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Monetary Policy and Noise Traders: A Welfare Analysis

May 2, 2016

Abstract

This paper studies the choice of monetary policy regime in a small open economy with noise traders in forex markets. We focus on two simple rules: fixed exchange rates and inflation targeting. We contrast the above two rules against optimal policy with commitment under productivity shocks. In general, the presence of noise traders increases the desirability of a fixed exchange rate regime. We also evaluate the welfare impact of Tobin taxes in such a milieu. These taxes help unambiguously in the absence of productivity shocks; their welfare impact under productivity shocks depends on the monetary regime in place and trade elasticity between domestic and foreign goods.

Keywords: Noise traders; Fixed exchange rates; Tobin taxes, Optimal monetary policy.

JEL Classification: E42, E52, F41

1 Introduction

There exists a large literature which focuses on market microstructure models that examine the role of noise traders in generating excess volatility in the foreign exchange market. This paper incorporates noise traders into a small open economy with incomplete markets and examines the role of monetary policy and Tobin taxes in such a setup. Within this setting, we welfare-rank two simple rules, namely a fixed exchange rate regime (PEG) and an inflation rate targeting regime (IT) by comparing them with optimal policy under commitment. Our objective is to identify the simple rule that in terms of welfare is closest to the optimal monetary policy under commitment. In addition, we examine the welfare implications of imposing Tobin taxes in such a setup.

Our results show that the differences in welfare across these regimes can be mapped with the real exchange rate volatility that the regimes allow relative to what optimal policy calls for. The analysis shows that in the face of productivity shocks, optimal monetary policy calls for a significantly lower volatility of the real exchange rate in the presence of noise traders. It therefore follows that a PEG outperforms an IT regime when there are noise traders in the economy. Further, we find in such a setup, the impact of Tobin taxes on welfare is critically dependent on the elasticity of substitution between domestic and foreign goods.

The work in this paper builds on the large literature which has sought to analyze monetary policy objectives in an open economy. An important debate in this literature has centered around the issue of whether monetary policy should focus only on targeting domestic inflation rates or should stabilization of the exchange rate also be a policy objective. Clarida et al. (2002) and Gali and Monacelli (2005), in seminal contributions show that the open economy version of optimal monetary policy problem is “isomorphic” to its closed economy counterpart. In this case, absent cost push shocks, a policy of strict domestic inflation targeting is always optimal. This literature laid the intellectual foundation for inflation targeting to be widely adopted in open economies.

Calvo and Reinhart (2002) in their seminal study, however, document that many developing countries which on paper classify themselves as inflation targeting regimes, in practice, actively stabilize their exchange rate. These countries exhibit unusually low exchange rate volatility, high volatility in interest rate and forex reserve prompting the authors to conclude

that there is extensive “fear of floating”.

Contributions, among others, by Clarida, Gali, and Gertler (2002), Benigno and Benigno (2003), Pappa (2004) and De Paoli (2009a) have sought to explain the observed stabilization of the exchange rate by emphasizing the role of the “terms of trade externality”. These authors have argued that, in an environment where domestic and foreign goods are not perfect substitutes, a strict form of domestic inflation targeting may not be optimal and some degree of terms of trade (or exchange rate) stabilization is welfare enhancing. Others such as Caballero et al. (2005) and Levy Yeyati et al. (2006) have argued that extensive liability dollarization may lead central banks to avoid exchange rate flexibility fearing financial instability and bankruptcies.

Our paper instead emphasizes the role of noise traders for the equilibrium terms of trade variability and its implications for an optimal monetary policy design. We build on De Paoli (2009b) who emphasizes the structure of asset markets in trying to explain monetary policy objectives in an open economy. Importantly, De Paoli shows that in an economy with a high elasticity of substitution between domestic and foreign goods, the PEG regime is preferred under complete financial markets whereas an IT regime is welfare superior under incomplete markets. In contrast, we show that if there are noise traders in the economy, then even with incomplete markets and a high elasticity of substitution between domestic and foreign goods, a PEG outperforms an IT regime.

The rest of the paper proceeds as follows. Section 2 develops the basic model with noise traders. Section 3 studies and welfare ranks the alternative monetary policy arrangements. Section 4 provides a summary of the results and concludes.

2 The Model

2.1 Households

The framework is a small open economy with incomplete markets and closely follows De Paoli (2009b). The world economy is populated with a continuum of household of unit mass, where the fraction of the population in the segment $[0, n)$ belongs to the home country, H , and the remainder of the world population in the segment $[n, 1]$ belongs to the foreign

country, F . The utility function of the representative household in country H is

$$U_t = E_t \sum_{s=t}^{\infty} \beta^{s-t} \left[\frac{C_t^{1-\rho}}{1-\rho} - \frac{1}{n} \int_0^n \frac{\epsilon_t^{-\eta} y_t(z)^{1+\eta}}{1+\eta} dz \right] \quad (1)$$

where C_t is individual consumption stream, ρ is the coefficient of relative risk aversion, η is equivalent to the inverse of the elasticity of labor supply, ϵ_t is the shock to productivity, and $y_t(z)$ is output of home-produced differentiated good z . The consumption aggregate for countries H and F are given by:

$$C = \left[\nu^{1/\theta} C_H^{\frac{\theta-1}{\theta}} + (1-\nu)^{1/\theta} C_F^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}}, \quad C^* = \left[\nu^{*\frac{1}{\theta}} C_H^{*\frac{\theta-1}{\theta}} + (1-\nu^*)^{1/\theta} C_F^{*\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}} \quad (2)$$

