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International Transmission of Shocks under Financial Frictions: Some Implications for International Business Cycle Comovement*

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Abstract

This paper analyzes the international transmission of shocks in economies with financial frictions. In a two-country flexible price monetary model with distribution costs in the imported good I study the transmission of shocks to productivity, money supply, government spending and to entrepreneurs' net worth.

Financial frictions amplify the effects of shocks both at the domestic and at the international level. In the model, international business cycle comovement, measured as cross-country output correlations, is increasing in the degree of openness and distribution costs, and as in previous literature, decreasing in the degree of financial frictions. Finally, fiscal shocks play an important role in international business cycle comovement in the presence of financial frictions. First, because the crowding out effect is stronger on private consumption and weaker on investment if there are financial frictions, and second, because fiscal shocks may reduce the cross-country correlation of output.

Keywords: international business cycles, distribution costs, financial frictions, flexible prices.

JEL: E32; E44; F41; F42

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1 Introduction

This paper studies the business cycle comovement across countries with imperfect credit markets. In a two-country flexible price general equilibrium monetary model I analyze the international transmission of shocks to productivity, money supply, government spending, and net worth, and the implications of the degree of financial frictions and transport costs in this transmission.

There is a growing literature on the determinants of international comovement.[1] Although there is no agreement on the key variables that explain cross-country correlations, the determinant that gathers most consensus is the degree of bilateral trade. However, evidence supporting other a priori relevant factors such as the degree of financial integration does not appear to be so conclusive (Baxter and Koupartisas, 2004; Bordo and Hebling, 2003).

This paper attempts to shed some light on the role of imperfections in financial markets for the international transmission of shocks. In a closed economy, financial frictions amplify and propagate the response of the economy to exogenous shocks (Bernanke et al., 2000; de Blas, 2003). In an open economy there is not only amplification and propagation because of financial frictions, but also additional effects incorporated by the international transmission of shocks. These additional channels are analyzed in this work. I also focus on the transmission of shocks to government spending and on the existence of distribution costs in the import of consumption goods.

Previous literature has investigated the international transmission of shocks in economies with nominal rigidities and financial frictions (Faia, 2002; Hairault et al., 2003). The main focus of these papers is to analyze the transmission of shocks to productivity across countries under different exchange rate regimes and monetary policy rules. However, little attention has been paid to the international transmission of fiscal shocks. This type of perturbations becomes relevant, for example, in the context of a monetary union, since fiscal policy is the only instrument left for stabilizing the economy. Moreover, these papers assume that the law of one price holds, so that any excess demand at home is automatically supplied at no extra

[1] For a recent example see Baxter and Kouparitsas (2004).

cost from the foreign country. However, trade costs can be large and may alter the response of the economy to certain shocks (Hummels, 1999; Burnstein et al., 2002).

The contribution of this paper to the literature is twofold. First, I develop a two-country flexible price monetary model in which each country has credit market imperfections.[2] Previous work with flexible price models (Schlagenhauf and Wrase, 1995) has failed to reproduce the dynamics of interest rate and exchange rates, mainly after a monetary supply innovation. The model presented here differs from previous setups in two ways. First, unlike Schlagenhauf and Wrase, households in the domestic country only need to hold their domestic currency to purchase a consumption basket made out of a combination of domestic and foreign consumption goods. Using a framework similar to that employed by Burnstein, Neves and Rebelo (2003), I introduce distribution costs in a flexible price monetary model to capture the effects of costly international trade in the correlation of consumption across countries.

The second main contribution is the analysis of the role of fiscal shocks in the international transmission of shocks. Although there is no doubt that innovations in government spending lead to a rise in employment and a fall in real wages, there is mixed evidence of the effects of such innovations on consumption (Fatás and Mihov, 2002; Burnside et al. 2002). Recently, Galí et al. (2003) analyze the effects of changes in government purchases on aggregate variables. They show that the final effects of government spending on consumption depend on several factors, including the degree of price stickiness and the proportion of rule-of-thumb consumers.

In the present paper, imperfections in credit markets amplify the effects of shocks both at the domestic and at the international level. However, if the degree of financial frictions increases in both countries, cross-country output correlations are reduced in response to both productivity and net worth shocks. That is, international business cycle comovement, measured as cross-country output correlations, is increasing in the degree of openness and distribution costs, and as in previous literature, decreasing in the degree of financial frictions.

Additionally, the output-consumption puzzle can be solved but this requires a degree of distribution costs that implies roughly more than 80% of distribution margin, which is too

[2]The frictionless version of this model is analyzed in detail in a previous paper (de Blas, 2005).

high compared to the values reported in the data. Nonetheless, it appears that a model with moderate importing costs might help improve the model's predictions in this dimension.

Finally, the paper finds a key role for fiscal shocks in two ways. First, in this neoclassical model, a rise in government spending reduces the crowding-out effect in investment while making it stronger on consumption if there are financial frictions. Second, fiscal shocks reduce the international comovement of output, more so the higher the degree of openness and distribution costs. In the case of financial frictions this is also true, and cross-country correlations even become negative if shocks are uncorrelated. This last result is relevant to the extent that it hinges on the role of fiscal policy in the comovement of output across countries. This model reports that under independent monetary policies, international output comovement may diverge if countries have imperfect financial markets. Notice that this is important in order to investigate whether monetary integration leads to a stronger comovement of cycles or not, which recently has become a topic of interest.

The paper is structured as follows. Some stylized facts of international business cycles are analyzed in Section 2. Sections 3 to 5 develop the model, equilibrium conditions and parameterization of the economy. In Section 6, I investigate the transmission of shocks in a scenario with financial frictions and compare it to the frictionless case. I discuss the international transmission of shocks in Section 7. Conclusions in Section 8 close the paper.

2 International business cycles in the data

In this section I provide with some stylized facts about the international comovement of output, consumption and investment. The sample analyzed goes from 1980:1 to 2004:2 (except for Germany where the starting point is 1991:1) and the countries considered are Belgium, Germany, Spain, France, Italy, an aggregate for the European Monetary Union (henceforth EMU), Japan, United Kingdom and the USA. Data are from the OECD Quarterly National Accounts, and have been logged and detrended using Hodrick-Prescott filter. Results are displayed in Tables 1 to 3.

As expected, cross-country correlations of output are higher than those of consumption or investment for most of the countries. Needless to say, output comovement across countries in the Euro area is stronger than with Japan, USA and even the UK. The same statement is true for consumption and investment, what confirms a kind of convergence in the behavior of these countries, now belonging to a monetary union. The case of Germany should be taken carefully due to the reduced number of data points available to analyze business cycles, and because this country has been subject to a distinct economic situation after the reunification.

In addition, Table 4 reports country-specific correlations for output, consumption, investment and government spending. The procyclicality of consumption and investment is confirmed for all the countries. Notice also that as in the literature, there is no clear pattern about the cyclical character of government spending. For the cases considered here, it varies from being procyclical to countercyclical and in many cases there is no relationship at all between output and public spending.

The same inconclusive pattern is derived for the correlation between private and public consumption. This is in line with the debate over the effects of government spending on private consumption. According to traditional Keynesian theory, higher government spending leads to higher private consumption due to the increase in disposable income. However, neoclassical economists would tend to say that the relationship is negative, and higher public spending reduces private consumption through an intertemporal substitution effect. Finally, there is a clear crowding out effect of public spending on private investment, since correlations are negative for all countries except for Spain and Italy.

3 The model

In this economy there are two countries of equal size, Home and Foreign, with identical preferences and technology. Variables referring to the Foreign country are denoted by an asterisk.

Each country is composed of households, firms, financial intermediaries, and a domestic monetary authority.[3] Only consumption goods are traded. Within each country households

[3] For simplicity, I adopt Lucas' terminology and deal with families in each country composed of different agents. This family splits early in the morning to play separate roles, and gather at the end of the day to share all their earnings.

consume a composite of the Home and Foreign goods. Labor input is immobile across countries, but not capital.

Firms in both countries hire people and rent capital from households to produce a homogeneous good. They have no initial funds so they borrow the wage bill from their own country's financial intermediaries. Home firms are affected by a productivity shock to production.

The model of Schlagenhauf and Wrase (1995) shares the same basic features of limited participation as this paper. Their model differs from mine in the way they open the economy. They assume that in order to buy foreign consumption goods, households need to hold foreign currency, which they obtain in the exchange market at the beginning of the period at a price e_t, the nominal exchange rate. In contrast to that setup, I assume (as do most open-economy macro papers) that households in each country have access to a composite of consumption goods made out of domestic and foreign goods. Households only need domestic currency for both types of purchases. I assume that final goods firms import foreign consumption goods, by trading directly with foreign firms. Any difference in value between imports and exports is covered by exchanging domestic bonds at the nominal exchange rate. In addition, I introduce distribution costs in this flexible price model, breaking the law of one price that holds in Schlagenhauf and Wrase's model.

At each moment the state of the economy is defined by s_t, whose history is given by $s^t = \{s_0, ..., s_t\}$ with probability $\pi(s^t)$. This information structure will apply to all variables except for the choice of deposits. I will assume limited participation of households in financial markets, this means that they will choose how much money to deposit at the bank depending on last period's information set, s_{t-1}, with history $s^{t-1} = \{s_0, ..., s_{t-1}\}$, and therefore with probability $\pi(s^{t-1})$. In all cases, the initial realization s_0 is given.

3.1 Households

There is a continuum of infinite-lived households in the interval [0,1] in each country. The representative household at Home chooses consumption, $C(s^t)$; labor supply, $L(s^t)$; and deposits,[4] $\bar{D}(s^{t-1})$; to maximize the expected value of discounted future utilities given by

$$\max_{C(s^t),N(s^t),\bar{D}(s^{t-1})} E_0 \sum_{t=0}^{\infty} \beta^t U\left[C(s^t), L(s^t)\right], \tag{1}$$

where E_0 denotes the expectational operator conditional on the time 0 information set, and $\beta \in (0,1)$ is the household's subjective discount factor. Households consume a composite of the Home, C_H, and the Foreign goods, C_F,

$$C(s^t) = C_H^{1-\gamma}(s^t) C_F^{\gamma}(s^t), \tag{2}$$

where the parameter γ denotes the degree of openness. The utility function is given by

$$U\left[C(s^t), L(s^t)\right] = \frac{C(s^t)^{1-\theta} - 1}{1-\theta} - \Psi \frac{L(s^t)^{1+\psi}}{1+\psi}, \tag{3}$$

where θ denotes the inverse of the constant intertemporal elasticity of consumption, and ψ is the inverse of the labor supply elasticity with respect to real wages, assumed to be constant. The representative household begins time t with money holdings from the previous period, $\bar{M}(s^{t-1})$. At the beginning of the period, a fraction of these money holdings is allocated to deposits at the bank, $\bar{D}(s^{t-1})$. These transactions are done in the domestic currency. In this setup, household's deposits, $\bar{D}(s^{t-1})$, are chosen before the state of the economy is known reflecting the *limited participation* character of the model. This disables households from responding to a current shock by changing deposits within the same period, and induces the *liquidity effect* of a money supply shock on the nominal interest rate observed in the data.[5]

Households supply elastically labor to firms and receive in return wage payments, $\bar{W}(s^t)L(s^t)$, that can be spent within the same period.[6] This wage income plus money holdings minus

[4]Henceforth, upper bar letters will denote nominal variables not normalized. Plain upper case letters will denote nominal variables once normalized. And lower case letters will refer to the growth rates of variables.

