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JEL Classification: C78, E44, E51, F41-42, G01, G15
Keywords: matching theory, financial markets, credit rationing, financial multiplier, international transmission, financial crises, open economy macroeconomics

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International Propagation of Financial Shocks in a Search and Matching Environment

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Abstract

This paper develops a two-country multi-frictional model where the freeze on liquidity access to commercial banks in one country raises unemployment rates via credit rationing in both countries. The expenditure-switching channel, whereby asymmetric monetary shocks traditionally lead to negative comovements of home and foreign outputs, is considerably weakened via opposite forces driving the exchange rate. Meanwhile, it is proved that financial market integration forms a transmission channel *per se*, without resorting to international cross-holdings of risky assets. The search and matching modeling serves two purposes. First, it accounts for the time needed to restore a normal level of confidence following financial market disruptions. Second, it allows dissociating pure liquidity contractions from non-walrasian financial shocks, arriving despite global excess savings and due to heterogeneity in the quality of the banking system. The former induce negative comovements of home and foreign outputs, in accordance with the literature, whereas the new type of financial shocks does generate financial contagion.

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1 Introduction

A salient feature of the 2007-2008 crisis is that an economic recession rapidly propagated throughout the developed world although originated by a downturn in specific US financial markets. In particular, most of the Eurozone countries experienced severe GDP falls and unemployment rises despite their flexible exchange rate regime with the dollar and a solvent internal demand that could have made them less vulnerable to external shocks than export-led emerging market economies.

While it is widely agreed that financial shocks transmit across countries within a fixed exchange rate regime or within a monetary union because tying the hands of monetary policy, there is much less theory about similar interactions between major economic areas in a floating exchange rate context. Even more surprisingly, traditional open-economy frameworks such as Obstfeld and Rogoff (1995) generally consider that negative monetary shocks would benefit other countries, since the relative appreciation of the domestic currency resulting from an interest rate rise boosts the exports of these foreign countries. In particular, total demand for foreign goods increases because expenditure-switching effects worldwide outweigh the negative wealth effect in the first country.

However, one may think that this reasoning could not necessarily hold in a more sophisticated setting where opposite forces drive the exchange rate dynamics implied by the shock and where financial frictions may result in a more than proportionate impact on real activity. This leads to investigate a potential *international finance multiplier* phenomenon, according to the term employed by Krugman (2008). Indeed, the recent events suggest the need for a general equilibrium model that can account both for a financial multiplier that magnifies the impact of a credit crunch on domestic real activity and for interaction mechanisms that result in a deteriorated situation in all countries, especially in the ones that did not originate the financial turbulences.

This question has been explored in models that rely on the incompleteness of financial markets in the countries to which crises are transmitted (since Allen and Gale, 2000, notably). More generally, contemporaneous open macro models with financial contagion within a floating exchange rate system assume *complementarity* between domestic and foreign financial assets. The simple intuition is that an unanticipated decline in domestic asset value damages the balance sheets of foreign investors because the latter had previously diversified their portfolio by acquiring domestic financial assets (Krugman, 2008). This is probably accurate when explaining the transmission of financial crises to emerging market economies (Dooley and Hutchison, 2009, Jotikasthira, Lundblad, and Ramadorai, 2009) which acquire US assets to alter the maturity and risk distribution of their holdings. However, no evidence supports this assumption for financial interactions between developed countries. On the contrary, it is more likely that the Eurozone distribution of financial assets is *substitutable* to the US distribution, as pointed out by Dedola and Lombardo (2009) for instance. In this case, the literature puzzle in the floating exchange rate regime remains.

This paper thus develops a two-country multi-frictional model where a new

type of financial shocks freezing the liquidity access to commercial banks in one country raises unemployment rates via credit rationing in both countries. Assuming that credit markets are important to firms, a sudden deterioration in loan opportunities constrains their participation to the labor market, therefore resulting in adverse employment outcomes rather than in a real interest rate surge. Hence, the exchange rate does not necessarily vary in the way predicted by the theory, in turn annihilating the traditional price competitiveness channel mentioned above. Meanwhile, the substitutability of home and foreign financial assets creates financial market integration that helps propagate the crisis by equalizing external finance conditions worldwide.

The search and matching theory is used to depict frictional credit markets in the spirit of Wasmer and Weil (2004). Its application to global financial markets further captures two important aspects here. First, this environment accounts for the fact that, after sudden financial market disruptions, restoring a normal level of confidence takes time, therefore preventing immediate market clearing by international arbitrage from financial investors. Second, it allows to nest the pure liquidity contractions of the literature as a particular case while introducing new non-walrasian financial shocks, called here *confidence shocks* as they arrive despite global excess savings and may reflect increased heterogeneity in the solvency of the banking system. It turns out that the former do not propagate within the flexible exchange rate system, in accordance with the literature, whereas both countries suffer from the latter, as a reduced demand and credit rationing cause unemployment to rise while all nominal advantages generally attributed to the foreign floating-currency country vanish in this second case.

The paper therefore proposes a new type of financial shocks transmitting the domestic downturn abroad, letting room for an international finance multiplier, and consequently fueling a global recession. This result is absent from the current literature on financial contagion as far as large developed economies within a floating exchange rate system are considered, and yet highly reminiscent of the recent crisis. The remainder of this paper is as follows. Section 2 gives the set up of the model and characterizes the domestic equilibrium. Section 3 explores the international relationships and the subsequent spillovers of country-specific financial shocks. In particular, it emphasizes the differentiated impact of confidence shocks *versus* liquidity supply shocks. Section 4 discusses the contribution vis-a-vis the existing literature, and Section 5 concludes.

2 Set-up of the model and domestic equilibrium

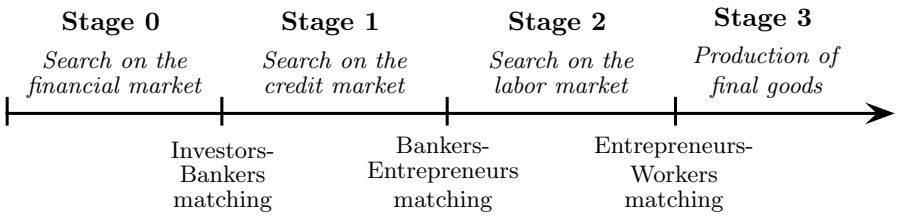
2.1 A sequential search and matching process

Each of the two economies produces one output and is composed of four types of infinitely-lived agents: financial investors, commercial banks, entrepreneurs, and workers. These agents interact in three (potentially) frictional markets: the financial market, the credit market and the labor market. For simplicity, all agents are risk-neutral and have the same discount rate, r. I assume a sequential

multi-bargaining process, with the timing of events given in Figure 1.

In stage 0, commercial banks look for investors in the financial market in order to raise funds before lending to entrepreneurs. Financiers are endowed with capital but are assumed to have not the competence to generate long-term investment opportunities. This category can encompass very different actors such as investment banks, hedge funds, foreign sovereign funds, but also the Central Bank via *quantitative easing*. On the other hand, I assume that commercial banks need capital in this stage of the process. That seems to be particularly realistic in periods when banks have already steep leverage ratios and hence have to find buyers to their outstanding debt before conceding new loans. One should note that these matches can however been made at infinitely high rates if investment and commercial banking activities are integrated.

Figure 1: Timing of Events



In stage 1, bankers look for a profitable loan opportunity among entrepreneurs who seek a credit to create a firm. Wasmer and Weil (2004) constructed a model in which such a credit market stage precedes a labor market stage, leading to a situation where frictions on both markets reinforce one another. Following them, I assume that entrepreneurs have no proper wealth *ex ante* and must find a credit before entering the worker recruitment stage. Acemoglu (2001) indeed argues that credit market frictions significantly constrain job creation for new firms, especially in Europe. Moreover, credit dependence of firms may be particularly relevant when a deep financial shock prevents even large firms from issuing equities as a perfectly substitutable fund-raising means.[1] In stage 2, entrepreneurs and workers look for each other in a usual search and matching approach. Finally, in stage 3, the newly created firm produces and pays back the banker who in turn pays for the former investor's services.

