Monetary arrangements for a small open economy

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Abstract

There exists a strong presumption in the literature in favor of flexible exchange rates. In this paper, we examine whether this is due to commonly employed but restrictive features regarding the types of frictions, shocks, and feasible monetary policies. We find that ruling out informationally demanding, sophisticated policies does indeed compromise the performance of flexible regimes and makes it vary with the degree and type of shocks and nominal frictions. In general, with a strong commitment to price stability, flexible exchange rates tend to perform better than a fixed exchange rate regime. Yet, we find that in some cases this result could be reversed. When the economy faces a stable external environment (low volatility of foreign output, interest rates, and prices) or when the main source of nominal rigidity is in the imported goods sector, a fixed regime may perform better.

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1 Introduction

The study of the properties of alternative, credible, exchange rate regimes has gone through two distinct phases. The first one is associated with the Mundell-Fleming model and its rational expectations offsprings of the 70s and 80s and the second one with the newly developed new Keynesian model.

The key features of the models of the first phase are: a) the reliance on aggregate, ad hoc specifications; b) the use of macroeconomic stability (typically output and inflation) as the criterion for the evaluation of alternative regimes; and c) the assumption that monetary policy is conducted according to a simple targeting procedure (typically, money or interest rate targeting). The main results that emerged from this literature are the following. First, floating exchange rates are useful in bringing about relative price adjustments when nominal goods prices are sluggish (Friedman, 1953). 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, 1970, analysis of the implications of alternative central bank operating procedures).

The second phase has adopted an approach that deviates from all of the above assumptions.[1] The models used have clear microfoundations. Consequently, it is possible to employ explicit utility-based criteria for the evaluation of welfare under alternative exchange rate systems. Moreover, the analysis of the properties of alternative regimes has been undertaken predominantly under the assumption that monetary policy is conducted optimally. Coupled with the assumption that policymakers are omniscient and omnipotent, the last assumption has introduced a strong bias in favor of the flexible exchange rate system, as this regime does not interfere with the desired actions of the monetary authorities. Consequently, with a few exceptions that arise in relatively stylized environments with pricing to market and buyer's currency denomination of trade, a flexible exchange rate system tends to represent the optimal choice.

Nevertheless, the second approach has some important limitations that undermine the strength of its case for flexible rates. First, typically, its ranking of regimes is conditional on the ability of the monetary authorities to design monetary policy optimally, rather than rely on some simple rules. This may be theoretically interesting but seems

[1] Examples are: Benigno and Benigno, 2003, Canzoneri, Cumby and Diba, 2002, Collard and Dellas, 2002, Corsetti and Pesenti, 2001, Devereux and Engel, 2003, Duarte, 2003, Gali and Monacelli, 2002, Kollmann, 2002, Obstfeld and Rogoff, 2000, Ohanian and Stockman, 1994, and Pappa, 2004.

to be of limited practical importance as it requires a great deal of detailed information regarding the structure of the economy and the shocks. The current debates in economics leave no doubt that such knowledge is not available. Second, most of the analysis is conducted in highly stylized environments in which either the non-monetary distortions have been eliminated through non-monetary instruments or they are constant. While it is legitimate to argue–as it is often done–that one should not let real distortions, as opposed to nominal frictions, shape the properties of monetary policy, the matter of fact is that such distortions are present in actual economies and cannot be ignored in the analysis of the consequences of alternative monetary policies. Third, a limited number of domestic and foreign shocks is considered. And finally, most of the literature on the optimal choice of the exchange rate regime has looked at large countries. The case of small open economies has not been scrutinized sufficiently.

The objective of the present paper is to undertake a more general and practically more relevant treatment of the choice of the exchange rate regime. We employ a small open economy that is characterized by a variety of real and nominal disturbances and we compare exchange rate systems under simple monetary policy rules that do not strain the information capabilities of the policymakers.[2] In particular, we allow for both price (for domestic and imported goods) and wage rigidities, a monetary distortion, real distortions as imperfect competition in both intermediate goods (whether domestically produced or imported) and labor markets, and active monetary policies that stabilize output around its trend rather than the flexible price equilibrium. We carry out both utility-based evaluations[3] and comparisons that rely on more traditional macroeconomic stability criteria.

Our findings confirm the speculation advanced above that the case for flexible exchange rates that has been made in the recent literature owes much to a) the assumption that monetary authorities are able to follow sophisticated, activistic rules and b) to the practice of focusing on a single nominal rigidity, namely that in domestic goods. We identify general conditions under which a flexible regime performs better than a peg. This occurs when external shocks (in foreign output, interest rates, and prices) are an important source of economic volatility, domestic sources of nominal frictions (in goods or labor markets) are substantial and exceed foreign ones (imported goods),

[2] Dellas, 2003, addresses the informational limitations involved in the conduct of policy more explicitly.

[3] The model is solved in a second-order approximation to allow for an accurate approximation to welfare.

and the monetary authorities aim strongly at price stability. Were the policymakers to follow instead the commonly used activistic rule that involves a response to both inflation and output (the standard Henderson-McKibbin-Taylor (HMT) rule) then it would often be the case that a system of fixed parities outperformed the flexible exchange rate system. This implies that adopting a flexible exchange rate regime in order to facilitate the execution of anticyclical policy is not a good idea. A flexible exchange rate regime must be restricted by strong inflation targeting procedures in order to have satisfactory properties.

The rest of the paper is organized as follows. Sections 2-3 present the model. Section 4 contains a description of the main experiments run and results obtained. Section 5 concludes.

2 The model

The model consists of a small open economy (SOE) and a foreign economy (rest of the world). There are three different types of firms operating in this SOE. The first type produces final goods, the second type produces domestically intermediate goods, and the third type imports foreign intermediate goods.

2.1 The final sector firms

Following Backus et al., 1995, we assume that the domestic final good y is produced by perfectly competitive domestic firms by combining domestic (x^{D}) and imported (x^{M}) intermediate goods. The final good y can solely be used for domestic private consumption and investment purposes. Its production is described by the following CES function

$$y_t = \left(\omega^{1-\rho} x_t^{\mathrm{D}\rho} + (1-\omega)^{1-\rho} x_t^{\mathrm{M}\rho}\right)^{\frac{1}{\rho}} \tag{1}$$

where $\omega \in [0,1]$ and $\rho \in \,]-\infty, 1]$.