[5] The mechanism is the following. After a money injection, there is an excess liquidity in the economy that needs to be absorbed to reestablish equilibrium. Households cannot change their portfolio choice until the following period, therefore firms are the only agents able to clear the money market. The central bank achieves money market clearing by reducing the interest rate so that firms are willing to borrow the excess amount of funds. For a formal explanation see Fuerst (1992).

[6]By allowing households to spend their wage earnings within the same period the impact of inflation on employment is eliminated. For more details on this, see Christiano and Eichenbaum (1992).

deposits is devoted to consumption purchases, $\bar{P}(s^t)C(s^t)$, as reflected in the following cash-in-advance constraint:

$$\bar{M}(s^{t-1}) - \bar{D}(s^{t-1}) + \bar{W}(s^t)L(s^t) \geq \bar{P}(s^t)C(s^t). \tag{4}$$

Monetary funds at home flow from time t to time $t+1$ according to

$$\begin{aligned}\bar{M}(s^t) &= \bar{M}(s^{t-1}) - \bar{D}(s^{t-1}) + \bar{W}(s^t)L(s^t) - \bar{P}(s^t)C(s^t) - \bar{P}_H(s^t)Q(s^t)Z^d(s^t) + \bar{Q}^k(s^t)K(s^{t-1}) \\ &\quad + R^D(s^t)\bar{D}(s^{t-1}) + \bar{\Pi}^{FI}(s^t) + \bar{\Pi}^F(s^t) - \bar{P}_H(s^t)T_t, \end{aligned} \tag{5}$$

with the demand for investment equal to

$$Z^d(s^t) = K(s^t) - (1-\delta)K(s^{t-1}). \tag{6}$$

Equation (5) says that at the end of the period, all the money in the economy goes back to the household's hands. That is, he gets what remains from consumption and capital purchases, $\bar{P}(s^t)C(s^t) + \bar{P}_H(s^t)Q(s^t)Z^d(s^t)$, where $Q(s^t)$ is the price of capital goods in terms of consumption goods, and deposits at the bank, $\bar{D}(s^{t-1})$, plus wage income, $\bar{W}(s^t)L(s^t)$, capital rents, $\bar{Q}^k(s^t)K(s^{t-1})$, at a rental price $\bar{Q}^k(s^t)$, principal plus interest from deposits at the gross rate $R^D(s^t)$, profits from firms, $\bar{\Pi}^F(s^t)$, and those from the financial intermediary, $\bar{\Pi}^{FI}(s^t)$, which he owns. Finally, households must pay lump sum taxes, T_t, that finance government spending.

The representative household maximizes (1) subject to (2), (4), (6) and (5). The optimal choices are

$$\frac{\bar{W}(s^t)}{\bar{P}(s^t)} = -\frac{U_L(s^t)}{U_C(s^t)}, \tag{7}$$

$$E\left[\frac{U_c(s^t)}{\bar{P}(s^t)}\middle| s^{t-1}\right] = \beta E\left[R^D(s^t)\frac{U_c(s^{t+1})}{\bar{P}(s^{t+1})}\middle| s^{t-1}\right], \tag{8}$$

$$\bar{P}_H(s^t)Q(s^t)E\left[\frac{U_c(s^{t+1})}{\bar{P}(s^{t+1})}\middle| s^t\right] = \beta E\left\{\frac{U_c(s^{t+2})}{\bar{P}(s^{t+2})}\left[\bar{Q}^k(s^{t+1}) + (1-\delta)\bar{P}_H(s^{t+1})Q(s^{t+1})\right]\middle| s^t\right\}, \tag{9}$$

$$\bar{P}_H(s^t)C_H(s^t) = (1-\gamma)\,\bar{P}(s^t)C(s^t), \tag{10}$$

$$\bar{P}_F(s^t)C_F(s^t) = \gamma\bar{P}(s^t)C(s^t), \tag{11}$$

and from the cost minimization, the consumer price index, $\bar{P}(s^t)$,

$$\bar{P}(s^t) = \frac{\bar{P}_H^{1-\gamma}(s^t)\bar{P}_F^{\gamma}(s^t)}{(1-\gamma)^{1-\gamma}\gamma^{\gamma}} = \kappa\bar{P}_H^{1-\gamma}(s^t)\bar{P}_F^{\gamma}(s^t), \tag{12}$$

with $\kappa = \frac{1}{(1-\gamma)^{1-\gamma}\gamma^{\gamma}}$.

Households are symmetric across countries, so the corresponding first order conditions apply to Foreign households.

3.2 Firms

Firms in each economy produce a homogeneous good, $Y(s^t)$. Production requires the use of labor, $H(s^t)$, and capital, $K(s^{t-1})$, as inputs through the following production function

$$Y(s^t) = A_t H(s^t)^{\alpha_h} K(s^{t-1})^{\alpha_k}, \tag{13}$$

where A_t is the aggregate productivity shock that evolves as

$$A_t = A_{t-1}^{\rho_a}\exp(\varepsilon_{a,t}), \tag{14}$$

where ρ_a is the autocorrelation of the shock, and ε_t is an i.i.d. exogenous disturbance. Firms own no initial funds so they borrow from the financial intermediary the wage bill, $\bar{\mathcal{L}}(s^t)$, at the gross interest rate, $R^{\mathcal{L}}(s^t)$. Firms only get indebted in their home currency. Additionally, firms are in charge of importing foreign goods for domestic consumption. To do that, they buy (sell) nominal bonds which are in zero net supply, $\bar{B}(s^t)$, to cover the extra amount sold (bought) of $C(s^t)$. These bonds cost an interest rate $R^B(s^t)$.

These perfectly competitive firms solve the following maximization problem:

$$\max_{H(s^t),K(s^{t-1}),\bar{B}(s^t),\bar{L}(s^t)} E_0\sum_{t=0}^{\infty}\Lambda(s^{t+1})\bar{\Pi}^F(s^t) \tag{15}$$

where

$$\bar{\Pi}^F(s^t) = \bar{P}_H(s^t)Y(s^t) - \bar{W}(s^t)H(s^t) - \bar{Q}^k(s^t)K(s^{t-1}) - \left[R^{\mathcal{L}}(s^t) - 1\right]\bar{\mathcal{L}}(s^t) + \bar{B}(s^t) - R^B(s^{t-1})\bar{B}(s^{t-1}), \tag{16}$$

subject to

$$Y(s^t) = A_t H(s^t)^{\alpha_h} K(s^{t-1})^{\alpha_k}, \tag{17}$$

$$\bar{\mathcal{L}}(s^t) \geq \bar{W}(s^t)H(s^t), \tag{18}$$

$$\bar{B}(s^t) = R^B(s^{t-1})\bar{B}(s^{t-1}) + \bar{e}(s^t)\bar{P}_F^*(s^t)C_F(s^t) - \bar{P}_H(s^t)C_H^*(s^t), \tag{19}$$

that is, firms produce a homogenous good, $Y(s^t)$ through the technology described in equation (17). To do that, they need to hire labor, $H(s^t)$, and capital, $K(s^{t-1})$.

Equation (19) is the Home country Current Account. It reflects the evolution of the nominal bonds, $\bar{B}(s^t)$, a firm buys (sells) depending on current imports, $\bar{e}(s^t)\bar{P}_F^*(s^t)C_F(s^t)$, being higher (lower) than current exports, $\bar{P}_H(s^t)C_H^*(s^t)$, and on the amount of past bonds held, $\bar{B}(s^{t-1})$, all in terms of the domestic currency. This equation will be spelled out further when I discuss distribution costs. The term $e(s^t)$ denotes the nominal exchange rate (units of Home currency per unit of Foreign currency).[7]

Firms discount future profits by the relative marginal utility of the household, $\Lambda(s^{t+1})$, with

$$\Lambda(s^{t+1}) = \beta^{t+1}\frac{U_c(s^{t+1})}{\bar{P}(s^{t+1})}. \tag{20}$$

The optimal conditions for labor, capital and bonds demands are

$$\frac{\bar{W}(s^t)}{\bar{P}_H(s^t)} = \frac{\alpha_h Y(s^t)}{R^L(s^t)H(s^t)}, \tag{21}$$

$$\frac{\bar{Q}^k(s^t)}{\bar{P}_H(s^t)} = \frac{\alpha_k Y(s^t)}{K(s^{t-1})}, \tag{22}$$

$$E\left[\left.\frac{U_c(s^{t+1})}{\bar{P}(s^{t+1})}\right| s^t\right] = \beta R^B(s^t) E\left[\left.\frac{U_c(s^{t+2})}{\bar{P}(s^{t+2})}\right| s^t\right]. \tag{23}$$

[7] Denoted in this way a *depreciation* of the Home currency means a increase of $e(s^t)$, and viceversa.

3.3 Distribution costs

In this model, I introduce distribution costs associated with the imported good in each country.[8] I consider the case in which part of the *importing* country's production is dedicated to transport. Introducing these costs means that at Home the price at which producers export consumption goods ($\bar{P}_H$) will not be the same as the price at which Foreign consumers import the same good ($\bar{P}_H^*$). The difference is that some *distribution costs* must be paid to consume the imported good. These distribution costs are represented by the fraction ϕ. This real friction means that absolute purchasing power parity need not always hold, in spite of the fact that prices are perfectly flexible. Let $rer(s^t)$ be the real exchange rate defined as

$$rer(s^t) = \frac{\bar{e}(s^t)\bar{P}^*(s^t)}{\bar{P}(s^t)}, \tag{24}$$

then with distribution costs $rer(s^t)$ need not equal 1. In principle, both ways of introducing distribution costs drive a wedge between prices indices in both countries making it possible for a model with flexible prices to depart from the law of one price. But as I show below, these formulations of transport costs yield different results in the dynamics of exchange rates and the current account.

3.3.1 Absence of distribution costs

Consider first the case in which there are no distribution costs of importing/exporting goods ($\phi = 0$). Then we have

$$\bar{P}_F(s^t) = \bar{e}(s^t)\bar{P}_F^*(s^t), \tag{25}$$

and

$$\bar{P}_H^*(s^t) = \frac{\bar{P}_H(s^t)}{\bar{e}(s^t)}, \tag{26}$$

that is, the law of one price holds for each of these goods.

[8] In de Blas (2005), I develop a more detailed analysis of the introduction of distribution costs in this flexible price model and compare it with the case of iceberg costs.