The parameter $\theta > 0$ is the intratemporal elasticity of substitution between home and foreign produced goods, C_H and C_F . The parameter determining home consumer's preferences for foreign goods, $(1-\nu)$ is a function of the relative size of the foreign economy, $(1-n)$, and of the degree of openness, λ ; more specifically, we follow De Paoli (2009b) and Sutherland (2002) in assuming $(1-\nu) = (1-n)\lambda$ and $\nu^* = n\lambda$. Further, it is assumed that $\nu \neq \nu^*$, which gives rise to “home bias” in consumption. It turns out that this feature gives rise to deviations from purchasing power parity. “Home bias”, as in their papers implies that home agents give a higher weight to home goods and foreign agents attach a higher weight to foreign goods. The home (foreign) consumption of domestic and foreign produced goods is given by C_H (C_H^*) and C_F (C_F^*), respectively, where:

$$C_H = \left[\left(\frac{1}{n} \right)^{\frac{1}{\sigma}} \int_0^n c(z)^{\frac{\sigma-1}{\sigma}} dz \right]^{\frac{\sigma}{\sigma-1}}, \quad C_F = \left[\left(\frac{1}{1-n} \right)^{\frac{1}{\sigma}} \int_n^1 c(z)^{\frac{\sigma-1}{\sigma}} dz \right]^{\frac{\sigma}{\sigma-1}} \quad (3)$$

$$C_H^* = \left[\left(\frac{1}{n} \right)^{\frac{1}{\sigma}} \int_0^n c^*(z)^{\frac{\sigma-1}{\sigma}} dz \right]^{\frac{\sigma}{\sigma-1}}, \quad C_F^* = \left[\left(\frac{1}{1-n} \right)^{\frac{1}{\sigma}} \int_n^1 c^*(z)^{\frac{\sigma-1}{\sigma}} dz \right]^{\frac{\sigma}{\sigma-1}} \quad (4)$$

where $\sigma > 1$ is the elasticity of substitution across the differentiated goods. The corresponding price indices are

$$P = [\nu P_H^{1-\theta} + (1-\nu) P_F^{1-\theta}]^{1/(1-\theta)} \quad (5)$$

$$P^* = [\nu^* P_H^{*1-\theta} + (1-\nu^*) P_F^{*1-\theta}]^{1/(1-\theta)} \quad (6)$$

where $P_X(P_X^*)$ is the price sub-index for goods produced in country X in the domestic (foreign) currency. The sub-indices are given by

$$P_H = \left[\frac{1}{n} \int_0^n p(z)^{1-\sigma} dz \right]^{1/(1-\sigma)}, \quad P_F = \left[\frac{1}{1-n} \int_n^1 p(z)^{1-\sigma} dz \right]^{1/(1-\sigma)} \quad (7)$$

$$P_H^* = \left[\frac{1}{n} \int_0^n p^*(z)^{1-\sigma} dz \right]^{1/(1-\sigma)}, \quad P_F^* = \left[\frac{1}{1-n} \int_n^1 p^*(z)^{1-\sigma} dz \right]^{1/(1-\sigma)} \quad (8)$$

Following De Paoli (2009b), we assume the law of one price holds for each individual differentiated goods and is given by:

$$p(h) = Sp^*(h) \text{ and } p(f) = Sp^*(f) \quad (9)$$

where S_t denotes the nominal exchange rate defined as the amount of home currency units (peso) required to buy one unit of the foreign currency (dollar). It follows from equations (7)-(9) that

$$P_H = SP_H^* \quad (10)$$

$$P_F = SP_F^*.$$

Substituting equation (10) in equation (5) we get

$$P = S \left[\nu P_H^{*1-\theta} + (1-\nu) P_F^{*1-\theta} \right]^{1/(1-\theta)} \quad (11)$$

Comparing equation (11) with equation (6) and noting $\nu \neq \nu^*$ it is easy to see that $P \neq SP^*$. In other words owing to the presence of “home bias”, PPP does not hold even when the law of one price holds.

The preference structure leads to the total demand for a differentiated good h , produced in country H

$$y_t^d(h) = \left[\frac{p_t(h)}{P_{H,t}} \right]^{-\sigma} \left\{ \left(\frac{P_{H,t}}{P_t} \right)^{-\theta} \left[(1-\lambda)(C_t) + \lambda \left(\frac{1}{Q_t} \right)^{-\theta} C_t^* \right] \right\} \quad (12)$$

where the real exchange rate $Q \equiv SP^*/P$.

Following De Paoli (2009b), the demand side of the small open economy ($n \rightarrow 0$) can be written in log-linear form as

$$y_t = (1-\lambda)c_t + \lambda c_t^* + \gamma q_t \quad (13)$$

where y is the home output, q is the real exchange rate and c_t^* is the foreign consumption, all expressed in log-linear terms. The parameter $\gamma = \frac{\theta\lambda(2-\lambda)}{1-\lambda}$, measures the sensitivity of domestic demand to movements in the real exchange rate and is a function of the degree of openness in the economy λ .

2.2 Price setting

Prices are set following the standard Calvo formulation the optimal choice of producers who can set price at time t , can be summarized by

$$E_t \left\{ \sum_T (\alpha\beta)^{T-t} U_C(C_T) \underbrace{\left(\frac{\tilde{p}_t(h)}{P_{H,T}} \right)^{-\sigma}}_{\tilde{y}_t(h)} Y_T \left[\frac{\tilde{p}_t(h)}{P_{H,T}} \frac{P_{H,T}}{P_T} - \mu_T \frac{\epsilon_T^{-\eta} y_T(z)^\eta}{U_C(C_T)} \frac{\sigma}{1-\sigma} \right] \right\} = 0 \quad (14)$$

where α is the fraction of firms do not change prices and $\tilde{p}(h)$ is the optimally adjusted price. Therefore, the price index evolves as

$$(P_{H,t})^{1-\sigma} = \alpha P_{H,t-1}^{1-\sigma} + (1-\alpha) \tilde{p}_t(h)^{1-\sigma} \quad (15)$$

Following Benigno and Benigno (2003) and De Paoli (2009b), it can be shown that (14) and (15) can be first order approximated by

$$\pi_t = k \left(\rho c_t + \eta y_t + \frac{\lambda}{1-\lambda} q_t - \eta \epsilon_t \right) + \beta E_t \pi_{t+1} \quad (16)$$

where $k = (1-\alpha\beta)(1-\alpha)/\alpha(1+\sigma\eta)$. Equation (16) is the supply side of the economy represented in log linear form. The price setting problem facing firms in the rest of the world is identical to those of the domestic firms.