Minimizing total expenditures, $P_{xt}x_t^{\mathrm{D}} + P_{mt}x_t^{\mathrm{M}}$, where P_{xt} and P_{mt} denote the price of, respectively, the domestic and the imported bundle of goods, we obtain the demand functions[4]

$$x_t^{\text{D}} = \left(\frac{P_{xt}}{P_t}\right)^{\frac{1}{\rho-1}} \omega y_t \quad \text{and} \tag{2}$$

$$x_t^{\text{M}} = \left(\frac{P_{mt}}{P_t}\right)^{\frac{1}{\rho-1}} (1-\omega) y_t. \tag{3}$$

P_t is the price of the domestic final good

$$P_t = \left(\omega P_{xt}^{\frac{\rho}{\rho-1}} + (1-\omega) P_{mt}^{\frac{\rho}{\rho-1}}\right)^{\frac{\rho-1}{\rho}}. \tag{4}$$

The bundles of goods x_t^{D} and x_t^{M} are themselves combinations of, respectively, the domestic and foreign intermediate goods, produced by each intermediate firm $i \in [0,1]$, according to

$$x_t^{\text{D}} = \left(\int_0^1 x_t^{\text{D}}(i)^\theta \text{d}i\right)^{\frac{1}{\theta}} \quad \text{and} \quad x_t^{\text{M}} = \left(\int_0^1 x_t^{\text{M}}(i)^\theta \text{d}i\right)^{\frac{1}{\theta}} \tag{5}$$

where $\theta \in]0,1]$. 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 within the domestic and foreign bundles. Minimizing total expenditures, $\int_0^1 P_{xt}(i) x_t^{\text{D}}(i)\text{d}i + \int_0^1 P_{mt}(i) x_t^{\text{M}}(i)\text{d}i$, yields demand functions

$$x_t^{\text{D}}(i) = \left(\frac{P_{xt}(i)}{P_{xt}}\right)^{\frac{1}{\theta-1}} x_t^{\text{D}} \quad \text{and} \tag{6}$$

$$x_t^{\text{M}}(i) = \left(\frac{P_{mt}(i)}{P_{mt}}\right)^{\frac{1}{\theta-1}} x_t^{\text{M}} \tag{7}$$

where

$$P_{xt} = \left(\int_0^1 P_{xt}(i)^{\frac{\theta}{\theta-1}} \text{d}i\right)^{\frac{\theta-1}{\theta}} \quad \text{and} \quad P_{mt} = \left(\int_0^1 P_{mt}(i)^{\frac{\theta}{\theta-1}} \text{d}i\right)^{\frac{\theta-1}{\theta}}. \tag{8}$$

2.2 The intermediate goods firms

Each intermediate firm i produces an intermediate good $x(i)$ using physical capital $k(i)$ and labor $h(i)$ according to a constant return-to-scale technology ($\alpha_k, \alpha_h \in [0,1]$,

[4] In the foreign economy, indexed by F, the demand for the domestic good is

$$x_t^{\text{F}} = \left(\frac{P_{xt}/s_t}{P_t^\star}\right)^{\frac{1}{\rho-1}} (1-\omega^\star) y_t^\star$$

where variables with a star denote world variables. s_t is the nominal exchange rate.

$\alpha_k + \alpha_h = 1$) represented by the production function

$$x_t(i) = \mathcal{A}_t k_t(i)^{\alpha_k} h_t(i)^{\alpha_h} \tag{9}$$

where $\mathcal{A}_t$ is an exogenous stationary stochastic technological shock, whose properties are defined in the next section.

Minimizing total labor expenditures, $\int_0^1 W_t(j)h_t(i,j)\mathrm{d}j$, leads to the following demand for labor of type j by firm i

$$h_t(i,j) = \left(\frac{W_t(j)}{W_t}\right)^{\frac{1}{\vartheta-1}} h_t(i) \tag{10}$$

where $\vartheta \in]0,1]$ is the elasticity of substitution between labor types. The aggregate wage level is given by

$$W_t = \left(\int_0^1 W_t(j)^{\frac{\vartheta}{\vartheta-1}}\mathrm{d}j\right)^{\frac{\vartheta-1}{\vartheta}}, \tag{11}$$

$W_t(j)$ is the nominal wage for labor of type j, and $h(i)$ takes the form

$$h_t(i) = \left(\int_0^1 h_t(i,j)^{\vartheta}\mathrm{d}j\right)^{\frac{1}{\vartheta}}. \tag{12}$$

Assuming that each firm i operates under perfect competition in the input markets, it determines its production plan so as to minimize its total cost, $W_t h_t(i) + P_t z_t k_t(i)$, z_t being the real cost of capital, subject to the production function (9). Using the first-order conditions, the input demand functions are given by

$$\alpha_k \psi_t P_t x_t(i) = P_t z_t k_t(i) \text{ and} \tag{13}$$

$$\alpha_h \psi_t P_t x_t(i) = W_t h_t(i) \tag{14}$$

where the real marginal cost is given by $\psi_t = \frac{z_t^{\alpha_k}(W_t/P_t)^{\alpha_h}}{\mathcal{A}_t \varsigma}$ using $\varsigma = \alpha_k^{\alpha_k}\alpha_h^{\alpha_h}$.

Intermediate goods producers are monopolistically competitive. Therefore, they set prices for the good they produce. It is assumed that they face an adjustment cost when they change their prices. The profit maximization problem, with discount factors[5] $D_{t,t} = 1$ and $D_{t,t+n} = \beta^n \frac{\Lambda_{t+n}(j)}{\Lambda_t(j)}$, is given by

$$\max_{P_{xt}(i)} \left\{ \mathbb{E}_t \sum_{n=0}^{\infty} D_{t,t+n} \Pi_{xt+n}(i) \right\} \tag{15}$$

[5] See next section for the calculation of the discount factors.

using the profit function $\Pi_{xt}(i) = (P_{xt}(i) - P_t\psi_t)x_t(i) - \frac{\xi_x}{2}\left(\frac{P_{xt}(i)}{P_{xt-1}(i)} - \pi_x\right)^2 P_t y_t$. The last element represents the cost of changing prices expressed in units of the final good. Variables without any time subscript indicate steady-state values and π_x is the steady-state rate of domestic price inflation. The first-order condition with regard to the choice of price, $P_{xt}(i)$, can be expressed as follows

$$P_{xt}(i) = \frac{1}{\theta}\left(P_t\psi_t + \frac{(\theta-1)}{x_t(i)}\left[\begin{array}{c} \frac{P_{xt}(i)}{P_{xt-1}(i)}\xi_x\left(\frac{P_{xt}(i)}{P_{xt-1}(i)} - \pi_x\right)P_t y_t - \\ \mathbb{E}_t D_{t,t+1}\frac{P_{xt+1}(i)}{P_{xt}(i)}\xi_x\left(\frac{P_{xt+1}(i)}{P_{xt}(i)} - \pi_x\right)P_{t+1}y_{t+1}\end{array}\right]\right). \quad (16)$$

2.3 The importers

Importers are also monopolistically competitive. They are also assumed to face an adjustment cost when they change their prices. Their profit maximization problem is given by

$$\max_{P_{mt}(i)}\left\{\mathbb{E}_t\sum_{n=0}^{\infty} D_{t,t+n}\Pi_{mt+n}(i)\right\} \quad (17)$$

where $\Pi_{mt}(i) = (P_{mt}(i) - s_t P_t^{\star})x_t^{\mathrm{M}}(i) - \frac{\xi_m}{2}\left(\frac{P_{mt}(i)}{P_{mt-1}(i)} - \pi_m\right)^2 P_t y_t$. The first-order condition with regard to the choice of price, $P_{mt}(i)$, is

$$P_{mt}(i) = \frac{1}{\theta}\left(s_t P_t^{\star} + \frac{(\theta-1)}{x_t^{\mathrm{M}}(i)}\left[\begin{array}{c} \frac{P_{mt}(i)}{P_{mt-1}(i)}\xi_m\left(\frac{P_{mt}(i)}{P_{mt-1}(i)} - \pi_m\right)P_t y_t - \\ \mathbb{E}_t D_{t,t+1}\frac{P_{mt+1}(i)}{P_{mt}(i)}\xi_m\left(\frac{P_{mt+1}(i)}{P_{mt}(i)} - \pi_m\right)P_{t+1}y_{t+1}\end{array}\right]\right). \quad (18)$$

