Open economies review **17**: 5–26, 2006

Price Rigidity and the Selection of the Exchange Rate Regime

FABRICE COLLARD fabrice.collard@univ-tlse1.fr
GREMAQ-CNRS, Manufacture des Tabacs, bât. F., 21 allée de Brienne, 31000 Toulouse, France

HARRIS DELLAS harris.dellas@vwi.unibe.ch
Department of Economics, University of Bern, CEPR and IMOP, Gesellschaftsstrasse 49, CH-3012 Bern, Switzerland

Key words: exchange rate systems, monetary policy, price sluggishness, inflation targeting

JEL Classification Numbers: E32, E52, F33, F42

Abstract

We evaluate and qualify Friedman's, 1953, "case for flexible exchange rates" in the presence of sticky prices in a two country model. We find that a flexible regime performs indeed better when the degree of nominal price rigidity is high while a bilateral peg does better when prices are fairly flexible. This result obtains independent of whether monetary policy is activistic or not and is mostly due to the negative relationship between employment and productivity shocks when prices are relatively sluggish (Gali, 1999). A unilateral peg tends to produce the lowest level of world welfare but it sometimes represents the best monetary arrangement for the pegger.

Exchange rate policy has exhibited considerable variation across countries and over time. It has been accompanied by a voluminous literature that investigates the properties and the implications of monetary policy in an open economy. The earlier literature was based on the Mundell-Fleming model and its rational expectations extensions and has generated two key insights (abstracting from credibility issues): First, floating exchange rates may provide the *needed* relative price adjustment when nominal goods prices are sluggish (Friedman, 1953). And second, the targeting of the exchange rate contributes to greater macroeconomic stability when domestic money demand shocks are the main source of volatility. For dominant domestic fiscal shocks, a flexible system fares better (for reasons related to Poole's seminal analysis of the implications of alternative central bank operating procedures).

The more recent -and fast expanding- literature has mainly relied on versions of either the Obstfeld and Rogoff model, or, the so-called New Neoclassical Synthesis (NNS) model[1] (see Goodfriend and King, 1997). It has concerned itself with the evaluation of the properties (welfare, volatility) of alternative exchange rate regimes[2] as well as the optimal design of monetary policy in open economies.[3] In addition to its reliance on microfoundations, this literature has significantly expanded the range of the analysis beyond the slopes of the IS-LM curves and the relative volatilities of the shocks. In particular, it has examined the role played by the choice of the market characterized by nominal rigidities (labor vs goods), market structure (perfect vs monopolistic competition), the currency denomination of prices (seller's vs buyer's) and the type of monetary policy pursued (passive vs active). Two general patterns have emerged.

First, models with a pricing to market assumption (imperfect competition plus seller's currency denomination) tend to find small differences in volatility across regimes. And second, flexible -or managed float- regimes are found to possess a welfare advantage over fixed ones when unconstrained activistic monetary policy is optimal (Obstfeld and Rogoff, 2000). This is due to the fact that a flexible exchange rate system -unlike a fixed one- does not constraint monetary policy.[4]

What is missing in this literature is an evaluation of the role of the key ingredient of these models, namely the the existence and degree of price sluggishness, in the performance of exchange rate systems. Without nominal rigidities, and in the absence of other distortions such as market segmentation, one does not expect the selection of the exchange rate system to be of any consequence. Nonetheless, the precise role of nominal rigidity has not been investigated. M. Friedman's, 1953, important insight that exchange rate fluctuations may be desirable because they may "undo" the effects of limited goods prices flexibility has not led to an investigation of how much rigidity and under what conditions is needed in order to make a difference for the choice of the regime. This is an important issue because price sluggishness is a quantitative rather than a qualitative concept and so it must be quantified before it can become operational. Moreover, as any exchange rate system gives rise to trade offs one wants to know how much price rigidity is required to make the flexible system desirable and whether the required degree of price rigidity falls within the set of empirically plausible values. And finally, Friedman assumed passive monetary policy. It is not at all obvious whether the desired relative price adjustment is consistent with activistic policy motivated by other considerations.

Our objective in this paper is to address these issues and, in the process, revisit Friedman's case for a flexible exchange rate regime. We use what has become a standard, two country model, (see Collard and Dellas, 2002). Its features include: imperfectly competitive firms that set prices a la Calvo, trade flows denominated in the currency of the seller, inflation targeting and three shocks (supply, fiscal, monetary). Our measure of price sluggishness is simply the average duration of price setting. We compare three systems: A perfect float, a bilateral peg and a unilateral peg. Monetary policy targets inflation under the first two regimes but under the bilateral peg, in addition to targeting inflation it must also satisfy the exchange rate restriction. In a unilateral peg, the "leader" country follows his optimal monetary policy-while the pegging country simply targets the exchange rate.[5]

Three results stand out: First, a flexible system tends to outperform the bilateral peg when the degree of aggregate price level sluggishness is sufficiently high. This confirms' Friedman's case for flexible exchange rates when prices are sluggish but the reasons are more subtle than previously thought. If, however, prices are adjusted fairly often, then a bilaterally fixed regime fares better not only because it delivers greater stability in real balances but also because it generates a more stable consumption profile. Nevertheless, the welfare differences between these two regimes tend to be quite small for the commonly used value of price sluggishness (an average duration of four quarters).

Second, a unilateral peg is dominated by either the pure float or the bilateral peg in terms of *world* welfare. But the pegger is occasionally better off under a unilateral peg relative to the other two regimes. This finding leads to intriguing questions concerning international policy coordination and monetary policy choices.

Third, the pursuit of inflation targeting cannot serve as a substitute for exchange rate flexibility. The superior performance of a bilateral peg under relatively flexible prices obtains independent of whether monetary policy targets inflation or the supply of money and even when real balances play a minor role in welfare calculations.

The remaining of the paper is organized as follows. Section 1 presents the model. Section 2 describes the calibration used. Section 3 presents and discusses the results.

1. The model

The model economy consists of two equally sized countries, each populated by a large number of identical infinitely-lived households. In each country there exist two sectors: one produces intermediate goods and the other final goods. The firms in the latter sector combine domestic and foreign intermediate goods to produce a homogeneous final good that can be either consumed or invested. We assume that capital is perfectly mobile between the two countries while labor is not. The final good is not traded internationally.

1.1. Domestic household

Household preferences are characterized by the lifetime utility function[6]:

$$\sum_{\tau=0}^{\infty}\sum_{s^{t+\tau}}\beta^{*t}\pi(s^{t+\tau}|s^{t})U\left(C(s^{t+\tau}),\frac{M(s^{t+\tau})}{P(s^{t+\tau})},\ell(s^{t+\tau})\right) \tag{1}$$

where $0 < \beta^{*} < 1$ is a constant discount factor, C denotes the domestic consumption bundle, M/P is real balances and ℓ is the quantity of leisure enjoyed by the representative household. The utility function, $U(C, \frac{M}{P}, \ell) : \mathbb{R}_+ \times \mathbb{R}_+ \times [0,1] \rightarrow \mathbb{R}$ is increasing and concave in its arguments.

The household is subject to the following time constraint

$$\ell(s^t) + h(s^t) = 1 \tag{2}$$

where h denotes hours worked. The total time endowment is normalized to unity.

