# Financial Frictions and The Choice of Exchange Rate Regimes*

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December 2008.

**Abstract**

This paper provides a quantitative assessment of the role of financial frictions in the choice of exchange rate regimes. I use a two country model with sticky prices to compare different exchange rate arrangements. I simulate the model without and with borrowing constraints on investment, under monetary policy and technology shocks. I find that the stabilization properties of floating exchange rate regimes in face of foreign shocks are enhanced relative to fixed exchange rates in presence of credit frictions. In presence of symmetric and correlated shocks fixed exchange rates regimes can perform better than floating. This analysis can have important policy implications for accession countries joining the ERM II system and with high degrees of credit frictions.

*JEL Classification Numbers:* E3, E42, E44, E52, F41.

*Keywords:* borrowing constraints on investment, exchange rate regimes, stabilization policy.

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*I thank Ignazio Angeloni, William Baumol, Pierpaolo Benigno, Thomas Cooley, Carsten Detken, Günter Coenen, Mark Gertler, Philipp Hartmann, Tommaso Monacelli and Frank Smets for useful discussions. I thank seminar participants at the European Central Bank, New York University, Ente Einaudi, 2001 SED conference in Stockholm, 2001 EEA conference in Lausanne, 2001 MMF conference in Belfast. I gratefully acknowledge financial support from the DSGE grant of the Spanish Ministry of Education and the Unicredit research grant. This paper has been previously circulated as ECB w.p. number 56 in April 2001. All errors are mine.

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# 1 Introduction

This paper provides a quantitative assessment of the role of financial frictions for the choice of exchange rate regimes in a two country model. The standard new open economy model neglects the role that financial frictions can play for the international transmission of shocks and for the optimal choice of exchange rate regimes. However several historical episodes, such as the global financial crises during the Gold Standard regime or the exchange rate crisis during the European Monetary System (EMS), have shown the dangers of a close association between financial instability and pegged exchange rates. In general pegged exchange rates tend to reduce monetary policy flexibility and those constraints become even more stringent when the domestic economy faces credit frictions. Nowadays those issues have acquired policy relevance for the euro area as some accession countries entered a system of managed exchange rates with the Eurozone, known as the ERM II Central Bank Agreement[1]: the relinquishing of part of their monetary policy flexibility might be a concern as some of those countries are still characterized by unstable financial markets.

To analyze the above-mentioned issues I use an artificial two country economy characterized by imperfect financial integration in the market for international securities and sticky prices in an imperfectly competitive framework. The introduction of sticky prices is particularly helpful for comparing different monetary arrangements. To this economy, otherwise similar to those analyzed in some of the recent open-economy-macro literature[2], I add borrowing constraints on investment associated with balance sheet effects in both countries[3]. Doing so adds realism to the model and moves a step forward towards integrating the analysis of the domestic and the international transmission mechanisms. I simulate the calibrated economy under monetary and productivity shocks and I compare three different exchange rate regimes - i.e. hard pegs, managed and floating exchange rates-. To evaluate the relative performance of the different regimes I rely on the comparison of volatilities for the main macro variables and on a simple welfare metric.

I first consider shocks originated in the foreign country. In the absence of financial frictions, floating exchange rates deliver good stability properties under both, productivity and monetary policy shocks. This result confirms Milton Friedman's 1953 case for flexible exchange rate: he argued that in presence of sticky prices floating exchange rates deliver better insulation properties from foreign shocks as they allow relative prices to adjust faster. In presence of financial frictions such insulating property is strengthened further. The intuition runs as follows. Under fixed or managed exchange rates an external shock with devaluation pressures forces the monetary authority

[1] As of 1 May 2004, the ten National Central Banks of the new member countries became party to the ERM II Central Bank Agreement. EU countries that have not adopted the euro are expected to participate for at least two years in the ERM II before joining the Eurozone.

[2] See among many others V. V. Chari, P. Kehoe and E. McGrattan 2002.

[3] In this respect I follow the structure proposed in the closed economy by Carlstrom and Fuerst 1997 and Bernanke, Gertler and Gilchrist 1999 which assume heterogeneity between borrowers and lenders and formalize a costly state verification contract in the general equilibrium.

to raise interest rates with a consequent increase in the cost of loans. The presence of borrowing constraints on investment exacerbates the tightening effect. To highlight the impact of borrowing constraints on investment I compare the dynamic properties of the economy with and without agency costs. Both the absolute value for the volatilities of the main macro variables (output, investment, inflation, consumption, asset prices and return on capital) and the difference in the same volatilities between the two regimes are higher when credit frictions are introduced into the model. Fixed and managed exchange rate regimes also appear to steepen the typical trade-off between inflation and output volatility. This effect is shown by illustrating the fact that the sacrifice ratio (the output-inflation volatility ratio) raises when moving from floating to fixed exchange rate regimes and that such an increase is higher in presence of credit frictions.

I therefore test the robustness of the results by analyzing the model with financial frictions under domestic shocks and under symmetric and correlated shocks. With domestic shocks results are reversed so that pegged exchange rates tend to stabilize more than floating. Consider for instance a domestic productivity slowdown: the decrease in investment opportunities generates an increase in the interest rate and in the cost of loans. Under floating exchange rates the amplifying effect of borrowing constraints deteriorates the financial conditions. On the contrary, under fixed or managed exchange rates the monetary authority dampens the increase in the interest rate in order to stabilize the currency.

The insulating property of floating regimes is also weakened under symmetric and correlated shocks. The dynamics in the latter case is in fact the result of the combined effects of domestic and foreign shocks. When the two shocks are considered in combination, the effect of the domestic shock tends to prevail hence floating exchange rates become more destabilizing than fixed exchange rate.

This paper is related to several strand of the literature. It is related to the literature analyzing the role of financial frictions for the transmission of shocks[4] as it aims at analyzing the role of real frictions, such as credit frictions, in the standard new open economy model[5]. Some recent contributions have analyzed the role of credit frictions, in the form of borrowing constraints to investment demand, for: a) the choice of exchange rate regimes in small open economy models of emerging markets[6], b) the international transmission of shocks[7]. This paper is also related to a strand of the literature that studies the role of other types of financial frictions for the choice of exchange rate regimes. In particular Lahiri, Singh and Vegh 2008 a,b challenge the standard Mundell-Fleming prescription by showing that in presence of segmented asset markets floating

[4] See Bernanke, Gertler and Gilchrist 1999, Carlstrom and Fuerst 1997, Kiyotaki and Moore 1997.

[5] See Obstfeld and Rogoff 1985 and Corsetti and Pesenti 2001 as first contribution in the new open economy literature, known as NOEM. For an exposition of the main characteristics and developments of the NOEM model see Corsetti 2007, New Palgrave Dictionary.

[6] See Cespedes, Chang and Velasco 2004, Gertler, Gilchrist and Natalucci 2007.

[7] Faia 2007 a, b.

exchange rate regimes perform better than fixed exchange rates when shocks are real and viceversa when shocks originate in the money market. Differently than Lahiri, Singh and Vegh 2008 a,b in this paper I focus on credit frictions rather than asset market segmentation. In addition the results in this paper show that the relative performance of floating versus fixed exchange rates depends more on the correlation of shocks across countries than on the type of shocks considered (real versus monetary).

The paper is organized as follows. Section 2 presents the theoretical model. Section 3 reports quantitative results under idiosyncratic shocks and section 4 reports quantitative results under symmetric or otherwise correlated shocks. Section 5 tests the robustness of the results under the assumptions that loans are denominated in foreign currency, section 6 reports results for a shocks to the uncovered interest rate parity and section 7 report results for the sacrifice ratios. Section 8 concludes. Tables and figures follow.

# 2 The Model

There are two countries of equal size. In both economies population is divided into two groups, workers and entrepreneurs, that account for a total measure of one. The workers are infinitely lived agents that choose consumption and leisure, invest in bank deposits and in international bonds. Workers also own the firms of a monopolistic sector which sets prices facing adjustment costs and produces different varieties of final goods. Varieties are then assembled into final goods by a competitive production unit. Entrepreneurs are finitely lived agents that choose consumption, invest in capital which they rent to the production sector and face idiosyncratic shocks on the return to capital investment. To finance capital entrepreneurs use internal funds as well as external borrowing. Indeed a financial intermediary collects funds from the workers - i.e. the lenders - and after pooling resources provides loans to the entrepreneurs - i.e. borrowers. As the loan contractual relationship is subject to an agency problem the borrowers must pay a premium on external finance.