2.4 The households

There exists a unit mass continuum of households, indexed by $j \in [0,1]$. The preferences of household j are given by (discounted sum of $U_t(c_t, h_t)$)

$$\mathbb{E}_t\sum_{\tau=0}^{\infty}\beta^{\tau}\left[\frac{\nu^c}{1-\sigma_c}c_{t+\tau}(j)^{1-\sigma_c} - \frac{\nu^h}{1+\sigma_h}h_{t+\tau}(j)^{1+\sigma_h}\right] \quad (19)$$

where $0 < \beta < 1$ is a constant discount factor, $c_t(j)$ denotes the domestic consumption bundle, and $h_t(j)$ is the quantity of hours supplied by household of type j. ν^c and ν^h are constants characterizing the preferences.

In each period, the representative household j faces a budget constraint

$$\begin{aligned}
& B^{\mathrm{D}}_{t+1}(j) + s_t B^{\mathrm{F}}_{t+1}(j) + M_t(j) \\
& + P_t \left((1+\eta_t(j))c_t(j) + i_t(j) + \frac{\xi_w}{2}(\frac{W_t(j)}{W_{t-1}(j)} - \pi_w)^2 y_t \right) \\
= \; & R_{t-1} B^{\mathrm{D}}_t(j) + R^{\mathrm{F}}_{t-1} s_t B^{\mathrm{F}}_t(j) + M_{t-1}(j) \\
& + P_t z_t k_t(j) + W_t(j) h_t(j) + N_t(j) + \Pi_t(j) \qquad (20)
\end{aligned}$$

where $B^{\mathrm{D}}_t(j)$ and $B^{\mathrm{F}}_t(j)$ are domestic and foreign currency bonds, R_t and R^{F}_t are gross rates of interest on domestic and foreign bonds, $i_t(j)$ is investment expenditure, and $k_t(j)$ is the amount of physical capital owned by the household and leased to the firms at the real rental rate z_t. $M_{t-1}(j)$ is the amount of money that the household brings into period t, $M_t(j)$ is the end of period t money, and $N_t(j)$ is a nominal lump-sum transfer received from the monetary authorities. $\Pi_t(j)$ denotes the profits distributed to the household by the firms. The expression $\frac{\xi_w}{2}\left(\frac{W_t(j)}{W_{t-1}(j)} - \pi_w\right)^2 P_t y_t$ captures the cost of adjusting nominal wages in terms of final good consumption. $\eta(v_t(j), \zeta_t)$ is a proportional monetary transaction cost that depends on the household's money velocity

$$v_t(j) = \frac{P_t c_t(j)}{M_t(j)} \qquad (21)$$

and on a money demand shock ζ_t, whose properties are defined in the next section. We use the function $\eta(.)$ borrowed from Schmitt-Grohé and Uribe, 2004,

$$\eta(v_t(j), \zeta_t) = \zeta_t \left(A v_t(j) + \frac{B}{v_t(j)} - 2\sqrt{AB} \right). \qquad (22)$$

Capital accumulates according to the law of motion

$$k_{t+1}(j) = i_t(j) - \frac{\varphi}{2}\left(\frac{i_t(j)}{k_t(j)} - \kappa\right)^2 k_t(j) + (1-\delta) k_t(j) \qquad (23)$$

where $\delta \in [0,1]$ denotes the rate of depreciation. $\kappa > 0$ is a constant term such that capital adjustment costs are nil in steady state.

The household then determines consumption/saving and money holdings decisions maximizing (19) subject to (20) and (23) where $\Lambda_t(j)$ and $\Lambda^k_t(j)$ are the Lagrange multipliers associated with both constraints. This leads to the following set of optimality conditions:

FOC c_t

$$\nu^c c_t(j)^{-\sigma_c} = \Lambda_t(j) P_t \left[1 + 2\zeta_t \left(A v_t(j) - \sqrt{AB} \right) \right], \qquad (24)$$

FOC M_t

$$\beta \mathbb{E}_t \frac{\Lambda_{t+1}(j)}{\Lambda_t(j)} = 1 - \zeta_t \left(A v_t(j)^2 - B \right), \tag{25}$$

FOC B^{D}_{t+1}

$$\frac{1}{R_t} = \beta \mathbb{E}_t \frac{\Lambda_{t+1}(j)}{\Lambda_t(j)}, \tag{26}$$

FOC B^{F}_{t+1}

$$\frac{1}{R^{\mathrm{F}}_t} = \beta \mathbb{E}_t \frac{\Lambda_{t+1}(j)}{\Lambda_t(j)} \frac{s_{t+1}}{s_t}, \tag{27}$$

FOC i_t

$$\Lambda_t(j) P_t = \Lambda^k_t(j) \left(1 - \varphi \left(\frac{i_t(j)}{k_t(j)} - \kappa \right) \right), \text{ and} \tag{28}$$

FOC k_{t+1}

$$\Lambda^k_t(j) = \beta \mathbb{E}_t \left[\Lambda_{t+1}(j) P_{t+1} z_{t+1} + \Lambda^k_{t+1}(j) \left(\frac{\varphi}{2} \left(\frac{i_{t+1}(j)^2}{k_{t+1}(j)^2} - \kappa^2 \right) + 1 - \delta \right) \right]. \tag{29}$$

The workers have monopoly power when selling their labor services. The first-order condition with regard to the choice of the nominal wage rate, $W_t(j)$, is obtained by maximizing (19) subject to (20) and the total demand for type j labor $h_t(j) = \int_0^1 h_t(i,j) \mathrm{d}i$ and is given by

$$W_t(j) = \frac{1}{\vartheta} \left(\frac{\nu^h h_t(j)^{\sigma_h}}{\Lambda_t(j)} + \frac{(\vartheta - 1)}{h_t(j)} \left[\begin{array}{c} \frac{W_t(j)}{W_{t-1}(j)} \xi_w \left(\frac{W_t(j)}{W_{t-1}(j)} - \pi_w \right) P_t y_t - \\ \mathbb{E}_t D_{t,t+1} \frac{W_{t+1}(j)}{W_t(j)} \xi_w \left(\frac{W_{t+1}(j)}{W_t(j)} - \pi_w \right) P_{t+1} y_{t+1} \end{array} \right] \right). \tag{30}$$

2.5 Market clearing conditions

Foreigners do not hold any domestic bonds so $B^{\mathrm{D}}_t(j) = 0$ for all t. The interest rate on foreign liabilities carries a risk premium

$$\frac{R^{\mathrm{F}}_t}{\pi^\star} = \frac{R^\star_t}{\pi^\star} - \varrho \left(\frac{B^{\mathrm{F}}_{t+1}}{P^\star_t} \right) \tag{31}$$

where the expression $\varrho \left(\frac{B^{\mathrm{F}}_{t+1}}{P^\star_t} \right)$ is strictly increasing in the aggregate level of real foreign debt. $R^\star_t$ is the world nominal interest rate which is assumed to be an exogenous stochastic process that is defined in the next section.