In each and every period, the representative household faces a budget constraint of the form

$$\begin{aligned}\sum_{s^t+1} P^b(s^{t+1}|s^t)B(s^{t+1}) + M(s^t) \leq B(s^t) + M(s^{t-1}) + N(s^t) + \Pi(s^t) \\ + P(s^t)W(s^t)h(s^t) + P(s^t)z(s^t)K(s^{t-1}) \\ - P(s^t)(C(s^t) + I(s^t)) - T(s^t)\end{aligned} \tag{3}$$

where $P^b(s^{t+1}|s^t)$ is the period t price of a contingent claim that delivers one unit of the final good in period $t+1$; $B(s^t)$ is the number of contingent claims owned by the domestic household at the beginning of period t; W is the real wage; P is the nominal price of the domestic final good;. C is consumption and I is investment expenditure; K is the amount of physical capital owned by the household and leased to the firms at the real rental rate z. $M(s^{t-1})$ is the amount of money that the household brings into period t, $M(s^t)$ is the end of period t money and N is a nominal lump-sum transfer received from the monetary authority; $T(s^t)$ is the lump-sum taxes paid to the government and used to finance government consumption.

Capital accumulates according to the law of motion

$$K(s^t) = \Phi\left(\frac{I(s^t)}{K(s^{t-1})}\right)K(s^{t-1}) + (1-\delta)K(s^{t-1}) \tag{4}$$

where $\delta \in [0, 1]$ denotes the rate of depreciation. The concave function $\Phi(.)$ reflects the presence of adjustment costs to investment. It is assumed to be twice differentiable and homogeneous of degree 0. Furthermore, we impose two assumptions that guarantee the absence of adjustment costs in the steady state: $\Phi(\gamma + \delta - 1) = \gamma + \delta - 1$ and $\Phi'(\gamma + \delta - 1) = 1$. γ is the real, gross rate of the economy.

The behavior of the foreign household is similar.

1.2. Final sector

Following Backus et al. (1995), we assume that the domestic final good, Y, is produced by combining domestic (X^d) and foreign (X^f) intermediate goods.

Final good production at home is described by the following CES function

$$Y(s^t) = \left(\omega^{\frac{1}{1-\rho}} X^d(s^t)^\rho + (1-\omega)^{\frac{1}{1-\rho}} X^f(s^t)^\rho\right)^{\frac{1}{\rho}} \tag{5}$$

where $\omega \in (0, 1)$ and $\rho \in (-\infty, 1)$. X^d and X^f are themselves combinations of the domestic and foreign intermediate goods according to

$$X^d(s^t) = \left(\int_0^1 X^d(i, s^t)^\theta i\right)^{\frac{1}{\theta}} \quad \text{and} \quad X^f(s^t) = \left(\int_0^1 X^f(i, s^t)^\theta i\right)^{\frac{1}{\theta}} \tag{6}$$

where $\theta \in (-\infty, 1)$. Note that ρ determines the elasticity of substitution between the foreign and the domestic bundle of goods, while θ determines the elasticity of substitution between goods in the domestic and foreign bundles. Final goods sectors producers behave competitively and determine their demand for each good $X^d(i, s^t)$ and $X^f(i, s^t)$, $i \in (0, 1)$ by maximizing the static profit equation

$$\begin{aligned}\max_{\{X^d(i,s^t), X^f(i,s^t)\}_{i\in(0,1)}} P(s^t)Y(s^t) &- \int_0^1 P_x(i, s^t)X^d(i, s^t)i \\ &- \int_0^1 e(s^t)P_x^*(i, s^t)X^f(i, s^t)i\end{aligned} \tag{7}$$

subject to (6), where $P_x(i, s^t)$ and $P_x^*(i, s^t)$ denote the price of each domestic and foreign intermediate good respectively, denominated in terms of the currency of the *seller*. This yields demand functions of the form:

$$X^d(i, s^t) = \left(\frac{P_x(i, s^t)}{P_x(s^t)}\right)^{\frac{1}{\theta-1}} \left(\frac{P_x(s^t)}{P(s^t)}^{\frac{1}{\rho-1}}\right)\omega Y(s^t) \tag{8}$$

and

$$X^f(i, s^t) = \left(\frac{e(s^t)P_x^*(i, s^t)}{e(s^t)P_x^*(s^t)}\right)^{\frac{1}{\theta-1}} \left(\frac{e(s^t)P_x^*(s^t)}{P(s^t)}\right)^{\frac{1}{\rho-1}}(1-\omega)Y(s^t) \tag{9}$$

and the following general price indexes

$$P_x(s^t) = \left(\int_0^1 P_x(i, s^t)^{\frac{\theta}{\theta-1}} i\right)^{\frac{\theta-1}{\theta}}, \; P_x^*(s^t) = \left(\int_0^1 P_x^*(i, s^t)^{\frac{\theta}{\theta-1}} i\right)^{\frac{\theta-1}{\theta}} \tag{10}$$

$$P(s^t) = \left(\omega P_x(s^t)^{\frac{\theta}{\theta-1}} + (1-\omega)(e(s^t)P_x^*(s^t))^{\frac{\theta}{\theta-1}}\right)^{\frac{\theta-1}{\theta}} \tag{11}$$

The final good can be used for domestic consumption and investment purposes. The behavior of the foreign final goods producers is similar.

1.3. Intermediate goods producers

Each intermediate firm i, $i \in (0, 1)$, produces an intermediate good by means of capital and labor according to a constant returns-to-scale technology, represented by the production function

$$X(i, s^t) \geq A_t K(i, s^t)^{\alpha}(\Gamma_t h(i, s^t))^{1-\alpha} \quad \text{with } \alpha \in (0, 1) \tag{12}$$

where $K(i, s^t)$ and $h(i, s^t)$ respectively denote the physical capital and the labor input used by firm i in the production process. Γ_t represents Harrod neutral, deterministic, technical progress evolving according to $\Gamma_t = \gamma\Gamma_{t-1}$ where $\gamma \geq 1$ is the deterministic rate of growth. A_t is an exogenous stationary stochastic technological shock, whose properties will be defined later. Assuming that each firm i operates under perfect competition in the input markets, the firm determines its production plan so as to minimize its total cost

$$\min_{\{K_t(i), h_y(i)\}} P(s^t)W(s^t)h(i, s^t) + P(s^t)z(s^t)K(i, s^t)$$

subject to (12). This yields the following expression for total costs:

$$P(s^t)\mathcal{C}_m(s^t)X(i, s^t)$$

where the real marginal cost, $\mathcal{C}_m$, is given by $\frac{W(s^t)^{1-\alpha} z(s^t)\alpha}{\chi A_t \Gamma_t^{1-\alpha}}$ with $\chi = \alpha^{\alpha}(1-\alpha)^{1-\alpha}$.

Intermediate goods producers are monopolistically competitive, and therefore set prices for the good they produce. We follow Calvo in assuming that firms set their prices for a stochastic number of period. In each and every period, a firm either gets the chance to adjusts its price (an event occurring with probability q) or it does not. We assume that the set price incorporates a nominal growth component Ξ_t. that is the nominal price in period t is $P_x(i, s^t) = \Xi_t p_x(i, s^t)$ where $p_x(i, s^t)$ is the deflated fixed price.[7] A firm i sets its price in period t in order to maximize its discounted profit flow:

$$\max_{p_x(i,s^t)} \tilde{\Pi}_x(i, s^t) + \sum_{\tau=1}^{\infty} \sum_{s^t+\tau} P^b(s^{t+\tau}|s^t)(1-q)^{\tau-1}\big(q\tilde{\Pi}_x(i, s^{t+\tau}) + (1-q)\Pi_x(i, s^{t+\tau})\big)$$

subject to the total demand it faces:

$$X(i, s^t) = \left(\frac{P_x(i, s^t)}{P_x(s^t)}\right)^{\frac{1}{\theta-1}} (X^d(s^t) + X^{d*}(s^t))$$

and where $\tilde{\Pi}_x(i, s^{t+r}) = (\Xi_{t+\tau} p_x(i, s^t) - P(s^{t+\tau})\mathcal{C}_m(s^{t+\tau})X(i, s^{t+\tau})$ is the profit attained when the price is maintained, while $\Pi_x(i, s^{t+\tau}) = (p_x(i, s^{t+\tau}) - P(s^{t+\tau})\mathcal{C}_m \times (s^{t+\tau}))X(i, s^{t+\tau})$ is the profit attained when the price is reset. This yields the price setting behavior

$$\tilde{p}_{x,t}(i) = \frac{1}{\theta} \frac{\sum_{\tau=0}^{\infty} \sum_{s^{t+\tau}} P^b(s^{t+\tau}|s^t)(1-q)^\tau \Xi_{t+\tau}^{\frac{1}{\theta-1}} P(s^{t+\tau}) P_x(s^{t+\tau})^{\frac{1}{\theta-1}} \mathcal{C}_m(s^{t+\tau}) X(s^{t+\tau})}{\sum_{\tau=0}^{\infty} \sum_{s^{t+\tau}} P^b(s^{t+\tau}|s^t)(1-q)^\tau \Xi_{t+\tau}^{\frac{\theta}{\theta-1}} P_x(s^{t+\tau})^{\frac{1}{\theta-1}} X(s^{t+\tau})} \tag{13}$$