## 2.1 Workers' Behavior in The Home and Foreign Country

Workers are infinite lived agents who consume, work and hold non-monetary assets in the form of bank deposits and in the form of international bonds. Workers' utility is increasing, concave and separable over consumption and leisure. In what follows I derive the maximization problem for the workers in the home region. Workers' utility in each country, is given by[8]:

$$E_0 \sum_{t=0}^{\infty} \beta^t [U(C_t) - V(N_t)] \quad (1)$$

where $N$ denotes the number of hours worked by the representative agent, and $V$ is increasing, convex and differentiable, and $C$ is a Dixit-Stiglitz-Spence aggregator. Their budget constraint reads like this:

$$P_t C_t + B_t^* e_t + D_t \leq W_t N_t + T_t + \Upsilon_t + R_{t-1}^F e_t B_{t-1}^* + R_{t-1}^n D_{t-1} \quad (2)$$

where $W_t N_t$ is nominal labor income, $D_t$ is nominal deposits, that pay $R_t D_t$ one period later, $B_t^*$ is nominal internationally traded bonds, that pay $R_t^F B_t^*$, and $e$ is the nominal exchange rate. $T_t$ are government transfers and $\Upsilon_t$ are nominal profits from the monopolistic sector. The following optimality conditions hold:

$$U_{c,t} \frac{W_t}{P_t} = V_{n,t} \quad (3)$$

$$U_{c,t} = \beta R_t^n E_t \left\{ U_{c,t+1} \frac{P_t}{P_{t+1}} \right\} \quad (4)$$

$$U_{c,t} = \beta R_t^F E_t \left\{ U_{c,t+1} \frac{P_t e_{t+1}}{P_{t+1} e_t} \right\} \quad (5)$$

Equation (3) gives the optimal choice of labor supply. Equation (4) is the Euler condition with respect to home deposits. Equation (5) is the Euler condition with respect to the foreign security. We can now define CPI inflation as $\pi_t = \frac{P_{t+1}}{P_t}$.

Due to imperfect capital mobility and/or in order to capture the existence of intermediation costs in foreign asset markets workers pay a spread between the interest rate on the foreign currency portfolio and the interest rate of the foreign country. This spread is proportional to the (real) value of the country's net foreign asset position:

$$\frac{R_t^F}{R_t^{n*}} = -\zeta \left( \frac{e_t B_t^*}{P_t} \right) \quad (6)$$

where $\zeta > 0$, $\zeta' > 0$[9]. Aggregating the budget constraints of the workers and substituting for (6) we obtain the following law of motion for the accumulation of bonds:

$$\frac{e_t B_t^*}{P_t} \leq R_t^* \zeta \left( \frac{e_t B_t^*}{P_t} \right) \frac{e_t B_{t-1}^*}{P_t} + [\Upsilon_t + \frac{W_t}{P_t} N_t] - [\frac{D_t}{P_t} - R_{t-1} \frac{D_{t-1}}{P_t}] - C_t \quad (7)$$

[8] Let $s^t = \{s_0, ....s_t\}$ denote the history of events up to date $t$, where $s_t$ denotes the event realization at date $t$. The date 0 probability of observing history $s^t$ is given by $\rho(s^t)$. The initial state $s^0$ is given so that $\rho(s^0) = 1$. Henceforth, and for the sake of simplifying the notation, let's define the operator $E_t\{.\} \equiv \sum_{s_{t+1}} \rho(s^{t+1}|s^t)$ as the mathematical expectations over all possible states of nature conditional on history $s^t$.

[9] As shown in Schmitt-Grohe and Uribe 2003 and Benigno 2002 this assumption is useful in order to maintain the stationarity of consumption in the model. Notice however that Schmitt-Grohe and Uribe 2003 have shown that such friction does not alter significantly the dynamic of the open economy compared to the complete market case and to alternative setting for the incomplete market case.

## 2.2 Demand Aggregation and Open Economy Relations

The final good $X$ in the domestic country, which is linearly allocated to workers' and entrepreneurs' consumption (respectively $C_t$ and $C_t^e$) and to investment, $I_t$, is obtained by assembling domestic and imported intermediate goods via the Armington aggregate production function:

$$X_t = \left( (1-\gamma)^{\frac{1}{\eta}} X_{H,t}^{\frac{\eta-1}{\eta}} + \gamma^{\frac{1}{\eta}} X_{F,t}^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}} \tag{8}$$

with $P_t \equiv [(1-\gamma)P_{H,t}^{1-\eta} + \gamma P_{F,t}^{1-\eta}]^{\frac{1}{1-\eta}}$ being the corresponding price index and where $\eta$ represents the elasticity between domestic and foreign goods.

We define $X_{H,t} \equiv \left(\int_0^1 X_{H,t}(i)^{\frac{\vartheta-1}{\vartheta}} di\right)^{\frac{\vartheta}{\vartheta-1}}$ and $X_{F,t} \equiv \left(\int_0^1 X_{F,t}(i)^{\frac{\vartheta-1}{\vartheta}} di\right)^{\frac{\vartheta}{\vartheta-1}}$ as the composite aggregates of domestic and imported intermediate goods respectively, with $\vartheta$ being the elasticity across different varieties and $P_{H_t} \equiv \left(\int_0^1 P_{H,t}(i)^{1-\vartheta} di\right)^{\frac{1}{\vartheta-1}}$, $P_{F,t} \equiv \left(\int_0^1 P_{F,t}(i)^{1-\vartheta} di\right)^{\frac{1}{\vartheta-1}}$ being the respective price indices.

Optimal demands for domestic and foreign goods are given by:

$$X_{H,t} = (1-\gamma)\left(\frac{P_t}{P_{H,t}}\right)^{\eta} X_t \ ; \quad X_{F,t} = \gamma \left(\frac{P_t}{P_{F,t}}\right)^{\eta} X_t \tag{9}$$

All the relations hold symmetrically for the foreign country.

For expositional convenience we now express all aggregators as functions of inflation and the nominal exchange rate. Lets' define the terms of trade is the relative price of imported goods:

$$S_t \equiv \frac{P_{F,t}}{P_{H,t}} \tag{10}$$

The terms of trade can be related to the CPI-PPI ratio as follows

$$\frac{P_t}{P_{H,t}} = [(1-\alpha) + \alpha {S_t}^{1-\eta}]^{\frac{1}{1-\eta}} \equiv g(S_t) \tag{11}$$

with $g^{'}(S_t) > 0$. A equivalent relation holds for the ratio $d(S_t) = \frac{P_t}{P_{F,t}}$. We can therefore express the demand functions for domestic and foreign goods as follows:

$$X_{H,t} = (1-\gamma)\,(g(S_t))^{\eta} \ X_t \tag{12}$$

$$X_{F,t} = \gamma\,(d(S_t))^{\eta} \ X_t \tag{13}$$

Finally we need to obtain the relation between terms of trade and nominal exchange rates which reads as follows:

$$\frac{S_t}{S_{t-1}} = \frac{\pi^*_{F,t}}{\pi_{H,t}} \frac{e_t}{e_{t-1}} \tag{14}$$

where $\pi_{H,t} = \frac{P_{H,t}}{P_{H,t-1}}, \pi^*_{F,t} = \frac{P^*_{F,t}}{P^*_{F,t-1}}$ are respectively the domestic and the foreign PPI inflation rate. Finally we can relate the CPI inflation rate to the PPI:

$$\pi_t = \pi_{H,t} \frac{g(S_t)}{g(S_{t-1})} \tag{15}$$

$$\pi_t = \pi_{F,t} \frac{d(S_t)}{d(S_{t-1})} \tag{16}$$

### 2.3 Production Sectors in Home and Foreign Country

Here I present the optimization problem for the domestic production sector. The one for the foreign production sector looks symmetric. Each domestic household owns an equal share of the intermediate-goods producing firms. Each of these firms assembles labor (supplied by the workers) and entrepreneurial capital to operate a constant return to scale production function for the variety $i$ of the intermediate good:

$$Y_t(i) = A_t F(N_t(i), K_t(i)) \tag{17}$$

where $A_t$ is a productivity shifter common to all entrepreneurs. Each firm $i$ has monopolistic power in the production of its own variety and therefore has leverage in setting the price. In so doing it faces a quadratic cost equal to, $\varkappa_t(i) = \frac{\omega_p}{2}\left(\frac{P_{H,t}(i)}{P_{H,t-1}(i)} - 1\right)^2$, with $\omega_p$ measuring the degree of nominal price rigidity. The higher $\omega_p$ the more sluggish is the adjustment of nominal prices. In the particular case of $\omega_p = 0$ prices are flexible. The problem of each domestic monopolistic firm is the one of choosing the sequence $\{K_t(i), N_t(i), P_{H,t}(i)\}_{t=0}^{\infty}$ in order to maximize expected discounted real profits:

$$E_0 \left\{ \sum_{t=0}^{\infty} \beta^t U_{c,t} \frac{\Upsilon_t}{P_{H,t}} \right\} \tag{18}$$

subject to the constraint:

$$Y_t(i) = A_t F(N_t(i), K_t(i)) \geq \left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\vartheta} X_t^W \tag{19}$$

where $\Upsilon_t \equiv P_{H,t}(i)Y_t(i) - (W_t N_t(i) + Z_t K_t(i)) - P_{H,t}(i)\varkappa_t(i)$ and where $X_t^W \equiv X_{H,t} + X^*_{H,t}$ is world demand for the domestic intermediate variety $i$ and $Z_t$ is the rental rate of capital. Since adjustment costs are symmetric across firms and since ultimately all firms will charge the same price we can impose symmetry on the optimality conditions. Let's denote by $\{mc_t\}_{t=0}^{\infty}$ the lagrange multiplier on the demand constraint[10], by $\widetilde{p}_{H,t} \equiv \frac{P_{H,t}(i)}{P_{H,t}}$ the relative price of variety $i$, and by $\pi_{H,t} \equiv \frac{P_{H,t}}{P_{H,t-1}}$ the gross inflation rate. The first order conditions of the above problem read as follows:

$$\frac{W_t}{P_{H,t}} = mc_t A_t F_{n,t} \tag{20}$$

[10] Notice that $mc_t$ plays the role of the *real* marginal cost of production.

$$\frac{Z_t}{P_{H,t}} = mc_t A_t F_{k,t} \tag{21}$$

$$\pi_{H,t}\left(\pi_{H,t}-1\right) = \beta E_t \left\{ \frac{U_{c,t+1}}{U_{c,t}} \left(\pi_{H,t+1}-1\right)\pi_{H,t+1} \right\} + \frac{X_t^W}{\omega_p}\left((1-\vartheta)+\vartheta mc_t\right) \tag{22}$$

### 2.4 The Entrepreneurs in The Home and Foreign Country

Entrepreneurs consume, invest in capital markets and run production in the competitive unit. In each period they rent to firms in the competitive unit the existing capital stock that they own and finance investment in new capital. To finance the purchase of new capital they need to acquire a loan from a competitive intermediary that raises funds through deposits.