2.3 International Markets

The budget constraint of the individual domestic household in country H is given by,

$$P_t C_t + \frac{B_t}{1+i_t} = \Pi_t^f + B_{t-1} + (1-T_t) P_{H,t} Y_t + P_{H,t} \Gamma_t \quad (17)$$

where P_t is the overall price index in the home country, $P_{H,t}$ is the price index of the domestically produced good, i_t is the nominal interest rate, T_t is the income tax, Γ_t is

the government transfer and B_t is the non-state-contingent risk-free bonds denominated in the local currency (peso). We follow Devereux and Engel (2002) in assuming that home households can directly trade only in peso-nominal bonds but cannot trade directly in dollar-denominated bonds. All trading in dollar-bonds is carried out by specialized forex dealers who act in the interest of home households. Households take Π_t^f or the net payment they receive from the dealers as given. The net payment Π_t^f is the profit from carry trading, denominated in peso. Given the above specification, we can write the small open economy's optimal intertemporal choice as

$$U_c(C_t) = (1 + i_t)\beta E_t \left[U_c(C_{t+1}) \frac{P_t}{P_{t+1}} \right] \quad (18)$$

As the foreign economy is large and closed, foreign households are assumed to trade only in dollar-bonds. Their intertemporal choice is given by

$$U_c(C_t^*) = (1 + i_t^*)\beta E_t \left[U_c(C_{t+1}^*) \frac{P_t^*}{P_{t+1}^*} \right] \quad (19)$$

As in Jeanne and Rose (2002), forex traders are modeled as overlapping generation of investors who live for two periods. In the first period of their lives they borrow funds from the households and purchase dollar-denominated bonds B_F . In the following period, the trader sells the foreign bonds and transfers all proceeds net of taxes, to its owners. Thus, the transfer Π_t^f from the traders to households every period is given by:

$$\Pi_t^f = \varpi_t B_{F,t-1} - P_{H,t-1} \Phi_{t-1} \quad (20)$$

$$\varpi_t = [S_t (1 + \hat{i}_{t-1}^*) - S_{t-1} (1 + i_{t-1})] / (1 + \hat{i}_{t-1}^*) \quad (21)$$

where ϖ_t is the net return from the trading before tax. The first component of ϖ_t denotes the amount households receive in period t from the foreign exchange dealer. The second component denotes the pre-tax amounts repaid to the household. S_t denotes the nominal exchange rate, and Φ denotes the sum of the forex trading tax that the government collects from the dealers. Further, to avoid non-stationarity of key variables such as consumption and current account, we assume, in the spirit of Schmidt-Grohé and Uribe (2003), that the world interest rate applicable to the small open economy is subject to an intermediation cost, ψ , increasing in net real foreign debt position $\psi' < 0$. i.e.

$$1 + \widehat{i}_t^* = (1 + i_t^*) \psi \left(\frac{B_{F,t} S_t}{P_t} \right)$$

The trader j born at t maximizes

$$\max_{B_{F,t}} E_t^j \left[\beta \left(\frac{C_{t+1}}{C_t} \right)^{-\rho} \frac{P_t}{P_{t+1}} \varpi_{t+1} B_{F,t}^j \right] - P_{H,t} \phi \left(\frac{S_t B_{F,t}^j}{P_t} \right) \quad (22)$$

where E_t^j refers to the conditional expectation of trader j at time t , and ϖ_{t+1} the net return from trading. Following the literature, we assume¹ the real foreign trading tax $\phi(X) = 0.5\tau X^2$. The trader's first order condition is given by:

$$0 = E_t^j \left[\beta \left(\frac{C_{t+1}}{C_t} \right)^{-\rho} \frac{P_t}{P_{t+1}} \varpi_{t+1} \right] - \tau \frac{S_t^2 B_{F,t}^j}{P_t} \frac{P_{H,t}}{P_t} \quad (23)$$

Equations (22) and (23) show that the optimal trading strategy chosen by the foreign exchange trader depends on their exchange rate expectations. Following De Long et al. (1990) and Jeanne and Rose (2002), we assume that a fraction, $\varsigma \in [0, 1]$, of the foreign exchange dealers are noise traders and the remaining $(1-\varsigma)$ are informed. The former's expectations about the future returns are noisy in the sense that they may deviate from the rational expectations by a noise shock. This will lead to differences in the expectations between noise traders and informed traders resulting in irrational, non-fundamentals-driven trade. This non-fundamental trade is useful for discussing potential gains from financial transaction taxes: if noise trading introduces an excess volatility in the real economy, a transaction tax which may be expected to curb noise trading may thereby also reduce noise-trade-driven excess real volatility. Formally, the informed traders have the model-consistent rational forecast,

$$E_t^I [q_{t+1} - q_t] = E_t [q_{t+1} - q_t] \quad (24)$$

and the noise traders have

$$E_t^N [q_{t+1} - q_t] = E_t [q_{t+1} - q_t] + v_t \quad (25)$$

where v_t is white noise with its variance σ_v^2 .

¹This assumption prevents traders from receiving subsidies by taking a short position. This also implies that the tax is imposed at the end of the period.

2.4 Market Clearing

The market clearing of the domestic bond market requires

$$\frac{B_t}{1 + i_t} = \frac{S_t B_{F,t}}{1 + i_t^*} \quad (26)$$

where the left-hand side is the amount of fund lent by household and the right-hand side is the amount of foreign bond purchased in the domestic currency. The government runs a balanced budget, which implies

$$0 = P_H (T_t Y_t - \Gamma_t) + P_{H,t-1} \Phi_{t-1} \quad (27)$$

Combining equations (17), (26) and (27), we get the economy's current account which can be expressed in log linear form as (See Appendix A.1 for details)

$$\beta b_t = b_{t-1} - \frac{\lambda}{1 - \lambda} q_t + y_t - c_t \quad (28)$$

Combining equations (23)-(25), we get (See Appendix A.2 for details)

$$(\tau + \delta) b_t = \rho E_t (c_{t+1}^* - c_t^*) - \rho E_t (c_{t+1} - c_t) + E_t \Delta q_{t+1} + \varsigma v_t \quad (29)$$

which can be expressed in in log-linear form as

$$i_t - i_t^* = E_t \Delta s_{t+1} + \varsigma v_t - (\tau + \delta) b_t \quad (30)$$

where ς is the fraction of noise traders, δ denotes the elasticity of borrowing cost with respect to net real foreign bond. The above equation represents the uncovered interest parity condition in the economy. We therefore interpret v_t , the noise term as a shock to the risk premium. Equations (13), (16), (28) and (30) are a summary of the models equilibrium conditions. An analogous set of expressions characterize the world economy. In what follows, we solely focus on shocks to the small open economy. It is assumed that the world economy is in steady state and $c_t^* = \pi_t^* = 0$.