Since the price setting is independent of any firm specific characteristic, all firms that reset their prices will choose the same price.

In each period, a fraction q of contracts ends, so there are $q(1-q)$ contracts surviving from period $t-1$, and therefore $q(1-q)^j$ from period $t-j$. Hence, from (10), the aggregate intermediate price index is given by

$$P_x(s^t) = \left(\sum_{i=0}^{\infty} q(1-q)^i (\Xi_{t-i} \tilde{p}_x(s^{t-i}))^{\frac{\theta}{\theta-1}} \right)^{\frac{\theta-1}{\theta}} \tag{14}$$

The price setting behavior is similar in the foreign economy.

1.3.1. The monetary authorities. The behavior of the monetary authorities depends on the international monetary arrangement in place. We examine three regimes: A flexible, a bilateral peg and a unilateral peg. Monetary authorities are assumed to pursue active monetary policy. In particular, central banks are assumed to follow a rule of the form

$$\log(R(s^t)) = \rho_r \log(R(s^{t-1})) + (1-\rho_r)(R + \kappa_y \hat{y}(s^t) + \kappa_\pi(\log(\pi(s^t)) - \log(\pi))) \tag{15}$$

where $R(s^t)$ is the gross nominal interest rate, $\hat{y}(s^t)$ is the output gap,[8] $\pi(s^t)$ is the CPI based inflation rate and π is the inflation rate target.

We allow the monetary authorities to select the parameters in the policy rule in order to maximize welfare (subject to the exchange rate system constraint). The money supply, $M(s^t)$ is selected endogenously in order to satisfy the constraint imposed by the nominal interest rate policy. Under a bilateral peg, the two countries select their money supplies, $M(s^t)$ and $M^*(s^t)$, in order to maintain a fixed nominal exchange rate parity, e. We assume perfect symmetry in the management of the exchange rate. Finally, under a unilateral peg, one country pursues its favorite policy while the other targets the exchange rate.

1.3.2. The government. The government finances government expenditure on the domestic final good using lump sum taxes. The stationary component of government expenditures is assumed to follow an exogenous stochastic process, whose properties will be defined later.

1.4. The equilibrium

We now turn to the description of the equilibrium of the economy. Recall that capital is perfectly mobile across countries while labor is not.

Definition 1. An equilibrium of this economy is a sequence of prices $\{\mathcal{P}(s^t)\}_{t=0}^{\infty} = \{W(s^t), W^*(s^t), z(s^t), z^*(s^t), P(s^t), P^*(s^t), P_x(s^t), P_x^*(s^t), \tilde{P}_x(s^t), \tilde{P}_x^*(s^t), e(s^t), R(s^t), R^*(s^t)\}_{t=0}^{\infty}$ and a sequence of quantities $\{\mathcal{Q}(s^t)\}_{t=0}^{\infty} = \{\{\mathcal{Q}^H(s^t)\}_{t=0}^{\infty}, \{\mathcal{Q}^F(S^t)\}_{t=0}^{\infty}\}$ with $\{\mathcal{Q}^H(s^t)\}_{t=0}^{\infty} = \{C(s^t), C^*(s^t), I(s^t), I^*(s^t), B(s^{t+1}), B^*(s^{t+1}), K(s^t), K^*(s^t), h(s^t), h^*(s^t)^*, M_{t+1}, M_{t+1}^*, G(s^t), G^*(s^t)\}_{t=0}^{\infty}$ and $\{\mathcal{Q}^F(s^t)\}_{t=0}^{\infty} = \{Y(s^t), Y(s^t)^*, X(i, s^t), X^*(i, s^t), X^d(i, s^t), X^{d*}(i, s^t), X^f(i, s^t), X^{f*}(i, s^t), K(i, s^t), K^*(i, s^t), h(i, s^t), h^*(i, s^t); i \in (0, 1)\}_{t=0}^{\infty}$ such that:

(i) given a sequence of prices $\{\mathcal{P}_t\}_{t=0}^{\infty}$ and a sequence of shocks, $\{\mathcal{Q}_t^H\}_{t=0}^{\infty}$ is a solution to the representative household's problem;
(ii) given a sequence of prices $\{\mathcal{P}_t\}_{t=0}^{\infty}$ and a sequence of shocks, $\{\mathcal{Q}_t^F\}_{t=0}^{\infty}$ is a solution to the representative firms' problem;
(iii) given a sequence of quantities $\{\mathcal{Q}_t\}_{t=0}^{\infty}$ and a sequence of shocks, $\{\mathcal{P}_t\}_{t=0}^{\infty}$ clears the markets

$$Y(s^t) = C(s^t) + I(s^t) + G(s^t) \tag{16}$$

$$Y^*(s^t) = C^*(s^t) + I^*(s^t) + G^*(s^t) \tag{17}$$

$$\int_0^1 X(i, s^t)di = \int_0^1 X^d(i, s^t) + X^{d*}(i, s^t)\,di \tag{18}$$

$$\int_0^1 X^*(i, s^t)di = \int_0^1 X^f(i, s^t) + X^{f*}(i, s^t)\,di \tag{19}$$

$$h(s^t) = \int_0^1 h(i, s^t)\,di \tag{20}$$

$$h^*(s^t) = \int_0^1 h^*(i, s^t)\,di \tag{21}$$

$$K(s^{t-1}) = \int_0^1 K(i, s^t)\,di \tag{22}$$

$$K^*(s^{t-1}) = \int_0^1 K^*(i, s^t)\,di \tag{23}$$

$$B(s^t) + \frac{B^*(s^t)}{e(s^t)} = 0 \tag{24}$$

$$P(s^t)G(s^t) = T(s^t) \tag{25}$$
$$P^*(s^t)G^*(s^t) = T^*(s^t) \tag{26}$$

and the money markets.

(iv) Prices satisfy (13) and (14).

2. Calibration

The model is calibrated on the postwar US economy, under the assumption of perfect symmetry across countries. For parameter values we rely heavily on Cooley and Prescott (1995), and Chari et al. (2003). The parameters are reported in table 1. ρ is set such that the elasticity of substitution between foreign and domestic goods in the Armington aggregator is 1.5, while ω is set such that the import share in the economy is 15%. The rate of growth of the economy, γ, is calibrated such that the model reproduces the rate of growth of real per capita output (0.012) on an annual basis. The nominal growth of the economy is set equal to 6.8% per year. Using the law of motion of physical capital together with the assumptions on adjustment costs we compute δ such that its value matches the steady-state investment/capital ratio in the

Table 1. Calibration.