Considering capital transactions (stage 0) as the beginning of the sequential process allows representing limited access to liquidity for financial intermediaries.[2] A recent empirical contribution by Hale and Santos (2010) shows, first, that even US banks that do not rely on the bond market to fund their activities (but exclusively on deposits) have become exposed to the conditions in the

[1] Campello, Graham and Harvey (2010) found that 86% of constrained US firms declared having restrained, canceled or postponed planned investment in attractive projects during the crisis of 2008, and so did almost half of unconstrained firms; even stronger results in Europe.

[2] As funds only come from financial operations in this model, we can equally call them *liquidities* from the standpoint of the banker; however modeling the investor-banker relationship make them closer to long-term assets on a frictional financial market here.

bond market, and second, that banks pass debt market shocks to all their borrowers, whether these borrowers have themselves access to the bond market or not. This suggests that a rarefaction of liquidity holders willing to finance long-term projects may have harmful consequences for real activity through credit rationing, even in a world where all agents do not depend on external finance to fund their business and where banks can discriminate the creditworthiness of entrepreneurs addressing them for a loan. The present paper studies real effects induced by a shock freezing these financial relationships, with a significant rise of external capitalization cost to banks stemming from the inability of potential investors to assess their solvency. If the process would have started at the so-called stage 1, simulating a shock to an exogenous liquidity access of commercial banks would be of the same kind than a traditional monetary restriction by the Central Bank and lead to the counterintuitive results mentioned earlier.

Market quantities within each of the non real production stages — financial funds, credit, employment — are therefore determined as a flow of matches between both sides of the relevant market. In a standard way (*à la* Mortensen and Pissarides, 1994), the labor market is characterized by a finite number N_U of unemployed workers looking for a job and a finite number N_V of firms opening job vacancies. A constant returns-to-scale matching function $m_L(N_U, N_V)$ determines the flow of new firms, *i.e.* new contracts between one entrepreneur and one worker. The relative mass of vacancies to unemployed workers defines the *labor market tightness* $\theta \equiv N_V/N_U$ from which are inferred the instantaneous probabilities $q_L(\theta) = m_L(N_U, N_V)/N_V$ for an entrepreneur to find a suitable worker and $\theta q_L(\theta) = m_L(N_U, N_V)/N_U$ for a worker to find a job.

A recent literature represents the credit market similarly, arguing that information asymmetries between borrowers and lenders make the creation of new credit relationships time- and effort-consuming. As a consequence, there are some bankers screening for credit applications while a pool of unmatched entrepreneurs is waiting for a loan in each period. At a macro level, this corresponds to a situation of credit rationing as in Stiglitz and Weiss (1981). Dell'Ariccia and Garibaldi (2005) and Craig and Haubrich (2006) have supported this representation of credit markets by providing evidence of a departure of gross from net credit flows persisting over time, that is, coexistent credit creation and credit destruction flows. Therefore, I consider that the ratio of a mass N_E of entrepreneurs looking for a bank to a mass N_C of bankers searching for a desirable loan opportunity measures the *credit market tightness*, denoted ϕ. A constant returns-to-scale technology, $m_C(N_E, N_C)$, increasing in both arguments, then determines the instantaneous probabilities $q_C(\phi) = m_C(N_E, N_C)/N_E$ for an entrepreneur to obtain a loan and $\phi q_C(\phi) = m_C(N_E, N_C)/N_C$ for a banker to find a real investment opportunity.

Finally, I construct financial market relationships similarly here. This does not preclude the case where financial markets are perfectly efficient but simultaneously allows for the representation of non-walrasian shocks, *i.e.* shocks freezing financial activities by creating frictions that cannot be immediately cleared by capital return adjustments. Moreover, this modeling accounts for the time that elapses between the shock arrival and the restoration of a confidence level

compatible with a normal functioning of financial markets, given heterogeneity and information asymmetries among participants. Therefore, I suppose that there are N_I financiers seeking investment opportunities and N_B commercial banks looking for capital in each period. Their ratio defines a comparable measure of the *financial market tightness*, $\xi \equiv N_B/N_I$. Total flows are then derived from a similar matching function $m_F(N_I, N_B)$, which specifies the Poisson time-varying arrival rates $q_F(\xi) = m_F(N_I, N_B)/N_B$ at which a banker raises funds on the financial market and $\xi q_F(\xi) = m_F(N_I, N_B)/N_I$ at which an investor meets a suitable banker. In each market, the matching rate decreases in the tightness on the demand side ($\partial q_L(\theta)/\partial\theta, \partial q_C(\phi)/\partial\phi$, and $\partial q_F(\xi)/\partial\xi < 0$), while the reverse holds on the supply side ($\partial\theta q_L(\theta)/\partial\theta, \partial\phi q_C(\phi)/\partial\phi$, and $\partial\xi q_F(\xi)/\partial\xi > 0$).

2.2 Individual behaviors

Hereafter are the equilibrium conditions for entrepreneurs, bankers, and financial investors resulting from this sequential process, given their proper constraints and search activities; proofs are given in Appendix. The setup is such that it is possible to abstract from the equilibrium condition of workers in the labor market without loss of generality, since I assume that unemployed workers accept the job when they encounter a vacancy as long as the wage is sufficiently high to allow for consumption, given the goods prices, the discount rate and the separation rate, *i.e.* when $(w/P)/(r + s) > 0$. The intuition lies in the fact that during financial crises the prime concern is involuntary unemployment associated with credit constraints whatever the labor supply in normal times. Michaillat (2010) recently found that unemployment is mostly explained by frictions on the labor market when the rate is near to 5% in the US but that this frictional part falls to less than 2% when the rate goes to 9%, so that the cyclical component is the quasi-exclusive source of unemployment in bad times.

2.2.1 Entrepreneurs

The entrepreneurs enter the process in stage 1 since it is assumed that they have productive ideas but not the necessary wealth to start the recruitment stage on their own, and therefore depend on the credit market to finance the costs of the labor recruitment stage. Searching for a loan involves a non-pecuniary flow cost (effort cost), denoted c_E. Once matched with a banker with probability $q_C(\phi)$, an entrepreneur starts looking for a suitable worker in stage 2. This implies a recruitment flow cost γ_L but not directly borne by entrepreneurs as exactly offset by the amount borrowed from the bank in the previous stage. In stage 3, the one entrepreneur-one worker constituted firm produces one unit of output, sold at price p which is taken as given by the individual firm. After paying for the worker's wage w, a part ρ_C of the net profit is used to reimburse the banker. I assume that the wage rate is exogenous without loss of generality here, whereas the determination of the repayment rate is discussed further below.

Entrepreneurs optimally decide whether to start looking for a loan in order to launch a business if their present-discounted expected cash flows in the pro-

duction stage exceed their present-discounted expected costs while searching for the loan, given the riskfree rate r and the conditional transition probabilities determining the expected duration of each stage (q_C, q_L, and s). Free entry implies that total costs and gains are exactly equalized at equilibrium (zero-profit condition), thus giving entrepreneurs' equilibrium condition as

$$\frac{c_E}{q_C(\phi)} = \frac{q_L(\theta)}{r + q_L(\theta)} \frac{p - w - \rho_C}{r + s} \tag{1}$$

(recursive profit-maximizing problem in Appendix). On the left hand side is the periodic search cost c_E times the average duration of the credit search stage $1/q_C(\phi)$. On the right hand side are the instantaneous profits in stage 3 $(p - w - \rho_C)$ discounted by the riskfree rate r, the firm separation rate s, and the average recruitment duration that depends on the labor market tightness θ.

