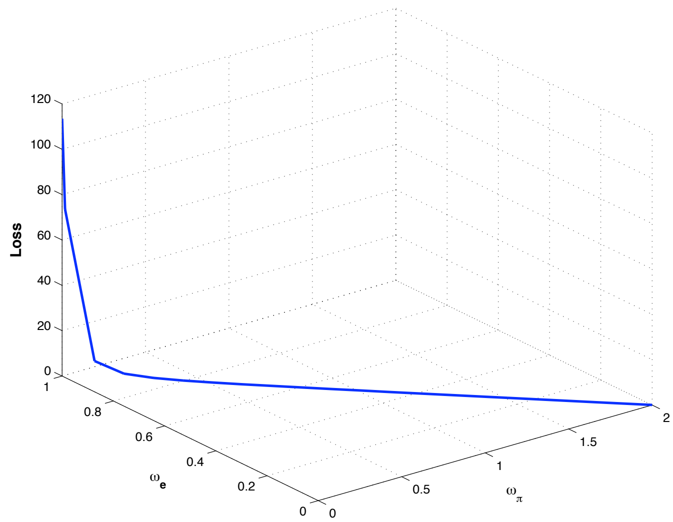

Figure 2: Loss function (as fraction of fixed exchange rate loss) varying ω_π and ω_e in the incomplete information case.

degree of substitutability between goods (the higher $\rho\theta$), the higher is the expenditure switching effect arising from the terms of trade. More in detail, I report in Table 4 and Table 5 the threshold value of ω_π that makes the exchange rate peg a dominated policy regime, for different values of ρ and θ. In the baseline calibration with complete information ($\rho = 1$, $\theta = 3$) the exchange rate peg is a dominated regime for $\omega_\pi > 0.2$, while for high values of $\rho\theta$[9] a simple rule that assigns the smallest (highest) value to ω_π (ω_e), hence a rule that is close to the exchange rate peg, is to be preferred. When domestic and foreign products are good substitutes to one another, in fact, the welfare gains from improving the terms of trade outweigh the gains from stabilizing domestic prices and the output gap. As a consequence, among the simple rules, the best in terms of welfare is the one that assigns the lower (higher) value to ω_π (ω_e). The table shows also that when $\rho\theta < 1$, the threshold value for ω_π is 0.4 or 0.5.

In Table 5 I repeat the same analysis about the effect of varying $\rho\theta$ under

[9]By high values I mean at least $\rho = 2$ and $\theta = 3$.

Table 2: Business cycle properties under alternative policy regimes (complete information).

	$\omega_\pi = 0.25$, $\omega_e = 0.875$	$\omega_\pi = 0.5$, $\omega_e = 0.75$	$\omega_\pi = 0.8$, $\omega_e = 0.6$	$\omega_\pi = 2$, $\omega_e = 0$	peg
domestic inflation	0.072	0.041	0 026	0.010	0.05
CPI inflation	0.045	0.026	0.018	0.0107	0.030
output gap	0. 023	0. 016	0.013	0.017	0.004
real exchange rate	0.014	1.376	0.0136	0.0138	0.015
nominal depreciation rate	0.022	0.014	0.012	0.051	0

Table 3: Business cycle properties under alternative policy regimes (incomplete information).

	$\omega_\pi = 0.25$, $\omega_e = 0.875$	$\omega_\pi = 0.5$, $\omega_e = 0.75$	$\omega_\pi = 0.8$, $\omega_e = 0.6$	$\omega_\pi = 2$, $\omega_e = 0$	peg
domestic inflation	0.110	0.055	0.033	0.0115	0.05
CPI inflation	0.069	0.035	0.021	0.0114	0.030
output gap	0.044	0.026	0.020	0.020	0.004
real exchange rate	0.018	0.015	0.0143	0014	0.015
nominal depreciation rate	0.042	0.024	0.0173	0.0169	0

incomplete information. In the baseline calibration ($\rho = 1$, $\theta = 3$), there are more parameter configurations of ω_π, ω_e such that the exchange rate peg performs better than the Taylor rule. Incomplete information, therefore, partly justifies the adoption of an exchange rate peg. Considering the other combinations of ρ and θ, Table 5 documents that the threshold value of ω_π for making the exchange rate peg a dominated strategy generally coincides with the complete information setup.

