Dynare Working Papers Series
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Guido Traficante

Working Paper no. 22

December 2012

CEPREMAP
CENTRE POUR LA RECHERCHE ECONOMIQUE ET SES APPLICATIONS
142, rue du Chevaleret — 75013 Paris — France
http://www.cepremap.ens.fr

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

Guido Traficante†

January 2012
Under revision, please do not quote!!!

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 standard 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

JEL: E52; F31

*This paper previously circulated with the title "Choosing the exchange rate system with incomplete information". The very first version of the paper was written while I was visiting the department of economics at the University of California Santa Cruz. I am grateful for the department's hospitality. I thank , Daniel Beltran, Helde Berger, Giorgio Di Giorgio, Mathias Hoffmann, Federico Ravenna Abhijit Sen Gupta and Carl Walsh for their insightful comments. Any remaining errors are, of course, my sole responsibility.

†Università Europea di Roma and LUISS Guido Carli University. Address for correspondence: viale Romania 32 00197 Rome, Italy. Email:gtraficante@luiss.it

1 Introduction

In open economy macroeconomics the central bank has to decide whether pegging the exchange rate or letting it float. Economic history gives us several examples of these two extreme policy arrangements, together with managed floating systems. A seminal paper by Giavazzi and Pagano (1988) shows that fixed exchange rate dominates the other alternative policies because an *inflation-prone* country 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. 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 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. In particular, 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, using a small-open economy model like the one in Galí and Monacelli, but with a parameterization such that the model is not isomorphic to a closed-economy counterpart, I will try to 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: This paper tries to analyze this issue in open economy, where there exist several sources of uncertainty, originating in the domestic economy or in other countries.

A very influent contribution about the effects of uncertainty on monetary policy is due to Brainard (1967). Brainard studies the so called *multiplicative* uncertainty, i.e. when the policymaker is unaware about the true size of the structural coefficients, hence on the impact monetary policy has on the economy. He finds that in case of uncertainty about the magnitude with which policy choices affect aggregate demand and inflation it is optimal to move the policy instrument by a smaller amount than in the case of no uncertainty. Recently, several papers have studied how to neutralize the effects of uncertainty in the conduct of monetary policy making. Söderström (2002) shows that the uncertainty about the dynamics of inflation leads to aggressive policy rules. In a scenario of model and data uncertainty, Rudebusch(2002) rejects the robustness of simple rules that include a response to nominal output growth.

The latter papers consider the case in which the policymaker has a single reference model while the true economy lies within a specified neighborhood of the reference model. Another way of modeling uncertainty was developed by Levin and Williams (2003), who look for a robust rule, described as a rule able to perform relatively well among the different competing models which can describe the economy.

The way in which we model uncertainty is different from the approaches described above and refers to recent work by Svensson and Woodford (2003), Ehrmann and Smets (2003) and Gerali and Lippi (2002) among the others. The source of uncertainty is the impossibility of observing all the state variables of the economic system without a measurement error. The policymaker can observe directly only a subset of variables, while the ones which are not observable are estimated through Kalman filtering. Therefore, with a noisy information set, the policy-maker is called to estimate the state of the economy before implementing his policy. 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

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

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

The paper is organized as follows. Section 2 describes briefly the small-open economy mode. In section 3 the monetary policy is modeled, while section 4 provides a numerical evaluation of monetary policy rules under complete and incomplete information. Section 5 concludes.

2 The model

The small open economy is modeled as in Galí and Monacelli (2005, GM henceforth). Therefore, I will present the log-linearised model, before focusing on the main contribution of the paper about the signal-extraction problem in open economy. The model consists of 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. 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. There is home bias in preferences and it is inversely related to the parameter $\alpha \in [0,1]$. Parameter $\eta > 0$ measures the substitutability between domestic and foreign goods. The IS schedule reads as

$$y_t = E_t y_{t+1} - \frac{1}{\sigma_a}\left(i_t - E_t \pi_{H,t+1}\right) + \alpha\Theta(\rho_y - 1)y_t^* \tag{1}$$

where $\sigma_a \equiv \frac{\sigma}{1-\alpha+\alpha\omega}$, $\omega \equiv \sigma+(1-\alpha)(\sigma\eta-1)$, and $\Theta \equiv (1-\alpha)(\sigma\eta-1) = \omega-\sigma$.