However, since each country has different preferences over the goods ($\gamma < \frac{1}{2}$ for home bias), the real price of consumption will differ in general between the two countries. The consumer price indices in the two countries are

$$\bar{P}(s^t) = \kappa \bar{P}_H^{1-\gamma}(s^t) \bar{P}_F^{\gamma}(s^t), \tag{27}$$

and

$$\bar{P}^*(s^t) = \kappa(\bar{P}_F^*(s^t))^{1-\gamma}(\bar{P}_H^*(s^t))^{\gamma} = \kappa \left[\frac{\bar{P}_F(s^t)}{\bar{e}(s^t)}\right]^{1-\gamma} \left[\frac{\bar{P}_H(s^t)}{\bar{e}(s^t)}\right]^{\gamma} = \frac{\kappa}{\bar{e}(s^t)} \left[\bar{P}_F(s^t)\right]^{1-\gamma} \left[\bar{P}_H(s^t)\right]^{\gamma}. \tag{28}$$

It can be seen from these formulas that absolute purchasing power parity will hold, that is $\bar{P}(s^t) = \bar{e}(s^t)\bar{P}^*(s^t)$ and therefore $rer(s^t) = 1$, in all states s^t, if and only if $\gamma = \frac{1}{2}$. (This is the case in which there is no bias for or against home goods, making preferences in the two countries symmetric.) Therefore, absolute purchasing power parity (henceforth PPP) does not hold at all times even with flexible prices and costless transport. However, empirical research rejects the hypothesis of the absolute PPP. Thus, it may be more interesting to analyze the relative version of the PPP.

In a flexible price setting, prices react immediately to any shock, and if this happens in both countries such reaction may offset any movement in the real exchange rate. In order to prevent such an offset from happening I recur to distribution costs.

The scenario is different in the case of distribution costs. For Home firms who import $C_F(s^t)$ this means that they will pay

$$\bar{P}_F(s^t) = \bar{e}(s^t)\bar{P}_F^*(s^t) + \phi \bar{P}_H(s^t), \tag{29}$$

reflecting expenditure of Home goods to import the Foreign good (due, for example, to transport costs or services necessary to bring the foreign good to the Home country). These extra costs are a fixed fraction, ϕ, of the Home good, and must be paid in domestic goods costing $\bar{P}_H(s^t)$.

A symmetric assumption will hold for the Foreign country, which imports $C_H^*(s^t)$ units of the Home produced good. In this case

$$\bar{P}_H^*(s^t) = \frac{\bar{P}_H(s^t)}{\bar{e}(s^t)} + \phi \bar{P}_F^*(s^t), \tag{30}$$

in units of the foreign currency. For simplicity, I will assume that the degree of distribution costs, ϕ, is the same across countries.

Under distribution costs, the current account (equation (19)) is

$$\bar{B}(s^t) = R^B(s^{t-1})\bar{B}(s^{t-1}) + \bar{e}_t\bar{P}_F^*(s^t)C_F(s^t) - \bar{P}_H(s^t)C_H^*(s^t). \tag{31}$$

Here it can be seen that exporter earnings do not include transport costs. Transport costs have no effect on the current account since they are paid inside the exporting country.

3.3.2 Distribution costs and exchange rates

Consider the linearized version of the price indices in both countries

$$\hat{p}_t = (1-\gamma)\hat{p}_{Ht} + \gamma\hat{p}_{Ft}, \tag{32}$$

$$\hat{p}_t^* = (1-\gamma)\hat{p}_{Ft}^* + \gamma\hat{p}_{Ht}^*. \tag{33}$$

In the case of distribution costs

$$\hat{p}_{Ft} = \frac{eP_F^*}{P_F}(\hat{e}_t + \hat{p}_{Ft}^*) + \frac{\phi P_H}{P_F}\hat{p}_{Ht}, \tag{34}$$

$$\hat{p}_{Ht}^* = \frac{P_H}{eP_H^*}\hat{p}_{Ht} + \left[\frac{\phi P_F^*}{P_H^*} - 1\right]\hat{e}_t + \frac{\phi P_F^*}{P_H^*}\hat{p}_{Ft}^*, \tag{35}$$

implying CPIs as follows:

$$\hat{p}_t = \left[1-\gamma+\frac{\gamma\phi P_H}{P_F}\right]\hat{p}_{Ht} + \gamma\frac{eP_F^*}{P_F}(\hat{e}_t + \hat{p}_{Ft}^*), \tag{36}$$

and

$$\hat{p}_t^* = \left[1-\gamma+\frac{\gamma\phi P_F^*}{P_H^*}\right]\hat{p}_{Ft}^* + \frac{\gamma P_H}{eP_H^*}\hat{p}_{Ht} + \gamma\left[\frac{\phi P_F^*}{P_H^*} - 1\right]\hat{e}_t. \tag{37}$$

In this case, the real exchange rate will be (after some algebra)

$$\widehat{rer}_t = \hat{e}_t + \hat{p}_t^* - \hat{p}_t = \left[1-\gamma+\frac{\gamma\phi P_F^*}{P_H^*} - \gamma\frac{eP_F^*}{P_F}\right](\hat{e}_t + \hat{p}_{Ft}^*) - \left[1-\gamma+\frac{\gamma\phi P_H}{P_F} - \frac{\gamma P_H}{eP_H^*}\right]\hat{p}_{Ht}. \tag{38}$$

Here the degree of distribution costs clearly affects the dynamics of the real exchange rate. In previous work (de Blas, 2005) I analyze more in detail the effects of introducing distribution costs in this way on the dynamics of nominal and real exchange rate dynamics. Most monetary models find it difficult to generate two of the stylized facts related with exchange rate dynamics. First, exchange rates are much more volatile than output, highly persistent and correlated. Considering distribution costs in the trade of goods allows the model presented here to generate nominal and real depreciation after a money injection. Exchange rates also are persistent and correlated in line with empirical evidence, but still the model fails to generate quantitatively highly volatile exchange rates. So, this approach seems to go in the direction of improving exchange rate dynamics, but still needs to investigate further the factors that contribute to generate variability of exchange rates.

3.4 Financial intermediaries

Banks have the role of taking funds from those who have resources to lend, and making them available to agents in need of funding. In this case, the representative Home bank will collect deposits from Home households, $\bar{D}(s^{t-1})$, and together with the monetary injection of the Home central bank, $\bar{X}(s^t)$, will transform these funds into loans to firms every period, $\bar{L}(s^t)$.

At the end of the period, the financial intermediary receives principal plus interest on the loans from firms, additionally, it has to pay back principal plus interests due on households' deposits, $R^D(s^t)\bar{D}(s^{t-1})$. These profits are then distributed to households, who own the banks, at the end of the period, as is seen from equation (5),

$$\bar{\Pi}_t^{FI} = R(s^t)\bar{X}(s^t). \tag{39}$$

3.5 Entrepreneurs

Capital is produced by entrepreneurs. Entrepreneurs are risk-neutral, live only one period, and can each carry out one project that requires one unit of consumption goods. The entrepreneur operates a technology that transforms this unit of consumption goods into $\widetilde{\omega}_t$ units of capital goods.[9] The variable $\widetilde{\omega}_t$ is an idiosyncratic shock uniformly distributed in the non-negative interval $[1-\omega, 1+\omega]$, with density $\phi(\widetilde{\omega}_t)$ and distribution function $\Phi(\widetilde{\omega}_t)$.

[9] Notice that in this sense, the production of capital will depend on the amount of consumption goods, that is affected by international factors such as the exchange rate and the current account.

Every period, after production takes place, part of the output Y_t is transferred lump-sum to entrepreneurs; this constitutes their net worth NW_t. According to the data, NW_t is positively related with output, and more volatile than output; the elasticity of net worth with respect to output will be called ξ.[10] Net worth will also be affected by a shock $\mathcal{Z}_t$ which captures other factors (e.g. changes in taxes or in market power) affecting firms' cash positions, so I assume $NW_t = \mathcal{Z}_t Y_t^{\xi}$.

To generate financial frictions, it is assumed that this net worth is insufficient for the entrepreneur's project. Moreover, since entrepreneurs live for only one period they cannot accumulate wealth.[11] Therefore, they need to borrow the difference between their required investment and their endowment, $1 - NW_t$. Firms are assumed to lend to entrepreneurs in a competitive market, and to be able to deal with a sufficient number of entrepreneurs in order to pool their idiosyncratic risk. In other words, firms can set up a "mutual fund" to lend to entrepreneurs.

The relationship between entrepreneurs and the mutual fund is affected by asymmetric information. When they sign their contract, neither the lender nor entrepreneurs can observe the idiosyncratic shock. Afterwards, $\widetilde{\omega}_t$ is revealed to the entrepreneurs, but the lender cannot observe this outcome unless he monitors. Monitoring costs are a fixed proportion $\mu_c > 0$ of the capital produced. Thus capital production involves a *costly state verification* problem, which is optimally solved by a *standard debt contract,* according to Townsend (1979), and Gale and Hellwig (1985). In this debt contract, an entrepreneur who borrows $(1 - NW_t)$ consumption goods agrees to repay $R_t^k(1 - NW_t)$ units of capital, if the realization of $\widetilde{\omega}_t$ is good. If the realization of $\widetilde{\omega}_t$ is bad, then the entrepreneur prefers to default. Thus the default decision is determined by a threshold value $\bar{\omega}_t$ which satisfies

$$\bar{\omega}_t \equiv R_t^k(1 - NW_t). \tag{40}$$

[10] This assumption is a reduced form way to deal with the fact that in good times investors end up with more cash available than in bad times. This could also be done through a dynamic problem for entrepreneurs, where net worth would be another state variable of the system, possibly different among entrepreneurs, but this difficult extension is left for future research.

[11] The transfer they receive is taxed away when entrepreneurs die, i.e. at the end of the period, and then returned lump sum to consumers.

In the optimal contract, the lender monitors in case of default, and confiscates all the entrepreneur's production, but nothing more. That is, entrepreneurs have *limited liability*.

To ensure that this debt contract is efficient and incentive compatible, the participation of lenders must be guaranteed. The mutual fund will find it profitable to lend the entrepreneurs as long as the expected return net of monitoring costs (at least) equals the amount lent:

$$\begin{aligned} 1 - NW(s^t) &= Q(s^t)\left\{\int_{1-\omega}^{\bar{\omega}(s^t)} \widetilde{\omega}(s^t)\Phi(d\widetilde{\omega}(s^t)) - \Phi(\bar{\omega}(s^t))\mu_c + [1-\Phi(\bar{\omega}(s^t))]\bar{\omega}(s^t)\right\} \equiv \\ &\equiv Q(s^t)g(\bar{\omega}(s^t)). \end{aligned} \tag{41}$$

Here the left hand side denotes the amount borrowed by entrepreneurs, and the right hand side reflects the expected return on this loan, net of monitoring costs.[12]

Also, participation of the entrepreneur in the contract must be assured. This means that his expected payoff must (at least) equal the net worth he invests in the project:

$$Q_t\left\{\int_{\bar{\omega}_t}^{1+\omega} \widetilde{\omega}_t\Phi(d\widetilde{\omega}_t) - [1-\Phi(\bar{\omega}_t)]\bar{\omega}_t\right\} \equiv Q_t f(\bar{\omega}_t) = NW_t, \tag{42}$$

where the left hand side denotes the entrepreneur's expected payoff. This expected value includes expected production of capital, minus what must be paid back on the loan, both conditional on not defaulting.