The return on capital is subject to an idiosyncratic shock, $\omega^j$. At the beginning of each period the entrepreneur observes the aggregate shock. Before buying capital, the entrepreneur goes to the loan markets and borrows money from the intermediary by making a contract which is written before the idiosyncratic shock is recognized. For the relationship with the lender is subject to an agency cost problem the entrepreneur needs to pay an external finance premium on the loan. I assume that entrepreneurs are risk neutral and they have a survival probability $\varsigma$[11].

I start by spelling out the optimization problem of the entrepreneur in the home country. The next section is devoted to the analysis of the optimal contract between the intermediary and the entrepreneur. As we shall see later in the section describing the optimal contract between the lender and the entrepreneur the assumption of a monitoring technology exhibiting constant returns to scale implies linearity and symmetry of the relationships which characterize the contracting problem. Hence we can spell out the consumption/investment problem of the entrepreneurs by imposing symmetry ex-ante.

Each entrepreneur chooses a sequence $\{C_t^e,\, I_t,\, K_{t+1},\, L_{t+1}\}_{t=0}^{\infty}$ to maximize:

$$E_0 \sum_{t=0}^{\infty} (\varsigma\beta)^t C_t^e, \quad \varsigma\beta \leq \beta \tag{23}$$

subject to the following sequence of constraints:

$$\frac{Z_t}{P_t} K_t + L_{t+1} + \Theta_t = C_t^e + I_t + R_t^L L_t \tag{24}$$

$$K_{t+1} = (1-\delta)K_t + I_t - \frac{\Phi}{2}\left(\frac{I_t}{K_t} - \delta\right)^2 K_t \tag{25}$$

Equation (24) is the Entrepreneurs' budget constraint in units of final goods. Wealth is derived from rental income $Z_t K_t$ for production, new loans $L_{t+1}$, and a transfer of wealth, $\Theta_t$, from old agents. The presence of the transfer $\Theta_t$ assures that aggregate net wealth are different from zero in

[11] See also Kiyotaki and Moore 1997 and Carlstrom and Fuerst 1997.

the steady state. Expenditure is allocated in final good consumption $C_t^e$, investment $I_t$ and in the service of the predetermined loan debt, $R_t^L L_t$. The term $-\frac{\Phi}{2}\left(\frac{I_t}{K_t}-\delta\right)^2 K_t$ in the constraint (25) indicates that, when investing in capital, entrepreneurs face adjustment costs. The entrepreneurs optimization problems delivers a consumption function and an optimal demand for capital. In order to derive the aggregate consumption function it is worth noticing that the probability of dying for the entrepreneurs corresponds, by law of large numbers, to the fraction of entrepreneurs that die in each period. The population is held steady by the birth of a new entrepreneur for each dying one. Under those assumption entrepreneurs behave as permanent income consumers since they consume a constant fraction, $\varsigma$, of their end of period wealth, $NW_t$, net of the transfers to the new born,$\Theta_t$ :

$$C_t^e = \varsigma(NW_t - \Theta_t) \tag{26}$$

In presence of adjustment costs the price of capital, $Q_t$, is given by:

$$Q_t = \left[1 - \Phi\left(\frac{I_t}{K_t} - \delta\right)\right]^{-1} \tag{27}$$

while the return from holding one unit of capital between $t$ and $t+1$ reads as:

$$R_{t+1}^k \equiv E_t\{\frac{\frac{Z_{t+1}}{P_{t+1}} + Q_{t+1}\left(1 - \delta - \frac{\Phi}{2}\left(\frac{I_{t+1}}{K_{t+1}} - \delta\right)^2 + \Phi\left(\frac{I_{t+1}}{K_{t+1}} - \delta\right)\frac{I_{t+1}}{K_{t+1}}\right)}{Q_t}\} \tag{28}$$

### 2.5 The Loan Contract Between the Entrepreneurs and the Financial Intermediary

A financial intermediary collects money from deposits, pools resources and supplies loans to the entrepreneurs facing an incentive problem due to asymmetric information. The asymmetric information in this economy arises from the fact that firms observe the idiosyncratic shock, $\varpi^j$, but banks can do so only at some cost, $\mu$. The financial contract follows the tradition and assumes the form of the costly state verification contract a' la Gale and Hellwig 1983[12]. I introduce financial frictions in the general equilibrium following the strategy of Bernanke, Gertler and Gilchrist 1999, Carlstrom and Fuerst 1997, Cooley and Nam 1998.

The entrepreneur and the lender negotiate a one period contract that induces the entrepreneur not to misrepresent his earnings and which minimizes the expected deadweight agency costs. This is achieved via a standard debt contract with costly bankruptcy which has two basic properties. The first is the incentive compatibility property which states that when the return to investment is above the cut-off value which determines the default states entrepreneurs repay a fixed amount,

[12] As in Bernanke, Gertler, and Gilchrist 1998 I restrict attention to one period contracts, which are not necessarily optimal in the dynamic setting. See Monnet and Quintin 2005.

$R_t^L$. The second is the maximum recovery property which states that under the default states the bank monitors the investment activity and repossess the assets of the firm.

For the time being each individual variable carries an index $j$. In the current period domestic entrepreneurs need to finance an investment value $Q_t K_{t+1}^j$.To this end they employ existing collateral $NW_{t+1}^j$ and resort to external funds via a financial intermediary. The amount of capital investment that needs to be financed is therefore, in real terms, $L_{t+1}^j = Q_t K_{t+1}^j - NW_{t+1}^j$. Default occurs when the return from the investment activity is lower than the amount that needs to be repaid. Hence the cut-off value is determined by the following zero profit condition - i.e. participation constraint to the borrower:

$$\varpi^j \equiv \frac{R_{t+1}^L L_t^j}{R_{t+1}^k Q_t K_t^j} \tag{29}$$

The contract maximizes the capital expected income for the entrepreneur which is defined as follows:

$$\Gamma(\varpi^j) R_{t+1}^k Q_t K_t^j = \int_{\varpi}^{\infty} (\varpi^j R_{t+1}^k Q_t K_t^j - R_{t+1}^L L_t^j) dF(\omega) \tag{30}$$

With $\Gamma'(\varpi^j) > 0$. The participation constraint for the bank states that the expected return from the lending activity must equal the return paid on the deposits to workers/lenders. Expected return form the lending activity is given by:

$$G(\varpi^j) R_{t+1}^k Q_t K_t^j = \int_{\varpi}^{\infty} (1-\mu) \varpi^j R_{t+1}^k Q_t K_t^j dF(\omega) + \int_{\infty}^{\varpi} R_{t+1}^L L_t^j dF(\omega) \tag{31}$$

With $G'(\varpi^j) > 0$. The return paid on deposits is given by $R_t L_t^j$.

Hence the contract specifies the optimal cut-off value, $\varpi_{t+1}^j$, and the amount of capital, $K_{t+1}^j$, which solve the following maximization problem:

$$Max \Gamma(\varpi^j) R_{t+1}^k Q_t K_t^j \tag{32}$$

$$s.to G(\varpi^j) R_{t+1}^k Q_t K_t^j = R_t (Q_t K_t^j - NW_t^j) \tag{33}$$

Let's define $\chi_t$ as the lagrange multiplier on (33). First order conditions to this contract read a follows:

- $K_{t+1}^j$ :

$$\Gamma(\varpi^j) R_{t+1}^k Q_t + \chi_t [G(\varpi^j) R_{t+1}^k Q_t - R_t Q_t] = 0 \tag{34}$$

- $\varpi_{t+1}^j$ :

$$\Gamma'(\varpi^j) R_{t+1}^k Q_t K_t^j + \chi_t G'(\varpi^j) R_{t+1}^k Q_t K_t^j = 0 \tag{35}$$

Two assumptions make aggregation feasible: 1) A constant fraction $\varsigma$ of entrepreneurs remain alive in every period. 2) The optimal contract linear relations. Using the first order conditions with respect $\left\{\varpi^j_{t+1}, K^j_{t+1}\right\}$ and aggregating yield a wedge between the return on capital and the safe return paid on deposits:

$$E_t\left\{R^k_{t+1}\right\} = \rho(\varpi_{t+1})R_t$$

where

$$\rho(\varpi_{t+1}) = \left[\frac{(1-\Gamma(\varpi_{t+1}))G'(\varpi_{t+1})}{\Gamma'(\varpi_{t+1})} + G(\varpi_{t+1}))\right]^{-1} \tag{36}$$

with $\rho'(\varpi) > 0$[13]. Let's define $\psi_t \equiv E_t\left\{\frac{R^k_{t+1}}{R_t}\right\}$ as the premium on external finance. This ratio captures the difference between the cost of finance reflecting the existence of monitoring costs, and the safe interest rate (which per se reflects the opportunity cost for the lender). By combining (33) with (36) one can write a relationship between capital expenditure $Q_tK_{t+1}$ and net worth $NW_{t+1}$ whose proportionality factor depends endogenously on $\psi_t$:

$$Q_tK_{t+1} = \left(\frac{1}{1-\psi_t(\Gamma(\varpi_{t+1}) - \mu M(\varpi_{t+1}))}\right)NW_{t+1} \tag{37}$$

Equation (37) is a key relationship in this context, for it explicitly shows the link between capital expenditure and entrepreneurs' financial conditions (summarized by aggregate net worth). On the one hand, one can view (37) as a demand equation, in which the demand of capital depends inversely on the price and positively on the aggregate financial conditions.