2.2.2 Bankers

Commercial banks enter the process one stage earlier since they have to raise funds before lending to entrepreneurs. Let denote c_B the periodic non-pecuniary search cost borne in stage 0 while looking for an investor with excess savings, and which may stand for the effort made by the bank to gather proofs of its solvency to this investor for instance. If the match is concluded, the investor provides the banker with the required capital while searching for a suitable entrepreneur (flow cost γ_C) and the amount that will be lent to this entrepreneur. During the production stage 3, bankers receive ρ_C from entrepreneurs, from which is extracted an instantaneous payout to the investor, at (endogenous) rate ρ_F. Hence a similar equilibrium condition from bankers' free entry is

$$\frac{c_B}{q_F(\xi)} = \frac{\phi q_C(\phi)}{r + \phi q_C(\phi)} \frac{q_L(\theta)}{r + q_L(\theta)} \frac{\rho_C - \rho_F}{r + s} \tag{2}$$

On the left hand side, expected costs of raising funds for bankers depend on the financial market tightness ξ which gives the expected duration of stage 0. On the right hand side, bankers' output share $(\rho_C - \rho_F)$ is discounted by the respective duration of the credit and labor search stages.

2.2.3 Financial investors

Similarly, investors pay a non pecuniary search cost c_I per period in stage 0, while searching for a banker they consider able to turn their idle savings into a profitable long term investment opportunity. When the financial market is such that the instantaneous matching rates of investors and bankers are infinitely high, this parameter simply drives the liquidity injection in the economy. In stages 1 and 2, the investors bear the costs γ_C and γ_L while banks are screening credit applications and while entrepreneurs are recruiting. In the production stage 3, they earn ρ_F in each period. Finally, they return to stage 0 if a separation comes up on the labor market. Investors' equilibrium condition is thus

$$\frac{c_I}{\xi q_F(\xi)} = \frac{-\gamma_C}{r+\phi q_C(\phi)} + \frac{\phi q_C(\phi)}{r+\phi q_C(\phi)} \left\{ \frac{-\gamma_L}{r+q_L(\theta)} + \frac{q_L(\theta)}{r+q_L(\theta)} \frac{\rho_F}{r+s} \right\} \tag{3}$$

Forward-looking investors' willingness to enter the sequential process depends on the costs induced by search activities (γ_C and γ_L times the respective expected search durations) and the present-discounted output share ρ_F in stage 3.

2.3 Surplus sharing

The two successive rates that drive the surplus sharing between entrepreneurs, bankers, and investors, ρ_C and ρ_F, are determined by Nash bargaining rules (Pissarides, 2000). The loan repayment rate ρ_C from the firm to the banker thus maximizes the value of the match between the banker and the entrepreneur

$$\rho_C = \arg\max (B_2 - B_1)^{\delta_C} (E_2 - E_1)^{(1-\delta_C)}$$

where B_1 and B_2 (respectively E_1 and E_2) are the values of bankers (resp. entrepreneurs) in stages 1 and 2, and where δ_C (resp. $1-\delta_C$) is the exogenous bargaining power of bankers (resp. entrepreneurs) in the credit market. Similarly, the flow ρ_F from bankers to investors is given by

$$\rho_F = \arg\max (I_1 - I_0)^{\delta_F} (B_1 - B_0)^{(1-\delta_F)}$$

where I_0 and I_1 are the values of investors in stages 0 and 1, and where δ_F is the bargaining power of investors in the financial market.

2.4 Domestic equilibrium

The two precedent Nash bargaining rules recursively give the equilibrium value of the tightness on each of the three frictional markets. First, the rule for ρ_F, together with zero-profit conditions for financial investors and bankers ($I_0 = 0$ and $B_0 = 0$), determines the equilibrium financial market tightness $\bar{\xi}$ as

$$\bar{\xi} = \frac{1-\delta_F}{\delta_F} \frac{c_I}{c_B} \tag{4}$$

(see Appendix for details). In equilibrium, the financial tightness thus depends on the relative flow costs: the higher is c_I, *i.e.* the costlier it is for an investor to find a commercial bank *ceteris paribus*, the less likely the former is to enter the financial market, and therefore the tighter is the market as the relative number of bankers to investors willing to trade N_B/N_I increases. The same reasoning holds for the respective bargaining powers δ_F of investors and $(1-\delta_F)$ of bankers, with relatively more bankers willing to participate to the financial market — a higher tightness — when $(1-\delta_F)$ is high. This simple result for $\bar{\xi}$ will be proved of particular importance in the international spillovers of shocks later on.

Recursively, the Nash rule for ρ_C together with the free-entry condition for entrepreneurs ($E_1 = 0$) gives the equilibrium credit market tightness $\bar{\phi}$ as

$$\bar{\phi} = \frac{1-\delta_C}{\delta_C} r \frac{c_B}{c_E} \frac{1}{q_F(\bar{\xi})} \tag{5}$$

This expression similarly says that the relative number of entrepreneurs to bankers is higher when entrepreneurs' bargaining power in the loan market is higher. On the contrary, when bankers' liquidity access is easy (high $q_F(\xi)$), numerous loan opportunities are provided to entrepreneurs, thus slackening the credit market tightness. Moreover, while $\bar{\phi}$ does not directly increase in bankers' application screening costs γ_C which are supported by the financial investor, it increases in bankers' previous costs c_B to find this former financier. Finally, for $r = 0$, all potential bankers would be willing to finance an entrepreneur whatever the matching probabilities, consequently driving the market tightness $\bar{\phi}$ to zero, whereas with $r > 0$ a banker decides to enter the credit market if the time spent in stages 1 and 2 is valuable enough to outweigh the discounting effect of the riskfree rate given that search activity is costly.

Finally, the steady-state unemployment rate $\bar{u}$ equalizes flows into unemployment $s(1-u)$ and flows out of unemployment $\theta q_L(\theta) u$, that is

$$\bar{u} = \frac{s}{\theta\, q_L(\theta) + s} \tag{6}$$

The recursive system of equations (1)–(6) in six unknowns $\{\theta,\ \phi,\ \xi,\ \rho_C,\ \rho_F,\ u\}$ characterizes the closed economy. In particular, replacing $\bar{\xi}$ (4) and $\bar{\phi}$ (5) in (1)–(3) simultaneously gives the equilibrium repayment rates $\bar{\rho}_C$ and $\bar{\rho}_F$, as well as the equilibrium labor market tightness $\bar{\theta}$ via the following expression

$$\Big(\frac{c_B}{q_F(\bar{\xi})} + \frac{c_I}{\bar{\xi} q_F(\bar{\xi})} + \frac{\gamma_C}{r + \bar{\phi} q_C(\bar{\phi})}\Big) \frac{r + \bar{\phi} q_C(\bar{\phi})}{\bar{\phi} q_C(\bar{\phi})} + \frac{c_E}{q_C(\bar{\phi})} = \frac{q_L(\theta)}{r + q_L(\theta)} \frac{p-w}{r+s} - \frac{\gamma_L}{r + q_L(\theta)} \tag{7}$$

from which the steady-state unemployment rate $\bar{u}$ is finally determined by (6).