This costly state verification problem is solved taking as given the sequence of variables $\{NW(s^t), Q(s^t), R^k(s^t)\}_{t=0}^{\infty}$. From equations (41) and (42) above, it follows that

$$Q(s^t) = \frac{1}{[E\widetilde{\omega}(s^t) - \Phi(\bar{\omega}(s^t))\mu_c]} = \frac{1}{[1-\Phi(\bar{\omega}(s^t))\mu_c]}. \tag{43}$$

Additionally, note that

$$f(\bar{\omega}(s^t)) + g(\bar{\omega}(s^t)) = 1 - \Phi(\bar{\omega}(s^t))\mu_c, \tag{44}$$

that is, if monitoring costs are positive, $\mu_c > 0$, part of the output is destroyed by these costs, $\Phi(\bar{\omega}(s^t))\mu_c$, while the rest is divided between the entrepreneur, $f(\bar{\omega}(s^t))$, and the lender, $g(\bar{\omega}(s^t))$. The number of projects undertaken, $i(s^t)$, net of monitoring costs, constitutes the supply of capital:

$$Z^s(s^t) = i(s^t)[1-\Phi(\bar{\omega}(s^t))\mu_c] = \frac{i(s^t)}{Q(s^t)}. \tag{45}$$

[12] Credit rationing issues are avoided in this setup since expected returns going to the mutual fund are increasing in the threshold value $\bar{\omega}_t$. For more details on this see Bernanke et al. (2000).

3.6 The fiscal authority

There is a government in this economy which consumes an amount G_t. This government spending is financed by lump sum taxes levied from households, T_t. In this economy government spending is random and fluctuates according to

$$G_t = G_{t-1}^{\rho_g} \exp(\varepsilon_{g,t}), \tag{46}$$

with $\rho_g \in (0,1)$, and $\varepsilon_{g,t}$ is an i.i.d. normal shock with zero mean and standard deviation σ_g^{ε}.

It is assumed that in each country, the fiscal authority maintains a balanced budget every period, that is,

$$G_t = T_t, \text{ for } \forall t. \tag{47}$$

3.7 The central bank

The central bank in this model is in charge of conducting monetary policy. It issues money directly to financial intermediaries at an exogenously given rate μ_t that follows an AR(1) process, with autocorrelation coefficient $\rho_\mu \in (0,1)$. According to this, the new injection of money each period is

$$\bar{X}(s^t) = \mu_t \bar{M}(s^{t-1}), \tag{48}$$

so that the total amount of money at the end of period t and beginning of $t+1$ will be

$$\bar{M}(s^t) = \bar{M}(s^{t-1}) + \bar{X}(s^t). \tag{49}$$

4 Equilibrium conditions

A competitive equilibrium in this economy is a set of functions, and a set of variables such that for each country and given the state of the economy $s_t = (K_t, B_t, K_t^*, B_t^*, A_t, X_t, G_t, \mathcal{Z}_t, A_t^*, X_t^*, G_t^*, \mathcal{Z}_t^*)$, the following needs to hold:

i) households' problem is solved, that is, utility is maximized (1), subject to (2)-(6);

ii) firms' problem is solved, that is, profits are maximized (15), subject to (16)-(19);

iii) the entrepreneur's problem is solved, given R^k, Q, and NW,

iv) banks behave in a competitive way;
v) there is no arbitrage in credit markets, that is,

$$R^D(s^t) = R^{\mathcal{L}}(s^t) = R(s^t), \tag{50}$$

$$R^{D*}(s^t) = R^{\mathcal{L}*}(s^t) = R^*(s^t), \tag{51}$$

vi) and finally markets clear, that is,

$$H(s^t) = N(s^t), \tag{52}$$

$$H^*(s^t) = N^*(s^t), \tag{53}$$

$$\bar{D}(s^t) + \bar{X}_t = \bar{W}(s^t)H(s^t), \tag{54}$$

$$\bar{D}^*(s^t) + \bar{X}_t^* = \bar{W}^*(s^t)H^*(s^t), \tag{55}$$

$$Z^s(s^t) = i(s^t)[1 - \Phi(\bar{\omega}(s^t))\mu_c] = Z^d(s^t) = K(s^t) - (1-\delta)K(s^{t-1}), \tag{56}$$

$$Y(s^t) = C_H(s^t) + C_H^*(s^t) + \phi C_F(s^t) + i(s^t) + G_t, \tag{57}$$

$$Y^*(s^t) = C_F^*(s^t) + C_F(s^t) + \phi C_H^*(s^t) + i^*(s^t) + G_t^*, \tag{58}$$

$$Z^{s*}(s^t) = i^*(s^t)[1 - \Phi^*(\bar{\omega}^*(s^t))\mu_c] = Z^{d*}(s^t) = K^*(s^t) - (1-\delta)K^*(s^{t-1}), \tag{59}$$

$$\bar{B}(s^t) = R^B(s^{t-1})\bar{B}(s^{t-1}) + \bar{e}_t\bar{P}_F^*(s^t)C_F(s^t) - \bar{P}_H(s^t)C_H^*(s^t), \tag{60}$$

$$\bar{B}^*(s^t) = R^{B*}(s^{t-1})\bar{B}^*(s^{t-1}) + \frac{\bar{P}_H(s^t)}{\bar{e}(s^t)}C_H^*(s^t) - \bar{P}_F^*(s^t)C_F(s^t), \tag{61}$$

$$G_t = T_t, \tag{62}$$

$$G_t^* = T_t^*, \tag{63}$$

$$\bar{B}(s^t) + e(s^t)\bar{B}^*(s^t) = 0. \tag{64}$$

5 Calibration

The model is solved by log-linearizing around the nonstochastic steady state with zero initial nominal bonds. Since both countries are symmetric, I will only specify the parameters for the Home country. The calibration intends to match certain stylized facts in US and European data. The time period is a quarter. The data are mean values for US over the period 1980:1-2001:2 obtained from OECD Main Economic Indicators.

Preferences: $\beta = 0.9945$, matching a annual nominal interest rate of 7.4% (US mean of FFR) given a quarterly growth rate of M1 equal to 1.6%; intertemporal elasticity of substitution $\theta = 1$, and inverse of labor supply elasticity with respect to wages $\psi = 0.7$, both parameters are consistent with other studies as mentioned by Chari et al. (1999) and with separable preferences over consumption and leisure imply a larger volatility for exchange rates; $\gamma = 0.15$ degree of openness implying a ratio of imports over output equal to 10.4% (consistent with the USA-Europe case).

Technology: capital's share of output $\alpha = 0.36$; due to constant returns to scale assumption labor's share of output is $1 - \alpha = 0.64$; rate of depreciation is $\delta = 10\%$ annual, meaning a ratio of capital over output of 10.77; distribution costs $\phi = 3.8\%$ meaning a distribution margin equal to 3.7% consistent with measures by Hummels (1999) for the US.

Exogenous shocks: the parameters governing the productivity and money growth processes for both countries are estimated from data for the US and an aggregate of European countries. Regarding productivity shocks, I follow the procedure employed by Backus, Kehoe and Kydland (1992) and use the data in Chari, Kehoe and McGrattan (2001) to estimate the Solow residuals for the US (Home) and Europe (Foreign). The sample goes from 1972:1 to 1994:4. The estimates of the bivariate process have the following estimated autocorrelation matrix:

$$\begin{bmatrix} \rho_a & \rho_{aa^*} \\ \rho_{a^*a} & \rho_{a^*} \end{bmatrix} = \begin{bmatrix} \underset{(0.0136)}{0.9916} & \underset{(0.0154)}{0.0122} \\ \underset{(0.0136)}{0.0286} & \underset{(0.0153)}{0.9776} \end{bmatrix}. \tag{65}$$

The variance covariance matrix for the innovations is

$$\Sigma_a = \begin{bmatrix} \sigma_a & \sigma_{aa^*} \\ \sigma_{a^*a} & \sigma_{a^*} \end{bmatrix} = \begin{bmatrix} 0.0066 & 0.000015 \\ 0.000015 & 0.0075 \end{bmatrix}. \tag{66}$$

However, to impose symmetry across countries I calculate the symmetric matrix whose eigenvalues are the same as the estimated matrix. This matrix is

$$\begin{bmatrix} \rho_a & \rho_{aa^*} \\ \rho_{a^*a} & \rho_{a^*} \end{bmatrix} = \begin{bmatrix} 0.9846 & 0.0189 \\ 0.0189 & 0.9846 \end{bmatrix}, \tag{67}$$

with 0.0071 and 0.2953 as standard deviation and correlations, respectively, for the productivity innovations.

Regarding money growth processes I proceed in the same way as before. The data now are M1 and obtained from the OECD and correspond to the US and an aggregate of European countries for the period 1980:1-2003:2. The matrix of autocorrelation coefficients is

$$\begin{bmatrix} \rho_\mu & \rho_{\mu\mu^*} \\ \rho_{\mu^*\mu} & \rho_{\mu^*} \end{bmatrix} = \begin{bmatrix} \underset{(0.1544)}{0.5839} & \underset{(0.2054)}{-0.2575} \\ \underset{(0.0696)}{-0.0172} & \underset{(0.1217)}{0.1381} \end{bmatrix}, \tag{68}$$

and for the innovations

$$\Sigma_\mu = \begin{bmatrix} \sigma_\mu & \sigma_{\mu\mu^*} \\ \sigma_{\mu^*\mu} & \sigma_{\mu^*} \end{bmatrix} = \begin{bmatrix} 0.0092 & -0.0006 \\ -0.0006 & 0.0055 \end{bmatrix}. \tag{69}$$

Again imposing symmetry across countries and assuming that monetary growth processes are independent (since they are not significant in the data) the matrices used in the simulations are

$$\begin{bmatrix} \rho_\mu & \rho_{\mu\mu^*} \\ \rho_{\mu^*\mu} & \rho_{\mu^*} \end{bmatrix} = \begin{bmatrix} 0.3611 & -0.1222 \\ -0.1222 & 0.3611 \end{bmatrix}, \tag{70}$$

with 0.0074 and 0.08 as standard deviation and correlations, respectively, for the monetary innovations.

The autocorrelation of fiscal shocks (ρ_g) is set to 0.95, and the standard deviation is $\sigma_g^\varepsilon = 0.004$. To compare the effects of correlated and uncorrelated fiscal shocks it is assumed that the correlation is 0.25.

Financial frictions: Gertler (1995) assigns ξ (elasticity of profits with respect to output) a value of 4.45. Taking data on corporate profits after tax and US GDP for the period 1947:1-2002:1 I obtain an elasticity of profits (net worth) with respect to output equal to 3.84. I calibrate R^k to match a risk premium of 191 basis points measured by the spread between the bank prime rate and the three-month commercial paper rate on average terms. The bound ω on the support of the uniform distribution of $\tilde{\omega}_t$ is chosen to match an annual bankruptcy rate, $\Phi(\bar{\omega}_t)$, of 10% for US data from 1980-2001.[13] The proportion of internal project financing, NW, is set equal to 0.15 as in Gertler (1995). The value of monitoring costs, μ_c, is set equal 20% as in Fuerst (1995). This calibration implies a threshold value, $\bar{\omega}$ of 0.8619, obtained from combining equations (40)-(43) in the steady state. Just for the simulations net worth shocks are assumed to be highly persistent ($\rho_{\mathcal{Z}} = 0.9$), and highly volatile ($\sigma_{\mathcal{Z}} = 0.02$).