On the other hand, one can write the finance premium $\psi_t$ as:

$$\psi_t = h(\varpi_{t+1})\left(1 - \frac{NW_{t+1}}{Q_tK_{t+1}}\right) \tag{38}$$

where $h(\varpi_{t+1}) \equiv [\Gamma(\varpi_{t+1}) - \mu M(\varpi_{t+1})]^{-1}$. One can easily show that $h'(\bullet) > 0$. This expression suggests that the external finance premium is an equilibrium inverse function of the aggregate financial conditions in the economy, expressed by the (inverse) leverage ratio $\frac{NW_{t+1}}{Q_tK_{t+1}}$. An increase in net worth or a decrease in the leverage ratio reduces the optimal cut-off value, as shown by equation (29). By reducing the size of the default space it also reduces the size of the monitoring cost and the external finance premium.

Aggregate net wealth accumulation of the economy, which is given by proceeds from capital investment minus the repayment on loan services, reads as follows:

$$NW_{t+1} = \varsigma[R^k_tQ_{t-1}K_t - (R_t + \psi_{t-1}(\frac{Q_{t-1}K_t}{NW_t}))(Q_{t-1}K_t - NW_t) - \Theta_t] \tag{39}$$

[13] The specific form of this relation depends upon assumptions on the probability distribution of shocks. Necessary and sufficient conditions for the uniqueness of the solution for the cut-off value, $\varpi$, require a probability distribution featuring a decreasing hazard rate - i.e. a uniform or a lognormal. Here I assume a lognormal distribution.

Notice that by law of large numbers the fraction of entrepreneurs that remains alive in every period corresponds to the probability of staying alive for the single entrepreneur.

### 2.6 The Equilibrium in Good and Asset Markets

To satisfy market clearing I assume that the total net supply of bonds at a world level is zero. Market clearing for domestic variety $i$ must satisfy:

$$Y_t(i) = X_{H,t}(i) + X^*_{H,t}(i) + \varkappa_t(i) + U_t(i)K_t(i) \tag{40}$$

for all $i \in [0,1]$ and $t$. Where $U_t = \mu \int_0^{\bar{\omega}^j} \omega^j dF(\omega)\} R^k_{t+1} Q_t$ and represents the output resources spent in the monitoring activity. Market clearing for foreign varieties holds symmetrically for the foreign country too. Market clearing in the final good sector in both countries implies:

$$X_t = C_t + I_t + C^e_t \tag{41}$$

$$X^*_t = C^*_t + I^*_t + C^{*e}_t \tag{42}$$

Asset markets have to clear as well. I assume that at a world level bonds are in zero net supply. At country level, deposits equal loans: $\frac{D_t}{P_t} = L_t$, $\frac{D^*_t}{P^*_t} = L^*_t$.

### 2.7 Monetary Policy Rules

There is an active monetary policy. The monetary authority sets the short term nominal interest rate by reacting to endogenous variables. I consider the general class of the Taylor rules of the following form:

$$R^n_t = (\frac{\pi_t}{\bar{\pi}})^{\varpi_\pi} (\frac{e_t}{\bar{e}})^{\frac{1}{1-\varpi_e}} M_t \tag{43}$$

where $R^n_t = R_t \frac{P_{t+1}}{P_t}$, $\varpi_\pi$ is the weight the monetary authority puts on the deviation of inflation from the target $\bar{\pi}$, $\varpi_e$ is the weight that the monetary authority puts on the deviation of the exchange rate from the target level and $M_t$ is a monetary policy shock that evolves according to $M_t = M^{\rho_M}_{t-1} \varepsilon^M_t$. A regime of pure floating exchange rate is identified by the case $\varpi^e = 0$. I then consider managed exchange rate regimes identified by a Taylor rule of the form (43) in which $\varpi^e > 0$. In the pure peg case I assume that $\varpi^e$ is large enough to ensure $R^n_t = R^{*n}_t$.

The monetary authority of the foreign country always follows a Taylor rule of the form (43). When analyzing temporary monetary policy shocks I assume some degree of interest rate smoothing (see Clarida, Gali' and Gertler 2000) and one period investment delays. These assumptions help to recover the lack of persistence which typically characterizes these shocks however they do not affect the quantitative results concerning the ranking of exchange rate regimes.

### 2.8 The Competitive Equilibrium in this Economy

**Definition 1** *For given nominal interest rate* $\{R_t^n, R_t^{n*}\}_{t=0}^{\infty}$*, initial conditions for asset evolution* $\{K_0, D_0, B_0, K_0^*, D_0^*\}_{t=0}^{\infty}$ *and for given set of the exogenous processes* $\{A_t, M_t, A_t^*, M_t^*\}_{t=0}^{\infty}$ *a determinate competitive equilibrium of the two country model is a sequence of allocation and prices* $\{C_t, N_t, I_t, K_{t+1}, Y_t, \pi_{H,t}, \pi_t, X_{H,t}, X_{F,t}, X_t, mc_t, NW_t, Q_t, R_t^k, \psi_t, \varpi_t, S_t, e_t, B_t^*, R_t^F\}_{t=0}^{\infty}$ *for the home country and a sequence of allocation and prices for the foreign country* $\{C_t^*, N_t^*, I_t^*, K_{t+1}^*, Y_t^*, \pi_{F,t}^*, \pi_t^*, X_{H,t}^*, X_{F,t}^*, X_t^*, mc_t^*, NW_t^*, Q_t^*, R_t^{*k}, \psi_t^*, \varpi_t^*\}$ *which satisfies equations (3),(4),(8),(12),(13),(15), (17),(20),(21),(22),(27),(28),(29),(38),(39),(41), an equivalent set of equations for the foreign country and equations (5),(6),(7),(14).*

The above set of equations summarizes the optimality conditions for the competitive economy allocation of the two country. In fact equations (3),(4),(5),(8),(12),(13),(15) are the optimality conditions of the workers' consumption optimization problem in the home country. Equations (17),(20),(21),(22) are the optimality conditions of the monopolistic firms' problem in the home country. Equations (27),(28) are the optimality conditions of the entrepreneurs' consumption/investment optimization problem in the home country. Equations (29),(38),(39) are the optimality conditions for the loan contract. An equivalent set of equations solves the optimization problems for the agents in the foreign economy. Finally equations (5),(6),(7),(14), (41), (42) are equilibrium conditions for the world economy.

### 2.9 Calibration

The two country are assumed to be symmetric in preference and technology specifications. Time is taken to be measured in quarters.

**Preferences**. I set the discount factor $\beta = 0.99$, so that the annual interest rate is equal to 4 percent. The utility function is separable and takes the following form: $U(C) - V(N) = \frac{C^{1-\sigma}}{1-\sigma} - \frac{N^{1+\tau}}{1+\tau}$. The utility parameters on consumption, $\sigma$, and on labor, $\tau$, are set respectively equal to 2 and 1. I set the degree of openness at $\gamma = 0.2$ which is consistent with trade share within European countries. The elasticity of substitution between domestic and foreign goods $\eta$ equal to 1.5 as in Backus, Kehoe and Kydland 1992. Following Schmitt-Grohe and Uribe 2003 and consistently with Lane and Milesi-Ferretti 2002 I set the elasticity of the spread on foreign bonds to the net asset position equal to 0.000742.

**Technology.** The share of capital in the production functions $\alpha = 0.35$ while the quarterly depreciation rate $\delta = 0.025$. The latter implies an annual depreciation rate of roughly 10%. Following Basu and Fernald 1997 I set the steady state mark-up value to 1.2. Loglinearizing the pricing conditions for the monopolistic sector yields a typical Phillips curve. Given the assigned value for the mark-up and consistently with estimates by Sbordone 1998, I set $\omega_p = 17.5$. The elasticity of the price of capital with respect to investment output ratio is set to 0.5 to generate a volatility of investment higher than the volatility of consumption.