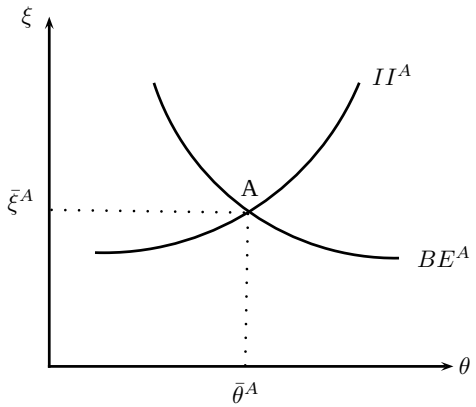
This equilibrium is depicted in the space formed by the labor market tightness θ and the financial market tightness ξ in Figure 2. I could have equally chosen the (θ,ϕ) or the (ϕ,ξ) spaces, but the (θ,ξ) space will be the most interesting for the comparative static analysis of financial shocks in the next Section. In order to represent the three representative agents (entrepreneurs, bankers, and investors) in this two-dimensional space, equations (1) and (2) are put together via the equalization of ρ_C to obtain a joint equilibrium condition for bankers and entrepreneurs (constrained agents) as follows

$$\Big(\frac{c_B}{q_F(\xi)} \frac{r + \phi q_C(\phi)}{\phi q_C(\phi)} + \frac{c_E}{q_C(\phi)}\Big) \frac{r + q_L(\theta)}{q_L(\theta)} = \frac{p - w - \rho_F}{r+s} \qquad \text{(BE)}$$

This expression is the downward-sloping curve BE in Figure 2. A high ξ corresponds to a high demand for funds from commercial banks relatively to the available financial market supply. Therefore, at a given equilibrium credit mar-

ket tightness $\bar{\phi}$, the tighter the labor market, the slacker the capital access must be to remain on the same banker-entrepreneur's joint condition. Conversely a relatively short duration of stage 2 while looking for a suitable worker can offset longer durations of the fund-raising stages. The upward-sloping II curve in Figure 2 stands for the financial investors' condition (3), which states that a tight financial market is required when the labor tightness θ is high. A large ξ increases investors' instantaneous probability of matching with a suitable banker, thus reducing the expected duration of search in the financial market, in order to outweigh the fact that stage 2 is time-consuming (θ is high), all other things equal.[3] The intersection between BE and II represents the initial aggregate equilibrium A of the closed economy, which satisfies $\{\bar{\theta}, \bar{\phi}, \bar{\xi}, \bar{\rho}_C, \bar{\rho}_F, \bar{u}\}$.

Figure 2: Initial equilibrium



After incorporating some additional mechanisms arising with the openness of the economy, next Section will therefore study the impact of two types of shocks that may come up in the financial market of these stylized economies:

- a shock to c_I — the parameter driving liquidity injection in the economy everything else equal —, interpreted as a *liquidity supply shock*. Its effects are comparable to a *monetary shock* though in the presence of financial accelerators that let room for credit rationing (and thus already different from a *traditional* monetary shock).

- a shock to c_B, which hinders financial relationships but arrives despite excess savings in the economy, and is thus interpreted as a *confidence shock*. It may be due to an exogenous change in the degree of heterogeneity among bankers — or a change in the degree of information asymmetry about bankers' characteristics at the expense of liquidity holders.

[3] In particular, a higher financial market tightness always means a higher bank-matching probability for investors in equilibrium assuming that the level of information asymmetry about the participants' creditworthiness is unaltered on average in the long run.

3 International Spillovers of Financial Shocks

3.1 International relationships and aggregate constraints

Consumption goods are assumed to be fully internationally mobile. Each economy is specialized in the production of one good, even though home and foreign goods can be perfectly substitutable for consumers without changing the model predictions. Each firm produces one unit of the good corresponding to its location every period during stage 3. The entrepreneur now chooses the respective parts of his output that will be sold at home and exported in addition to his search entry decision (1), according to the exchange rate and the competitively determined prices $p_{i_{h,t}}$ and $p_{i_{f,t}}$ of his good i $(i = h, f)$ in country j $(j = h, f)$ at time t, where h and f stands for Home and Foreign henceforth.

Neither the entrepreneurs nor the workers are mobile here. The country-specificity of entrepreneurs can be justified by the inertia in the production relocating decisions following unexpected financial shocks. In fact, entrepreneurs could migrate to the foreign country conditional on paying for sunk costs — due to a change in their production specialization for example — without changing the model predictions but I do not make this outside option explicit here for simplicity. Workers, whether employed or not, are supposed immobile since observed labor mobility between large economic areas within the floating exchange rate world — think of US and EU — is very limited as compared to labor mobility between countries within each of these areas. This allows to abstract from a comparable outside option for workers, and to normalize to one each national working population in order to compare variations in unemployment rates.

As regards commercial bankers, the fact that they lend an indivisible unit of final credit to small and local entrepreneurs also makes them primarily local because once a banker has contracted with an entrepreneur he *de facto* belongs to the same country. Formally, no direct outside option abroad is made explicit here but the number of potential banks in one country has not to be fixed *ex ante*, so that a generalization with initial free entry and free exit worldwide is possible. Theoretical and empirical literatures have widely documented that geographical distance between lenders and (potential) borrowers indeed affect loan decisions. Degryse, Cerqueiro and Ongena (2007) and Agarwal and Hauswald (2008) recently summarized the two mechanisms through which distance matters. On the one hand, transportation costs hinder matching between remote credit market participants: a potential borrower has to spend time and effort to personally interact with loan officers or to look for a suitable loan (because of product differentiation) while banks endure costs in assessing loan applicants or in monitoring loans that both increase with physical distance (Sussman and Zeira, 1995). On the other hand banks' capacity to collect critical information about expected returns and probabilities of default of potential borrowers is enhanced by proximity, thus encouraging banks to concentrate on a limited geographical area to benefit from the monopoly power created by this informational advantage (Hauswald and Marquez, 2006). This results in spatial price discrimination and geographical credit rationing that have been empirically supported

at a micro level (Degryse and Ongena, 2005; Agarwal and Hauswald, 2008) and within a medium size country (Casolaro and Mistrulli, 2008). Although the generalization at an international level would require a specific analysis, two intuitions support it in the present setting. First, if transaction costs and informational advantages are decisive channels in very limited areas, they are probably deeper between major areas because additional differences, in regulation for instance, are likely to prevent from collecting private information or detecting credit delinquency. Second, both banks and firms are small ones and new ones (think of a particular bank agency), two major characteristics for which the aforementioned channels are particularly strong in this literature.

Finally, financial capital is on the contrary perfectly mobile across countries. The investors holding it therefore need not to be assigned a particular citizenship *ex ante*, and are free to enter the financial search stage in the country where their intertemporal value, denoted I, is the highest, given the search costs, the production prices, and the separation rate. Therefore, at equilibrium, it must be that $\bar{I}_j = \bar{I}$ for all countries j ($j = h, f$). This implies that if a shock arrives investors will choose to relocate their assets in the country where their matching rate with a commercial bank is the highest, *i.e.* where the financial market is the tightest (since $\partial \xi q_F(\xi)/\partial \xi > 0$), *ceteris paribus*. Equilibrium is thus characterized by a unique financial tightness at the world level, that is an integrated financial market with external finance conditions equalized worldwide.

Given these international relationships, the balance of payments and the subsequent expression for the exchange rate are set up. The current account of the home country expressed in domestic currency is standardly written as

$$CA_t \equiv C_{h_{f,t}} S_t \, p_{h_{f,t}} - C_{f_{h,t}} p_{f_{h,t}}$$

where $C_{i_{j,t}}$ denotes the level of consumption of good i in country j at time t, and where S is the nominal floating exchange rate defined as the price of the domestic currency in terms of the foreign currency. The law of one price is assumed to always hold, such that the price of the each good at home depends on its price abroad times the exchange rate: $p_{h_{h,t}} = S_t \, p_{h_{f,t}}$ and $p_{f_{h,t}} = S_t \, p_{f_{f,t}}$.