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

$$\pi_{H,t} = \beta E_t \pi_{H,t+1} + \kappa_a x_t + \xi_t \tag{2}$$

where $\kappa_a \equiv \lambda\left(\sigma_a + \varphi\right)$, x_t is the output gap (defined below), and ξ_t is a first-order autoregressive cost-push shock.

Being in a small open economy model, the potential output $\overline{y}_t$ will be affected by domestic and foreign variables,

$$\overline{y}_t = \frac{1+\varphi}{\varphi+\sigma_a} a_t + \alpha\Psi y_t^* \quad \Psi \equiv -\frac{\Theta\sigma_a}{\sigma_a+\varphi} \tag{3}$$

As equation (3) shows, in open economy, the policy-maker should take into account a wider number of shocks to estimate potential output

Finally, 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 compared with r_t^*):

$$i_t - i_t^* = E_t \Delta e_{t+1} \tag{4}$$

3 Monetary policy

The performance of alternative policy rules is assessed by assuming that the central bank's objective function is a standard quadratic loss function depending on the output gap and domestic inflation:

$$\mathcal{L}_t = \frac{1}{2} \left[\text{var}\left(\pi_{H,t}\right) + 0.5 \text{var}\left(x_t\right) \right] \tag{5}$$

The monetary authority minimizes the loss function (5) choosing a policy within the family of simple linear policy rules:

$$i_t = \omega_\pi \pi_{H,t} + \omega_x x_t + \omega_e \Delta e_t \tag{6}$$

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), $\omega_e = \left[\max\left(\omega_\pi\right) - \omega_\pi\right]/2$, hence policies that place a lower weight on the inßation target also place a higher weight on the exchange rate target[2]. When $\omega_\pi \to 0$, the central bank's monetary policy regime is close to an exchange rate peg. The model is solved by plugging the interest rate rule (6) into (1) - (4).

In the baseline case of complete information the agents and the central bank observe current output, the exchange rate and domestic inflation, as well as potential output. With complete information set, it is possible to understand in real time which shock is hitting the economy.

In the alternative scenario, information is incomplete: the central bank and the private sector observe observe current output and inflation but they do not observe potential output directly. As a consequence, they will face a

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

signal extraction problem in trying to distinguish cost-push shocks from productivity shocks and foreign output shocks. From the IS equation it emerges that the central bank and the private sector will be able to estimate the shock to foreign output perfectly. However, if we look at the inflation dynamics, they will face a signal extraction problem in trying to distinguish cost-push shocks from productivity and foreign output shocks. The impossibility of distinguishing which shock is hitting the economy gives rise to output gap uncertainty. Being in open economy, output gap uncertainty deals also with foreign output: the smaller α, the higher the home bias and the less foreign output contributes to the determination of potential output[3].

It is possible to summarize the economy with the following state-space form:

$$\begin{bmatrix} X_{t+1} \\ x_{t+1|t} \end{bmatrix} = A^1 \begin{bmatrix} X_t \\ x_t \end{bmatrix} + A^2 \begin{bmatrix} X_{t|t} \\ x_{t|t} \end{bmatrix} + Bi_t + C_u u_{t+1} \tag{7}$$

where X_t is a vector containing the predetermined variables, a_t, ξ_t y_t^* and r_t^*, x_t is a vector containing the forward-looking variables e_t, y_t and $\pi_{H,t}$. i_t is the policy instrument and, finally, u_{t+1} is a composite vector of structural shocks $\begin{bmatrix} \varepsilon_{t+1} \\ \widehat{\xi}_{t+1} \\ \eta_{t+1} \end{bmatrix}$ with covariance matrix given by Σ_u. A^1, A^2, B, C_u are matrices of appropriate dimensions.[4]

As (5) tells us, the period loss function is a quadratic form of the goal variables Y_t in which W is a positive-semidefinite weight matrix:

$$Y_t = C^1 \begin{bmatrix} X_t \\ x_t \end{bmatrix} + C^2 \begin{bmatrix} X_{t|t} \\ x_{t|t} \end{bmatrix} + C_r r_t \tag{8}$$

so that the policy maker aims at minimizing the loss function $L_t \equiv Y_t' W Y_t$.