3 Monetary Policy

Having characterized the decentralized equilibrium, we are now set to evaluate and compare alternative monetary policies under risk premium and productivity shocks. We first derive

the policymaker's objective function as a second order approximation of the household's utility function and then study optimal monetary policy under commitment. The two simple rules of fixed exchange rates, and domestic inflation targeting are addressed thereafter. Following De Paoli (2009b), we derive the loss function of the central bank as a second order approximation of the utility function:

$$L = \frac{1}{2} [y_t \ q_t] L_y [y_t \ q_t]' + [y_t \ q_t] L_e \epsilon_t + \frac{1}{2} l_\pi \pi_t^2 \quad (31)$$

where $L_y = [l_{yy} \ l_{yq}; \ l_{yq} \ l_{qq}]$, $L_e = [l_{y\epsilon}; \ l_{q\epsilon}]$. The coefficients l 's are functions of fundamental parameters of the economy (See Appendix B for details). Essentially, the loss function indicates that the central bank aims at balancing fluctuations in output, inflation and real exchange rate. Intuitively, the presence of staggered prices and monopolistic competition implies there are gains in minimizing output and inflation fluctuations. Finally, the open-economy side friction introduces incentive to stabilize the exchange rate to minimize the wedge between the marginal utility of consumption and the marginal cost of production.

3.1 Optimal Policy

Given this loss function, the Lagrangian for the optimal policy under commitment is the loss function (31) subject to equations (13), (16), (28) and (30) as below:

$$\begin{aligned} \min L = & \sum \beta^t [L \\ & + \varphi_{1,t} \left\{ \pi_t - k \left(\rho c_t + \eta y_t + \frac{\lambda}{1-\lambda} q_t - \eta \varepsilon_t \right) - \beta E_t \pi_{t+1} \right\} \\ & + \varphi_{2,t} \{ y_t - (1-\lambda) c_t - \lambda c_t^* - \gamma q_t \} \\ & + \varphi_{3,t} \{ (\tau + \delta) b_t - \rho (E_t c_{t+1}^* - c_t^*) - E_t q_{t+1} + q_t - \varsigma v_t + \rho (E_t c_{t+1} - c_t) \} \\ & + \varphi_{4,t} \left\{ \beta b_t - b_{t-1} + \frac{\lambda}{1-\lambda} q_t - y_t + c_t \right\} \end{aligned}$$

The optimal policy then is characterized by the system of the following first order conditions

$$\begin{aligned}
0 &= \Delta\varphi_{1,t} + l_\pi\pi_t \\
0 &= l_{yy}y_t + l_{yq}q_t + l_{y\epsilon}\epsilon_t - k\eta\varphi_{1,t} + \varphi_{2,t} - \varphi_{4,t} \\
0 &= l_{yq}y_t + l_{qq}q_t + l_{q\epsilon}\epsilon_t - k\frac{\lambda}{1-\lambda}\varphi_{1,t} - \gamma\varphi_{2,t} + \left(\varphi_{3,t} - \frac{\varphi_{3,t-1}}{\beta}\right) + \frac{\lambda}{1-\lambda}\varphi_{4,t} \\
0 &= -k\rho\varphi_{1,t} - (1-\lambda)\varphi_{2,t} - \rho\left(\varphi_{3,t} - \frac{\varphi_{3,t-1}}{\beta}\right) + \varphi_{4,t} \\
0 &= -E_t \Delta\varphi_{4,t+1} + \frac{(\delta + \tau)}{\beta}\varphi_{3,t}
\end{aligned}$$

As shown by De Paoli (2009b), when $\tau = \delta = 0$, it can be shown that the optimal policy can be written as

$$0 = E_t [W_y (\Delta y_{t+1} - y_{t+1}^T) + W_q (\Delta q_{t+1} - q_{t+1}^T) + W_\pi \pi_{t+1}]$$

where

$$\begin{aligned}
W_y &= l_{yq} + \left(\gamma + \frac{1-\lambda}{\rho}\right) l_{yy}, \quad W_q = l_{qq} + \left(\gamma + \frac{1-\lambda}{\rho}\right) l_{yq} \\
W_\pi &= \left(\frac{1}{1-\lambda}\right) + \left(\gamma + \frac{1-\lambda}{\rho}\right) \eta \\
y_t^T &= -\frac{\left(\gamma + \frac{1-\lambda}{\rho}\right)}{W_y} \epsilon_t, \quad q_t^T = -\frac{l_{q\epsilon}}{W_q} \epsilon_t = 0
\end{aligned}$$

and x_{t+1}^T denotes a targeting value for variable x . According to the above rule, optimal policy responds to movements in output, inflation and real exchange rate. It is worth noting that the efficient level of output in this special case is given by $y_t^T = -\left(\gamma + \frac{1-\lambda}{\rho}\right) W_y^{-1} \epsilon_t$ and therefore a function only of productivity shocks.²

More importantly, even though the weights W of optimal policy are a function of the structural parameters of the model, one can show that the welfare is, in general, critically effected by the nature of the shock and the magnitude of the Tobin tax.

²As has been extensively noted in the literature, there are challenges to implementing this as a rule as there are issues of determinacy that crop up.

3.2 Impulse Response

We next characterize equilibrium dynamics as well as welfare under alternative policies when the economy is subject to the risk premium shocks v_t and productivity shocks ϵ_t . Specifically, we compare the dynamics of inflation, output, consumption and real exchange rate obtained under optimal monetary policy with those obtained under two simple rules namely inflation targeting (IT, $i_t = \chi\pi_t$)³ and the fixed exchange rate (PEG, $\Delta s_t = 0$). These exercises are conducted using the baseline parameters shown in Table 1. We then proceed to examine how these responses are altered when we vary the magnitude of the Tobin tax.

3.2.1 Shocks to the risk premium

Consider now a temporary increase in the the risk premium v_t . Notice that unlike the case of the productivity shock, there is no change in the efficient level of output in the case of a risk premium shock. It follows that in this case, optimal policy calls for insulating the real side of the economy from the shock. Figure 1.A shows that the movement in inflation, output and real exchange rates are minimal under optimal policy. In order to stabilize demand, optimal policy raises interest rate to lower domestic consumption, which leads to higher savings and higher bond holdings. Essentially optimal policy smooths the exchange rate and allows the interest rate to rise (see equation 30). The rise in interest rate stabilizes demand and hence inflation.