Rate of growth	γ	1.0069
Capital elasticity of intermediate output	α	0.2800
Discount factor	β	0.9880
Persistence of technology shock Pa	ρ_a	0.9060
Spillover of technology shock	ρ_a^*	0.0880
Standard deviation of technology shock	σ_a	0.0085
Correlation between foreign and domestic shocks	ψ	0.2580
Depreciation rate	δ	0.0123
Elasticity of marginal capital adjustment cost	φ	−0.1500
Probability of price resetting	q	$q \in (0, 1)$
Relative risk aversion	σ	2.0000
CES weight in utility function	ν	0.3301
Parameter of Armington aggregator	ρ	0.3333
Parameter of markup	θ	0.8050
One minus the import share	ω	0.8500
Parameter of CES in utility function	η	−1.5600
Weight of money in the utility function	ζ	0.0500
Persistence of government spending shock	ρ_g	0.9700
Volatility of government spending shock	σ_g	0.0200

US economy $(i/k = 0.076)$. This leads to an annual depreciation rate of 0.048 ($\delta = 0.012$ on a quarterly basis). The elasticity of the marginal adjustment cost, φ is set to −0.15. θ is set such that markups in the economy are 20%. α, the elasticity of the production function to physical capital is set such that the labor share in the economy is 0.6. $a_t = \log(A_t/A)$ and $a_t^* = \log(A_t^*/A^*)$ are assumed to follow a stationary VAR(1) process of the form

$$\begin{pmatrix} a_t \\ a_t^* \end{pmatrix} = \begin{pmatrix} \rho_a & \rho_a^* \\ \rho_a^* & \rho_a \end{pmatrix} \begin{pmatrix} a_{t-1} \\ a_{t-1}^* \end{pmatrix} + \begin{pmatrix} \varepsilon_{a,t} \\ \varepsilon_{a,t}^* \end{pmatrix}$$

with $|\rho_a + \rho_a^*| < 1$ and $|\rho_a - \rho_a^*| < 1$ for the sake of stationarity and

$$\begin{pmatrix} \varepsilon_{a,t} \\ \varepsilon_{a,t}^* \end{pmatrix} \rightsquigarrow \mathcal{N}\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \sigma_a^2 \begin{pmatrix} 1 & \psi \\ \psi & 1 \end{pmatrix} \right)$$

Following Backus et al. (1995), we set $\rho_a = 0.906$, $\rho_a^* = 0.088$, $\sigma_a = 0.0085$ and $\psi = 0.258$.

The instantaneous utility function takes the form

$$U\left(C_t, \frac{M_t}{P_t}, \ell_t\right) = \frac{1}{1-\sigma}\left[\left(\left(C_t^{\eta} + \zeta \frac{M_t{}^{\eta}}{P_t}\right)^{\frac{\nu}{\eta}} \ell_t^{1-\nu}\right)^{1-\sigma} - 1\right]$$

where ζ is set such that we match the ratio of money to consumption expenditures in the US data $(M/PC = 1.2)$. σ, the coefficient ruling risk aversion, is set to 2. η is borrowed from Chari et al. (2003), who estimated it on postwar US data. ν is set such that the model generates a total fraction of time devoted to market activities of 31%. Finally the discount factor, β, is set such that households discount the future at a 4% annual rate.

q, the probability of price resetting is varied across experiments. The parameters of the Taylor also vary across experiments. The government spending shock is assumed to follow an AR(1) process

$$\log(g_t) = \rho_g \log(g_{t-1}) + (1 - \rho_g)\log(\bar{g}) + \varepsilon_{g,t}$$

with $|\rho_g| < 1$ and $\varepsilon_{g,t} \rightsquigarrow \mathcal{N}(0; \sigma_g^2).\rho_g$ is set to 0.97, while $\sigma_g = 0.02$.

3. The results

The model is first log-linearized around the deterministic steady state and then solved. Welfare is computed using a quadratic approximation to the utility function. Below we discuss the characteristics and implications of optimal monetary policy within a particular class of rules, namely, the popular Taylor type. Throughout the analysis it is assumed that the monetary authorities can commit to a policy rule.

3.1. The properties of the model

There are three distortions in the model. The first is associated with sluggish prices, the second with imperfect competition, and the third with the demand for money when the nominal interest rate is not zero. In discussing optimal monetary policy we will ignore the implications that the desire to eliminate the third distortion has for *steady state inflation* and will only pay attention to its implications for interest rate smoothing. As the steady state nominal interest rate is the same across the three regimes under consideration, we feel that this assumption does not bias the results in favor of any particular regime.

We know that optimal monetary policy in a model such as ours implies a great deal of inflation stabilization in order to eliminate the nominal price distortion. Inflation stabilization, however, may fall short of being perfect because the money demand distortion calls for some nominal interest rate smoothing. These considerations have led us to look at a Taylor rule of the type

$$\log(R(s^t)) = \rho_r \log(R(s^{t-1})) + (1-\rho_r)(\log R + \kappa_y \hat{y}(s^t) + \kappa_\pi(\log(\pi(s^t)/\pi))) \tag{27}$$

where $\hat{y}(s^t)$ is the output gap (actual minus flexible price output.[9] $\pi(s^t)$ is the CPI inflation rate[10] and π is the inflation rate target (assumed to be equal to the steady state inflation rate). We have computed—numerically—the parameter configuration $\{\rho_r, \kappa_y, \kappa_\pi\}$ that maximizes welfare under a flexible and a bilateral peg (in the latter case, subject also to the restriction that the exchange rate remains fixed[11]). For the unilateral peg we have computed the optimal policy only for the "leader" as the follower's policy is to simply target the exchange rate. Note that we do not include an exchange rate target under flexible exchange rates ("a managed float"). This choice reflects two elements. First, our experiments indicated that an exchange rate target did not increase welfare. And second, there exists considerable evidence that the inclusion of an exchange rate target to a Taylor rule does not improve performance (Taylor, 2001).

Figure 1 shows how welfare varies as a function of κ_π and for different values of ρ_r. As can be seen, welfare is an increasing function of κ_π, but it becomes quickly flat. Adding persistence (increasing ρ_r) does not improve welfare. We thus postulate that the optimal monetary policy rule involves $\rho_r = \kappa_y = 0$ and a "sufficiently large" κ_π, that is, it exhibits strict inflation targeting.