**Financial frictions parameters.** The financial contract is characterized by three deep parameters which are the volatility of the idiosyncratic shock, $\sigma^2_{\varpi}$, the probability of the firm being alive next period, $\varsigma$, and the monitoring/bankruptcy cost as percentage of bank assets, $\mu$. Given the values for these parameters the contract yields the external finance premium in steady state, $\rho_{ss}$, the elasticity of the external finance premium with respect to the leverage ratio, $\rho(.)$, and the business failure rate, $F(\bar{\omega})$. It is assumed that the idiosyncratic shock is lognormally distributed. The calibration strategy is as follows. I set the survival probability of firms, $\varsigma$, so as to generate a default probability, $F(\bar{\omega})$, of 5.4% on an annual basis. This value is compatible with earlier studies - e.g. Bernanke, Gertler and Gilchrist 1999 and Carlstrom and Fuerst 1997 - which calibrate this parameter using data for industrialized countries. The external finance premium in steady state is set to 300 basis point, value compatible with industrialized countries, while the elasticity of the same premium to collateral takes a value of 0.05. The volatility of the idiosyncratic shock and the monitoring costs are calibrated indirectly so as to generate the assigned values for the external finance premium.

**Monetary policy parameters.** I fix the weight on inflation in the Taylor rule at $\varpi_{\pi} = 1.5$. The parameter, $\varpi^e$, is set equal to zero in the floating exchange rate regime and equal to 0.5 in the managed exchange rate regime. Consistently with Clarida, Gali' and Gertler 2000 the interest rate smoothing parameter is set to 0.8.

**Exogenous shocks.** The monetary policy shock is assumed to be i.i.d., since I assume that any persistence in the short term interest rate is captured by the interest rate smoothing parameter. I calibrate standard deviation (for the annual inteerest rate) to 1.007%, using data on monetary policy shocks for Germany obtained as estimated residuals of a VAR with the identification scheme employed by Mojon and Peersman 2000[14].

The productivity shock, $A_t$, is an AR(1) and is symmetric in the two countries. To calibrate the latter I refer to Backus, Kehoe and Kydland 1992 which using data for European countries estimate the process for the Solow residual and find an auto-correlation of 0.906 , a standard deviation of 0.00852 and a cross-correlations of 0.25.

# 3 Comparison of Exchange Rate Regimes Under External Shocks

As our main goal is to test the insulating property of floating exchange rate we begin our quantitative assessment by considering foreign shocks. We start by comparing impulse responses, volatilities

[14] Mojon and Peersman 2000 analyze the effects of monetary policy shocks in 10 countries of the euro area for the pre-EMU period. For each country, the identification scheme imposed depends on the monetary integration with Germany and the nominal anchor to the EMS.

and welfare under three alternative exchange rate systems: pure floating; pure fixed; and an intermediate regime, managed floating in which the Central Banks partly adjusts the interest rate in response to exchange rate movements. To appreciate the role played by financial frictions I will compare the results of the present model with the one without credit frictions. Using a simple welfare measure, I also establish a ranking among the three exchange regimes.

### 3.1 Monetary Tightening in the Foreign Country

Figure (1) shows the dynamics of the home country variables in response to a one percent increase in the foreign interest rate, under floating (solid line) and fixed exchange (dashed line) rate regimes. Under fixed exchange rates almost all macroeconomic variables, with the obvious exception of the exchange rate and the trade balance, show higher persistence and volatility. The external shock generates devaluation pressures in the home economy. The monetary authority reacts by increasing the nominal interest rate. Under sticky prices, the real interest rate also increases. The increase of the real interest rate raises the cost of loans thereby deteriorating balance sheet conditions. As a consequence the external finance premium increases thereby exacerbating the decrease in the demand for loans, investment and employment. Under floating exchange rates, instead, the effects of the external shock are absorbed by the movements in the exchange rates. The nominal and real interest rates remain almost unchanged as if the economy was perfectly insulated from the foreign monetary tightening.

Table (1) shows standard deviations of several macroeconomic variables - output, investment, asset prices, return on capital, inflation, consumption and the terms of trade - under three different exchange rate regimes. The standard deviations for all variables (except for the terms of trade) are highest under the fixed exchange rate regime, followed by the managed exchange rate regime and the floating exchange rates.

The ranking identified remains valid for both the model with financial frictions and the model without financial frictions. However in presence of financial frictions both the absolute stabilization cost (measured by the standard deviation of the main macroeconomic variables) and the relative stabilization cost (measured by the difference in the standard deviations across regimes) widen. Table (1) shows that all variables are more volatile in presence of financial frictions, independently of the regime considered. Secondly, for all macroeconomic variables the difference in the standard deviations between the floating and the fixed exchange rate regime is higher in presence of borrowing constraints on investment. Hence, in this model, and assuming that collective welfare is inversely related to macroeconomic volatility, the relative benefits (costs) of abandoning (joining) a currency peg are higher in presence of financial distortions.

The ranking so far obtained among monetary policy arrangements is confirmed by the comparison of welfare costs. The welfare metric I use is a fraction of steady state consumption that households would be willing to give up in order to be indifferent between a constant sequence of consumption and working hours and the stochastic sequences of the same variables under the monetary regime considered[15]. The measure is constructed by second order Taylor approximation of workers' utility[16]:

$$\upsilon = -\frac{1}{2}[(1-\chi_c)Var(\overset{\wedge}{c}_t) + (1-\chi_n)Var(\overset{\wedge}{n}_t)] \tag{44}$$

where $Var(\overset{\wedge}{c}_t)$ and $Var(\overset{\wedge}{n}_t)$ are the unconditional second moments and $\chi_c = -\frac{U_{cc}}{U_c C}, \chi_n = -\frac{U_{nn}}{U_n N}$. It is important to notice that this welfare metric is intended to capture only first order effects of volatilities but does not account for the indirect effect of volatilities on mean welfare: this choice does not alter the welfare ranking in the context of the present paper as other authors have shown that in presence of financial frictions alternative welfare matrix tend to reproduce similar ranking[17]. Table (6) shows that welfare costs increase in presence of credit frictions and under fixed exchange rate regimes. Moreover the increase in the welfare costs observed when moving from fixed to floating is higher in presence of credit frictions.

### 3.2 Productivity Decline in the Foreign Country

Figure (2) is analogue to (1), but instead of a monetary tightening assumes a negative technology shock in the foreign country. In the foreign country a productivity decline induces an increase in marginal costs and inflation. Under both regimes the international transmission mechanism of a foreign productivity shock is characterized by three effects. First, there is an absorption effect due to which the decrease in foreign output induces a fall in domestic exports. Second, a demand switch from foreign to domestically produced goods caused by the increase in foreign inflation. Since the latter effect is predominant we observe an increase in domestic exports and inflation. This triggers a tightening in monetary policy for the home country and a nominal and a real appreciation. Under sticky prices this induces an increase in the real interest rates as well. If the model is augmented with borrowing constraints, the increase in the real interest rate induces an increase in the cost of loans which reduces investment demand, worsens balance sheet conditions and raises the external finance premium. The domestic country in this case reacts as if it had imported the productivity slowdown in a way that the real and financial tightening of the foreign country is mirrored domestically. This happens despite the increase in domestic net exports.

As one would intuitively expect, this financial tightening at home is higher under fixed or pegged exchange rates. The impulse response functions show clearly that the recession is much more pronounced under fixed than under floating exchange rate regimes.

[15] See also Lucas 1987 and Schmitt-Grohe and Uribe 2001.

[16] Since entrepreneurs have a linear utility they do not suffer from variability of the business cycle.

[17] See Devereux, Lane and Xu 2006 and Faia and Monacelli 2007.

Another interesting feature of this case is the overshooting displayed by the impulse response of inflation. Under fixed rates and in response to a productivity shock, the domestic price level is pinned down to the initial level. The initial downward movement of inflation is compensated by the expected, and actual, future overshooting. A Taylor rule, which allows greater monetary policy flexibility, does not deliver this feature of anchoring the domestic nominal variables. In a way we can interpret this as a credibility gain that the domestic central bank acquires by resorting to an irrevocable fixed exchange rate as a nominal anchor. This outcome rationalizes the choice of high inflation countries (Greece, Italy and Spain) that joined the EMS with the goal of reducing inflation variability by anchoring the exchange rate to the German DM, thereby adopting a strategy of importing credibility.

As before, table (2) shows the volatilities, also comparing the model with and without agency costs. Once again standard deviations of all macro variables (except the terms of trade) are higher under fixed than under floating exchange rate regimes. Again, the differential increase in standard deviations between the floating and the fixed exchange rate regime is higher in presence of agency costs, except for inflation, where the differential increase remains almost the same under the two regimes. I will return to this when analyzing the "sacrifice ratio" in section 7.

Finally table (6) shows that welfare costs are higher under fixed exchange rates. Moreover the increase in the welfare costs observed when moving from fixed to floating is higher in presence of credit frictions.

## 4 Symmetric and Correlated Shocks

In this section I extend the analysis to consider domestic shocks and shocks in both countries (symmetric and correlated). Though somewhat apart from the main focus of this paper this case is nonetheless of interest because it allows to test robustness of the results. The theory for an optimal currency area generally links the superiority of the floating exchange rate regimes as a stabilization device to the presence of asymmetric shocks. The goal in this section is to explore whether in a model with agency costs the superiority of floating rates is preserved under domestic shocks and symmetric/correlated shocks.