In contrast, an IT regime allows the real exchange rate to depreciate strongly, resulting in a sharp increase in demand. The dynamics under a PEG regime are similar to those exhibited under optimal policy. By stabilizing the real exchange rate, the interest rates absorb the risk premium shock under the PEG regime. The consequent rise in interest rate stabilizes demand and inflation. This is verified by Table 2, which reports standard deviations and the welfare loss, expressed as a percentage of steady state consumption, under the alternative monetary policy regimes. The lower inflation and output variability under the PEG regime results in it outperforming the IT regime.

³De Paoli (2009b) considers a strict inflation targeting rule wherein domestic inflation is always set to zero. However, as has been documented in the literature, there are challenges to implementing this policy as a simple rule as there are issues of determinacy. We therefore adopt the more practical flexible inflation targeting rule.

Table 2 shows that welfare under all regimes improves with an increase in Tobin tax. Intuitively, an increase in Tobin tax reduces the demand for foreign bonds while a positive risk premium shock increases the demand for foreign bonds. *Ceteris paribus*, raising Tobin taxes offsets rise in v_t in the forex market. As a result, required responses in policy interest rate are muted, which in turn minimizes the adverse effects on output and inflation.

3.2.2 Productivity Shocks

Now consider a temporary rise in productivity. Figure 1.B shows that inflation under the optimal policy stays flat while the output rises. Intuitively, a rise in productivity calls for an increase in output as in De Paoli (2009b) due to an increase in its efficient level. This is engineered by a decrease in policy interest rate that also lets real exchange rate depreciate. As a result, the demand for home goods rises, thus raising its output. Since the output, domestic consumption, and real exchange rate comove with the productivity shock, the real marginal cost and inflation (see equation 16) remain stabilized.

Since the optimal policy entails inflation stabilization, the dynamics exhibited by the IT regime closely mimic those under the optimal policy. The PEG on the other hand, by unduly stabilizing real exchange rate (Table 2), constrains interest rate and output movements. It leads to a substantial deflation and muted rise in domestic consumption and home output. As a result, as in De Paoli (2009b), the IT regime welfare dominates PEG (Table 2).

As evident from Table 2, a positive Tobin tax reduces welfare under all regimes. Intuitively, as savings (and bond holdings) comove with productivity shock (income effect) a positive Tobin tax stabilizes nominal (and therefore real) exchange rates excessively relative to what optimality commands.⁴

⁴As can be seen from equation (30), for a given interest rate, a positive Tobin tax requires an appreciation (depreciation) under positive (negative) productivity shock if b comoves with ϵ .

3.3 Simultaneous Shocks

We next analyze the performance of alternative monetary policies and Tobin taxes when the two shocks are turned on together. Consider the following structure of shocks

$$\epsilon_t = \rho_\epsilon \epsilon_{t-1} + e_{\epsilon,t} \quad (32)$$

$$v_t = e_{v,t}$$

where $e_{\epsilon,t}$ and $e_{v,t}$ are uncorrelated i.i.d white noise shocks. Table 3 clearly indicates that under this scenario the PEG dominates the IT regime regardless of the size of elasticity of substitution between home and foreign goods (θ). For $\theta > 1$, productivity shocks call for real exchange rate flexibility with inflation stability, whereas the risk premium shocks require the opposite. For our baseline specification, exhibited in Table 1, it turns out that risk premium shock takes precedence over productivity shock in the determination of optimal policy response. As a result, the PEG dominates the IT regime for $\theta = 2$. The results for $\theta < 1$, follow from De Paoli (2009b) who shows under incomplete markets and productivity shocks, a policy of exchange rate stabilization is welfare improving when the degree of substitutability between home and foreign good is low. This is because a low elasticity of substitution between imported and domestic goods reduces the negative income effect of terms of trade improvement on consumption. This welfare improving feature of the PEG regime is compounded in our framework due to the presence of noise traders.

To summarize, we find that when we add noise traders to the simple small open economy incomplete markets framework of De Paoli (2009b), a PEG regime dominates an IT regime under productivity shocks. Our results are in contrast to that of De Paoli, who shows that the above result holds true only when $\theta < 1$.

Next consider an increase in Tobin taxes. Table 3 clearly shows that when $\theta > 1$, increasing the Tobin tax causes welfare to fall under the PEG while it rises under the IT regime. Recall from our preceding discussion that with only productivity shocks (but no noise traders), the IT regime outperforms the PEG; now it is the presence of noise traders in addition that makes the PEG superior. Imposing Tobin taxes in addition stabilize real exchange rate excessively and thus reduces welfare under the PEG. In contrast, since the IT performs poorly precisely because of real exchange rate instability, Tobin taxes help the

IT perform better. On the other hand, when $\theta < 1$, imposing Tobin taxes improves welfare irrespective of the regime in place. The result follows from the discussion in the preceding paragraph where we established that exchange rate stabilization unambiguously improves welfare when $\theta < 1$. Tobin taxes by stabilizing the real exchange rate therefore are welfare enhancing under both regimes.⁵

4 Conclusions

Our objective in this paper is twofold. First, two classic rules, fixed exchange rates and inflation targeting are studied and ranked by comparing them with the optimal monetary policy under commitment in a small open economy with incomplete markets and noise traders in the forex market. Second, we examine the impact of Tobin taxes under each of these monetary policy regimes.

The key message of the paper is that the presence of noise traders in the forex market increases the desirability of fixed exchange rates vis-à-vis inflation targeting, irrespective of the trade elasticity between domestic and foreign goods. More specifically, with noise traders in the forex market and with shocks to productivity, a fixed exchange rate regime dominates inflation targeting even when the two goods are substitutes, reversing the result highlighted by De Paoli (2009b). The impact of Tobin taxes is found to be critically dependent upon the elasticity of substitution between the goods. When domestic and foreign goods are substitutes, these taxes overstabilize the real exchange rate under a fixed exchange rate regime and perform poorly, whereas under inflation targeting, they improve welfare by providing some stability to the real exchange rate. On the other hand, when the domestic and foreign goods are complements, Tobin taxes improve performance irrespective of the regime in place – a result which is in line with the findings in De Paoli (2009b). A key drawback in this model is that the number of noise traders in the market at any point assumed to be exogenous. One potential direction for future research would be to endogenize the entry of noise traders and examine its implications for monetary policy and Tobin taxes in a DSGE setup.