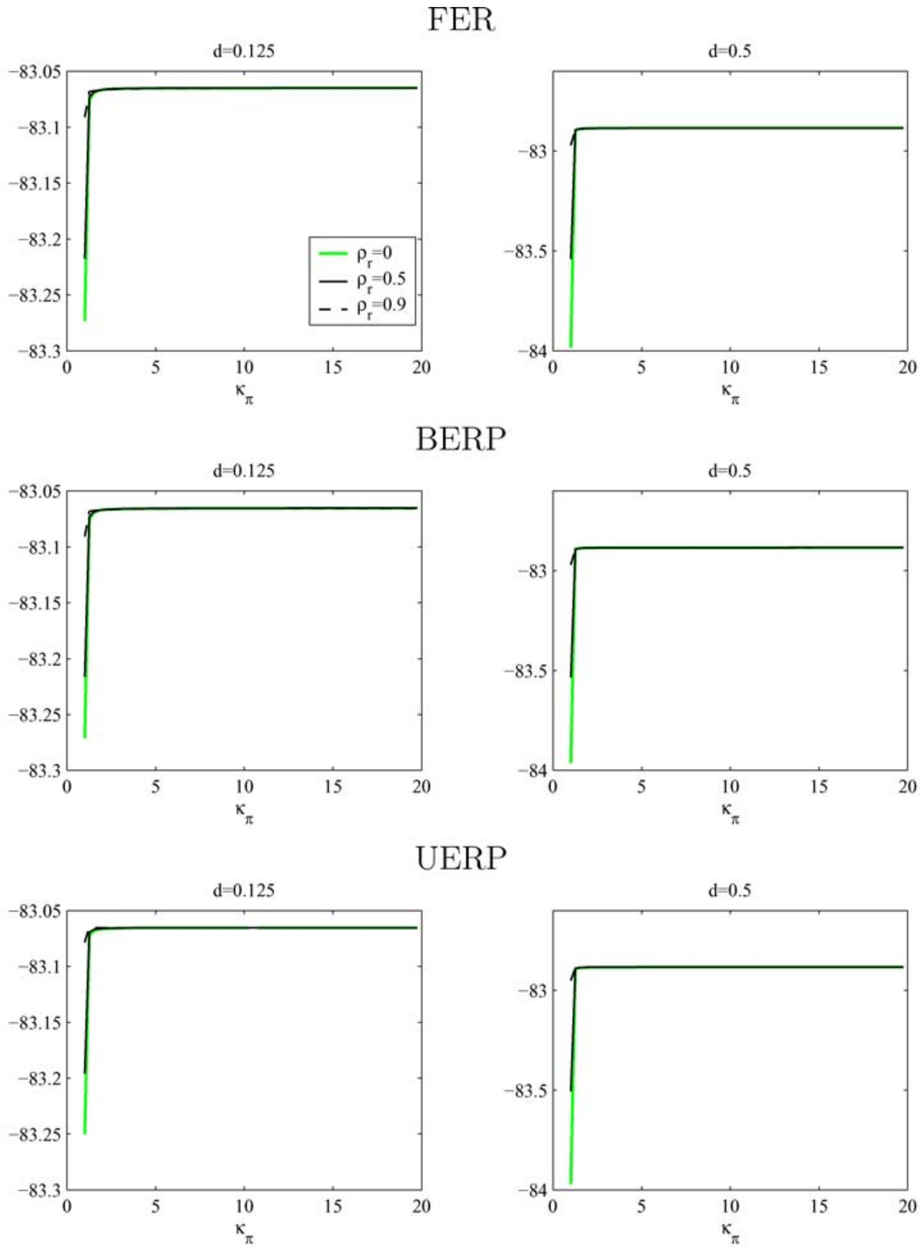

Figure 1. Welfare as a function of κ_π and ρ_r.

Table 2. Elasticities.

	FER				BERP				UERP			
	A	A^*	g	g^*	A	A^*	g	g^*	A	A^*	g	g^*
						$q = 0.250$						
x	0.747	0.243	0.106	−0.011	0.588	0.402	0.121	−0.026	0.967	0.023	0.086	0.008
x^*	0.243	0.747	−0.011	0.106	0.402	0.588	−0.026	0.121	0.782	0.208	−0.061	0.156
h	−0.350	0.336	0.146	−0.015	−0.571	0.557	0.168	−0.036	−0.045	0.031	0.120	0.012
h^*	0.336	−0.350	−0.015	0.146	0.557	−0.571	−0.036	0.168	1.082	−1.096	−0.084	0.216
p_x	−0.063	0.063	0.007	−0.007	−0.120	0.120	0.014	−0.014	−0.036	0.036	0.004	−0.004
p_x^*	0.063	−0.063	−0.007	0.007	0.120	−0.120	−0.014	0.014	0.204	−0.204	−0.024	0.024
π	0.000	−0.000	−0.000	0.000	−0.084	0.084	0.010	−0.010	−0.000	0.000	0.000	0.000
π^*	−0.000	0.000	0.000	−0.000	0.084	−0.084	−0.010	0.010	0.168	−0.168	−0.020	0.020
e	0.293	−0.293	−0.031	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
eP^*/P	0.293	−0.293	−0.031	0.031	0.168	−0.168	−0.020	0.020	0.168	−0.168	−0.020	0.020
eP_x^*/P_x	0.419	−0.419	−0.045	0.045	0.241	−0.241	−0.028	0.028	0.241	−0.241	−0.028	0.028
						$q = 0.667$						
x	1.051	−0.065	0.080	0.017	0.957	0.028	0.088	0.010	1.068	−0.083	0.079	0.019
x^*	−0.065	1.051	0.017	0.080	0.028	0.957	0.010	0.088	0.139	0.847	0.000	0.097
h	0.069	−0.088	0.108	0.023	−0.057	0.038	0.119	0.013	0.092	−0.111	0.106	0.025
h^*	−0.088	0.069	0.023	0.108	0.038	−0.057	0.013	0.119	0.188	−0.207	0.001	0.131
p_x	−0.118	0.118	0.011	−0.011	−0.339	0.339	0.033	−0.033	−0.102	0.102	0.010	−0.010
p_x^*	0.118	−0.118	−0.011	0.011	0.339	−0.339	−0.033	0.033	0.576	−0.576	−0.056	0.056
π	−0.000	0.000	0.000	0.000	−0.237	0.237	0.023	−0.023	−0.000	0.000	0.000	0.000
π^*	0.000	−0.000	0.000	0.000	0.237	−0.237	−0.023	0.023	0.475	−0.475	−0.046	0.046
e	0.552	−0.552	−0.052	0.052	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
eP^*/P	0.552	−0.552	−0.052	0.052	0.475	−0.475	−0.046	0.046	0.475	−0.475	−0.046	0.046
eP_x^*/P_x	0.789	−0.789	−0.075	0.075	0.678	−0.678	−0.065	0.065	0.678	−0.678	−0.065	0.065

The next tables offer information on the properties of the model. Table 2 reports elasticities with regard to the four shocks (A, A^*, g, g^*) for $q = 0.25$ and $q = 2/3$ under a flexible (FER), bilateral peg (BERP) and unilateral fixed exchange rate (UERP) system respectively. Consider first a flexible system with relatively high price rigidity $(q = 0.25)$. A positive domestic productivity shock reduces employment at home but has a positive effect on domestic output. The increase in the quantity of the domestic intermediate good increases the marginal product of the foreign intermediate good. With sluggish prices abroad, foreign employment and output increase. The excess relative supply of the domestic good requires a domestic nominal exchange rates depreciate and the terms of trade deteriorate. In general, part of the terms of trade adjustment occurs through the goods prices that are reset within this period (that is, lower domestic and higher foreign intermediate goods prices) and another part through the exchange rate. When nominal goods prices are very sluggish, most of the terms of trade adjustment occurs through the nominal exchange rate.

Under a bilateral peg, the nominal exchange rate cannot assist the relative price adjustment and as a result the domestic terms of trade deteriorate by less (nominal goods prices change by more but they cannot fully compensate for the lack of an exchange rate effect). This limits the domestic gains in international competitiveness and thus the expansion in domestic output while it supports a higher expansion in foreign employment and output. The smaller expansion in domestic output means a larger reduction in domestic employment. Consequently, domestic output is more and domestic employment is *less* stable under a bilateral peg relative to a free float in the face of domestic productivity shocks. Foreign output and employment are more stable under a flexible system.

When prices are relatively flexible $(q = 0.125)$ nominal goods prices have a bigger contribution to the terms of trade adjustment. Because the output effects of a productivity shock are much larger under more flexible prices (employment now also expands as in the standard RBC model) the terms of trade changes are bigger too. The larger changes in terms of trade imply greater gains in international trade competitiveness and thus a negative international transmission. Moreover, note that the differences in the response of employment across the regimes is much smaller and this means, that unlike the earlier case of relatively fixed prices $(q = 0.25)$ the welfare comparisons will depend more on output (consumption) than employment stability. The fact that output is more stable under a bilateral peg will favor this regime in welfare comparisons.