Figure (3) shows the response of the usual set of domestic macroeconomic variables in a model with financial frictions under a negative domestic technology shock. The graphs also compare the responses under floating (solid lines) and fixed (dashed lines) exchange rates. The detrimental effect coming from a worsening of the investment opportunities is higher under floating than under fixed exchange rates. Under floating exchange rates a negative technology shock at home generates a decrease in the marginal productivity and a consequent increase in the real interest rate and in the cost of loans. This deteriorates the firms' financial conditions, depressing investment demand and employment. On the contrary, under fixed or managed exchange rates the monetary authority controls the domestic interest rate in order to stabilize the exchange rate. The reaction of the monetary authority dampens the detrimental effect coming form the decrease in the marginal productivity to investment thereby smoothing the deflationary effect. In general all macroeconomic variables seem now more volatile under floating exchange rates.

Under symmetric and correlated productivity technology shocks (table 4) floating exchange rates are slightly more destabilizing than managed and fixed exchange rates, the more so with financial frictions. As observed earlier floating exchange rates tend to be less destabilizing under foreign productivity shocks but more destabilizing under domestic productivity shocks. When the domestic and the foreign productivity shocks are considered in combination, the effect of the domestic shock tends to prevail, hence floating exchange rates become more destabilizing than fixed exchange rate.

Finally I consider symmetric and correlated monetary policy shocks. Table (3) shows that, for the case with financial frictions, standard deviations of all macroeconomic variables (except terms of trade) are almost the same under floating exchange rates and under fixed exchange rates. The reason is once again related to the fact that floating exchange rates are more destabilizing than fixed under domestic shocks and viceversa under foreign shocks. When we consider the combination of those two shocks, the those opposite effects tend to balance each other.

# 5 Exchange Rate Indexation of Debt Does Not Change the Results

A frequent experience of countries pegging their exchange rate systems is the proliferation of debt denominated in foreign currency. Currently all accession countries belonging to the ERM II agreement experienced a strong wave of capital inflows from the euro zone and residents of those countries are increasing the fraction of their asset portfolio denominated in euros. In this case a system of floating exchange rates might be destabilizing as much as a system of fixed exchange rates but for a different reason. Under external shocks and if loans are denominated in foreign currency, allowing for exchange rate devaluations increases the domestic currency cost of servicing the debt, hence worsening the firms' balance sheet conditions. Depending on the fraction of loans denominated in foreign currency, a floating exchange rate might become more destabilizing than a fixed one.

To test this hypothesis I repeated some of the previous experiments (negative productivity and monetary policy shocks in the foreign country) by assuming that all debt is denominated in foreign currency. The volatility of output and investment[18] in this case are slightly higher under floating exchange rates but they remain below the one under fixed exchange rate (which did not change significantly).

[18] Results not reported here for brevity but available upon request.

The key reason for this is that a depreciation does not change significantly the overall value of balance sheets. For example, consider the effect of a foreign monetary policy shock. Under floating exchange rates, this induces a depreciation of the domestic currency. With liabilities denominated in foreign currency, this channel produces a decrease in net worth. However, there are also positive consequences from the asset side of firms' balance sheets: since the depreciation makes domestic goods cheaper, export revenue rises, creating a positive impact on net worth. If the two effects compensate each other, the overall impact of the depreciation need not be contractionary.

## 6 Shocks to the Uncovered Interest Rate Parity

At last I consider shocks to the uncovered interest rate parity. Those shocks play an important role for two reasons. First, there is much evidence that the uncovered interest rate parity does not hold because of exogenous shocks that affect the exchange rate itself. Second, such source of volatility could in principle tilt the balance in favour of pegs and against floating as in the latter case the additional exchange rate volatility might destabilize consumption and consequently output. Following Kollman 2004 this shocks has been calibrated using a data sample that covers the period 1971 to 1998 and by regressing the deviation from the UIP over a four lags for the GDP and the interest rate for some pairs of industrialized countries. The estimation results give a standard for this type of shocks around 4.4%. There is no significant degree of persistence for this shock.

Table (5) shows volatilities of selected variables in the model with and without financial frictions and under alternative exchange rate regimes. Results show once more that fixed are more destabilizing than floating exchange rates both, in the case with financial frictions and in the case without. As usual in presence of financial frictions volatilities are higher under all regimes. It is worth noticing that in absence of financial frictions managed exchange rates perform better than floating exchange rates: this is so as some degree of exchange rate stabilization allows the policy maker to optimize the trade-off between improving consumption smoothing and maintaining monetary policy independence.

## 7 Summary of Results and The "Sacrifice Ratio"

Table (8) summarizes the results found until now. The table reports in every box two statistics: the first is the ratio of output volatility under fix over the one under floating exchange rate the second is the corresponding welfare ratio. The statistics are shown for both the case with financial friction and for the case without. We see that for both types of foreign shocks those ratios raise under financial frictions while they decrease (or do not change significantly) for symmetric and correlated shocks. This shows once more that in presence of financial frictions the superiority of floating exchange rates depends upon whether we consider asymmetric or symmetric shocks.

Before concluding it is worth analyzing a synthetic measure of monetary policy trade-offs across different scenarios and exchange rate regimes. We focus on the sacrifice ratios. An interesting feature which emerges from the analysis is that fixed exchange rates tend to destabilize real and financial variables much more than inflation. And this is even more so when we add credit frictions. This effect is emblematic of the trade-off faced by monetary policy between output and inflation stabilization. In the standard open macroeconomic models it is emphasized that the severity of such trade-off is amplified in presence of supply side shocks. In this section I show that fixed exchange rates and borrowing constraints on investment are also factors which contribute to aggravate this trade-off.

Table (7) compares a measure of sacrifice ratio (the output-inflation volatility ratio) implied by the model under different regimes and in the model with and without credit frictions. The sacrifice ratio is the most commonly used measure of the trade-off between output and inflation stabilization. Higher values for this statistics imply steeper trade-off since the monetary authority needs to generate more output volatility to stabilize inflation. The table shows clearly that the sacrifice ratio becomes higher under fixed exchange rates and in presence of credit frictions. Moreover, the increase in the sacrifice ratio observed when moving from floating to fixed exchange rates is higher in presence of credit frictions. This is true for all shocks with the exception given by the symmetric and correlated productivity shocks. In the latter case indeed the presence of domestic shocks tends to lessen the trade-off.

## 8 Conclusions

The traditional theory of the optimal currency area argues for the superiority of floating exchange rate regimes as a stabilization device mostly in the presence of asymmetric shocks. This paper shows that the presence of credit frictions strengthens the case for floating exchange rate regimes, and also tends to exacerbate the typical output-inflation trade-off. The policy implication is that, if currency pegs are adopted to stabilize domestic inflation then this is likely to come at the cost of significantly higher output volatility. This is even more so in presence of credit frictions.

The treatment of the fixed exchange rates case in this paper only applies to a situation where the regime is fully credible. In fact, a foreign exchange peg which may be characterized by less-than-full credibility. Analyzing the latter case would require a different model for expectations, something I leave to future research.

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Table 1: **Foreign monetary policy shock. Standard deviations of selected macroeconomic variables under different regimes with financial frictions, $\rho(.) = 0.05$, and without, $\rho(.) = 0$. All values are in percentage.**

| Exchange Rate Regime | Floating exchange rates | | Fixed exchange rates | | Managed exchange rates | |
|---|---|---|---|---|---|---|
| Variables | $\rho(.) = 0$ | $\rho(.) = 0.05$ | $\rho(.) = 0$ | $\rho(.) = 0.05$ | $\rho(.) = 0$ | $\rho(.) = 0.05$ |
| Output | 0.15 | 0.14 | 0.46 | 1.09 | 0.20 | 0.60 |
| Investment | 0.18 | 0.39 | 0.91 | 4.32 | 0.68 | 2.50 |
| Asset prices | 0.17 | 0.26 | 0.87 | 2.23 | 0.55 | 1.30 |
| Return on capital | 0.16 | 0.22 | 0.87 | 1.51 | 0.49 | 0.84 |
| CPI Inflation | 0.15 | 0.14 | 0.32 | 0.40 | 0.23 | 0.30 |
| Consumption | 0.11 | 0.18 | 0.42 | 0.65 | 0.27 | 0.42 |
| Terms of trade | 0.67 | 0.81 | 0.00 | 0.02 | 0.03 | 0.04 |

Table 2: **Foreign productivity shock. Standard deviations of selected macroeconomic variables under different regimes with financial frictions, $\rho(.) = 0.05$, and without, $\rho(.) = 0$. All values are in percentage.**

| Exchange Rate Regime | Floating exchange rates | | Fixed exchange rates | | Managed exchange rates | |
|---|---|---|---|---|---|---|
| Variables | $\rho(.) = 0$ | $\rho(.) = 0.05$ | $\rho(.) = 0$ | $\rho(.) = 0.05$ | $\rho(.) = 0$ | $\rho(.) = 0.05$ |
| Output | 0.20 | 0.12 | 0.33 | 0.56 | 0.20 | 0.26 |
| Investment | 0.59 | 1.04 | 0.84 | 3.10 | 0.78 | 1.90 |
| Asset prices | 0.33 | 0.54 | 0.64 | 1.57 | 0.50 | 1.03 |
| Return on capital | 0.25 | 0.34 | 0.59 | 0.98 | 0.39 | 0.61 |
| CPI Inflation | 0.14 | 0.11 | 0.26 | 0.21 | 0.23 | 0.18 |
| Consumption | 0.49 | 0.50 | 0.58 | 0.69 | 0.55 | 0.60 |
| Terms of trade | 1.80 | 1.81 | 1.64 | 1.62 | 1.69 | 1.71 |