⁵In exercises not reported we also find this result robust to changes in the variance and persistence of risk premium shocks as well as trade openness and activeness of IT policy.

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A Appendix

A.1 Current Account

In the Appendix, we follow De Paoli (2009b) in deriving first and second order approximations to the equilibrium conditions of the model. Combining equations (17), (26) and (27), we get the economy's current account

$$P_t C_t + \frac{S_t B_{F,t}}{1 + \hat{i}_t^*} = S_t B_{F,t-1} + P_{H,t} Y_t \quad (\text{A.1})$$

With a definition the real bond balance $B_R \equiv \frac{S B_F}{P}$ and the domestic household's Euler equation $(1 + \hat{i}_t^*)^{-1} = \beta E_t \left[\left(\frac{C_{t+1}}{C_t} \right)^{-\rho} \frac{S_{t+1}}{S_t} \frac{P_t}{P_{t+1}} \right]$, (A.1) can be re-expressed as

$$\begin{aligned} C_t + \frac{S_t B_{F,t}}{P_t (1 + \hat{i}_t^*)} &= \frac{P_{t-1}}{P_t} \frac{S_t}{S_{t-1}} \frac{S_{t-1} B_{F,t-1}}{P_{t-1}} + \frac{P_{H,t}}{P_t} Y_t \\ C_t + B_{R,t} \beta E_t \left[\left(\frac{C_{t+1}}{C_t} \right)^{-\rho} \frac{S_{t+1}}{S_t} \frac{P_t}{P_{t+1}} \right] &= \frac{S_t}{S_{t-1}} \frac{P_{t-1}}{P_t} B_{R,t-1} + \frac{P_{H,t}}{P_t} Y_t \\ B_{R,t} \beta E_t \left[C_{t+1}^{-\rho} \frac{S_{t+1}}{S_t} \frac{P_t}{P_{t+1}} \right] &= C_t^{-\rho} \frac{S_t}{S_{t-1}} \frac{P_{t-1}}{P_t} B_{R,t-1} + C_t^{-\rho} \left[\frac{P_{H,t}}{P_t} Y_t - C_t \right] \end{aligned}$$

Furthermore, with $B_t \equiv B_{R,t} E_t \left[C_{t+1}^{-\rho} \frac{S_{t+1}}{S_t} \frac{P_t}{P_{t+1}} \right]$, the current account can be rewritten as

$$\beta B_t = B_{t-1} + C_t^{-\rho} \left[\frac{P_{H,t}}{P_t} Y_t - C_t \right] \quad (\text{A.2})$$

The first order log-linear approximation to the current account equation (A.2) around a symmetric equilibrium with zero bond holdings is

$$\beta b_t = b_{t-1} + p_{H,t} + y_t - c_t$$

where $b_t = \frac{B_t - \bar{B}}{\bar{B}}$, $\bar{B} = \frac{\bar{Y}^{-\rho} \bar{Y}}{1 - \beta}$ and $p_{H,t} = \hat{P}_{H,t} - \hat{P}_t$. The second order approximation to (A.2) is

$$b_t = (1 - \beta) \left[b'_y y_t + \frac{1}{2} y'_t B_y y_t + y'_t B_\epsilon \epsilon_t \right] + \beta E_t b_{t+1} + t.i.p + O^3 \quad (\text{A.3})$$

where

$$\begin{aligned} \mathbf{y}'_t &= \begin{bmatrix} y_t & c_t & p_{H,t} & q_t \end{bmatrix}, \\ B_y &= \begin{bmatrix} -1 & \rho & -1 & 0 \\ -1 & 1-2\rho & \rho & 0 \\ -1 & \rho & -1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \\ b'_y &= \begin{bmatrix} -1 & 1 & -1 & 0 \end{bmatrix} \\ B'_\epsilon &= \begin{bmatrix} 0 & 0 & 0 & 0 \end{bmatrix} \end{aligned}$$

A.2 Uncovered interest parity

The first order condition of the traders is given by

$$\frac{P_{H,t}}{P_t} \frac{\tau S_t^2 B_{F,t}^j}{P_t} = E_t^j \left[\beta \left(\frac{C_{t+1}}{C_t} \right)^{-\rho} \frac{P_t}{P_{t+1}} \varpi_{t+1} \right]$$

After substituting the definition of ϖ_t and foreign household's Euler equation, we get,

$$\frac{P_{H,t}}{P_t} \frac{\tau S_t B_{F,t}^j}{P_t} = E_t^j \left[\left[\beta \left(\frac{C_{t+1}}{C_t} \right)^{-\rho} \frac{P_t}{P_{t+1}} \frac{S_{t+1}}{S_t} \right] - \left[\beta \left(\frac{C_{t+1}^*}{C_t^*} \right)^{-\rho} \frac{P_t^*}{P_{t+1}^*} \right] \right] \quad (\text{A.4})$$

The noise trader's information set is given by

$$E_t^N [\Delta q_{t+1}] = E_t [\Delta q_{t+1}] + v_t$$

$$\Delta q_{t+1} = \Delta s_{t+1} + \pi_{t+1}^* - \pi_{CPI,t+1}$$

where $\pi_{CPI,t} = \log(P_{t+1}/P_t)$. Taking linear approximation of (A.4), we get

$$\begin{aligned} \tau b_t^j &= E_t^j \left[\rho (c_{t+1}^* - c_t^*) - \rho (c_{t+1} - c_t) - \delta b_t + \underbrace{\Delta s_{t+1} + \pi_{t+1}^* - \pi_{CPI,t+1}}_{\Delta q_{t+1}} \right] \\ &= E_t [\rho (c_{t+1}^* - c_t^*) - \rho (c_{t+1} - c_t) - \delta b_t] + \Delta q_{t+1} + D_{\varsigma_j} v_t \end{aligned}$$

where $D_{\varsigma_j} = 1$ if j is a noise trader, 0, otherwise. Aggregating this over j , we have

$$(\tau + \delta) b_t = \rho (c_{t+1}^* - c_t^*) - \rho (c_{t+1} - c_t) + \Delta q_{t+1} + \varsigma v_t$$

where $\varsigma = \sum_j D_{\varsigma_j}$ = fraction of noise traders.