Fiscal shocks are expansionary and lead to higher domestic prices and a nominal and real exchange appreciation. The main difference between the low and high nominal rigidity cases is that in the latter case the real appreciation is greater and this makes foreign output go up too (positive transmission). The differences across exchange rate regimes are minor.

3.2. *Welfare comparisons*

Table 3 reports welfare rankings as well as the various components of welfare as a function of the frequency of price resetting $(q = 0.125, q = 0.25, q = 2/3$ and $q = 0.9)$.

Four features stand out. First, the welfare *ranking* is a monotone function of the degree of price sluggishness. For instance, when a quarter of firms gets the chance to reset prices in each period then the flexible regime fares better than the bilateral peg. When two thirds of the firms reset prices, then the bilateral fares better. There are two elements behind this ranking reversal. First, note that money is not neutral even under completely flexible prices[12] due to the money demand distortion. On this account, the fixed

Table 3. Welfare comparisons as a function of price sluggishness.

	σ_c^2	σ_ℓ^2	σ_m^2	$\sigma_{c\ell}$	σ_{cm}	$\sigma_{m\ell}$	Welfare
				$q = 0.125$			
FER	0.9190	0.0063	1.0554	0.0502	0.9772	0.0524	−83.064346
BERP	0.9189	0.0080	1.0425	0.0494	0.9746	0.0550	−83.064839
UERP (L)	0.9207	0.0046	1.0711	0.0511	0.9825	0.0572	−83.064285
UERP (F)	0.9244	0.0164	1.0778	0.0418	0.9877	0.0370	-83.066669
UERP (W)	–	–	–	–	–	–	−83.065477
				$q = 0.250$			
FER	0.8380	0.0045	0.9844	0.0454	0.8985	0.0486	−82.936144
BERP	0.8373	0.0052	0.9628	0.0453	0.8944	0.0506	−82.936167
UERP (L)	0.8393	0.0041	1.0010	0.0454	0.9041	0.0504	−82.936359
UERP (F)	0.8385	0.0083	0.9896	0.0427	0.8980	0.0416	−82.936973
UERP (W)	–	–	–	–	–	–	−82.936666
				$q = 0.667$			
FER	0.7982	0.0040	0.9589	0.0425	0.8634	0.0464	−82.871440
BERP	0.7974	0.0040	0.9240	0.0428	0.8552	0.0480	−82.871025
UERP (L)	0.7984	0.0040	0.9675	0.0425	0.8650	0.0461	−82.871572
UERP (F)	0.7967	0.0041	0.9369	0.0429	0.8489	0.0480	−82.871497
UERP (W)	–	–	–	–	–	–	−82.871534
				$q = 0.900$			
FER	0.7925	0.0040	0.9611	0.0421	0.8593	0.0456	−82.862290
BERP	0.7919	0.0039	0.9187	0.0423	0.8499	0.0475	−82.861731
UERP (L)	0.7925	0.0040	0.9623	0.0421	0.8594	0.0455	−82.862302
UERP (F)	0.7914	0.0039	0.9290	0.0424	0.8422	0.0487	−82.862192
UERP (W)	–	–	–	–	–	–	−82.862247

Note: L: Leader, F: Follower (Pegging Country), W: World. All variances and covariances have been multiplied by 100.

exchange rate regime has a -perhaps small- advantage over the flexible exchange rate regime as it is associated with lower real balance volatility (because of the "cooperative" monetary response there is lower variation in nominal money in each country in the face of shocks). Second and more importantly, as Friedman has emphasized, endogenous exchange rate fluctuations can contribute to "desired" relative price adjustment when goods prices are sluggish. But "desired" adjustment is a much more subtle concept than it is commonly perceived. As argued earlier, when nominal prices are rigid, the change in the nominal exchange rate indirectly acts as a countercyclical -from the point of view of employment- policy instrument. That it, its fluctuations generate greater international competitiveness gains when employment is low, contributing to greater employment stability. On the other hand, it acts (again indirectly) as a procyclical -with regard to employment—policy instrument when prices are relatively flexible. At the same time, exchange rate fluctuations always amplify fluctuations in output and consumption independent of the value of q, but their effect is larger when prices are flexible because output is more responsive to both the shocks and to relative price changes in this case. Consequently, under relatively rigid prices, the strong countercyclical employment effect dominates the weak procyclical consumption effect making the flexible regime superior. Under relatively fixed prices, the strong procyclical effect dominates the weaker countercyclical effect making the fixed regime the winner in terms of welfare.

These findings demonstrate the importance of the price adjustment specification. The commonly used assumption that all prices are set in advance for a fixed time - usually one period—is far from being fully revealing. Whether the specification of the degree of activism of monetary policy matters or not will be addressed below. It is not clear at this point whether the fact that exchange rates fluctuations *can* bring about needed changes in the terms of trade necessarily means that they will do so in the presence of monetary policy interventions motivated by other objectives.

Second, the unilateral peg always generates the lowest level of world welfare. Nevertheless, the "pegger" may be better of when exchange rate flexibility is not very valuable (when prices are relatively flexible). In this case, it seems that if a country commits to stabilizing inflation then the optimal monetary strategy of the other country may be to target the exchange rate. This finding opens up interesting strategic issues which are, however, beyond the scope of the present paper.

The third feature is that welfare is decreasing in the degree of price sluggishness (that is, the lower q). As Woodford, 2003, has argued, perfect inflation stabilization may not be sufficient to reproduce the flexible price equilibrium in the presence of multiple distortions.

And forth, the differences in welfare across regimes are quite small[13], in particular for commonly used values of aggregate price rigidity (for instance, for $q = 0.25$). Similarly small differences are observed in the volatility of macroeconomic activity (see Table 3). We believe that the former feature is mostly the reflection of market completeness. The latter matches well the real world experience.

3.3. Extensions

What is the contribution of activism in monetary policy as well as of the weigh placed on real balances in the ranking of alternative regimes? Table 4 reports welfare comparisons when ζ (the weight of real balances in the utility function) is very low (namely, $\zeta = 0.0005$). Table 5 reports welfare rankings for the three regimes when central banks target the *supply of money*. The

Table 4. Welfare comparisons as a function of price sluggishness, $\zeta = 0.0005, \pi - targeting$

	σ_c^2	σ_ℓ^2	σ_m^2	$\sigma_{c\ell}$	σ_{cm}	$\sigma_{m\ell}$	Welfare
			$q = 0.125$				
FER	0.9154	0.0063	1.0501	0.0507	0.9728	0.0531	36.061850
BERP	0.9153	0.0081	1.0377	0.0498	0.9705	0.0555	36.061515
UERP (L)	0.9169	0.0047	1.0655	0.0516	0.9778	0.0579	36.062021
UERP (F)	0.9206	0.0164	1.0724	0.0425	0.9830	0.0378	36.060494
UERP (W)	–	–	–	–	–	–	36.061257
			$q = 0.250$				
FER	0.8343	0.0046	0.9788	0.0459	0.8939	0.0493	39.340086
BERP	0.8338	0.0053	0.9581	0.0457	0.8903	0.0512	39.339945
UERP (L)	0.8354	0.0042	0.9953	0.0460	0.8992	0.0512	39.340073
UERP (F)	0.8350	0.0083	0.9841	0.0433	0.8934	0.0424	39.339618
UERP (W)	–	–	–	–	–	–	39.339845
			$q = 0.667$				
FER	0.7943	0.0041	0.9529	0.0431	0.8585	0.0472	40.961652
BERP	0.7939	0.0041	0.9194	0.0433	0.8512	0.0486	40.961673
UERP (L)	0.7945	0.0041	0.9618	0.0431	0.8601	0.0470	40.961632
UERP (F)	0.7935	0.0042	0.9316	0.0433	0.8445	0.0487	40.961612
UERP (W)	–	–	–	–	–	–	40.961622
			$q = 0.900$				
FER	0.7886	0.0041	0.9548	0.0427	0.8542	0.0464	41.191512
BERP	0.7885	0.0040	0.9141	0.0427	0.8458	0.0481	41.191561
UERP (L)	0.7886	0.0041	0.9567	0.0427	0.8545	0.0464	41.191508
UERP (F)	0.7883	0.0040	0.9237	0.0428	0.8378	0.0494	41.191515
UERP (W)	–	–	–	–	–	–	41.191512

comparison of Tables 3 and 4 indicates that the rankings obtained above do not hinge on the contribution of real balances. In both cases, a bilateral peg performs better when $q \geq 2/3$). The comparison of Tables 3 and 5 indicates that the rankings obtained above do not depend on the degree of passivity in monetary policy either. Again in both cases, a bilateral peg performs better when $q \geq 2/3$). This suggests that activism in monetary policy cannot substitute for exchange rate flexibility.