Table 3: **Home and foreign monetary policy shock (symmetric and correlated). Standard deviations of selected macroeconomic variables under different regimes with financial frictions, $\rho(.) = 0.05$, and without, $\rho(.) = 0$. All values are in percentage.**

| Exchange Rate Regime | Floating exchange rates | | Fixed exchange rates | | Managed exchange rates | |
|---|---|---|---|---|---|---|
| Variables | $\rho(.) = 0$ | $\rho(.) = 0.05$ | $\rho(.) = 0$ | $\rho(.) = 0.05$ | $\rho(.) = 0$ | $\rho(.) = 0.05$ |
| Output | 0.58 | 1.10 | 0.46 | 1.09 | 0.39 | 0.89 |
| Investment | 0.80 | 4.06 | 0.91 | 4.03 | 0.79 | 3.50 |
| Asset prices | 0.76 | 2.07 | 0.87 | 2.23 | 0.72 | 1.81 |
| Return on capital | 0.78 | 1.37 | 0.87 | 1.51 | 0.71 | 1.22 |
| CPI Inflation | 0.42 | 0.46 | 0.32 | 0.40 | 0.30 | 0.33 |
| Consumption | 0.36 | 0.56 | 0.42 | 0.65 | 0.35 | 0.54 |
| Terms of trade | 0.79 | 0.96 | 0.00 | 0.02 | 0.41 | 0.48 |

Table 4: **Home and foreign productivity shocks (symmetric and correlated). Standard deviations of selected macroeconomic variables under different regimes with financial frictions, $\rho(.) = 0.05$, and financial frictions, $\rho(.) = 0$. All values are in percentage.**

| Exchange Rate Regime | Floating exchange rates | | Fixed exchange rates | | Managed exchange rates | |
|---|---|---|---|---|---|---|
| Variables | $\rho(.) = 0$ | $\rho(.) = 0.05$ | $\rho(.) = 0$ | $\rho(.) = 0.05$ | $\rho(.) = 0$ | $\rho(.) = 0.05$ |
| Output | 2.06 | 2.30 | 1.94 | 1.95 | 1.06 | 2.10 |
| Investment | 2.88 | 4.60 | 2.86 | 3.90 | 2.83 | 4.05 |
| Asset prices | 1.36 | 2.00 | 1.33 | 1.80 | 1.31 | 1.86 |
| Return on capital | 0.59 | 0.89 | 0.64 | 1.00 | 0.55 | 0.82 |
| CPI Inflation | 0.28 | 0.24 | 0.37 | 0.34 | 0.32 | 0.28 |
| Consumption | 1.20 | 1.20 | 1.18 | 1.23 | 1.18 | 1.21 |
| Terms of trade | 2.54 | 2.50 | 2.31 | 2.29 | 2.39 | 2.41 |

Table 5: **Shocks to the uncovered interest rate parity. Standard deviations of selected macroeconomic variables under different regimes with financial frictions, $\rho(.) = 0.05$, and financial frictions, $\rho(.) = 0$. All values are in percentage.**

| Exchange Rate Regime | Floating exchange rates | | Fixed exchange rates | | Managed exchange rates | |
|---|---|---|---|---|---|---|
| Variables | $\rho(.) = 0$ | $\rho(.) = 0.05$ | $\rho(.) = 0$ | $\rho(.) = 0.05$ | $\rho(.) = 0$ | $\rho(.) = 0.05$ |
| Output | 1.18 | 1.40 | 0.81 | 0.85 | 0.41 | 2.10 |
| Investment | 0.66 | 2.91 | 1.00 | 1.31 | 0.28 | 8.58 |
| Asset prices | 1.10 | 1.88 | 0.56 | 0.71 | 1.94 | 4.55 |
| Return on capital | 1.72 | 2.06 | 0.54 | 0.58 | 2.66 | 3.74 |
| CPI Inflation | 0.87 | 0.88 | 0.54 | 0.57 | 0.48 | 0.52 |
| Consumption | 0.64 | 0.64 | 0.28 | 0.30 | 0.97 | 1.23 |
| Terms of trade | 2.90 | 3.14 | 1.63 | 1.69 | 2.07 | 2.76 |

Table 6: **Welfare costs (percentage units of steady state consumption) across different exchange rate regimes, under different shocks, with and without financial frictions.**

| Type of shock | Floating exchange rates | | Fixed exchange rates | |
|---|---|---|---|---|
| | $\rho(.) = 0$ | $\rho(.) = 0.05$ | $\rho(.) = 0$ | $\rho(.) = 0.05$ |
| Foreign monetary policy shock | 0.19 | 0.14 | 0.48 | 0.70 |
| Symmetric and correlated monetary policy shocks | 0.71 | 0.81 | 0.48 | 0.70 |
| Foreign productivity shock | 0.15 | 0.10 | 0.27 | 0.23 |
| Symmetric and correlated productivity shocks | 0.22 | 0.14 | 0.67 | 0.65 |

Table 7: **Sacrifice ratios (output-inflation volatility ratios) implied by the model under different exchange rate regimes, in the models with and without financial frictions.**

| Type of shock | Floating exchange rates | | Fixed exchange rates | |
|---|---|---|---|---|
| | $\rho(.) = 0$ | $\rho(.) = 0.05$ | $\rho(.) = 0$ | $\rho(.) = 0.05$ |
| Foreign monetary policy shock | 1.05 | 1.01 | 1.43 | 2.72 |
| Symmetric and correlated monetary policy shocks | 1.39 | 2.37 | 1.43 | 2.72 |
| Foreign productivity shock | 1.47 | 1.11 | 1.23 | 2.57 |
| Symmetric and correlated productivity shocks | 7.14 | 9.62 | 5.14 | 5.72 |

Table 8: **Summary of results. First entry in each box is the** $\sigma_y(fix)/\sigma_y(flex)$. **Second entry is** $welfare(fix)/welfare(flex)$.

| Type of shock | $\rho(.) = 0$ | $\rho(.) = 0.05$ |
|---|---|---|
| Foreign monetary policy shock | 3.06; 2.52 | 7.78; 5.00 |
| Foreign productivity shock | 1.65; 2.6 | 4.66; 5.05 |
| Symmetric and correlated monetary policy shocks | 0.79; 0.67 | 0.99; 0.86 |
| Symmetric and correlated productivity shocks | 0.94; 0.68 | 0.84; 0.86 |

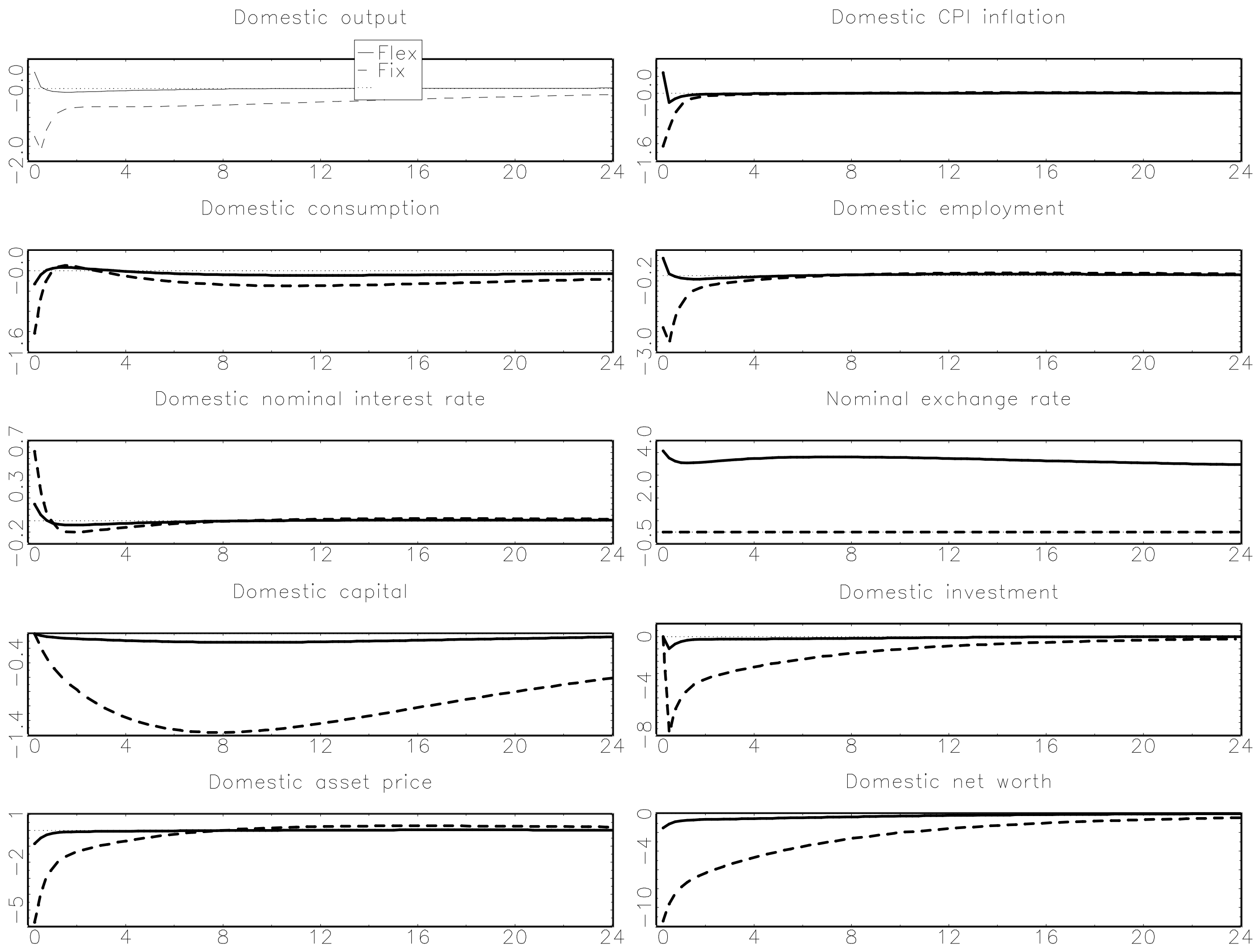


Figure 1: **Impulse responses to negative foreign monetary policy shock in the model with financial frictions. Floating exchange rates (solid line) versus fixed (dashed line).**