B Derivation of Loss function

Next, we proceed to derive the Loss function. We begin by obtaining a second order approximations for the Phillips equation, demand and real exchange rate. These are then useful in obtaining an expression for the loss function.

B.1 Phillips curve

The second order approximation to the Phillips curve is given by

$$V_0 = E_0 \sum \beta^t \left[a'_y \mathbf{y}_t + \frac{1}{2} \mathbf{y}'_t A_y \mathbf{y}_t + \mathbf{y}'_t A_\epsilon \epsilon_t + \frac{1}{2} a_\pi \pi_t^2 \right] + t.i.p + O^3 \quad (\text{B.1})$$

where

$$\begin{aligned} a'_y &= \begin{bmatrix} \eta & \rho & -1 & 0 \end{bmatrix} \\ A_y &= \begin{bmatrix} \eta(2+\eta) & \rho & -1 & 0 \\ \rho & -\rho^2 & \rho & 0 \\ -1 & \rho & -1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \\ A'_\epsilon &= \begin{bmatrix} -\eta(1+\eta) & 0 & 0 & 0 \end{bmatrix} \\ a_\pi &= (1+\eta) \sigma/k \end{aligned}$$

$$V_t = k^{-1} [\pi_t + v_\pi \pi_t^2 + v_z \pi_t Z_t]$$

For v_π , v_z , and Z_t , see Appendix to Benigno and Benigno (2003).

B.2 Demand

The first order approximation to the demand for small open economy goods is

$$y_t = -\theta p_{H,t} + (1-\lambda) c_t + \lambda c_t^* + \theta \lambda q_t \quad (\text{B.2})$$

The second order approximation is

$$0 = \sum \beta^t \left[d'_y \mathbf{y}_t + \frac{1}{2} \mathbf{y}'_t D_y \mathbf{y}_t + \mathbf{y}'_t D_\epsilon \epsilon_t \right] + t.i.p + O^3 \quad (\text{B.3})$$

where

$$d'_y = \begin{bmatrix} -1 & 1 - \lambda & -\theta & \theta\lambda \end{bmatrix}$$

$$D_y = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & (1 - \lambda)\lambda & 0 & -\theta(1 - \lambda)\lambda \\ 0 & 0 & 0 & 0 \\ 0 & -\theta(1 - \lambda)\lambda & 0 & \theta^2(1 - \lambda)\lambda \end{bmatrix}$$

$$D'_\epsilon = \begin{bmatrix} 0 & 0 & 0 & 0 \end{bmatrix}$$

B.3 Real exchange rate

The consumer price index $P_t = [(1 - \lambda)P_{H,t}^{1-\theta} + \lambda P_{F,t}^{1-\theta}]^{\frac{1}{1-\theta}}$ can be log-linear approximated by

$$p_{H,t} = -\frac{\lambda}{1 - \lambda}q_t \quad (\text{B.4})$$

and second order approximated by

$$0 = E_0 \sum \beta^t \left[f'_y \mathbf{y}_t + \frac{1}{2} \mathbf{y}'_t F_y \mathbf{y}_t + \mathbf{y}'_t F'_\epsilon \epsilon_t \right] + t.i.p. + O^3 \quad (\text{B.5})$$

where

$$f'_y = \begin{bmatrix} 0 & 0 & -(1 - \lambda) & -\lambda \end{bmatrix}$$

$$F'_y = \lambda(\theta - 1) \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1 \\ 0 & 0 & -1 & 1 - \frac{\lambda}{1 - \lambda} \end{bmatrix}$$

$$F'_\epsilon = \begin{bmatrix} 0 & 0 & 0 & 0 \end{bmatrix}$$

B.4 Loss function

Following Benigno and Benigno (2003) and De Paoli (2009b), the utility function can be second order approximated by

$$U = E_0 \sum_t \beta^t \left[\frac{C_t^{1-\rho}}{1-\rho} - \frac{1}{n} \int_0^n \frac{\epsilon_t^{-\eta} (y_t^j)^{1+\eta}}{1+\eta} \right] \\ \simeq U_C C E_0 \sum_t \beta^t \left[w'_y \mathbf{y}_t - \frac{1}{2} \mathbf{y}'_t W_y \mathbf{y}_t - \mathbf{y}'_t w_\epsilon \epsilon_t - \frac{1}{2} w_\pi \pi_t^2 \right] + t.i.p + O^3$$

where

$$W_y = \begin{bmatrix} \frac{1+\eta}{\mu} & 0 & 0 & 0 \\ 0 & \rho - 1 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \\ \mathbf{y}'_t = \begin{bmatrix} y_t & c_t & p_{H,t} & q_t \end{bmatrix}, \\ w'_y = \begin{bmatrix} -\frac{1}{\mu} & 1 & 0 & 0 \end{bmatrix}, \\ w_\epsilon = -\frac{\eta}{\mu}$$

Using a second order approximation to the equilibrium conditions, the first order term, $w'_y y_t$ is eliminated and the loss function is obtained:

$$L = -U \simeq U_C C E_0 \sum_t \beta^t \left[\frac{1}{2} \mathbf{y}'_t L_y \mathbf{y}_t + \mathbf{y}_t L_\epsilon \epsilon_t + \frac{1}{2} l_\pi \pi_t^2 \right] + t.i.p + O^3$$

where

$$L_y = W_y + L_{x1} A_y + L_{x2} D_y + L_{x3} F_y + L_{x4} B_y \\ L_\epsilon = w_\epsilon + L_{x1} A_\epsilon + L_{x2} D_\epsilon + L_{x3} F_\epsilon + L_{x4} B_\epsilon \\ l_\pi = w_\pi + L_{x1} a_\pi \\ L_x \equiv [L_{x1}; L_{x2}; L_{x3}; L_{x4}] \\ = \begin{bmatrix} a_y & d_y & f_y & b_y \end{bmatrix}^{-1} w_y$$

To write the loss function in terms of y , q , and π , we apply the following transformation using (B.4) and (B.2):

$$\mathbf{y}_t = N \begin{bmatrix} y_t & q_t \end{bmatrix}'$$

where

$$N = \begin{bmatrix} 1 & 0 \\ \frac{1}{1-\lambda} & -\frac{\theta\lambda(2-\lambda)}{(1-\lambda)^2} \\ 0 & -\frac{\lambda}{1-\lambda} \\ 0 & 1 \end{bmatrix}$$