As financial investors already matched with a banker cannot immediately withdraw their invested capital when shocks arise, the definition of the financial account comes down to the inter-country difference in new investor-banker relationships, *i.e.* the difference of financial match flows at home and abroad

$$FA_t \equiv m_F(N_{I_t}, N_{B_{h,t}}) - m_F(N_{I_t}, N_{B_{f,t}})$$

Re-expressed in terms of matching rates (by definition, $\xi_i q_F(\xi_i) \equiv \frac{m_F(N_I, N_{B_i})}{N_I}$), it highlights the importance of the inter-country financial market tightness differential in driving international capital flows

$$FA_t = N_{I_t} \xi_{h,t} q_F(\xi_{h,t}) - N_{I_t} \xi_{f,t} q_F(\xi_{f,t})$$

It is noteworthy that, even if financial flows are driven by the financial tightness differential, the dynamics however will not necessarily lead unmatched investors

to immediately pour their savings into the foreign market following a shock at home. In fact, even if they are allowed to do so, general equilibrium effects will also imply a rarefaction of suitable bankers in the foreign country, and therefore similar movements of the financial tightness abroad. In particular, scarcity of real business opportunities and internal credit frictions will also be at play in the foreign economy, with an overall amplification stemming from the inertia in financial relationships before a normal level of confidence is restored.

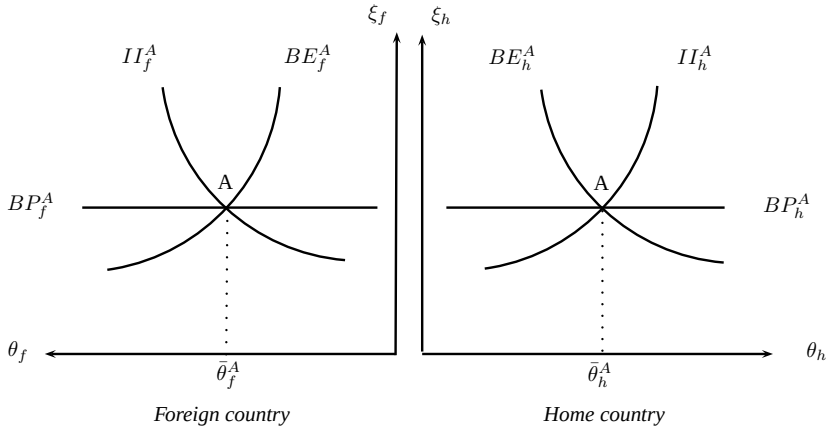
The balance of payments identity $CA + FA \equiv 0$ finally gives the expression for the exchange rate as follows, with time subscripts dropped

$$S = \frac{p_{f_h} C_{f_h} - N_I \xi_h q_F(\xi_h) + N_I \xi_f q_F(\xi_f)}{p_{h_f} C_{h_f}} \tag{8}$$

Unsurprisingly, the domestic currency appreciates (S decreases) with exports and relative financial opportunities to capital holders in the home country, while it depreciates with imports and relative financial advantages abroad.

The general equilibrium in the two-country case is now determined by adding to the previous symmetric set of unknowns for both countries $\{\theta_h,\ \theta_f,\ \phi_h,\ \phi_f,\ \xi_h,\ \xi_f,\ \rho_{C_h},\ \rho_{C_f},\ \rho_{F_h},\ \rho_{F_f},\ u_h,\ u_f\}$ the consumption levels $\{C_{h_h}, C_{f_h}, C_{h_f}, C_{f_f}\}$, prices $\{p_{h_h}, p_{f_h}, p_{h_f}, p_{f_f}\}$, and the exchange rate $\{S\}$. Two first order conditions from consumers' optimization problem, the two laws of one price, two aggregate constraints on goods, and each country's resource constraint are added (standard equations relegated in Appendix), as well as the balance of payments (8).

Figure 3: International equilibrium



This equilibrium is depicted as point A in Figure 3. It includes symmetric internal equilibria of frictional markets as described in Section 2, with the previous banker-entrepreneur BE and investor II equilibrium conditions, in the (θ,ξ) space for each country, Home and Foreign. This point also stands for the external equilibrium whereby the financial tightness is equalized worldwide. The balance of payments BP horizontal line depicts this perfect financial market

integration through which capital flows take advantage of all opportunities.[4]

Subsections 3.2 and 3.3 respectively study the qualitative impact of each type of domestic financial shocks on both the domestic and the foreign labor markets characterized in point A. The analytical results will be completed with comparative statics that remind the traditional IS-LM-BP picture in the representation of real-financial interactions, while being supported here by the microfoundations of the search and matching approach.

3.2 Effect of liquidity supply shocks

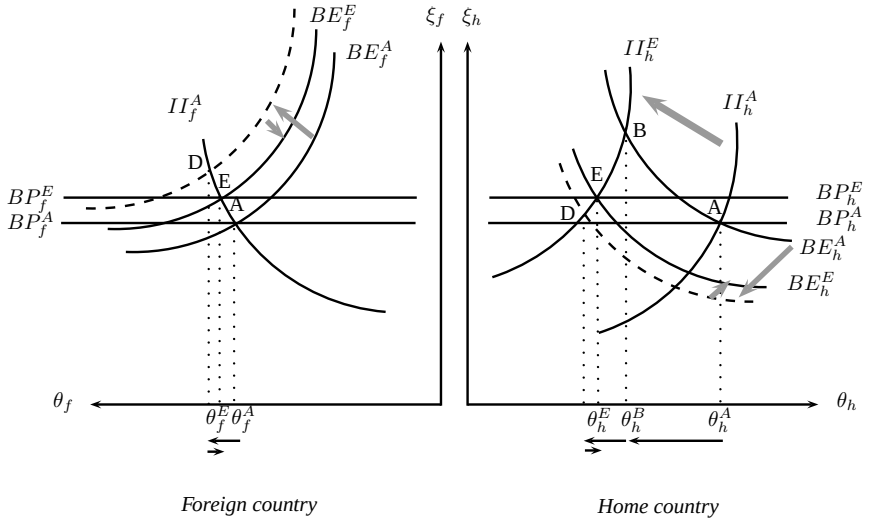
Let first consider a shock to the liquidity injection parameter c_I in Figure 4. A domestic increase in c_I displaces the liquidity holders' equilibrium condition II_h^A leftwards, from point A to point B at home. This is associated with a large relative appreciation of the domestic currency, which further causes a price-competitiveness recession in the home country (point D). Meanwhile, the symmetric depreciation abroad boosts the economic activity in the second country. The reduced demand in the first country subsequently generates negative second-round effects abroad but not large enough to be detrimental to the foreigners, since the economy *in fine* stabilizes at the general equilibrium where home and foreign financial market tightnesses are equalized, that is at point E.

A financial multiplier here magnifies the impact of the rarefaction of liquidity holders via longer fund-raising stage durations for credit intermediaries. However, one should note that the international transmission channels do not qualitatively differ from the literature even in the presence of a financial multiplier because the solvency of commercial banks was not the source of the shock. The spillover effect of pure liquidity supply shocks is therefore similar to the one of traditional monetary shocks, that is negative co-movements between home and foreign outputs.

The search and matching framework allows to corroborate these comparative statics by simple analytical results. First, let define the elasticities of the matching functions at equilibrium as $\eta_L \equiv -q_L'(\bar{\theta})\bar{\theta}/q_L(\bar{\theta})$ (labor market), $\eta_C \equiv -q_C'(\bar{\phi})\bar{\phi}/q_C(\bar{\phi})$ (credit market), and $\eta_F \equiv -q_F'(\bar{\xi})\bar{\xi}/q_F(\bar{\xi})$ (financial market), with $\eta_L, \eta_C, \eta_F \in (0,1)$. Then, loglinearizing the expressions for $\bar{\xi}$, $\bar{\phi}$, and $\bar{\theta}$ around the two-country equilibrium (see Appendix) using the last notations gives the analytical impacts of asymmetric liquidity supply shocks summarized in Table 1. A hatted variable denotes the loglinear deviation from its steady-state value ($\hat{x} = \frac{x-\bar{x}}{\bar{x}}$), and each particular cell in Table 1 indicates the elasticity of the (loglinearized) market tightness relatively to the shock, *i.e.* the value of $\partial\hat{\xi}_h/\partial\hat{c}_{I_h}$ in the northwestern cell for instance.