The third block to close the system provides us with the measurement equation:

$$Z_t = D^1 \begin{bmatrix} X_t \\ x_t \end{bmatrix} + D^2 \begin{bmatrix} X_{t|t} \\ x_{t|t} \end{bmatrix} + \begin{bmatrix} v_t \\ v_t \end{bmatrix} \tag{9}$$

[3] More in detail, $\alpha = 1$ means that there is not any home bias in preferences, $\Theta = \Psi = 0$ and foreign output do not affect domestic output and inflation. Another case in which domestic output and inflation are not affected by foreign output can be obtained by imposing (as in GM) $\sigma = \eta = 1$.

[4] Henceforth, all the matrices introduced will be known conformable matrices.

where $D^2 = 0$, the matrix D^1 selects the observables y_t and $\pi_{H,t}$ which can be observed; finally, the vector v_t is an iid stochastic vector of measurement error, with mean zero and covariance matrix Σ_v. Through the analysis and simulation below, I will start with a setup in which $v_t = 0$ and I will vary it to evaluate the effect of increasing the noise on the measurement equation[5].

In the case of incomplete information, the information set available in t to the policy maker and the private sector $\mathfrak{I}_t$ consists of the measurement of the observable states up to the current period, the structural parameters and the covariance matrices of the disturbances:

$$\mathfrak{I}_t \equiv \left\{ Z_i, i \leq t; A^1, A^2, B, C_u, W, C^1, C^2, C_r, D^1, D^2, \Sigma_u, \Sigma_v \right\} \tag{10}$$

The model is calibrated following GM, except for the value of the elasticity of substitution between domestic and foreign goods η. GM assume $\eta = 1$ and, with this assumption, the transmission of foreign variables and shocks to domestic variables is completely absent and the reference model is completely isomorphic to the closed economy setup. With the objective of analyzing the transmission mechanism of the foreign variables to the domestic economy, I move from the assumption of unitary elasticity of substitution between domestic and foreign goods and I assume that $\eta = 1.5$. The variance of the measurement error v is assumed to be zero in the baseline setup and it is varied to measure the effect of a bigger noise to the loss function. Table 1 summarizes the baseline calibration.

4 Policy performance under complete and incomplete information

The policy rule (6) 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 and output, the higher the loss function. However, among the possible combinations of ω_π

[5] Even in the case of zero-measurement error, the signal-extraction problem is relevant. The assumption of equal measurement error for domestic output and inflation is without loss of generality.

Table 1: GM's calibration for the structural parameters of the model

Parameter	Description	Numerical Value
σ	Consumption risk aversion	1
θ	Elasticity of substitution (domestic vs foreign)	1.5
γ	Elasticity of substitution (differentiated goods)	6
α	Degree of openness	0.4
φ	Labor elasticity	3
θ	Probability of not adjusting prices	0.75
β	Discount factor	0.99
ρ_a	**AR** coefficient of technology shock	0.66
σ_a	Standard deviation of a	0.0071
ρ_r	**AR** coefficient of world's interest rate	0.8
σ_r	Standard deviation of r^*	0.01379
ρ_y	**AR** coefficient of world's output	0.86
σ_{y^*}	Standard deviation of y^*	0.0078

and ω_e in (6), 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 (6) 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 approximately $\omega_e = 0.5$ (that corresponds to $\omega_\pi = 1$) loss function attains the same value it would have under a peg regime. For values of $\omega_e > 0.5$ 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, for $\sigma_v = 0.05, 0.15$. First, figure 2 shows that the loss function is increasing in the noise attached to the observables, independently of the value that ω_π and ω_e have. Second, incomplete information is not a sufficient condition to prefer the fixed exchange rate regime as the preferred policy regime. Interestingly, the same conclusions in terms of combinations of ω_π and ω_e hold in the case of incomplete information: only for values of $\omega_e > 0.5$ the fixed exchange rate regime performs better, while for the rest of parameter configuration a Taylor rule - especially when there is no reaction to the expected exchange rate variation - is the dominating policy rule.