2.6 Monetary policy

We study two international monetary arrangements: A flexible system and a unilateral peg. In the latter case, the monetary authorities in the small open economy keep the nominal exchange rate vis a vis the rest of the world perfectly constant.

Under a flexible exchange rate system, monetary policy can be conducted without any reference to the exchange rate. Henceforth, we consider three different rules:

a) Strict monetary targeting (MT)

$$\frac{M_t - M_{t-1}}{M_{t-1}} = constant, \tag{32}$$

b) A standard HMT rule

$$r_t = k_\pi(\pi_t - \pi) + k_y(y_t - y), \tag{33}$$

c) Strict (CPI) inflation targeting (IT),[6]

where r_t is the nominal interest rate, M_t is the money supply, π_t is the overall inflation rate, π is the inflation target (equal to the steady state rate of inflation), y_t is output and y is the output target (equal to the steady state value of output).

The motivation for restricting attention to these simple rules is purely practical. We believe that the conduct of monetary policy is limited by severe informational problems that prevent policymakers from computing globally 'optimal' policies and using the flexible price or the efficient level of output as their policy target.

3 Calibration

We are mostly interested in establishing results that hold for a 'generic' rather than for a particular, real world economy.[7] Hence, we rely mostly on parameters that are commonly used in the open economy literature. The benchmark calibration is reported in table 1.

<Table 1 here>

Table 1 calls for the following comments. There is not much information in the literature regarding the appropriate range of values for the parameters of nominal prices (ξ_x, ξ_m) and wage adjustment costs (ξ_w). Following Hairault and Portier, 1993,

[6] This procedure is implemented by assuming $k_y = 0$ and a suitably large value for k_π.

[7] For this see Cuche, Dellas, and Natal, 2004.

we use a value of 1 in the benchmark case but vary this value in the experiments run when studying the effects of asymmetries in price rigidity across sectors (where we use a value of 10). Note that a value of 1 means that changing the inflation rate by 1% (0.01) from its steady state value entails an output cost of $\frac{0.01}{2}$% of GDP. ρ is set equal to 0.8 so that the elasticity of substitution between foreign and domestic goods is quite high (as befits a small open economy). ω is set such that the import share in the economy is 15%. The depreciation rate δ is set to 0.025. The capital adjustment cost φ is set to 10. Both elasticities θ and ϑ are set such that markups in the economy are 25%. α_k, the elasticity of the production function to physical capital, is set such that the labor share in the economy is 0.6. σ_c and σ_h, the coefficients of risk aversion in consumption and labor supply elasticity, are set to 1.5 and 1, respectively. ν^h is set in order for the model to generate a total fraction of time devoted to market activities of 31%. The discount factor β takes a value such that households discount the future at an annual rate of about 4%. Steady-state inflation is set to an annual value of 3.9%.

All shocks are assumed to follow independent AR(1) processes with an autoregressive coefficient of 0.9. In the benchmark case, the standard deviation of all shocks has been set to 0.004. The steady state values are shown in table 2.

<Table 2 here>

4 The results

4.1 Evaluation based on welfare

After computing the deterministic steady state we take a second-order log approximation around it. Welfare is computed using a quadratic approximation to the utility function around the efficient equilibrium as described by Woodford, 2002 and 2003, and Collard and Dellas, 2005.

While we are working with a 'generic' economy, we still want such an economy to have good empirical properties. Table 3 reports second moments for the main variables in the benchmark case under a flexible exchange rate regime and an interest rate (HMT) rule. It can be seen that the model behaves satisfactorily as far as relative volatilities are concerned. Its main weaknesses are to be found in the low autocorrelations as well as in the countercyclicality of employment.

<Table 3 here>

The welfare results are reported in tables 4-5f. In order to have some idea of the relative importance of the real and monetary distortions we start by reporting welfare in the case of real distortions only (that is, those associated with imperfect competition) and also in the case with both real and monetary distortions (that is, those associated, in addition, with the monetary transaction cost).[8] In the former case, the monetary arrangement in place is of no consequence (see table 4). As can be seen (at least in the benchmark case) real frictions matter much more than nominal ones.

<Table 4 here>

We then proceed to report welfare levels for each individual shock (i.e. setting the standard deviation of that shock to 0.01 and that of all other shocks to 0) as we vary the relative importance of a particular nominal friction (keeping the level of real distortions fixed).

<Table 5a-5e here>

Several patterns can be seen in these tables. The welfare rankings of alternative regimes vary as a function of both the shock and the relative importance of individual sources of nominal rigidity.

For domestic supply shocks (table 5a), with the exception of the case of dominant domestic nominal price rigidity, the pegged regime fares better, with a flexible regime under passive money targeting being a close second. That a flexible exchange rate regime with strict inflation targeting would fare well under supply shocks in the presence of significant domestic goods price rigidity is not surprising, this is the standard case considered in the literature. It is true that most of this literature uses specifications in which the flexible price equilibrium is efficient, which automatically makes strict inflation targeting (and hence a flexible exchange rate system) the globally optimal policy. Nevertheless, as Collard and Dellas, 2003 and 2005, show in a closed economy, a strong case for price stability remains even when the flexible price equilibrium is not efficient. Our results indicate that this result generalizes to the open economy.

For foreign shocks (tables 5c-e), welfare is typically higher under a flexible exchange rate system with activistic monetary policy as long as the degree of nominal price rigidity in imported goods is not both substantial and large relative to that in domestic

[8]The appendix gives an overview of the different distortions, frictions, and shocks of the model.

goods prices and wages. Interestingly, the flexible exchange rate regime under strong inflation targeting fares well not only in the presence of inertia in domestic good prices but also when wages are sluggish. Finally, for money demand shocks (table 5b), the choice of the regime does not matter much.

Henceforth, the novelty of our analysis lies in two findings. First, wage rigidity supports a fixed over a flexible regime in the case of supply shocks, while it works in favor of a flexible exchange rate regime in the case of external shocks. Second, in the case of external shocks, it is sluggishness in imported goods prices that works against the flexible regime.

The intuition for the poor performance of an activistic, flexible regime in the case of supply shocks and under wage or import price stickiness can be understood as follows (see figure 1). Consider first the case of nominal wage rigidity. In the efficient economy, the response of inflation to a supply shock tends to be small (in our model). This implies that the increase in the real wage following a positive supply shock is accomplished mostly via an increase in nominal wages. When it is costly to adjust the nominal wage, then there is a need for a larger drop in p_x in order to support the efficient increase in real wages. Under inflation targeting, p_x is prevented from dropping enough, so the real wage is too low, and the increase in output and employment too high relative to the efficient response. Under a peg, in contrast, exchange rate stabilization requires contractionary policy (because a positive domestic supply shock leads to a domestic currency depreciation as part of the required home terms of trade deterioration) which contributes to a lower p_x.