As is well known, in model like ours, monetary policy should target inflation in the sector that is characterized by overlapping price contracts rather than CPI (Goodfriend and King, 1997, Woodford, 1999). If we postulate that policy targets inflation in the -distorted- intermediate goods sector, then a higher level of welfare is indeed achieved. Nevertheless, as can be seen from Table 7 (and similar results obtain when $\zeta = 0.00005$), pursuing such a policy does not change the ranking of alternative regimes relative to the case of CPI targeting.

Finally, it should be noted that the relative attractiveness of a bilateral peg increases with lower substitutability between domestic and foreign goods, a higher mark up and a larger weigh of real balances in the utility function.

3.4. Caveats

There are several issues that the paper abstracts from, some of which could be the subject of future research.

First, fixed regimes tend to be associated with-costly-speculative attacks, currency crises and devaluations, a fact that gives an indirect advantage to the flexible exchange rate system. We could in principle incorporate an exogenous probability of a devaluation, conditional on some development in the economy. We have decided against doing so because our objective is to evaluate the role played by price sluggishness in the optimal choice of the exchange rate system, rather than carry out an exhaustive study of benefits and costs associated with alternative regimes.

Second, we have assumed perfect symmetry across the two countries. One could instead, without any additional computational cost, study the optimal choice of monetary policy allowing for interesting sources of asymmetries across countries (size, structure of shocks etc.).

Third, there is an issue concerning the Taylor rule. We have assumed that the policymaker targets output at its flexible price level. This carries stringent informational assumptions concerning the structure of the economy and the observability of the shocks, things that hinder the practical implementation of the postulated rule. Nevertheless, the use of trend output would not change anything in our analysis because the optimal Taylor rule involves a zero output reaction coefficient.

And forth, there are some issues regarding the order of the approximation of the model. Woodford, 2003, has argued that in certain cases, using a linear approximation to the decision rules and a quadratic approximation to the utility function may lead to misleading welfare comparisons. We do not know the extent of such problems in general models such as the one used in this paper, so this remains an issue that needs further investigation.

4. Conclusions

The new macroeconomic models have provided a rigorous and empirically relevant framework for the study of the properties and implications of monetary policy. In this paper, we have used a popular version (the NNS model) to study how the degree of price rigidity affects exchange rate system comparisons. The main findings are as follows: First, a high degree of sluggishness (an average persistence of price setting for more than a year) tends to favor the flexible system mainly for reasons related -but not fully elaborated –to Friedman, 1953 (that is, permits desired relative price adjustment). A low degree of price stickiness, on the other hand, favors the fixed regime. And second, following a policy of inflation stabilization does not render exchange rate fluctuations any less valuable.

A. Appendix

Table 5. Welfare comparisons as a function of price sluggishness, M-targeting, $\zeta = 0.05$.

	σ_c^2	σ_ℓ^2	σ_m^2	$\sigma_{c\ell}$	σ_{cm}	$\sigma_{m\ell}$	Welfare
				$q = 0.125$			
FER	0.8076	0.0239	0.8413	0.0496	0.8233	0.0566	−83.05911121
BERP	0.8399	0.0460	0.8670	0.0274	0.8521	0.0375	−83.06227087
UERP (L)	0.8076	0.0238	0.8414	0.0497	0.8233	0.0567	-83.05915855
UERP (F)	0.8083	0.0256	0.8438	0.0482	0.8249	0.0522	-83.05942997
UERP (W)	–	–	–	–	–	–	-83.05929426
				$q = 0.250$			
FER	0.7956	0.0093	0.8314	0.0472	0.8129	0.0501	-82.93300419
BERP	0.7961	0.0117	0.8310	0.0455	0.8131	0.0482	-82.93323067
UERP (L)	0.7956	0.0093	0.8314	0.0472	0.8129	0.0501	-82.93302476
UERP (F)	0.7956	0.0098	0.8309	0.0468	0.8127	0.0485	-82.93306576
UERP (W)	–	–	–	–	–	–	-82.93304526
				$q = 0.667$			
FER	0.7895	0.0043	0.8263	0.0437	0.8075	0.0453	-82.86990949
BERP	0.7891	0.0044	0.8250	0.0437	0.8067	0.0453	-82.86990726
UERP (L)	0.7895	0.0043	0.8263	0.0437	0.8075	0.0453	-82.86991102
UERP (F)	0.7894	0.0043	0.8247	0.0437	0.8066	0.0452	-82.86990198
UERP (W)	–	–	–	–	–	–	-82.86990650
				$q = 0.900$			
FER	0.7882	0.0040	0.8250	0.0428	0.8062	0.0443	-82.86089562
BERP	0.7881	0.0041	0.8240	0.0428	0.8057	0.0443	-82.86088867
UERP (L)	0.7882	0.0040	0.8250	0.0428	0.8062	0.0443	-82.86089501
UERP (F)	0.7882	0.0040	0.8234	0.0428	0.8054	0.0443	-82.86088495
UERP (W)	–	–	–	–	–	–	-82.86088998

Table 6. Elasticities, *M*-targeting, $\zeta = 0.05$.

	FER				BERP				UERP			
	A	A^*	g	g^*	A	A^*	g	g^*	A	A^*	g	g^*
						$q = 0.250$						
x	0.054	−0.191	0.177	0.056	0.044	−0.181	0.190	0.043	0.057	−0.193	0.177	0.056
x^*	−0.191	0.054	0.056	0.177	−0.142	0.006	0.042	0.191	−0.130	−0.007	0.030	0.204
h	−1.309	−0.265	0.246	0.077	−1.323	−0.250	0.263	0.060	−1.306	−0.268	0.245	0.078
h^*	−0.265	−1.309	0.077	0.246	−0.197	−1.376	0.059	0.264	−0.180	−1.394	0.041	0.282
p_x	−0.290	−0.060	0.031	0.009	−0.317	−0.033	0.040	0.001	−0.290	−0.060	0.031	0.009
p_x^*	−0.060	−0.290	0.009	0.031	−0.077	−0.274	0.011	0.029	−0.050	−0.301	0.002	0.038
π	−0.249	−0.101	0.024	0.016	−0.281	−0.069	0.035	0.005	−0.254	−0.096	0.026	0.014
π^*	−0.101	−0.249	0.016	0.024	−0.113	−0.238	0.016	0.024	−0.086	−0.265	0.007	0.033
e	0.043	−0.043	−0.021	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
eP^*/P	0.191	−0.191	−0.030	0.030	0.168	−0.168	−0.020	0.020	0.168	−0.168	−0.020	0.020
eP_x^*/P_x	0.273	−0.273	−0.042	0.042	0.240	−0.240	−0.028	0.028	0.240	−0.240	−0.028	0.028
						$q = 0.667$						
x	0.811	−0.131	0.103	0.031	0.808	−0.127	0.106	0.028	0.812	−0.131	0.103	0.031
x^*	−0.131	0.811	0.031	0.103	−0.121	0.802	0.027	0.107	−0.118	0.799	0.025	0.110
h	−0.254	−0.176	0.139	0.042	−0.259	−0.172	0.143	0.038	−0.254	−0.177	0.139	0.042
h^*	−0.176	−0.254	0.042	0.139	−0.164	−0.267	0.037	0.144	−0.159	−0.272	0.033	0.148
p_x	−0.728	−0.073	0.071	0.022	−0.742	−0.058	0.080	0.013	−0.728	−0.073	0.071	0.022
p_x^*	−0.073	−0.728	0.022	0.071	−0.064	−0.737	0.015	0.078	−0.049	−0.752	0.006	0.087
π	−0.625	−0.176	0.061	0.032	−0.641	−0.160	0.070	0.023	−0.626	−0.175	0.062	0.032
π^*	−0.176	−0.625	0.032	0.061	−0.166	−0.635	0.025	0.069	−0.151	−0.650	0.016	0.077
e	0.030	−0.030	−0.020	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
eP^*/P	0.480	−0.480	−0.048	0.048	0.475	−0.475	−0.046	0.046	0.475	−0.475	−0.046	0.046
eP_x^*/P_x	0.685	−0.685	−0.069	0.069	0.679	−0.679	−0.065	0.065	0.679	−0.679	−0.065	0.065