It is also possible to assess the properties of a pure Taylor rule regime ($\omega_\pi = 2, \omega_e = 0$), a mixed Taylor rule regime ($\omega_\pi = 0.5, \omega_e = 0.75$) and a fixed exchange rate regime by analyzing the impulse response function after a unit innovation in a_t. For example, Figure 3 shows that, with complete information, the main difference under the two Taylor rules considered is about the dynamic response of the exchange rate, which is stronger if the central bank does not react to the variation in the exchange rate. The

Table 4: Minimum value of ω_π such that the exchange rate peg is a dominated policy regime (complete information). $*$ indicates that the exchange rate peg is always a dominated regime.

ρ/θ	**0.3**	**0.5**	**0.7**	**3**
1	0.5	0.4	0.4	0.2
2	0.4	$*$	0.3	$*$

Table 5: Minimum value of ω_π such that the exchange rate peg is a dominated policy regime (incomplete information). $*$ indicates that the exchange rate peg is always a dominated regime.

ρ/θ	**0.3**	**0.5**	**0.7**	**3**
1	0.5	0.5	0.4	0.4
2	0.4	$*$	0.3	$*$

extremely opposite reaction, of course, occurs under a fixed exchange rate regime, where the impossibility of lowering the exchange rate in order to sustain the expansion in the output makes the output gap very volatile.

If we introduce incomplete information about the state of the economy, the policy rule is independent of the signal-extraction problem, but it will be set in response to the optimal estimate of the state of the economy. Therefore, the results under complete and incomplete information can be different. When output and the domestic inflation rate are observable with some degree of noise, the policy-maker learns only gradually about the realization of the true shock. Through its effect on the expectation of the state of the economy, imperfect information affects the dynamics of forward-looking variables and also the way the instrument is set up, since the perceived magnitude of the shocks is smaller. Moreover, the incompleteness of information available to the policy-maker does not allow to identify with precision what kind of shock actually hits the economy. From the domestic inflation equation, he is facing a signal extraction problem with the aim of distinguishing between a potential output shock from a cost-push shock. In fact, with incomplete information a decrease in domestic inflation can be explained either with a positive supply-shock or with a negative cost-push shock. From figure 4 it