Consider now the case of import price rigidity. In the efficient equilibrium, the excess supply of domestic goods following a positive supply shock requires a domestic terms of trade deterioration, which is accomplished partly through a decrease in p_x and partly through an increase in p_m and an domestic currency depreciation. When p_m is sticky there is a need for a larger drop in p_x and a larger depreciation. An inflation targeting policy implies expansionary policy which prevents p_x from dropping but supports a weaker currency. A peg, on the other hand, requires contractionary monetary policy which leads to a lower p_x but takes away the exchange rate change. Although the comparison is ambiguous, in our model, assuming perfect price flexibility for domestic intermediate goods (p_x), a peg will be preferred.

<Figure 1 here>

Similar arguments can be used to compare alternative monetary policies in the case of external shocks. Consider, for instance, a situation with nominal wage rigidity and foreign output shocks. An increase in world output increases the demand for the domestic intermediate good. The domestic terms of trade (p_x/p_m and $p_x/sp^\star$) improve, via a combination of a higher p_x, a lower p_m, and a stronger domestic currency. The demand for domestic labor increases, pushing the real wage up, which is accomplished partly through an increase in the nominal wage. Were the nominal wage sticky, the required real wage increase would need a smaller increase in p_x relative to that in the efficient economy. It turns out, that under a flexible regime and inflation targeting, the effect of the foreign output shock on domestic inflation is quite small, and thus monetary policy does not need to respond much in order to stabilize the inflation rate. This is not true, though, for the exchange rate targeting policy, as the effect of the foreign shock on the exchange rate is relatively strong (appreciation of the domestic currency). In order to counter the exchange rate depreciation, looser monetary policy is called for, which leads to a higher p_x. Hence, under a peg p_x is moved in the wrong direction, which undermines its performance.

Consider now a situation with imported goods price rigidity and foreign price shocks (see figure 2). An increase in the price of foreign goods increases the demand of foreign producers for the domestic intermediate good. The excess demand can be eliminated via an increase in p_x relative to $sp^\star$ and to p_m. The former discourages foreign users of the intermediate good while the latter discourages the domestic users. When p_m is sluggish, more of the adjustment needs to fall on p_x and s. As domestic inflation falls following an increase in $p^\star$–due to the large appreciation of the domestic currency– monetary policy needs to be expansionary under inflation targeting. It hence moves p_x in the right direction (but the exchange rate in the wrong direction). Under a peg, monetary policy is expansionary too. The comparison is in general ambiguous and turns out to depend critically on the degree of price rigidity.

<Figure 2 here>

The more rigid p_m, the larger the effect on the exchange rate relative to that on inflation under passive policy (money targeting). This implies that for large values of rigidity, monetary policy becomes more expansionary following a positive foreign price shock under a peg in comparison to inflation targeting. This brings the economy closer to the efficient responses.

<Table 5f here>

We now turn to the presentation of welfare results in the case where all the shocks are operative. In addition to examining the role of asymmetries in nominal rigidities as before, we also examine the effect of symmetric changes in the average level of frictions as a means of gauging the role of nominal rigidities in general. As we have not calibrated the model to a specific economy, we do not have any guidance on how to assign volatility to the various sources of uncertainty. We have opted for a symmetric treatment, namely, we have used the value of 0.004 for all five shocks. If one believes that some shocks are relatively more volatile than other then one can use the results from the case of individual shocks to form an idea of the combined effect. Note, though, that there is likely no monotonicity in the rankings as a function of the volatility of the shocks even in the symmetric case.

The main finding of interest is that the flexible regime with strict inflation targeting performs better, at least when the degree of price sluggishness in import good prices is not too high.

4.2 Evaluation based on macroeconomic volatility

We now briefly comment on the volatilities of key macroeconomic variables associated with the alternative monetary arrangements discussed above. This used to be the standard procedure in the earlier literature on exchange rate regimes and still has some interest as these comparisons do not rely on the specification of the utility function and hence may carry greater robustness. Tables 6a-e report the results.

<Table 6a-e here>

By construction, the strict inflation targeting rule gives the lowest volatility of inflation. The interesting question is whether this comes at the expense of output volatility. It turns out that this is indeed the case, with either the fixed regime delivering considerably more stable output in the case of supply shocks than inflation targeting, and the passive money targeting rule or the HTM rule doing better for the other shocks. This finding should not come as a surprise, as most of these shocks move inflation and output in opposite directions, creating a policy dilemma.

4.3 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, which 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, the exchange rate in our model is determined fully by fundamentals. If some (perhaps much) of the volatility of the exchange rate, however, came from non fundamental sources, a flexible regime would be associated with excessive volatility and its performance would be compromised. There has not been much progress in modelling these types of effects in the literature, though, so we do not feel that we can incorporate them in a non-controversial way.

5 Conclusions

The new macroeconomic models have provided a rigorous and empirically relevant framework for the study of the properties and implications of monetary arrangements, both domestic and international. In this paper we use a more general model of a small open economy, namely a model that includes several nominal and real disturbances, to evaluate alternative exchange rate regimes. We find that the strong support for flexible exchange rate systems claimed in the literature reflects, to some degree, certain modelling biases. Nonetheless, a clear case for flexible exchange rates can still be made as long as the shocks originate mainly from abroad, the nominal frictions are mostly domestic, and monetary policy aims strongly at price stability.

Another lesson that emerges from our analysis is that adhering to a standard nominal interest rate rule (such as the HMT rule) and ignoring movements in the exchange rate is not a good idea. In most of the cases considered, such a policy is dominated by one that simply targets strictly the exchange rate. In order for a country to take advantage of the benefits associated with a flexible exchange rate regime it must accompany this choice with a policy of strict inflation targeting.

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Tables and figures

Table 1: Calibration, benchmark case

Parameter, steady-state variable		Value
Production	α_k	0.2268
Transaction cost	A	0.0111
Transaction cost	B	0.0752
Wage markup	ϑ	0.8000
Invest. adjust. cost	φ	10.0000
Depreciation rate	δ	0.0250
Trade elasticity	ρ	0.8000
Goods markup	θ	0.8000
Trade share	ω	0.8500
Discount factor	β	0.9900
Utility	σ_h	1.0000
Utility	σ_c	1.5000
Preferences	ν^c	1.0000
Preferences	ν^h	8.4342
Inflation rate	π, π_x, π_m, π_w	1.0096
Work	h	0.3100
Risk premium	ϱ	0.0200
Nominal rigidities	ξ_x, ξ_m, ξ_w	1.0000

Table 2: Steady-state value of shocks

Shock		Value
Money demand	ζ	1.000
Domestic productivity	$\mathcal{A}$	1.000
World interest rate	$R^\star$	1.019
Real exchange rate	$p^\star$	0.807
World output	$y^\star$	$10y$

Notes: $10y$ = world output is ten times bigger than domestic output; $p^\star = \frac{sP^\star}{P}$.