6 Adding financial frictions

In this section, I study how the international transmission of shocks changes when financial frictions are introduced. In particular, I assume the economy is affected by three types of shocks: productivity, fiscal, and net worth shocks. Results are depicted in Figures 1 to 4 for the case without ($\mu_c = 0$) and with ($\mu_c > 0$) financial frictions. In both cases, correlated shocks are assumed. By correlated shocks I mean the case in with the autocorrelation and variance-covariance matrices are both full matrices, in contrast with the uncorrelated case in which both cross-country correlation coefficients and covariances are zero in each of the shock processes.

In all the cases below, the figures show the impulse responses to a one-standard-deviation shock at Home, at time $t = 2$. Variables are plotted in percentage deviations from steady state. The solid-crossed line stands for the frictionless case and the dash-circled line for the model with financial frictions.

Before analyzing each shock separately, Table 5 reports the simulated unconditional moments for the correlated and uncorrelated shocks in the models with and without financial frictions. First fact to remark is that as expected, the volatility of output increases in the model with financial frictions. The procyclicality of consumption is somehow reduced in the model with financial frictions, whereas those of investment and labor are increased. Finally,

[13] US Business Bankruptcy Filings over Total Filings 1980-2001. Source: ABI World. This value is similar to the ones provided by Gertler (1995) and Fisher (1999).

cross-country output correlations are closer to zero in the framework with credit market imperfections. The international comovement of consumption is quite similar, whereas that of investment is stronger, either negative or positive, when there are financial frictions.

These moments, even though they include many different effects, characterize the implications of the main ingredients of the model. Basically, that the introduction of financial frictions in the way it is done here strengthens the relationship between output and investment while reducing that between output and consumption. In what follows below, I analyze separately the implications of each shock for the dynamics of the model taking into account the existence of financial frictions.

6.1 Productivity shocks

Figure 1 and Table 6 show the results. In the two cases, the productivity shock increases output at Home (where the shock originated) leading to an rise in consumption, investment and labor. Prices fall and there is both a nominal and a real depreciation. The higher productivity in the production of the Home good makes it less expensive compared to the Foreign good. Internationally, this shifts demand from the Foreign to the Home good and induces a fall in Foreign output (which is usually called *expenditure switching effect*).

When financial frictions are considered, the responses of almost all variables are enhanced with respect to the frictionless case, as found in closed economy models. The international transmission mechanism works through two channels: the expenditure switching effect, and the high procyclicality of entrepreneurs' net worth (absent in the frictionless case). Higher output increases the internal financing capacity of entrepreneurs that produce more capital at a lower price. This boosts investment and therefore amplifies the response of output. The effects are transmitted abroad with a lag. Foreign households switch consumption of their domestic good for Home consumption goods.

Since productivity is correlated across countries over time, output in the foreign country eventually rises. But initially, the expenditure switching effect abroad dominates the incipient boom, driving output down as demand for Foreign goods declines. Hence investment falls, especially in the economy with financial frictions. Thus overall, in the foreign country, consumption rises, investment falls, and prices fall, especially when there are financial frictions.

Finally, in all the cases analyzed in this paper, nominal exchange rates react more and real exchange rates less when there are financial frictions. The reason is that, in addition to the supply effect of the shock there is a demand effect at Foreign that makes foreign goods more expensive relatively to Home goods. Therefore, the real depreciation is less so under credit market imperfections.

As a conclusion, countries move in the same direction in response to productivity shocks, but financial frictions reduce this comovement. Table 6 displays second order properties of the model after a productivity shock. The table also considers the case of uncorrelated shocks under financial frictions in order to help separate out what aspects of the dynamics are caused by international correlation between the shocks. Unsurprisingly, the increase in the correlation of the shocks makes countries move closer, as shown in Table 6. The magnitude of the comovement of consumption across countries is reduced and so are those of output and investment if there are financial frictions. This result is developed in more detail in the next section, where I analyze cross-country correlations as the degree of financial frictions increase. An interesting question is how the presence of financial frictions affects international business cycle correlations in the event of shocks to productivity. It is also of interest to see how independent monetary policies or a common monetary policy should react to these shocks.

6.2 Money supply shocks

Although the study of the transmission of monetary policy focuses recently on the use of interest rate rules by the central bank, in this section I analyze a sudden and exogenous increase in money supply. The reason for this analysis is to get some insight of the transmission of monetary shocks in a two-country world with flexible prices and financial frictions. I undertake a more detailed analysis of such a perturbation in a frictionless model (see de Blas, 2005). In that paper, I investigate which alternative specifications of this flexible price monetary model can reproduce the liquidity effect after a money injection together with both nominal and real depreciations in an open economy framework. Now, I go further by analyzing the implications of such effects when there are financial frictions.

The results are shown in Figure 2 an Table 7. Although not reported here, the model with frictions still reports liquidity effects and increased international interest rates spreads together with nominal depreciation of the domestic currency. In contrast to what is observed in the data, the model shows real appreciation after a money injection. The magnitude of the effects is larger under financial frictions, and is driven mainly through the adjustment of consumption and investment with no significant different effect on output. The stronger international transmission of shocks across countries makes foreign prices fall by more than in the frictionless case. Then, despite the nominal depreciation, the real exchange rate goes down. In the face of extra money supply, interest rates fall, reducing the wedge between the prices of cash and credit goods. Labor and consumption increase, but the fall in the price of capital is not enough to boost investment.

Notice that the boom at Home is not transmitted to the Foreign country. Instead, resources are reallocated from investment towards consumption. The reason is that the money injection at Home rises domestic goods prices and this shifts demand towards the foreign good. Such an effect is absent in a closed economy. Since capital is country specific it is not favored by lower prices abroad. Therefore resources are shifted from investment towards consumption. At the same time the nominal depreciation of the Home currency favors exports, and increase foreign consumption.

With financial frictions the effects are stronger. Lower interest rates favor cash goods instead of credit goods. If there are credit market imperfections the wedge between consumption and investment prices is larger. The effects of the shock then become stronger because the rise in consumption reduces the amount of goods available for capital production. Since capital is country specific, then it is constrained, and the fall in investment is larger. The model fails in reflecting a real appreciation that is stronger under credit market imperfections. This appreciation strengthens the expenditure switching effect towards foreign goods.

The main differences in the dynamics with respect to the closed economy case are two. First, now in contrast to the closed economy case, households have access to foreign goods and therefore a money injection increases consumption. And with respect to the frictionless case, since capital is country specific, the presence of financial frictions makes the effects stronger. This last result points to the direction of introducing capital as a composite of both home and foreign goods.

Table 7 shows some statistics for the simulated series. It stands out the countercyclicality of investment, reflecting the dynamics analyzed previously. This countercyclicality is lowered under credit market imperfections. Furthermore, financial frictions strengthen the international transmission of a money injection. The reason is that the expenditure switching effect towards foreign consumption reduces even more investment.

6.3 Fiscal shocks

What are the effects of rising fiscal expenditure in one country, and how are these transmitted to another economy? Understanding these shocks becomes relevant in monetary unions without fiscal harmonization like the Euro zone.

For simplicity and for purposes of illustration, this paper focuses on the simple case in which government spending is financed by lump sum taxes from households. Figure 3 and Table 8 show the results. The shock illustrated in the impulse response functions is a one standard deviation shock at time $t = 2$, and it is very persistent ($\rho_g = 0.95$). The persistence of the fiscal shock generates a wealth effect on households, increasing their supply of labor. Thus, the rise in government spending fuels output and labor. In the absence of financial frictions there is a crowding-out effect that reduces both consumption and investment at Home. At the same time, the rise in Home demand makes local goods more expensive, leading to nominal and real appreciations. Higher Home prices reduce Foreign demand for Home goods, and force the Foreign country to produce more as expenditure shifts towards Foreign. The crowding-out effect on consumption is transmitted to the Foreign country.

As in the productivity shock, the response of most variables is stronger when there are financial frictions. More concretely, the expansion is not only amplified at Home but also more persistent. However, the crowding-out effect is stronger on private consumption and weaker on investment under financial frictions, because higher output favors investment through the procyclicality of entrepreneurs' net worth, whereas higher prices harm consumption.

Table 8 shows some conditional moments for the two cases plotted and compares them with the uncorrelated case under financial frictions and the frictionless model. From the table two main results arise. First, as shown in the impulse response functions, the financial channel incorporated here shows that the crowding-out effect on consumption is stronger and that on investment is weaker if there are financial frictions. This suggests a role for financial frictions in the crowding-out effects of fiscal shocks, an aspect which is investigated further in the next section. Second, in response to fiscal shocks and in a scenario of financial frictions, countries move further apart than in the frictionless case. This is reflected in the correlation of output across countries that is reduced if there are financial frictions, whereas cross-country investment comovement is increased. The expenditure switching effect plus the reallocation of resources towards investment are the main reasons for this second result.

6.4 Net worth shocks

In this instance, the case without financial frictions is trivial: the impulse response functions are zero because the shock has no effect. On the other hand, in the case with frictions, a positive shock to entrepreneurs' net worth reduces their demand for loans and what they borrow is at a lower price. This boosts investment and production. Local prices rise due to increased investment demand, so that the real exchange rate falls, and households switch demand towards the Foreign good. This dampens the boom in output. The effects of such a shock appear in Figure 4 and Table 9.

The net worth shock is very persistent ($\rho_{\mathcal{Z}} = 0.9$) so the resulting expansion lasts a long time. The shock causes very different behavior in the two countries: after a financial shock at Home, higher output at Home coincides with a depression in the Foreign country. Later, as consumption demand for foreign goods builds up, output and investment rise in the foreign country too.

Higher expected productivity of capital prolongs the fall in consumption and the rise in prices. The financial channel here favors clearly investment at the cost of consumption.

Also cross-country consumption correlations are stonger under financial frictions, as appears in Table 9, for both the correlated and uncorrelated shocks. The table also reports other conditional moments for the simulated series. The results are closer to the ones implied by the productivity shock regarding the procyclicality of variables. However, consumption is countercyclical whereas investment is highly procyclical. This is explained by the nature of the shock, favoring investment as opposed to consumption.

7 International transmission and spillovers

Little is known of what drives international business cycles closer or further apart. There is some agreement on the role played by variables such as trade intensity, but little consensus on the relevance of other determinants.[14] This model allows us to address this issue, so this section analyzes the effects of changes in the degree of openness, distribution costs and financial frictions on the international transmission of shocks. The previous section already shed some light on the direction of the comovements. The focus now is on the changes in cross-country correlations of output, consumption and investment. The benchmark considered is the baseline calibration of the model with financial frictions of Section 5.

7.1 The degree of openness

Previous work has studied the role of financial frictions in a closed-economy flexible and sticky price general equilibrium monetary models.[15] Recently there are more papers that investigate the effects of opening the economy and considering financial frictions in sticky price models. This section analyzes how the results presented in the previous section change if we increase the degree of openness of both economies. Notice that this parameter determines the strength of the expenditure switching effect, and therefore is crucial for the international dynamics of the model.