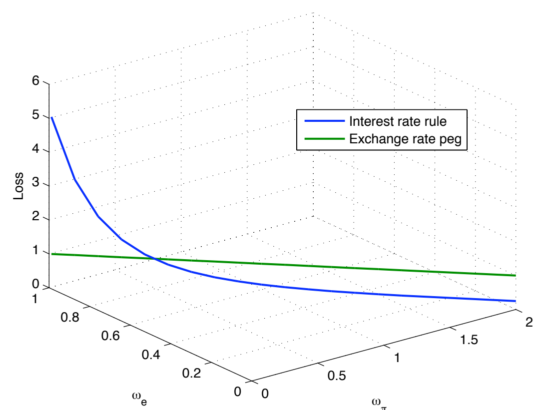

Figure 1: Loss function varying ω_π and ω_e and with a fixed exchange rate regime in the full information case. Losses are computed as fraction of fixed exchange rate loss

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 extremely opposite reaction, of course, occurs under a fixed exchange rate regime, where the impossibility of lowering the exchange rate in order to

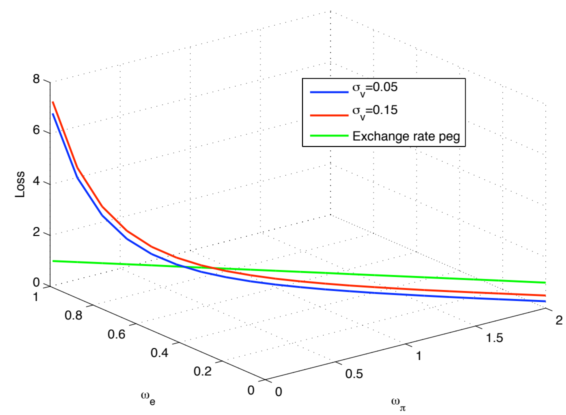

Figure 2: Loss function varying ω_π and ω_e and with a fixed exchange rate regime in the incomplete information case. Losses are computed as fraction of fixed exchange rate loss

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 $X_{t|t}$. 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 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