Table 3: Business cycle statistics, benchmark case

Variable	Rel. st. dev.	Corr. w. GDP	Autocorr.
c	0.8106	0.9944	0.4194
h	0.9979	−0.9231	0.2631
i	3.5591	0.9768	0.2821
π	0.9631	−0.9985	0.3871
TOT	1.7511	−0.9113	0.1989
TB	0.7350	−0.9206	0.2612
Δs	2.7195	−0.9552	0.2395

Notes: These moments correspond to the scenario using a HMT rule with all shocks having a standard deviation of 0.004; TOT = terms of trade; TB = trade balance; Δs = appreciation of the exchange rate.

Table 4: Welfare under real and nominal distortions

	Flexible regime			Fixed
	MT	HMT	IT	regime
Real	−337.3093	−337.3075	−337.3088	−337.3091
Monetary	−228.1096	−228.1326	−228.1177	−228.1110
Real + monetary	−337.0742	−337.1003	−337.0853	−337.0751

Notes: Values for all price distortions set to 1; all shocks included; standard deviation of all shocks set to 0.004.

Table 5a: Supply shocks $\mathcal{A}$

	Flexible regime			Fixed	Efficient
	MT	HMT	IT	regime	economy
$\xi_w = 10$	−337.2322	−337.5816	−337.2649	−337.2321	−330.2941
$\xi_x = 10$	−337.2280	−337.5733	−337.2219	−337.2598	−330.2941
$\xi_m = 10$	−337.2363	*na*	−337.3252	−337.2370	−330.2941

Notes: Monetary and real distortions are included; the value for the other nominal distortions is set to 1; standard deviation of the shock is 0.01; na = non available.

Table 5b: Money demand shocks ζ

	Flexible regime			Fixed	Efficient
	MT	HMT	IT	regime	economy
$\xi_w = 10$	−337.2393	−337.2392	−337.2392	−337.2392	−330.2941
$\xi_x = 10$	−337.2394	−337.2392	−337.2392	−337.2392	−330.2941
$\xi_m = 10$	−337.2398	−337.2392	−337.2392	−337.2392	−330.2941

Notes: Monetary and real distortions are included; the value for the other nominal distortions is set to 1; standard deviation of the shock is 0.01.

Table 5c: Foreign price shocks $p^\star$

	Flexible regime			Fixed	Efficient
	MT	HMT	IT	regime	economy
$\xi_w = 10$	−340.8863	−342.2528	−337.0138	−338.5040	−330.2941
$\xi_x = 10$	−341.4605	−342.8822	−336.9465	−338.8304	−330.2941
$\xi_m = 10$	*na*	*na*	−340.7173	−337.4420	−330.2941

Notes: Monetary and real distortions are included; the value for the other nominal distortions is set to 1; standard deviation of the shock is 0.01; na = non available; $p^\star = \frac{sP^\star}{P}$.

Table 5d: Foreign demand shocks $y^\star$

	Flexible			Fixed	Efficient
	MT	HMT	IT	regime	economy
$\xi_w = 10$	−337.2372	−337.2374	−337.2322	−337.2450	−330.2941
$\xi_x = 10$	−337.2392	−337.2395	−337.2322	−337.2470	−330.2941
$\xi_m = 10$	−337.2703	−337.5505	−337.2341	−337.2406	−330.2941

Notes: Monetary and real distortions are included; the value for the other nominal distortions is set to 1; standard deviation of the shock is 0.01.

Table 5e: Foreign interest rate shocks $R^\star$

	Flexible regime			Fixed	Efficient
	MT	HMT	IT	regime	economy
$\xi_w = 10$	−347.7556	−352.7135	−336.7002	−337.8990	−330.2941
$\xi_x = 10$	−348.3564	−354.0385	−336.6858	−338.2327	−330.2941
$\xi_m = 10$	*na*	*na*	−350.6849	−337.3218	−330.2941

Notes: Monetary and real distortions are included; the value for the other nominal distortions is set to 1; standard deviation of the shock is 0.01; na = non available.

Table 5f: All shocks, symmetric rigidities

	Flexible regime			Fixed	Efficient
	MT	HMT	IT	regime	economy
$\xi_w, \xi_x, \xi_m = 1$	−337.6950	−337.7367	−337.0624	−337.2227	−330.2941
$\xi_w, \xi_x, \xi_m = 5$	−346.1769	−345.1734	−337.2731	−337.3608	−330.2941
$\xi_w, \xi_x, \xi_m = 10$	−346.8833	−337.2198	−337.4798	−337.4089	−330.2941

Notes: Monetary and real distortions are included; standard deviation of all shocks is 0.004.

Table 6a: Moments of the welfare tables, $\mathcal{A}$ shocks

	y	c	h	i	π	TOT	TB
ξ_w	0.00049859	0.00032974	0.00013092	0.00295077	0.00001745	0.00020891	0.00003365
ξ_x	0.00042754	0.00028537	0.00003828	0.00247158	0.00000996	0.00015570	0.00002433
ξ_m	0.00044383	0.00029344	0.00002013	0.00264630	0.00002216	0.00003355	0.00000943
ξ_w	0.00054061	0.00042654	0.00018887	0.00323213	0.00051211	0.00014158	0.00001389
ξ_x	0.00047813	0.00039247	0.00006516	0.00242015	0.00045950	0.00012225	0.00001129
ξ_m	*na*	*na*	*na*	*na*	*na*	*na*	*na*
ξ_w	0.00060548	0.00039361	0.00025668	0.00382374	0.00000000	0.00037881	0.00005110
ξ_x	0.00047854	0.00031419	0.00004157	0.00291178	0.00000000	0.00021055	0.00003177
ξ_m	0.00054325	0.00035583	0.00008672	0.00349192	0.00000000	0.00043589	0.00004210
ξ_w	0.00041674	0.00027887	0.00002604	0.00239588	0.00006909	0.00006909	0.00002018
ξ_x	0.00037499	0.00025028	0.00002227	0.00218751	0.00004669	0.00004669	0.00001481
ξ_m	0.00044396	0.00029320	0.00001766	0.00026528	0.00002463	0.00002463	0.00000848

Notes: Reported figures are the relative standard deviations; each bundle of nominal restrictions corresponds to a monetary policy scenario in the following order: MT, HMT, IT, and fixed exchange rate regime; the table corresponds to the scenarios reported in table 5a.