Table 7. Welfare comparisons as a function of price sluggishness, $\zeta = 0.005$, π_x targeting.

	σ_c^2	σ_ℓ^2	σ_m^2	$\sigma_{c\ell}$	σ_{cm}	$\sigma_{m\ell}$	Welfare
				$q = 0.125$			
FER	1.2587	0.0028	0.0043	−0.0014	0.0682	−0.0002	−83.090094
BERP	1.2570	0.0054	0.0051	−0.0019	0.0695	0.0009	−83.091256
UERP (L)	1.2610	0.0026	0.0039	−0.0013	0.0687	−0.0002	−83.090380
UERP (F)	1.2619	0.0136	0.0083	−0.0086	0.0713	−0.0037	−83.093170
UERP (W)	–	–	–	–	–	–	−83.091775
				$q = 0.250$			
FER	0.8364	0.0043	0.0030	0.0465	0.0462	0.0026	−82.942777
BERP	0.8352	0.0053	0.0050	0.0466	0.0484	0.0036	−82.943227
UERP (L)	0.8375	0.0043	0.0028	0.0465	0.0465	0.0026	−82.942947
UERP (F)	0.8360	0.0084	0.0084	0.0442	0.0485	0.0030	−82.943927
UERP (W)	–	–	–	–	–	–	−82.943437
				$q = 0.667$			
FER	0.7513	0.0051	0.0027	0.0499	0.0421	0.0029	−82.874535
BERP	0.7510	0.0050	0.0065	0.0501	0.0458	0.0031	−82.874548
UERP (L)	0.7515	0.0051	0.0027	0.0499	0.0421	0.0029	−82.874567
UERP (F)	0.7507	0.0052	0.0143	0.0501	0.0476	0.0032	−82.874704
UERP (W)	–	–	–	–	–	–	−82.874635
				$q = 0.900$			
FER	0.7436	0.0051	0.0027	0.0498	0.0417	0.0029	−82.865067
BERP	0.7438	0.0051	0.0069	0.0498	0.0458	0.0029	−82.865035
UERP (L)	0.7437	0.0051	0.0027	0.0498	0.0417	0.0029	−82.865078
UERP (F)	0.7438	0.0051	0.0162	0.0498	0.0485	0.0025	−82.865152
UERP (W)	–	–	–	–	–	–	−82.865115

Acknowledgments

We are grateful to seminar participants at the European Monetary Forum, Catholic University of Leuven, AUEB as well as an anonymous referee for many valuable suggestions.

Notes

1. Both of these classes of open economy models typically postulate imperfect competition, optimally set nominal prices (wages) and welfare maximizing monetary authorities. The former class tends to adopt fairly restrictive specifications for the sake of analytical tractability (for instance, price staggering and capital accumulation are assumed away, the utility function is separable -often logarithmic- and so on. The latter class exhibits greater generality in its modelling specification but is forced to operate with a linear approximation.
2. Collard and Dellas, 2002; Obstfeld and Rogoff, 2000; see also Stockman and Ohanian, 1993.
3. Kollmann, 2002; Pappa, 2004.

4. Dellas, 2005, shows that this alleged superiority of the flexible regime owes much to the favorable informational assumptions made about the conduct of monetary policy.
5. We abstract from strategic interactions in the design of monetary policy.
6. $E_t(.)$ denotes mathematical conditional expectations. Expectations are conditional on information available at the beginning of period t.
7. We allow for sustained inflation in order to achieve long term money neutrality.
8. $\hat{y}(s^t) = \log(Y(s^t)) - \log(\bar{Y}(s^t))$, where $\bar{Y}(s^t)$ denotes potential output and is taken to be equal to the flexible price output.
9. Using flexible price output rather than a deterministic trend in the output gap is important for the properties of optimal monetary policy. In our case, the optimal Taylor rule turns out to assign a zero weigh to output stabilization. Consequently, the choice of the target output measure does not matter for the results reported below.
10. Using PPI inflation instead makes a difference for the results. See below.
11. There are many different ways of supporting a bilateral peg. We have chosen to work with a perfectly symmetric arrangement.
12. The solution to the flexible price model uses the corresponding monetary policy rule from the fixed price model.
13. In terms of steady state consumption equivalent, these welfare differences amount to 2–3% of one percentage point (between FER and BERP). They are larger for the UERP, where they can be as high as 15–20% of one percentage point.

References

Backus, D., P. Kehoe and F. Kydland (1985) "International Business Cycle: Theory and Evidence, in Cooley." *Frontiers of Business Cycle Research*. Princeton University Press, Ch. 11: 331–356.

Chari, V., P. Kehoe and E. McGrattan (2003) "Can Sticky Price Models Generate Volatile and Persistent Real Exchange Rate Changes?" *Review of Economic Studies* (69), 3: 53–563.

Cooley, T. and E. Prescott (1995) *Frontiers of Business Cycle Research*. Princeton University Press.

Christiano, L., M. Eichenbaum and G. Evans (2005) "Nominal Rigidities and the Dynamic Effects of a Monetary Policy Shock." *Journal of Political Economy* 113:1–45.

Collard, F. and H. Dellas (2002) "Exchange Rate Systems and Macroeconomic Stability." *Journal* of Monetary Economics 49(3):571–599.

Dellas, H. (2005) "Monetary Policy in an Open Economy." *European Economic Review* (forthcoming).

Friedman, M. (1953) *The Case for Flexible Exchange Rates*. In Essays in Positive Economics, Chicago: University of Chicago Press.

Goodfriend, M. and R. King (1997) "The New Neoclassical Synthesis and the Role of Monetary Policy, NBER Macroeconomics Annual." 12: 231–283.

Kollmann, R. (2002) "Monetary Policy Rules in the Open Economy, CEPR wp. 3279.

Obstfeld, M. and M. Rogoff (2000) "New Directions for Stochastic Open Economy Models." *Journal of International Economics*. 50:117–153.

Pappa, E. (2004) "Do the ECB and the FED Really Need to Cooperate? Optimal Monetary Policy in a Two-Country World." *Journal of Monetary Economics* 51(4):753–779.

Taylor, J. (2001) "The Role of the Exchange Rate in Monetary Policy Rules." *American Economic Review* 91(2):263–267.

Woodford, M. (2003) *Interest and Prices: Foundations of a Theory of Monetary Policy*. Princeton University Press.