Therefore, the loss function can be reduced into

$$L = U_c C E_0 \sum \beta^t \left[\frac{1}{2} \begin{bmatrix} y_t & q_t \end{bmatrix} \mathbf{L}_y \begin{bmatrix} y_t & q_t \end{bmatrix}' + \begin{bmatrix} y_t & q_t \end{bmatrix} \mathbf{L}_\epsilon \epsilon + \frac{1}{2} l_\pi \pi_t^2 \right] + t.i.p + O^3$$

where

$$\mathbf{L}_y = N' L_y N \equiv \begin{bmatrix} l_{yy} & l_{yq} \\ l_{yq} & l_{qq} \end{bmatrix}$$

$$\mathbf{L}_\epsilon = N' L_\epsilon = \begin{bmatrix} l_{y\epsilon}; & l_{q\epsilon} \end{bmatrix}$$

and

$$l_{yy} = \frac{(-1 + \mu + \eta\mu + \rho) (\eta(1 + \theta(-2 + \lambda))(-1 + \lambda)^2 - (-1 + \lambda + \theta(2 - 5\lambda + 2\lambda^2)) \rho)}{(-1 + \lambda)^2 \mu (\eta(1 + \theta(-2 + \lambda)) - \lambda) + \rho - 2\theta\rho + \lambda(-1 + \theta\rho)}$$

$$l_{yq} = \frac{\theta\lambda(-1 + \mu + \eta\mu + \rho) (1 + \lambda^2(3 - 4\theta\rho) + \lambda^3(-1 + \theta\rho) + \lambda(-3 + 4\theta\rho))}{(-1 + \lambda)^3 \mu (\eta(1 + \theta(-2 + \lambda)) - \lambda) + \rho - 2\theta\rho + \lambda(-1 + \theta\rho)}$$

$$l_{qq} = -\frac{\theta\lambda(-1 + \mu + \eta\mu + \rho) \left(\begin{aligned} &(-1 + \lambda)^2 (1 - 3\lambda + \lambda^2) + \theta^2(-2 + \lambda)^3 \lambda \rho \\ & - \theta(-1 + \lambda) (-2 + \lambda^3(1 + \rho) - \lambda^2(5 + 4\rho) + \lambda(6 + 4\rho)) \end{aligned} \right)}{(-1 + \lambda)^4 \mu (\eta(1 + \theta(-2 + \lambda)) - \lambda) + \rho - 2\theta\rho + \lambda(-1 + \theta\rho)}$$

$$l_{y\epsilon} = -\frac{\eta(1 + \theta(-2 + \lambda))(-1 + \mu + \eta\mu + \rho)}{\mu (\eta(1 + \theta(-2 + \lambda)) - \lambda) + \rho - 2\theta\rho + \lambda(-1 + \theta\rho)}$$

$$l_{q\epsilon} = 0$$

Table 1: Baseline Parameters

Parameter	Value	Remarks
λ	0.4	Trade openness
β	0.99	Discount factor (annual real interest rate of 4%)
η	1.6	Inverse Frisch elasticity of labor supply
α	0.75	Calvo sticky price parameter: average of 4 quarters of price rigidity
θ	1.5	Elasticity of substitution between domestic and foreign goods
δ	0.01	Elasticity of risk premium with respect to foreign debt size
σ	6	Elasticity of substitution among differentiated intermediate goods
ρ	2	Coefficient of relative risk aversion
γ	$\theta\lambda(2 - \lambda) / (1 - \lambda)$	
k	$(1 - \alpha\beta)(1 - \alpha) / \alpha(1 + \sigma\eta)$	
ρ_ϵ	0.95	Persistence of productivity shock
$\sigma_\epsilon, \sigma_v$	0.07	Standard deviation of productivity and risk premium shocks
χ	2.5	Activeness of interest rate targeting

Table 2: Welfare Loss and Variance of Key Variables

Policy	Parameter	Welfare loss	var(q)	var(y)	var(π)
<i>Risk premium Shock</i>					
IT	$\tau = 0$	0.0018	9.95E-04	2.54E-03	6.17E-07
PEG		-4.45E-07	9.26E-07	8.78E-05	1.05E-07
OP		-0.00022	8.34E-05	5.41E-05	2.00E-09
IT	$\tau = 0.01$	0.0017	9.54E-04	2.45E-03	6.04E-07
PEG		-1.00E-06	8.83E-07	8.56E-05	1.00E-07
OP		-0.00021	7.95E-05	5.11E-05	2.07E-09
<i>Productivity Shock</i>					
IT	$\tau = 0$	-0.0155	0.0017	0.0117	1.23E-05
PEG		-0.0130	0.0011	0.0083	8.97E-06
OP		-0.0189	0.0018	0.0124	1.16E-08
IT	$\tau = 0.01$	-0.0131	0.0015	0.0112	1.50E-05
PEG		-0.0121	0.0010	0.0081	8.18E-06
OP		-0.0171	0.0016	0.0120	7.62E-09

Table 3: Welfare Loss and Variance When Both Shocks Are Turned On

Policy	$\tau = 0$	Parameter	Welfare loss	$\text{var}(q)$	$\text{var}(y)$	$\text{var}(\pi)$
IT		$\theta=2$	0.1025	0.0464	0.1687	2.27E-04
PEG			0.0334	0.0017	0.0368	5.03E-05
IT		$\theta=0.5$	-0.2076	0.0078	0.0006	1.05E-05
PEG			-0.4845	0.0016	0.0006	3.04E-06

Policy	$\tau = 0.01$	Parameter	Welfare loss	$\text{var}(q)$	$\text{var}(y)$	$\text{var}(\pi)$
IT		$\theta=2$	0.0930	0.0407	0.1522	1.80E-04
PEG			0.0349	0.0015	0.0364	4.68E-05
IT		$\theta=0.5$	-0.3157	0.0089	0.0007	1.52E-06
PEG			-0.5249	0.0016	0.0006	3.28E-06

Figure 1: Impulse Response of Key Variables

A. Risk Premium Shock

B. Productivity Shock