Table 6c: Moments of the welfare tables, $p^{\star}$ shocks

	y	c	h	i	π	TOT	TB
ξ_w	0.00139970	0.00071155	0.00610278	0.01687180	0.00058597	0.00545679	0.00184265
ξ_x	0.00139078	0.00070313	0.00840877	0.01587764	0.00040778	0.00588678	0.00215273
ξ_m	0.01496848	0.00742317	0.04476388	0.15051369	0.01264347	0.08810047	0.01676093
ξ_w	0.00122747	0.00137477	0.00828199	0.02485550	0.00155982	0.00635124	0.00231107
ξ_x	0.00090586	0.00135309	0.00990592	0.02148888	0.00140935	0.00645310	0.00239363
ξ_m	*na*	*na*	*na*	*na*	*na*	*na*	*na*
ξ_w	0.00210449	0.00103081	0.00011764	0.01922890	0.00000000	0.00266172	0.00045602
ξ_x	0.00197507	0.00096881	0.00022012	0.01841839	0.00000000	0.00286596	0.00048173
ξ_m	0.00287123	0.00149672	0.00131257	0.03668534	0.00000000	0.00340847	0.00129398
ξ_w	0.00272084	0.00084932	0.00077352	0.02063321	0.00104223	0.00037754	0.00020659
ξ_x	0.00283345	0.00077606	0.00082261	0.02038225	0.00110799	0.00041438	0.00022541
ξ_m	0.00027824	0.00011705	0.00002406	0.00383505	0.00031082	0.00027162	0.00006506

Notes: Reported figures are the relative standard deviations; each bundle of nominal restrictions corresponds to a monetary policy scenario in the following order: MT, HMT, IT, and fixed exchange rate regime; the table corresponds to the scenarios reported in table 5c.

Table 6d: Moments of the welfare tables, $y^{\star}$ shocks

	y	c	h	i	π	TOT	TB
ξ_w	0.00000678	0.00002630	0.00003603	0.00009040	0.00000449	0.00010108	0.00000760
ξ_x	0.00000559	0.00000210	0.00004860	0.00007734	0.00000291	0.00010675	0.00000838
ξ_m	0.00001002	0.00000392	0.00003001	0.00013592	0.00001021	0.00021434	0.00000856
ξ_w	0.00001085	0.00000567	0.00003817	0.00010811	0.00000842	0.00012217	0.00000999
ξ_x	0.00000882	0.00000469	0.00004523	0.00008612	0.00000700	0.00012405	0.00001044
ξ_m	0.00003433	0.00001980	0.00006095	0.00046509	0.00002872	0.00022380	0.00002673
ξ_w	0.00002606	0.00001246	0.00000124	0.00027925	0.00000000	0.00004668	0.00000523
ξ_x	0.00002403	0.00001155	0.00000235	0.00025634	0.00000000	0.00004946	0.00000550
ξ_m	0.00002251	0.00001104	0.00000785	0.00023849	0.00000000	0.00012739	0.00000755
ξ_w	0.00002949	0.00001253	0.00000569	0.00034962	0.00001232	0.00001232	0.00000195
ξ_x	0.00002805	0.00001139	0.00000468	0.00034984	0.00001320	0.00001320	0.00000218
ξ_m	0.00000419	0.00000182	0.00000011	0.00004879	0.00000501	0.00000501	0.00000049

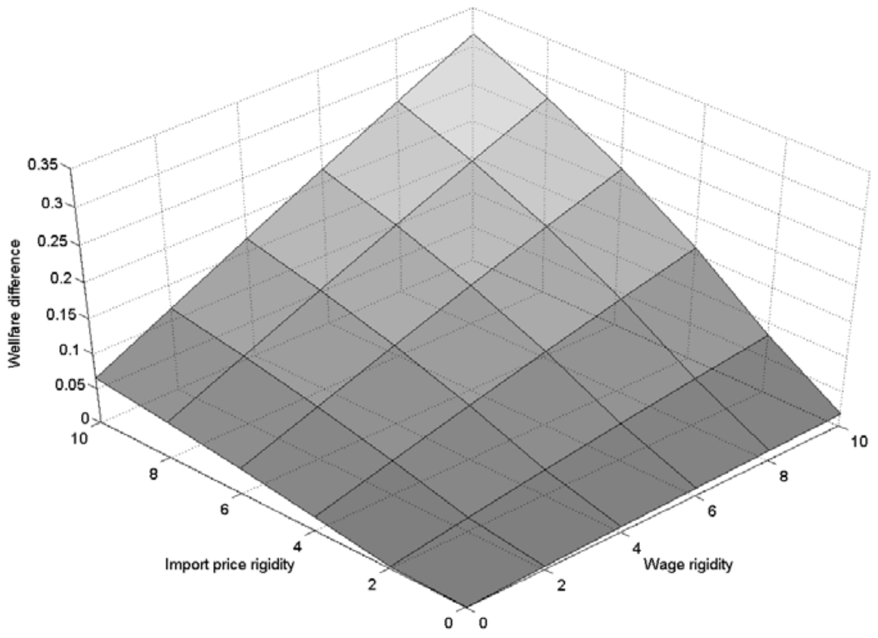
Notes: Reported figures are the relative standard deviations; each bundle of nominal restrictions corresponds to a monetary policy scenario in the following order: MT, HMT, IT, and fixed exchange rate regime; the table corresponds to the scenarios reported in table 5d.

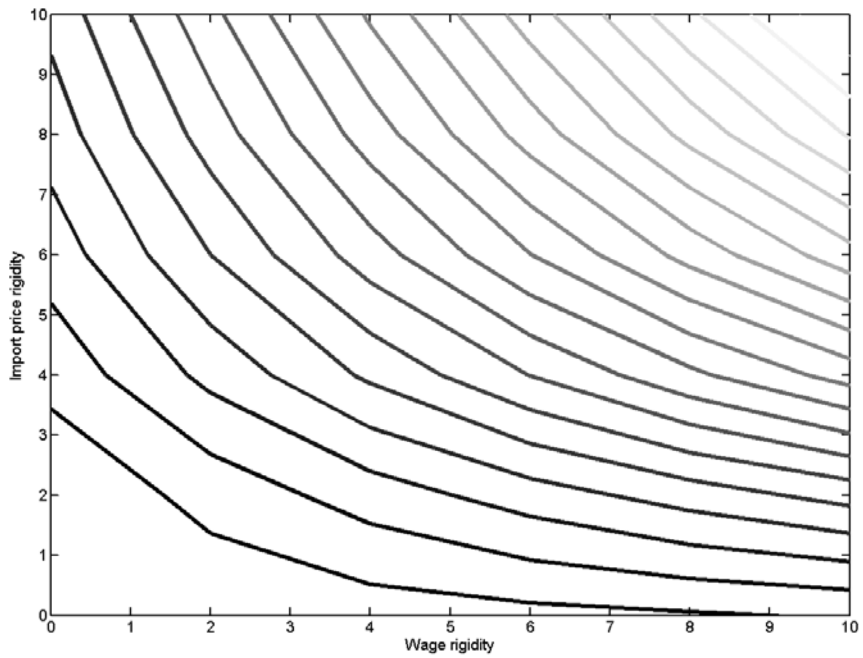
Table 6e: Moments of the welfare tables, $R^{\star}$ shocks

	y	c	h	i	π	TOT	TB
ξ_w	0.00313667	0.00165957	0.01261907	0.03324415	0.00110794	0.00998700	0.00398947
ξ_x	0.00312660	0.00161837	0.01702863	0.03100055	0.00076635	0.01121172	0.00461080
ξ_m	0.02838538	0.01369442	0.08807762	0.28133112	0.02426168	0.20788976	0.03234769
ξ_w	0.00183830	0.00433717	0.02481248	0.06424902	0.00369706	0.01195503	0.00592146
ξ_x	0.00132806	0.00420215	0.02814748	0.05733688	0.00338182	0.01232146	0.00587026
ξ_m	0.00002637	0.00001500	0.00004425	0.00032824	0.00002171	0.00018783	0.00001944
ξ_w	0.00320534	0.00152025	0.00022406	0.03457557	0.00000000	0.00381070	0.00075520
ξ_x	0.00297557	0.00141618	0.00042179	0.03258670	0.00000000	0.00412638	0.00081142
ξ_m	0.00742398	0.00428200	0.00366723	0.08217179	0.00000000	0.00800916	0.00341623
ξ_w	0.00423517	0.00169839	0.00075967	0.04072624	0.00075221	0.00075221	0.00039456
ξ_x	0.00425279	0.00157826	0.00081164	0.03930507	0.00081876	0.00081876	0.00042269
ξ_m	0.00169316	0.00078956	0.00019009	0.02020290	0.00068554	0.00068554	0.00042518