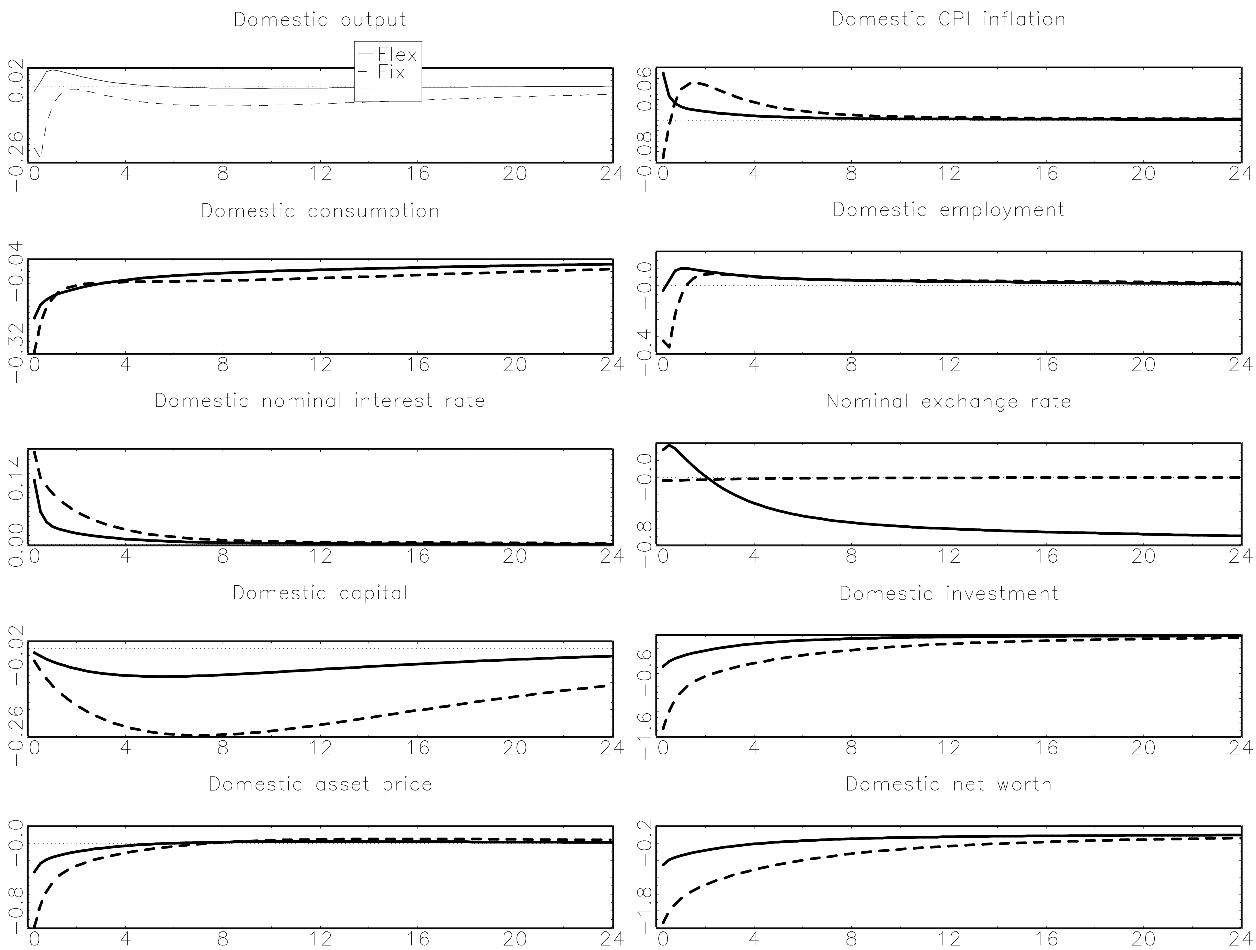


Figure 2: **Impulse responses to negative foreign productivity shock in the model with financial frictions. Floating exchange rates (solid line) versus fixed (dashed line).**

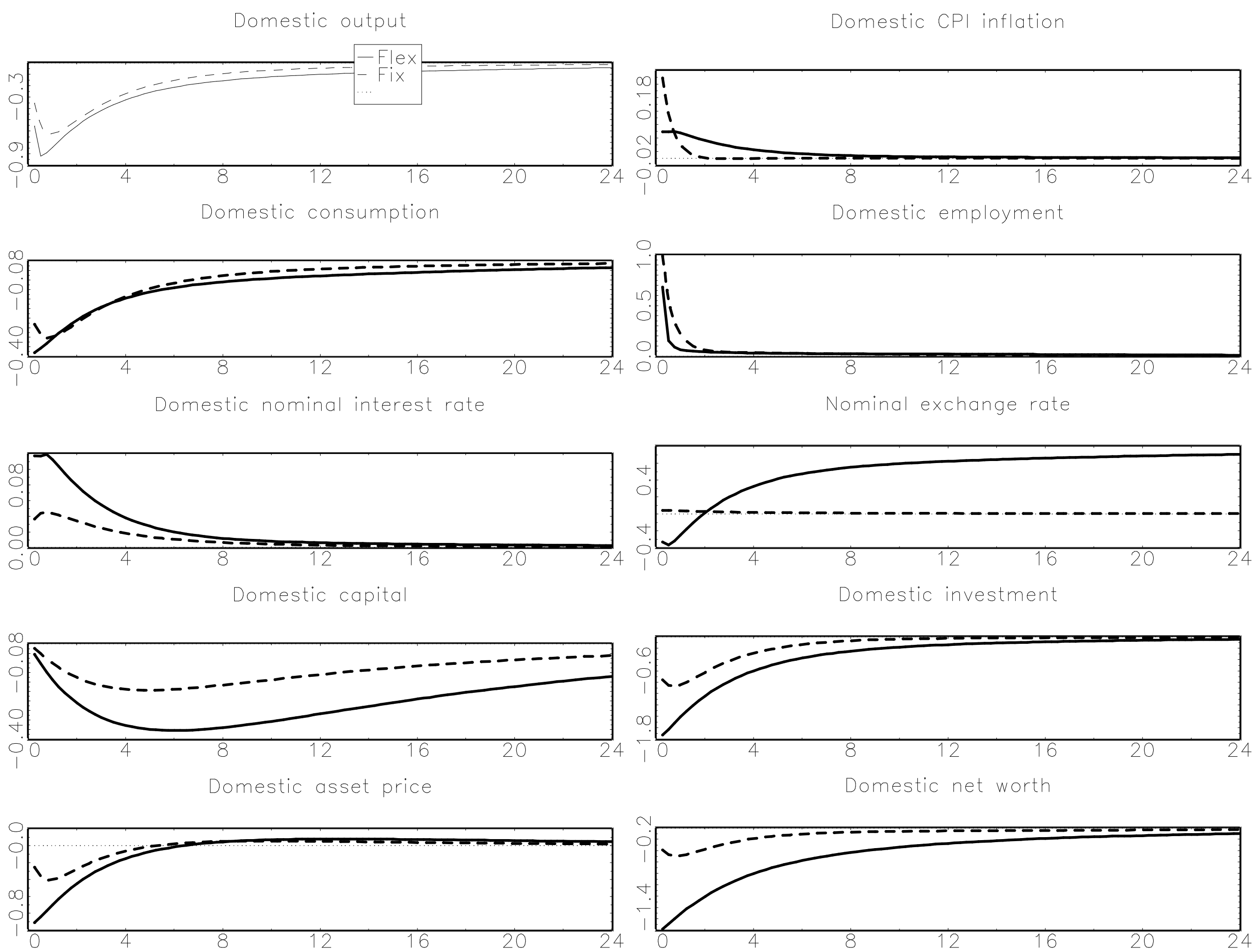


Figure 3: **Impulse responses to negative domestic productivity shock in the model with financial frictions. Floating exchange rates (solid line) versus fixed (dashed line).**