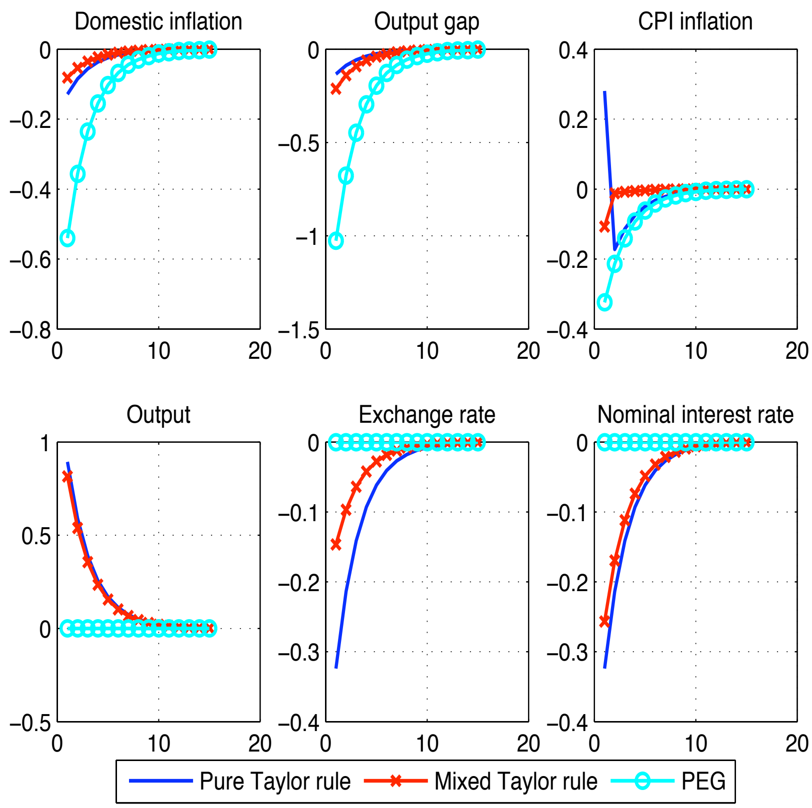

Figure 3: Dynamic responses to a productivity shock in the full information case

is possible to observe that, with incomplete information, the reaction of the exchange rate when the central bank targets both domestic inflation and the variation of the exchange rate is more muted and it looks similar to the case of the exchange rate peg.

6 Concluding remarks

The effect of uncertainty on the conduct of monetary policy has been analyzed mainly in closed economy, through different ways of modeling the degree of uncertainty a policymaker has to face. This paper seeks to determine the performance of simple rules in a new Keynesian DSGE small-open

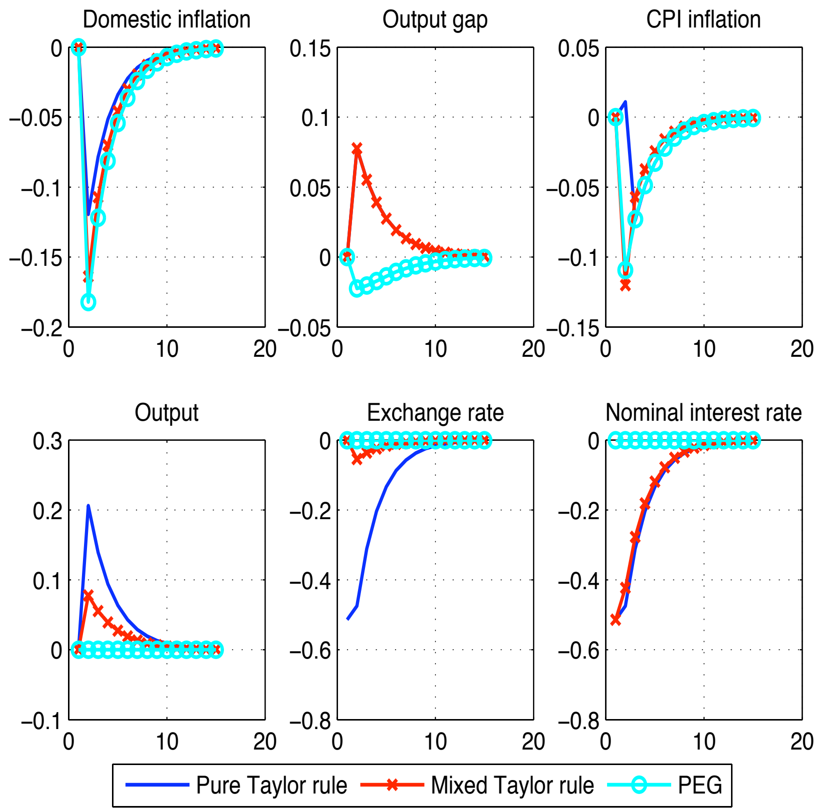

Figure 4: Dynamic responses to a productivity shock with incomplete information

economy model in the case of incomplete information about the state of the economy. Furthermore, assessing the performance of simple rules in open economy is considered as an implicit test of the relative advantage of choosing a flexible exchange rate system rather than a fixed one, since an exchange rate peg is the simplest policy rule available to the policymaker in open economy.