Tables 11a to 11.d report the cross-country correlations for output, consumption and investment to different degrees of openness for productivity, money supply, fiscal and net worth

[14] See, for example, Baxter and Kouparitsas (2004).

[15] See for example Bernanke, Gertler and Gilchrist (2000) for the sticky price case, and Carlstrom and Fuerst (2000) or de Blas (2003) for the flexible price model.

shocks, respectively. I consider symmetric shocks both correlated and uncorrelated. A higher degree of openness increases the cross-country correlations of investment and consumption with little change in that of output when there is a rise in productivity. Notice that the correlation of output across countries is always negative when shocks are uncorrelated.

When there are money supply shocks countries move closer the higher the degree of openness. The same is true for investment and less so for consumption.

Results do not change much with respect to the benchmark if the economy is shocked by a shock in government spending. However, cross-country investment and output correlations fall under correlated fiscal shocks the higher the degree of openness. This means that the demand shock generated at Home (the rise in government spending) translates into a supply shock at Foreign, with a stronger negative effect on Home investment and output as γ increases.

In the case of a shock to net worth, increasing the openness of the economy increases the cross-country correlation of consumption, reflecting a kind of risk sharing. The expenditure switching effect becomes stronger as γ rises, since the degree of home bias is reduced. The correlation of investment across countries changes sign depending on the shocks being correlated or not. With correlated shocks good times for entrepreneurs at Home are transmitted to Foreign with delay and lower magnitude. The boom experienced at Home reduces prices and increases demand for Home goods. International trade allows Foreign consumers to enjoy lower prices in the Home produced good. The benefit is increasing in the degree of openness. If shocks are correlated, the benefit goes in both directions and in detriment of investment. However, the cross-country correlation of investment decreases as the degree of openness rises, in the same direction of output.

As a conclusion, the reduced home bias (i.e. higher degree of openness, γ) strengthens the links of consumption across countries but decreases those of investment. This is a natural feature of this model, since consumption is a composite of Home and Foreign goods, whereas investment is made out of domestic goods only. A natural extension would be to consider capital goods as a composite also of Home and Foreign goods, and then make investment be tied to international factors too.

7.2 Distribution costs

Next I consider the role of distribution costs in the international transmission of shocks. The introduction of trade costs in the way it is done in this paper is rather new. I follow Burnstein, Neves and Rebelo (2003) and assume that part of the *importing* country's production is dedicated to transport. In this sense, the cost of transport will be affected by the efficiency of the economy and other fundamentals. This efficiency can be also altered by the presence of distortions in financial markets. Therefore, it is interesting to study how much these distribution costs may affect the transmission mechanism in this scenario.

The results are displayed in Tables 12.a to 12.d. As before, I report cross-country correlations under productivity, money supply, fiscal and net worth shocks for output, consumption and investment under three different scenarios. The first column corresponds to the benchmark calibrated value of distribution costs, and the rest simulate the model for increasing values of ϕ. In all cases, the simulations are made for symmetric shocks both correlated and uncorrelated.

In the face of productivity shocks, higher distribution costs increase the comovement of output across countries, whereas consumption and investment are less connected. The reason is that higher ϕ means a higher cost of importing goods, that is, to consume a certain amount of the Foreign good, more domestic goods must be devoted. This increases the cross-country correlation of output. At the same time, Foreign households find it more expensive to consume Home goods, reducing the correlation of consumption across countries. This suggests that there must be a level of distribution costs such that the output-consumption puzzle may be solved. This means that a model in which it is very costly to import consumption goods might be good to calibrate cross-country output and consumption correlations. Such a model could include the existence of nontraded goods, that is, goods whose importing costs is very high. Regarding investment, entrepreneurs need consumption goods to produce capital, and higher trade costs increase the price of capital in the two countries.

Under money supply shocks, the benefits from nominal exchange rate depreciations are lower the higher distribution costs. So cross-country output correlations are reduced and so are for investment. There are almost no change in consumption. The effects are stronger if there are no correlations.

Countries business cycles diverge in all cases the higher dsitribution costs and if the economies are shocked by fiscal shocks.

When there are shocks to net worth at Home, cross-country correlation of output slightly increases while reducing that of consumption. The reasoning above helps understand the mechanism. In this case, it is more costly and less efficient in terms of the own domestic goods to consume foreign goods (the expenditure switching effect) and this favors investment. This increases the correlation of investment across countries, while lowering that of consumption.

7.3 Financial frictions

In this model, there are several parameters that capture the degree of financial frictions. I focus on monitoring costs in this section, since $\mu_c = 0$ makes the model collapse to a standard two-country frictionless model, and $\mu_c > 0$ establishes a wedge between capital and consumption goods that drives the dynamics of the model.

Worse financial conditions increase the sensitivity of output and the economy in general to shocks, as shown in Section 6. The focus here will be more on the transmission of these shocks across countries when the degree of financial frictions worsens worldwide. Tables 13.a to 13.d report the cross-country correlations for output, consumption and investment for productivity, fiscal and net worth shocks to increasing degrees of financial frictions.

In the case of productivity shocks, as analyzed in Section 6, larger monitoring costs increase the volatility of the domestic real variables facing uncorrelated asymmetric shocks, while keeping more or less constant a Foreign. At the same time, the correlation of output across countries is reduced, making them diverge as financial frictions become worse.

This table confirms the results anticipated in Section 6.1. Recent studies find that increasing differences in financial systems reduce the comovement of business cycles across countries.[16] In this paper, results go in the same line since increasing the degree of financial imperfections makes countries diverge in their behavior, independently on the correlated

[16] See Faia (2002) and Hairault et al. (2002).

or uncorrelated source of the shocks. The rationale goes as follows. A productivity shock at Home is interpreted as a supply shock. Home consumption goods become relatively less expensive for Foreign consumer, who substitute domestic for imported goods (the expenditure switching effect), in this sense the supply shock at Home induces a demand shock at Foreign. Furthermore, if there are financial frictions that amplify and propagate the effects of the shocks, not only is the supply shock at Home stronger, but also the demand shock at Foreign. This is why increasing financial frictions makes countries' business cycles diverge.

If money supply shocks affect the economy, countries' comovement is lower if there are financial frictions. The opposite is true for consumption and investment.

Under shocks to government spending, the first remarkable fact is that financial frictions make outputs in the two countries move in opposite directions. This fact was analyzed in section 6.2. As mentioned above the source of divergence is the effect that more public expenditure has on investment and how this is transmitted abroad. Worse financial conditions reduce even more the comovement of output and consumption across countries with a positive effect on investment. The results presented here suggest that a higher degree of financial frictions may offset the crowding-out effect on investment, leading to a procyclical investment after a fiscal shock. The opposite is true for consumption. At the same time, higher μ_c increases the cross-country correlation of investment, reducing that of consumption. Thus, a high degree of financial frictions may help breaking the output-consumption puzzle in the event of a fiscal shock.

Finally, when a positive shock to entrepreneurs' net worth is considered the correlation across countries falls in all cases. Results do not change qualitatively as shocks become correlated.

8 Conclusions and future research

The aim of this paper is to shed some light on the international transmission of shocks in economies in which financial markets are not perfect. To this aim, I have developed a two-country flexible price general equilibrium model with distribution costs and financial frictions. Additionally, the paper leads to some conclusions on the international comovement of business cycles.

Results show that imperfections in credit markets amplify the effects of shocks both at the domestic and at the international level. However, if the degree of financial frictions increases in both countries, cross-country output correlations are reduced in response to productivity, fiscal and net worth shocks. That is, international business cycle comovement, measured as cross-country output correlations, is increasing in the degree of openness and distribution costs, and as in previous literature, decreasing in the degree of financial frictions.

The introduction of distribution costs allows for the study of cross-country consumption correlations too. In this model, the output-consumption puzzle can be solved but this may require a degree of distribution costs too high compared to the values reported by the data. However, the result leads to the conclusion that a model with very high costs in importing some of the consumption goods might be a good instrument to analyze international consumption issues.

Finally, the paper finds a key role for fiscal shocks in two ways. First, the behavior of the fiscal authority is relevant for its effects on investment. In this classical model, a rise in government spending induces a lower crowding-out effect on investment and stronger on consumption if there are financial frictions. Second, correlated asymmetric fiscal shocks reduce the international comovement of output the higher the degree of openness and distribution costs. In the case of financial frictions this is also true, and cross-country correlations become even negative if shocks are uncorrelated. This last result relevant to the extent that it hinges on the role of fiscal policy (a stabilizing instrument in the hands of governments) in the comovement of output across countries.

Therefore, the immediate extension is to analyze the role of fiscal policy in the transmission of shocks across countries in a monetary union. In this scenario, countries will only have one stabilization instrument (fiscal policy) to respond to shocks. Different responses by each country to the same perturbation may lead to a convergence or divergence of business cycles. The degree of financial integration will also be an important factor to consider in such a framework.

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Tables

Table 1. Cross-country output correlations

Belgium	1.0000							
Germany*	0.9947	1.0000						
Spain	0.7062	0.9831	1.0000					
France	0.7737	0.9865	0.7159	1.0000				
Italy	0.7122	0.9943	0.5678	0.6393	1.0000			
EMU	0.8400	0.9954	0.7801	0.8371	0.7745	1.0000		
Japan	0.4492	0.9368	0.3900	0.3294	0.3636	0.4372	1.0000	
UK	0.3867	0.9869	0.3518	0.3089	0.4524	0.2438	0.1000	1.0000
USA	0.3557	0.9856	0.1426	0.0807	0.3365	0.2568	0.0794	0.4920

Table 2. Cross-country consumption correlations

Belgium	1.0000							
Germany*	0.9784	1.0000						
Spain	0.6439	0.9520	1.0000					
France	0.6013	0.9538	0.6203	1.0000				
Italy	0.6576	0.9615	0.7732	0.4285	1.0000			
EMU	0.6898	0.9823	0.8249	0.7279	0.8049	1.0000		
Japan	0.2111	0.9179	0.1870	0.1886	0.0673	0.1493	1.0000	
UK	0.0845	0.9703	0.3318	0.2839	0.1102	0.2284	0.0927	1.0000
USA	0.0555	0.9745	0.0508	−0.0447	0.0083	0.1076	−0.1703	0.5717

Table 3. Cross-country investment correlations

Belgium	1.0000							
Germany*	0.4115	1.0000						
Spain	0.5919	0.2398	1.0000					
France	0.6052	0.3002	0.8165	1.0000				
Italy	0.5099	0.2715	0.6650	0.6950	1.0000			
EMU	0.6766	0.4588	0.8180	0.8808	0.7988	1.0000		
Japan	0.4867	0.2419	0.5469	0.5171	0.5389	0.5470	1.0000	
UK	0.5815	0.2388	0.3422	0.3298	0.2570	0.3516	0.2639	1.0000
USA	0.2744	0.3608	−0.1079	0.0835	0.1018	0.1894	0.0710	0.3866

Table 4. Country-specific correlations

	$\rho(y,c)$	$\rho(y,i)$	$\rho(y,g)$	$\rho(g,c)$	$\rho(g,i)$
Belgium	0.6697	0.6035	0.0047	0.2206	−0.3003
Germany*	0.9878	0.3207	0.9447	0.9436	0.2348
Spain	0.8201	0.8332	0.5039	0.5505	0.4565
France	0.7668	0.8950	−0.3556	−0.2624	−0.5357
Italy	0.6526	0.7598	−0.0344	0.0658	0.0332
EMU	0.8119	0.9036	−0.1107	0.0857	−0.1262
Japan	0.6493	0.9102	−0.0574	−0.0335	−0.0823
UK	0.8570	0.7391	−0.2755	−0.2998	−0.2688
USA	0.8283	0.9351	−0.0364	0.0822	−0.1126

For all the tables the sample goes from 1980:1-2004:2, except for Germany (1991:1 to 2004:2).