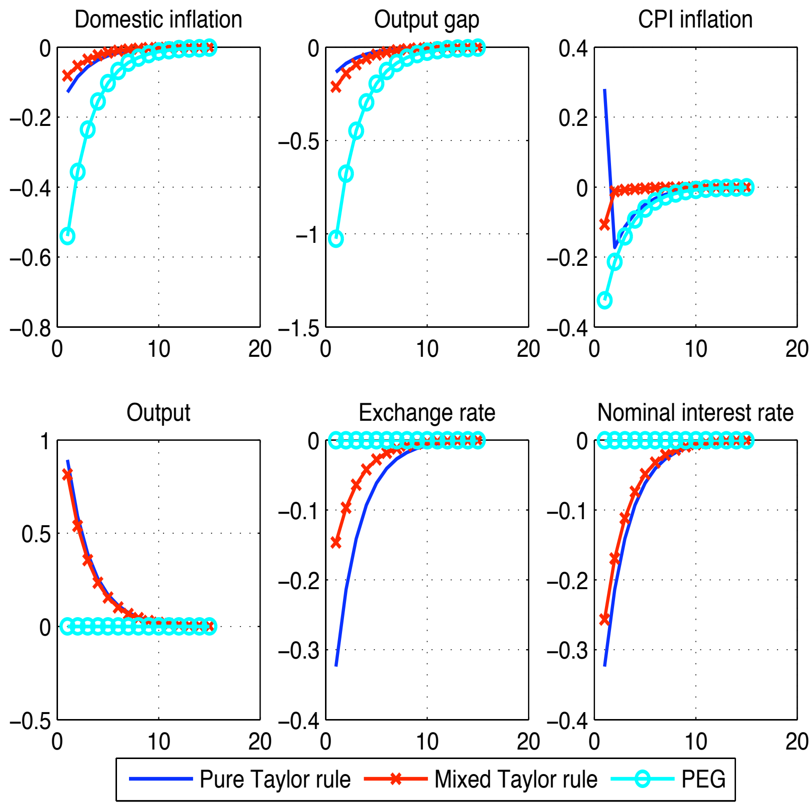

Figure 3: Dynamic responses to a productivity shock in the full information case

of the exchange rate is more muted and it looks similar to the case of the exchange rate peg.

5 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 economy model in the case of incomplete information about the state of the economy. Furthermore, assessing the performance of simple rules in

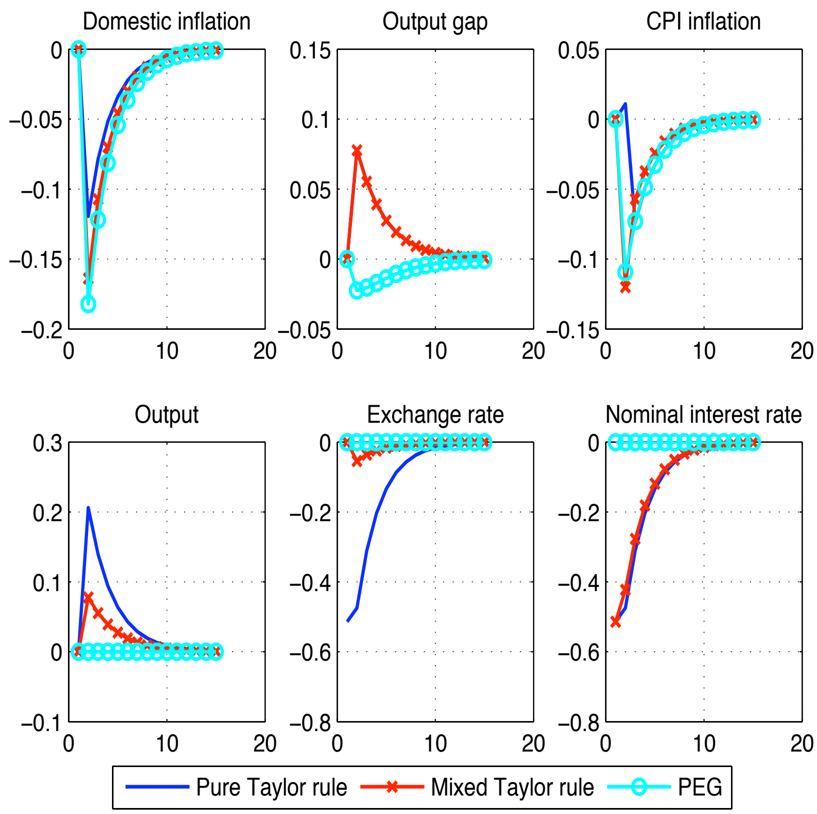

Figure 4: Dynamic responses to a productivity shock with incomplete information

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 can be amended with respect to some aspects. First, since the recent contribution of Benigno and Woodford (2004), it has be shown how a utility-based welfare measure can be derived even without the restrictive assumption of steady state without distortions[6]. De Paoli (2004) extends Benigno and Woodford's analysis to the case of a small open economy. To really check the robustness of simple rules, I should run a similar analysis for a more general specification of preferences than the one adopted in the paper. Moreover, I assumed that the commitment to peg the exchange rate is fully credible: This assumption is clearly unrealistic, but once the policymaker can only estimate the true state of economy, he can find it optimal to follow the easiest simple rule in an open economy, i.e. pegging the exchange rate. The need to peg the exchange rate can also lie in the possibility of borrowing credibility from a more credible central bank, as emphasized by Ravenna (2011). These issues are left for future research.

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