In a small open economy model with domestic and foreign shocks, I found that there are some combinations of the coefficients in the Taylor rule such that the exchange rate peg is preferable, both with complete and incomplete information set.

The paper assumes that the commitment to peg the exchange rate is fully credible:as emphasized by Ravenna (2011), the need to peg the exchange rate can also lie in the possibility of borrowing credibility from a more credible central bank. Future research aims at assessing if the lack of credibility suffered by a central bank weighs more than incomplete information to make the exchange rate peg preferable to other policy regimes.

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A The model

The small open economy is modeled in a similar way to Galí and Monacelli (2005) and De Paoli (2009). There is a continuum of firms in the interval [0,1], a representative household and a monetary authority. All agents are infinitely lived and there are two sources of nominal rigidities: 1) price setting à la Calvo; 2)monopolistic competition. We denote with an asterisk all the variables referred to the world economy.

A.1 Households

The representative household living in the small open economy seeks to maximize $E_0 \sum_{t=0}^{\infty} U(C_t, N_t)$ with

$$U(C_t, N_t) \equiv \frac{C_t^{1-\rho}}{1-\rho} - \frac{L_t^{1+\eta}}{1+\eta} \tag{8}$$

where N_t denotes hours of labor and C_t is a consumption index defined as

$$C_t \equiv \left[(1-\lambda)^{\frac{1}{\theta}} (C_{H,t})^{\frac{\theta-1}{\theta}} + \lambda^{\frac{1}{\theta}} (C_{F,t})^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}} \tag{9}$$

In (9) $\theta > 0$ is the elasticity between domestic and foreign goods, while $C_{H,t}$ and $C_{F,t}$ are the index of consumption of domestic and foreign goods respectively, which are defined in the usual way:

$$C_{H,t} = \left[\left(\frac{1}{n}\right)^{\frac{1}{\sigma}} \int_0^n c(z)^{\frac{\sigma-1}{\sigma}} dz \right]^{\frac{\sigma}{\sigma-1}} \tag{10}$$

$$C_{F,t} = \left[\left(\frac{1}{1-n}\right)^{\frac{1}{\sigma}} \int_n^1 c(z)^{\frac{\sigma-1}{\sigma}} dz \right]^{\frac{\sigma}{\sigma-1}} \tag{11}$$

$$C_{H,t}^* = \left[\left(\frac{1}{n}\right)^{\frac{1}{\sigma}} \int_0^n c^*(z)^{\frac{\sigma-1}{\sigma}} dz \right]^{\frac{\sigma}{\sigma-1}} \tag{12}$$

$$C_{F,t}^* = \left[\left(\frac{1}{1-n}\right)^{\frac{1}{\sigma}} \int_n^1 c^*(z)^{\frac{\sigma-1}{\sigma}} dz \right]^{\frac{\sigma}{\sigma-1}} \tag{13}$$

$$\tag{14}$$

The consumption-based price indices that correspond to the above specifications of preferences are given by:

$$P = \left[(1-\lambda) P_H^{1-\theta} + \lambda P_F^{1-\theta} \right]^{\frac{1}{1-\theta}}$$
$$P^* = P_F^*$$

The optimality conditions are:

$$C_t^{\rho} N_t^{\eta} = \frac{W_t}{P_t} \tag{15}$$

$$\beta R_t E_t \left[\left(\frac{C_{t+1}}{C_t} \right)^{-\rho} \left(\frac{P_t}{P_{t+1}} \right) \right] = 1 \tag{16}$$

where $R_t = \frac{1}{E_t Q_{t,t+1}}$ is defined as the gross return of a one-period discount bond paying off one unit of domestic currency in $t+1$.

The law of one price (LOP) holds, but because of the home bias PPP is violated. Finally, there is complete risk sharing and uncovered interest parity holds.

B Derivation of potential output

TBA

C Monetary policy

TBA