[4]The perfect international mobility of financial investors assumed here for analytical and graphical simplicity ensures that financial market tightnesses, ξ_h and ξ_f, are instantaneously equalized between countries. If BP were not perfectly horizontal but slightly upward-sloping, this would not affect the qualitative conclusion even if it may quantitatively reduce the financial transmission. In another setting where financial investors would be strongly immobile, portfolio composition effects would substitute to ensure capital mobility, producing similar contagion effects though via different channels (Krugman, 2008, Dedola and Lombardo, 2010).

Figure 4: Effect of a domestic liquidity supply shock at home and abroad



The first two rows present intuitive results. A negative domestic liquidity supply shock (a rise in c_{I_h}) tightens the *financial* market (row 1) via a negative wealth effect. As financiers are internationally mobile, the same effect is obtained worldwide. The *credit* market also tightens in both countries (row 2) because less capitalized banks are able to finance a given mass of entrepreneurs, hence ϕ rises. However, the literature puzzle appears here as the home and foreign *labor* markets present opposite responses to the shock in row 3 (assuming that the elasticity in the southwestern cell is negative, see Appendix for details). Further loglinearization of (6) makes clear that unemployment decreases in the labor market tightness in a given country, as

$$\hat{u} \approx -(1-\eta_L)(1-\bar{u})\hat{\theta}$$

while output increases in the labor market tightness since output is proportional in employment in each country. Therefore, the unemployment rate increases in the country where the negative liquidity supply shock arrives but decreases abroad. Note that the magnitude of the effect does not depend on the consumer preference parameters and thus even a strong national consumption bias does not question the present transmission channels.

There is a striking paradox in the fact that these results are in line with the literature but counterintuitive as regards the recent financial crisis since they predict that an expansion prevails in the foreign economic area when a recession hits the first area within a flexible exchange rate system. This is simply the reverse case of an expansive 'beggar-thy-neighbor' monetary policy or competitive devaluations by which short-term booms are expected at the expense

Table 1: Elasticity to asymmetric liquidity supply shocks at home and abroad

Tightness	**Home country**	**Foreign country**
$\hat{\xi}$	1	1
$\hat{\phi}$	η_F	η_F
$\hat{\theta}$	$\frac{q_L(\bar{\theta})}{\gamma_L \eta_L}\Big\{ - \frac{\bar{c}_{B_h}\eta_F}{q_F(\bar{\xi}_h)} - \frac{\bar{c}_{I_h}\eta_F}{\bar{\xi}_h q_F(\bar{\xi}_h)} - \frac{\bar{c}_{E_h}\eta_C\eta_F}{q_C(\bar{\phi}_h)} + \frac{\gamma_C(1-\eta_C)\eta_F}{\bar{\phi}_h q_C(\bar{\phi}_h)} - (1-\bar{N}_I)(1-\eta_F)\Big\}$	$\frac{q_L(\bar{\theta})}{\gamma_L \eta_L}(1-\bar{N}_I)(1-\eta_F)$

of trading partners in the literature. As far as monetary shocks are concerned in open DSGE models, the early Mundell-Fleming negative comovements of home and foreign outputs are confirmed, and thus no international financial contagion can emerge without resorting either to fixed exchange rates or to financial market incompleteness (financial asset complementarity) when neither can hold for developed-country interactions. Note again that the standard results are confirmed here despite the presence of financial multiplier mechanisms. This potentially explains why the literature on international contagion within a floating exchange rate system has not integrated more sophisticated financial channels, or on the contrary, why the credit constraints literature has focused on closed economy or monetary union settings. The present setup confirms that incorporating financial multipliers into existing models is not sufficient to account for positive output comovements as long as liquidity shocks are concerned.

3.3 Effect of confidence shocks

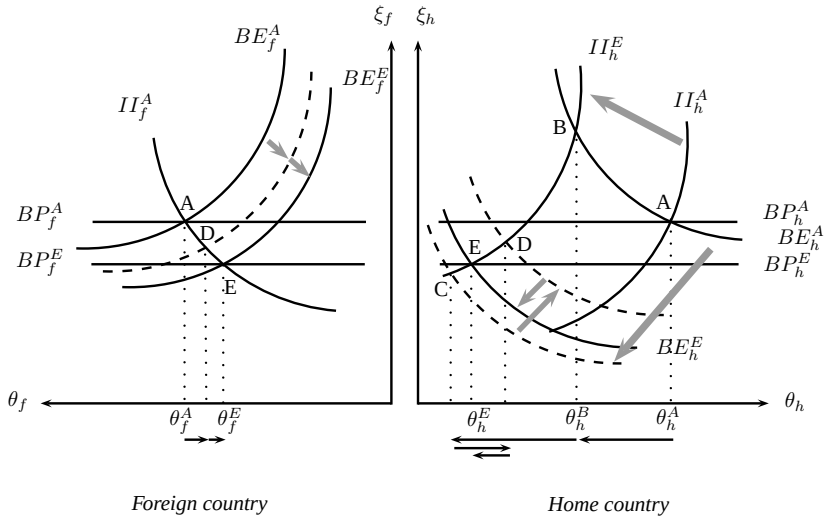
In order to let room for international transmission of financial shocks, the present paper argues for considering financial shocks of a different nature, departing from the walrasian perspective in the sense that they prevent interest rate movements to immediately clear the market: let call them *confidence* shocks. Hence, let now consider in Figure 5 a shock to the search cost c_B of banks in the fund-raising stage. One can imagine that bank capitalization is suddenly costlier because higher (real or perceived) heterogeneity in the banking sector requires either that banks make a sustained effort to gather the proofs of their creditworthiness to investors and/or that they bear a higher opportunity cost in the climate of mistrust due to prohibitive information asymmetry to investors.

Graphically, this shock to c_B simultaneously shifts the BE_h and the II_h curves to the left. Zero-profit conditions directly imply that the number of banks willing to enter decreases with a higher liquidity search cost c_B, and so does the number of credit-constrained entrepreneurs. The number of investors also contracts because it becomes indirectly more difficult to find a suitable banker. Let suppose for the moment that the entry condition of investors is less affected by the deteriorated matching with bankers than the one of bankers directly is through the shock (added to the one of entrepreneurs which is subsequently affected through credit rationing). Then the displacement of the BE_h^A curve to

BE_h^C is larger than the one of the II_h^A curve to II_h^E, thus driving to point C where the domestic currency slightly tends to depreciate.

This exchange rate movement creates potential export opportunities for the rare but yet newly created firms — resulting from entrepreneurs' successful match with the remaining banks in the home country —, displacing BE_h^C to BE_h^D. Meanwhile, the relative appreciation of the foreign currency induced by the financial distrust on domestic banks, combined with the domestic recession, damages the situation of foreign entrepreneurs by narrowing their export possibilities (BE_f^D). The situation is then aggravated abroad by the fact that global investors choose not to pour their savings into the foreign economy, even if the match with commercial bankers would comparatively be easier, because of weakest business opportunities magnified by internal credit frictions. The foreign country is therefore kept away from new leverage facilities. It results that the deteriorated foreign labor market (in BE_f^E) in turn worsens the situation of the first country by restraining international trade opportunities despite the positive exchange rate fluctuation at home. These negative second-round effects finally lead to the internal-external equilibrium E in Figure 5.