Source: OECD Quarterly National Accounts.

Table 5: Unconditional moments

	No CMI		CMI	
	Uncorrelated	Correlated	Uncorrelated	Correlated
σ_y	1.065	1.07	1.172	1.162
$\rho(y,c)$	0.601	0.629	0.404	0.450
$\rho(y,i)$	0.894	0.823	0.916	0.874
$\rho(y,h)$	0.795	0.746	0.805	0.753
$\rho(y,y^*)$	-0.022	0.134	-0.017	0.059
$\rho(c,c^*)$	0.109	0.751	0.127	0.738
$\rho(i,i^*)$	0.002	0.021	0.018	-0.121

Table 6: Conditional moments to a productivity shock at Home

	No CMI		CMI	
	Uncorrelated	Correlated	Uncorrelated	Correlated
σ_y	1.06	1.08	1.15	1.14
$\rho(y,c)$	0.952	0.909	0.798	0.761
$\rho(y,i)$	0.992	0.975	0.981	0.970
$\rho(y,h)$	0.809	0.758	0.839	0.804
$\rho(y,y^*)$	0.042	0.191	-0.030	0.093
$\rho(c,c^*)$	0.401	0.826	0.320	0.793
$\rho(i,i^*)$	0.018	-0.183	-0.027	-0.234

Table 7: Conditional moments to a money supply shock at Home

	No CMI		CMI	
	Uncorrelated	Correlated	Uncorrelated	Correlated
σ_y	0.062	0.062	0.058	0.059
$\rho(y,c)$	0.952	0.909	0.966	0.909
$\rho(y,i)$	-0.923	-0.835	-0.934	-0.821
$\rho(y,h)$	0.963	0.950	0.973	0.960
$\rho(y,y^*)$	0.040	0.169	0.048	0.187
$\rho(c,c^*)$	-0.037	0.699	-0.027	0.752
$\rho(i,i^*)$	0.346	0.896	0.406	0.938

Table 8: Conditional moments to a fiscal shock at Home

	No CMI		CMI	
	Uncorrelated	Correlated	Uncorrelated	Correlated
σ_y	0.008	0.009	0.009	0.011
$\rho(y,c)$	-0.717	-0.719	-0.808	-0.815
$\rho(y,i)$	-0.283	-0.126	0.036	0.193
$\rho(y,h)$	0.994	0.997	0.999	0.999
$\rho(y,y^*)$	0.093	0.663	0.055	0.599
$\rho(c,c^*)$	0.347	0.760	0.382	0.756
$\rho(i,i^*)$	0.016	-0.100	-0.017	0.095

Table 9: Conditional moments to a net worth shock at Home

	No CMI		CMI	
	Uncorrelated	Correlated	Uncorrelated	Correlated
σ_y	*na*	*na*	0.178	0.181
$\rho(y,c)$	*na*	*na*	-0.572	-0.575
$\rho(y,i)$	*na*	*na*	0.873	0.874
$\rho(y,h)$	*na*	*na*	0.957	0.954
$\rho(y,y^*)$	*na*	*na*	0.019	0.207
$\rho(c,c^*)$	*na*	*na*	0.333	0.458
$\rho(i,i^*)$	*na*	*na*	0.025	0.192

Table 10 Cross-country correlations to all shocks

	$\rho(y, y^*)$	$\rho(c, c^*)$	$\rho(i, i^*)$
$\gamma = 0$	0.1026	0.6251	-0.0522
$\gamma = 0.15$	0.1052	0.7300	-0.0397
$\gamma = 0.4$	0.1101	0.8404	-0.0241
$\phi = 0$	0.1026	0.7348	-0.0464
$\phi = 0.038$	0.1052	0.7300	-0.0397
$\phi = 0.5$	0.1241	0.6910	-0.0016
$\phi = 1$	0.1317	0.6716	0.0063
$\mu_c = 0$	0.1645	0.7325	0.1044
$\mu_c = 0.2$	0.1052	0.7300	-0.0397
$\mu_c = 0.4$	0.0348	0.5337	-0.1064

Table 11.a. Cross-country correlations to productivity shock

		$\gamma = 0.15$ (*benchmark*)		$\gamma = 0.4$	
Output		Uncorrelated	-0.030	Uncorrelated	-0.024
		Correlated	0.045	Correlated	0.049
Consumption		Uncorrelated	0.320	Uncorrelated	0.947
		Correlated	0.788	Correlated	0.980
Investment		Uncorrelated	-0.027	Uncorrelated	-0.013
		Correlated	-0.334	Correlated	-0.325

Table 11.b. Cross-country correlations to money supply shock

		$\gamma = 0.15$ (*benchmark*)		$\gamma = 0.4$	
Output		Uncorrelated	0.048	Uncorrelated	0.107
		Correlated	0.187	Correlated	0.221
Consumption		Uncorrelated	-0.027	Uncorrelated	-0.066
		Correlated	0.752	Correlated	0.724
Investment		Uncorrelated	0.415	Uncorrelated	0.999
		Correlated	0.944	Correlated	0.986

Table 11.c. Cross-country correlations to fiscal shock

		$\gamma = 0.15$ (*benchmark*)		$\gamma = 0.4$	
Output		Uncorrelated	-0.033	Uncorrelated	-0.050
		Correlated	0.538	Correlated	0.526
Consumption		Uncorrelated	0.287	Uncorrelated	0.920
		Correlated	0.704	Correlated	0.975
Investment		Uncorrelated	-0.011	Uncorrelated	-0.020
		Correlated	0.155	Correlated	0.147

Table 11.d. Cross-country correlations to net worth shock

		$\gamma = 0.15$ (*benchmark*)		$\gamma = 0.4$	
Output		Uncorrelated	0.016	Uncorrelated	0.015
		Correlated	0.195	Correlated	0.195
Consumption		Uncorrelated	0.333	Uncorrelated	0.927
		Correlated	0.451	Correlated	0.945
Investment		Uncorrelated	0.026	Uncorrelated	0.039
		Correlated	0.204	Correlated	0.218

Robustness analysis: distribution costs

Table 12.a. Cross-country correlations to productivity shock

	$\phi = 0.038$ (*benchmark*)		$\phi = 0.5$		$\phi = 1$	
Output	Uncorrelated	-0.030	Uncorrelated	-0.005	Uncorrelated	0.006
	Correlated	0.045	Correlated	0.063	Correlated	0.071
Consumption	Uncorrelated	0.320	Uncorrelated	0.2182	Uncorrelated	0.171
	Correlated	0.788	Correlated	0.7267	Correlated	0.698
Investment	Uncorrelated	-0.027	Uncorrelated	0.019	Uncorrelated	0.032
	Correlated	-0.334	Correlated	-0.303	Correlated	-0.295

Table 12.b. Cross-country correlations to money supply shock

	$\phi = 0.038$ (*benchmark*)		$\phi = 0.5$		$\phi = 1$	
Output	Uncorrelated	0.048	Uncorrelated	0.038	Uncorrelated	0.032
	Correlated	0.187	Correlated	0.180	Correlated	0.177
Consumption	Uncorrelated	-0.027	Uncorrelated	-0.016	Uncorrelated	-0.011
	Correlated	0.752	Correlated	0.759	Correlated	0.763
Investment	Uncorrelated	0.415	Uncorrelated	0.267	Uncorrelated	0.192
	Correlated	0.944	Correlated	0.916	Correlated	0.899

Table 12.c. Cross-country correlations to fiscal shock

	$\phi = 0.038$ (*benchmark*)		$\phi = 0.5$		$\phi = 1$	
Output	Uncorrelated	-0.033	Uncorrelated	-0.088	Uncorrelated	-0.101
	Correlated	0.538	Correlated	0.498	Correlated	0.489
Consumption	Uncorrelated	0.287	Uncorrelated	0.145	Uncorrelated	0.084
	Correlated	0.704	Correlated	0.620	Correlated	0.580
Investment	Uncorrelated	-0.011	Uncorrelated	-0.042	Uncorrelated	-0.049
	Correlated	0.155	Correlated	0.128	Correlated	0.125

Table 12.d. Cross-country correlations to net worth shock

	$\phi = 0.038$ (*benchmark*)		$\phi = 0.5$		$\phi = 1$	
Output	Uncorrelated	0.016	Uncorrelated	0.016	Uncorrelated	0.018
	Correlated	0.195	Correlated	0.196	Correlated	0.198
Consumption	Uncorrelated	0.333	Uncorrelated	0.212	Uncorrelated	0.153
	Correlated	0.451	Correlated	0.342	Correlated	0.287
Investment	Uncorrelated	0.026	Uncorrelated	0.067	Uncorrelated	0.074
	Correlated	0.204	Correlated	0.245	Correlated	0.252

Robustness analysis: financial frictions

Table 13.a. Cross-country correlations to productivity shock

	$\mu_c = 0$		$\mu_c = 0.2$ *(benchmark)*		$\mu_c = 0.4$	
Output	Uncorrelated	-0.023	Uncorrelated	-0.030	Uncorrelated	-0.033
	Correlated	0.133	Correlated	0.045	Correlated	-0.069
Consumption	Uncorrelated	0.347	Uncorrelated	0.320	Uncorrelated	0.340
	Correlated	0.811	Correlated	0.788	Correlated	0.358
Investment	Uncorrelated	-0.047	Uncorrelated	-0.027	Uncorrelated	-0.032
	Correlated	-0.246	Correlated	-0.334	Correlated	-0.481

Table 13.b. Cross-country correlations to money supply shock

	$\mu_c = 0$		$\mu_c = 0.2$ *(benchmark)*		$\mu_c = 0.4$	
Output	Uncorrelated	0.040	Uncorrelated	0.048	Uncorrelated	0.055
	Correlated	0.692	Correlated	0.187	Correlated	0.195
Consumption	Uncorrelated	-0.037	Uncorrelated	-0.027	Uncorrelated	-0.051
	Correlated	0.699	Correlated	0.752	Correlated	0.762
Investment	Uncorrelated	0.346	Uncorrelated	0.415	Uncorrelated	0.462
	Correlated	0.895	Correlated	0.944	Correlated	0.973