Notes: Reported figures are the relative standard deviations; each bundle of nominal restrictions corresponds to a monetary policy scenario in the following order: MT, HMT, IT, and fixed exchange rate regime; the table corresponds to the scenarios reported in table 5e.

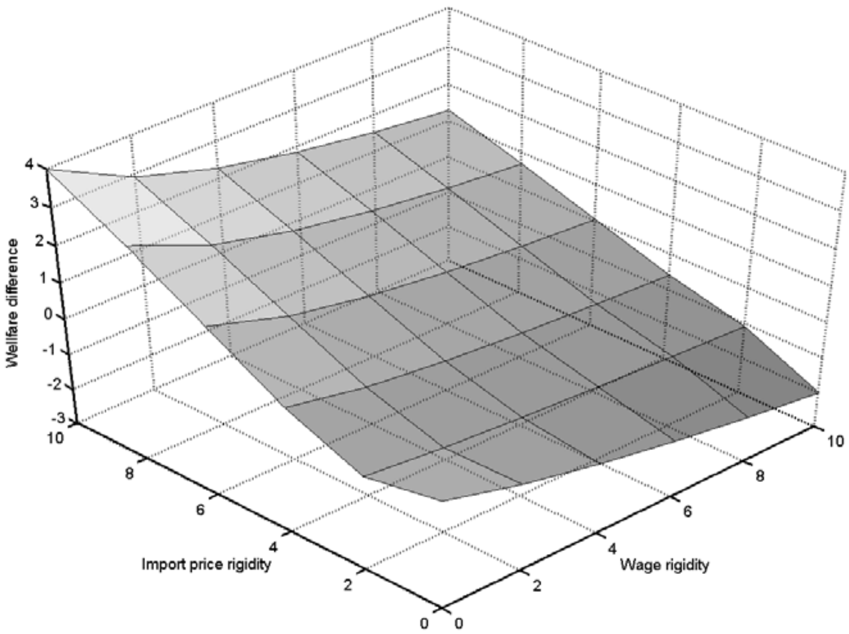
Figure 1: Welfare comparison, supply shocks $\mathcal{A}$

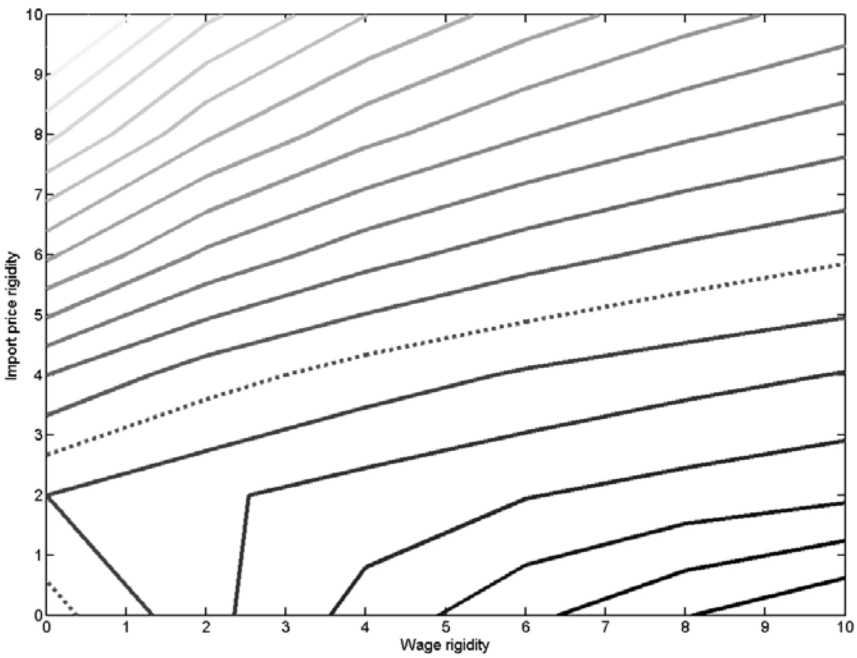




Notes: Figure expresses the welfare difference between a fixed regime and a flexible regime using IT in the presence of supply shocks; domestic price rigidity set to 0; wellfare diffence is the difference of the utility values; interval between contours is 1/20 of the wellfare difference scale.

Figure 2: Welfare comparison, foreign price shocks $p^\star$

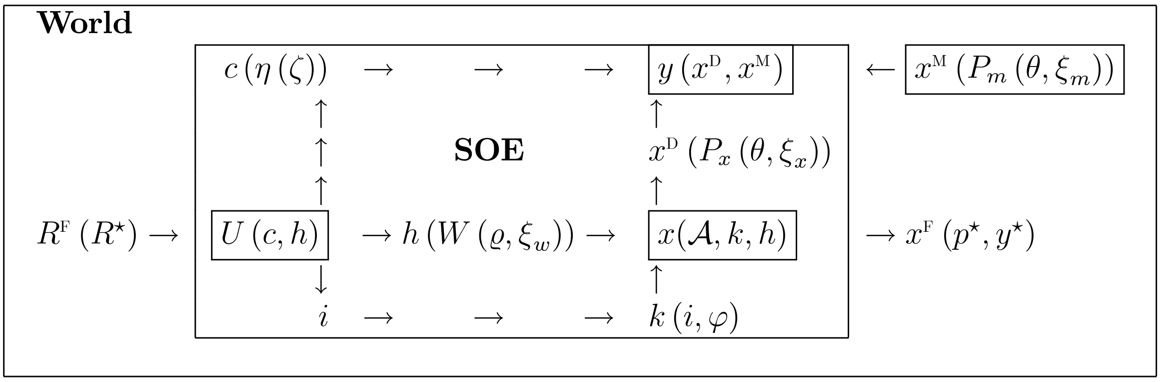




Notes: Figure expresses the welfare difference between a fixed regime and a flexible regime using IT in the presence of foreign shocks; domestic price rigidity set to 0; wellfare diffence is the difference of the utility values; interval between contours is 1/20 of the welfare difference scale; dotted line has a welfare difference of zero.

Appendix

Model overview



Notes: SOE = small open economy; shocks: $\mathcal{A}, R^\star, p^\star, y^\star, \zeta$; monetary distortions η; real distortions θ, ϱ; nominal frictions ξ_w, ξ_x, ξ_m.