Figure 5: Effect of a domestic confidence shock at home and abroad



Three lessons can be drawn. First, the domestic labor market tightness is far lower from its initial level (θ_h^A), and therefore the domestic unemployment rate far higher. Investors' decision to exit the financial market when banking heterogeneity rises in turn forces more banks to exit the market because the rarefaction of funds adds to the fact that their search for funds was already costlier. This effect is itself passed on entrepreneurs — whatever their productivity level — and the three frictions reinforce one another creating internal financial accelerator mechanisms in the home country. Second, the unemployment rate also

goes up in the foreign country, which did not directly experience the financial distress but ends up absorbing part of the consequences that would have otherwise impacted the home country, despite the flexible exchange rate regime. The financial disruption thus causes a worldwide downturn, but real adverse effects are tempered by global interactions in the first area while transmitted to the other zone. Last but not least, these overall effects are concomitant to a slackening of the financial tightness at the world level (global excess savings) in spite of the negative asymmetric financial shock. This confirms that the nature of the shock is different from a standard monetary contraction in DSGE models.

A last question naturally arises: what if the initial displacement of the II_h curve had been relatively larger than the first displacement of the BE_h curve, leading to a point C above the BP line? Then there would be a slight appreciation of the domestic currency, but both far reduced if compared to the traditional framework and whose effects are mitigated by the dynamic interactions between a frictional financial market constraining commercial banks on the one hand and a frictional credit market constraining real activity on the other hand. Therefore, the depreciation of the foreign currency is not sufficient to offset the initial harmful impact created by the massive exit of banks and the consequent credit frictions while the traditional price-competitiveness channel turns out to be insignificant, thus producing similar conclusions.

The analytical version is summarized in Table 2. The first row indicates that the *financial* tightness is lower, *i.e.* there is *global* excess liquidity, after the shock to c_B: the fact that financiers do not want to capitalize commercial banks anymore does not come from fewer available funding but from a disruption of their confidence about bankers' solvency. The second row reflects *credit* rationing worldwide as in the case of liquidity supply shocks (the magnitude only differs by the elasticity of the financial market to both types of shocks). Finally, home and foreign *labor* market tightnesses, and therefore home and foreign outputs, appear here with positive comovements as one would expect.

Table 2: Elasticity to asymmetric confidence shocks at home and abroad

Tightness	**Home country**	**Foreign country**
$\hat{\xi}$	-1	-1
$\hat{\phi}$	$1-\eta_F$	$1-\eta_F$
$\hat{\theta}$	$\frac{q_L(\bar{\theta})(1-\eta_F)}{\gamma_L \eta_L}\left\{-\frac{\bar{c}_{B_h}}{q_F(\bar{\xi}_h)}-\frac{\bar{c}_{I_h}}{\bar{\xi}_h q_F(\bar{\xi}_h)}-\frac{\bar{c}_{E_h}\eta_C}{q_C(\bar{\phi}_h)}\right.$ $\left.+\frac{\gamma_C(1-\eta_C)}{\bar{\phi}_h q_C(\bar{\phi}_h)}+(1-\bar{N}_I)\right\}$	$-\frac{q_L(\bar{\theta})(1-\eta_F)}{\gamma_L \eta_L}(1-\bar{N}_I)$

Two major stylized facts in 2008-9 seem to validate that this new type of shocks — interpreted as confidence disruptions — is more relevant than the traditional liquidity supply shock type. First, the real effects of the US financial crisis were indeed transmitted to the Eurozone in a dampened way despite the flexible euro-dollar exchange rate: the unemployment rate increased by 111% in the US between February, 2008 and October, 2009 while it rose by 36% in

the Eurozone in the same period.[5] Second, a sharp contraction in international trade spread in a context of lesser exchange rate volatility as compared to the pre- and post-crisis periodes: annual exports of goods fell by 18% in value in the US in 2009 from 2008 and by 23% in the Eurozone in the same period.[6]

3.4 Quantitative Evaluation

This subsection estimates the magnitude of international spillovers resulting from both types of financial shocks, and confirms the model predictions in light of the recent events. As most of the financial parameters considered in this new approach lack of empirical counterparts, they are chosen so that steady-state values are realistic, while discussion about micro measures and interpretation of these missing parameters could constitute further research. The calibration of labor markets is mainly standard and kept as simple as possible here.[7]

The matching functions are supposed to be Cobb-Douglas

$$m_F(N_B, N_I) = \mu_F N_B^{\eta_F} N_I^{1-\eta_F}$$
$$m_C(N_E, N_C) = \mu_C N_E^{\eta_C} N_C^{1-\eta_C}$$
$$m_L(N_U, N_V) = \mu_L N_U^{\eta_L} N_V^{1-\eta_L}$$

where μ_F, μ_C, and μ_L, stand for matching efficiency measures in the financial market, credit market, and labor market, respectively. On the financial and credit markets, let assume that this efficiency parameter is normalized to unity, that the tightness elasticity of the matching functions is 0.5, and that the bargaining powers of investors and bankers which characterize the Nash bargaining rules, δ_C and δ_F, are also equal to 0.5. On the labor market, the tightness elasticity η_L is set up to 0.66, as I will also assume that two third of the surplus is earned by workers at equilibrium, in order to be consistent with the Hosios rule. The matching efficiency on the labor market is allowed to vary between 1.1 and 1.5, a range around Shimer (2005)'s estimation at 1.355. The quarterly separation rate is 0.1 and the riskless rate is 0.05.

For the moment, let see what the equilibrium labor market tightness — and therefore the equilibrium unemployment rate — would be with moderate financial frictions and moderate credit frictions. Hence, I suppose that flow costs on the financial market, c_I and c_B, are both at 0.1 so that the equilibrium tightness in (4) is equal to 1. With an entrepreneurs' non pecuniary cost c_E at 0.005, the equilibrium credit market tightness is then also equal to 1 by (5). Finally, the flow cost γ_C of bankers screening credit applications is equally set to 0.1. With a flow cost γ_L of job vacancies at 1.5, it results by (7) and (6) that the predicted unemployment rates are 4.68% when $\mu_L = 1.5$ (highly efficient

[5] From 4.8% in February, 2008 to 10.1% in October, 2009 in the US, and from 7.2% to 9.8% in the same period in the Eurozone. Source: Eurostat.

[6] From 1,277 billions of US dollars in 2008 to 1,046 billions in 2009 for the US, and from 2,312 billions of US dollars to 1,791 billions for the Eurozone. Source: OECD.

[7] For specific discussions about the quantitative performance of the search and matching modeling of labor markets for macroeconomic analysis, see Yashiv, 2009 or Cardullo, 2010.

labor market), and 7.26% when $\mu_L = 1.1$ (lower structural efficiency). These are particularly close to the pre-crisis rates in the US and in the Eurozone, which were respectively at 4.8% and 7.2% in February, 2008.

Now let consider a more realistic initial situation in which unemployment rates are of similar magnitude but in a context where banks find liquidities at very high rates, whereas entrepreneurs are indeed moderately credit constrained. In other words, the steady-state is re-parameterized in order to make a distinction between the credit market, where the information about entrepreneurs' creditworthiness is not immediately available to bankers, on the one hand and the financial market, where banker-investor relationships are essentially frictionless in normal times, on the other hand. Assuming that investors' and bankers' bargaining powers on the financial market are now $\delta_F = 0.995$ and $(1 - \delta_F) = 0.005$ respectively, with unchanged values for the search costs ($c_I = c_B = \gamma_C = 0.1$), it results from (4) that bankers now raise funds immediately as the Poisson rate at which they match with a financier ($q_F(\xi)$) is now 14 times larger. This can be interpreted as the existence of large excess savings in the pre-crisis equilibrium, modeled here by much more financial investors initially entering the process. The credit tightness remains at 1, implying that entrepreneurs' flow cost must now equal 0.00035 from (5). Therefore, with $\gamma_L = 0.5$, the initial unemployment rates are now evaluated at 4.94% and 7.66% (when $\mu_L = 1.5$ and $\mu_L = 1.1$ respectively), that is, quite close to the previous numbers. This verifies that the model is quantitatively able to reproduce frictionless financial markets in normal times, and therefore to evaluate the impact of the shocks from a realistic starting equilibrium.