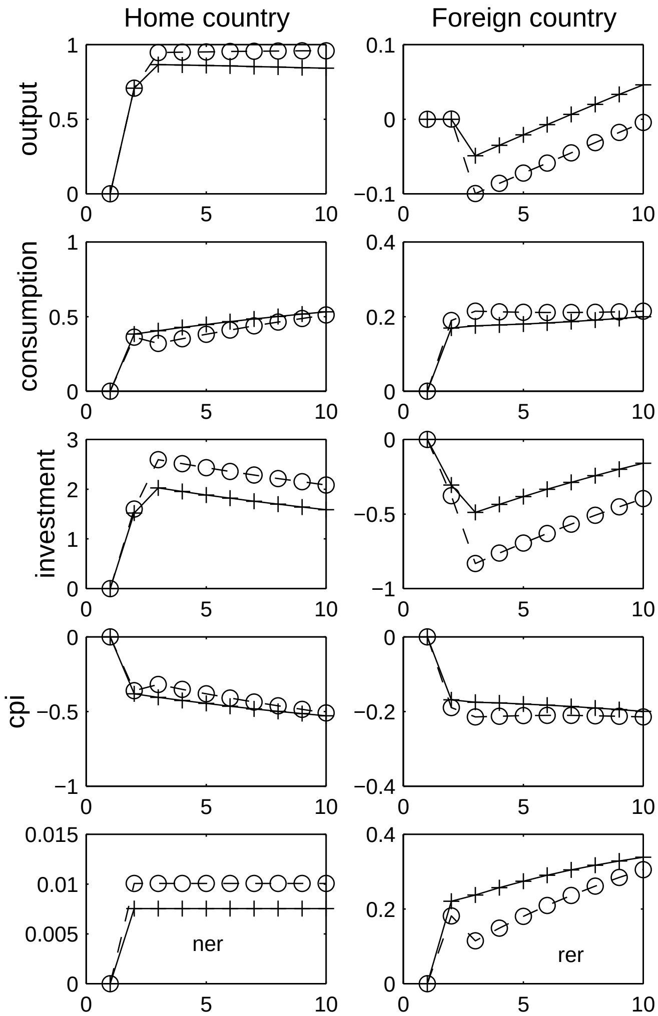
Table 13.c. Cross-country correlations to fiscal shock

	$\mu_c = 0$		$\mu_c = 0.2$ *(benchmark)*		$\mu_c = 0.4$	
Output	Uncorrelated	0.005	Uncorrelated	-0.033	Uncorrelated	-0.035
	Correlated	0.608	Correlated	0.538	Correlated	0.445
Consumption	Uncorrelated	0.262	Uncorrelated	0.287	Uncorrelated	0.283
	Correlated	0.715	Correlated	0.704	Correlated	0.648
Investment	Uncorrelated	-0.015	Uncorrelated	-0.012	Uncorrelated	-0.006
	Correlated	0.124	Correlated	0.093	Correlated	0.321

Table 13.d. Cross-country correlations to net worth shock

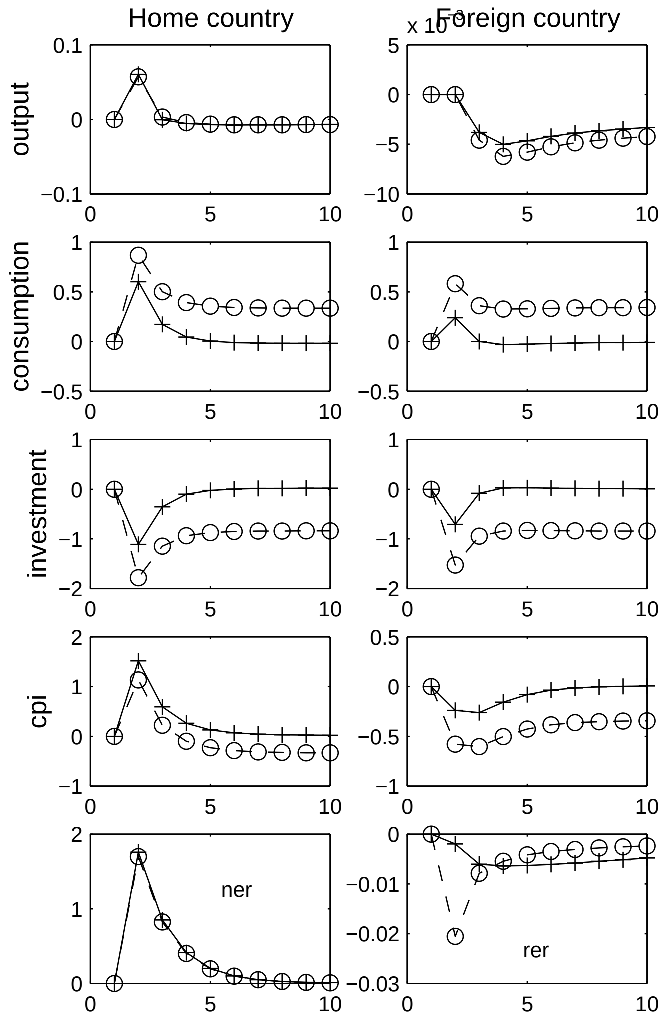
	$\mu_c = 0$		$\mu_c = 0.2$ *(benchmark)*		$\mu_c = 0.4$	
Output	Uncorrelated	*na*	Uncorrelated	0.016	Uncorrelated	0.012
	Correlated	*na*	Correlated	0.195	Correlated	0.107
Consumption	Uncorrelated	*na*	Uncorrelated	0.333	Uncorrelated	0.331
	Correlated	*na*	Correlated	0.451	Correlated	0.391
Investment	Uncorrelated	*na*	Uncorrelated	0.026	Uncorrelated	0.022
	Correlated	*na*	Correlated	0.204	Correlated	0.130

Figure 1: Figure 1: Impulse response functions to a correlated one standard deviation increase in productivity at Home at $t = 2$.



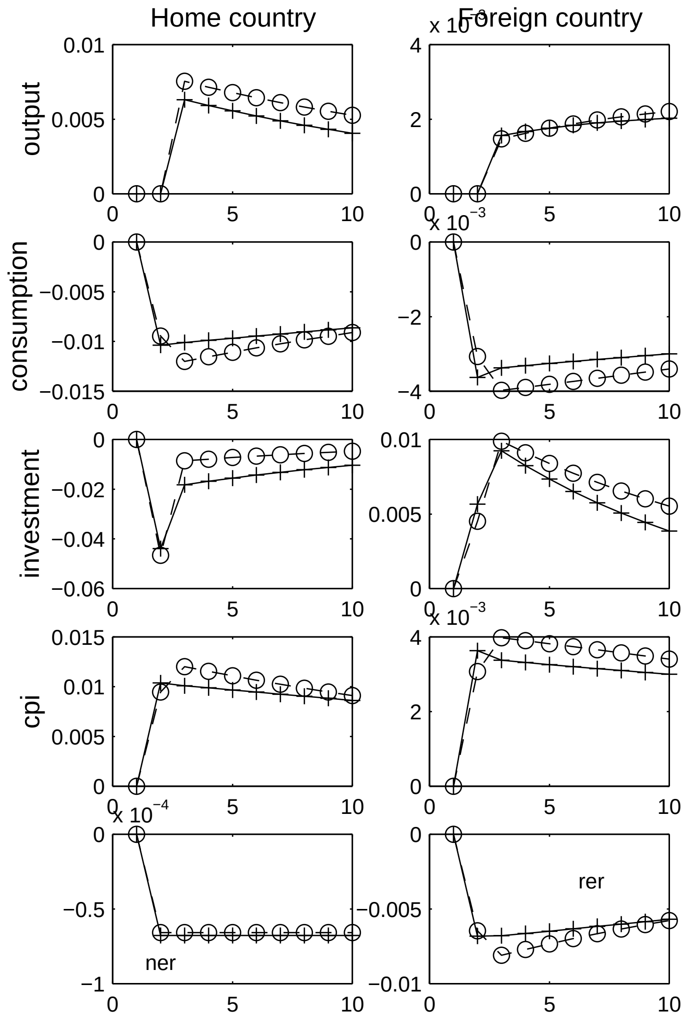
The solid-crossed line refers to the frictionless model and the dash-circled line to the model with financial frictions. All variables are plotted as percentage deviations from their steady state values.

Figure 2: Figure 2: Impulse response functions to a correlated one standard deviation increase in money supply at Home at $t = 2$.



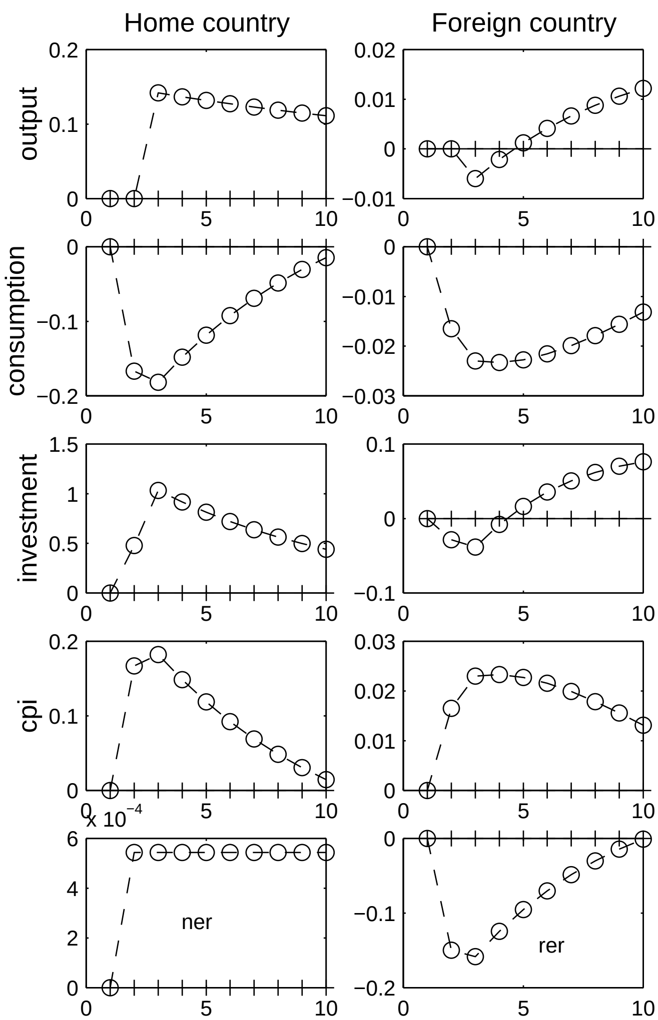
The solid-crossed line refers to the frictionless model and the dash-circled line to the model with financial frictions. All variables are plotted as percentage deviations from their steady state values.

Figure 3: Figure 3: Impulse response functions to a correlated one standard deviation increase in government spending at Home at $t = 2$.



The solid-crossed line refers to the frictionless model and the dash-circled line to the model with financial frictions. All variables are plotted as percentage deviations from their steady state values.

Figure 4: Figure 4: Impulse response functions to a correlated one standard deviation increase in entrepreneurs' net worth at Home at $t = 2$.



The solid-crossed line refers to the frictionless model and the dash-circled line to the model with financial frictions. All variables are plotted as percentage deviations from their steady state values.