In order to stay consistent with the symmetry of the model, the average labor market efficiency ($\mu_L = 1.355$) is used to compare the quantitative impact of the different financial shocks from a unique initial unemployment rate at 5.72%. The elasticity of the labor market tightnesses to *liquidity supply shocks* are thus evaluated at -0.82 at home while $+0.19$ abroad. In line with the qualitative analysis, it confirms the literature negative co-movements between domestic and foreign responses, in opposition to the recent events. In the case of *confidence shocks*, the elasticities respectively become -0.44 and -0.19, implying that this type of shocks is transmitted across countries.[8] In terms of unemployment rate, the response to negative confidence shocks is $+0.0083$ in the country where the shock arrives while $+0.0036$ in the foreign country. These numbers are not directly interpretable since there is no data equivalence for the parameters driving the confidence shock. However, they allow to evaluate the magnitude of the contagion, as they indicate that the relative unemployment effect is 2.3 times bigger in the home country. On the period from February 2008 to October 2009, the relative increase in unemployment rate has been about three times larger in the US than in the Eurozone (see previous footnote 5). The gap with the model predictions could be explained by a distinct degree of (de-)compartmentalization between financial and commercial banks between the two economic areas that the model does not capture. Another asymmetry

[8] Both financial shocks have the same negative real effect at the world level (-0.63).

lies in the labor market structures beyond the matching efficiency parameter considered here, for instance higher firing costs may have further dampened the response of unemployment in the Eurozone. Finally, differences in monetary and fiscal policies implementation during the crisis are still to incorporate. The model thus reproduces the US-Eurozone financial contagion that characterized the last financial crisis but was not reproduced in the standard frameworks.

4 Discussion

This Section relates the present results to three separate bodies of literature and highlights the novelty of the contribution. First, although this paper has accounted for a financial multiplier by which credit constrained firms overreact to a change in borrowing conditions from commercial banks (Bernanke and Blinder, 1989, Bernanke, Gertler and Gilchrist, 1999, Kiyotaki and Moore, 1997), it has showed that this is yet not sufficient to make international transmission of financial crises emerge. The representation of credit frictions has adopted here the tractable formalizations in a closed-economy setting of Den Haan, Ramey and Watson (2003) and Wasmer and Weil (2004), but the analysis of liquidity supply shocks has indicated that a trivial extension of such a mechanism to an open-economy framework does not solve the puzzle embedded in the traditional open macro predictions within a floating exchange rate system. The combination of non-walrasian shocks *à la* Wasmer and Weil (2004) and financial markets integration is however decisive.

More generally, this paper has demonstrated that introducing specific financial relationships in an international macro model alters the standard contagion mechanisms. Major recent two-country frameworks reached the same conclusions than the early Mundell-Fleming-Dornbusch models as far as monetary shocks were concerned because they ignored that financial frictions caused by information asymmetry and agent heterogeneity create potential occurrence of non-walrasian shocks. As very recently reminded by Boivin, Kiley and Mishkin (2010), "the core channels of policy transmission (...) have remained steady from early policy-oriented models to modern DSGE models" while "in contrast, non-neoclassical channels, such as credit-based channels, have remained outside the core models." In particular, they added that the exchange rate channel was the sole neoclassical channel resulting from the openness of the economy.

For instance, the well-known model by Obstfeld and Rogoff (1995) that notably provided the Keynesian analysis with microeconomic foundations in a two-country model lead to counterintuitive results in light of the recent events when concluding that monetary expansions in one country imply negative comovements between home and foreign outputs because of exchange rate fluctuations. In their own words, following a unilateral increase in home money supply, "the world real interest rate falls and world demand rises, but because the domestic currency depreciates, some world demand is shifted toward home products at foreign producers' expense. (...) A similar ambiguity is familiar

from two-country versions of the Mundell-Fleming-Dornbusch model."[9]

Later improvements of the Obstfeld-Rogoff monopolistic competition framework did not change the predictions; Betts and Devereux (2000a, 2000b) included local price stickiness to depart from the law of one price hypothesis, and confirmed the negative output co-movement induced by monetary shocks, as well as 'beggar-thy-neighbor' effects in terms of welfare, in the presence of pricing-to-market. Even more surprisingly, one-area estimated models used until very recently by the Federal Reserve and the European Central Bank similarly featured that monetary contractions lead to significant and persistent nominal and real appreciations of the domestic currency (for e.g. Eichenbaum and Evans (1995) for the US, Smets and Wouters (2003) for the Eurozone). This implies in a two-country world that financial market disruptions at home — represented through monetary contractions in those frameworks — benefit the second country, in strike opposition to the 2008 episode.

The few existing two-country papers that had introduced more sophisticated monetary mechanisms remained in a fixed exchange rate case and thus eluded the issue of the US-Eurozone financial contagion. For instance, Gilchrist, Hairault and Kempf (2002) constructed a two-country model where a financial multiplier is at work but in the context of a monetary union; more recently Devereux and Yetman (2010) studied the international transmission of shocks when investors are highly levered in one country but eluded here again the question of the exchange rate regime, and did not represent the labor market whose interactions with financial variables are of crucial interest to the real economy.

Aside from this macro part of the literature on international contagion, other papers have attempted to account for the complexity of modern financial interrelations but relying on the incompleteness of financial markets in the countries to which crises are transmitted. This representation has been commonly adopted to study the effect of shocks from developed to emerging market economies, from the famous paper by Allen and Gale (2000) — underlying the claims that banking systems have on one another due to regional incompleteness of financial markets as observable in Asia or in the US in the late nineteenth century — to sudden stops in capital flows (Calvo, Izquierdo and Mejía, 2004) and the current evidence about recoupling movements with US financial circumstances for large and prolonged US financial distress (Dooley and Hutchison, 2009).

Recent papers following this approach to explain the last financial crisis propagation have highlighted the weakening of the international trade based mechanism in global effects but still cannot account for the transmission channels to external developed economies. In the partial equilibrium model by Krugman (2008) notably, highly leveraged institutions hold domestic and foreign assets,

[9]The authors reserve the term 'beggar-thy-neighbor' for welfare implications across countries, and explain that uncooperative effects on utility disappear in a dynamic setting because foreigners "enjoy more leisure, improved terms of trade, and consumption higher than income" when their output falls in the short run. However it may be likely that, for a large and prolonged disruption, individuals perceive more disutility from reduced consumption and potential unemployment than utility from leisure, so that I restrain the term to output (unemployment) variations throughout this paper. Anyway, this semantic use does not change the main focus that is the positive correlation between outputs versus negative in the literature.

and international cross-holding is thus the main propagation channel. But as far as developed countries are concerned, it is more likely that highly integrated financial structures make domestic and foreign assets *substitutes* rather than *complements*, and that the equalization of external finance premia across countries is instead the source of international propagation.

Dedola and Lombardo (2009) thus developed a two-country general equilibrium model, where "financial and real interdependence can be very strong even with minimal balance sheet exposure to foreign risky assets, if asset markets are integrated across the board". Yet, they also need a minimum level of asset cross-holdings even in the presence of internal financial accelerators to propagate the financial disruption. The current paper has thus taken a different approach, by assuming that leveraged banks issue equities on perfectly integrated financial markets, in order to prove that there is room for international contagion without relying on cross-holdings effects. Home and foreign financial assets are considered as perfect substitutes here, which is likely to be the case for Euro and US financial assets. In particular, this means that interest rate distributions are comparable even though there may exist a home bias in equity or bond portfolio as suggested by Coeurdacier, Kollman, and Martin (2010).

In its methodological aspects, my paper has used the search and matching modeling to represent frictions in different markets. Kiyotaki and Wright (1993) and Dell'Ariccia and Garibaldi (1998) adopted the Mortensen and Pissarides (1994) formalization to deal with rationing in monetary and credit markets. The further theoretical developments for macroeconomic purposes (Wasmer and Weil, 2004) have provided the foundations for the closed-economy version of the economy presented here, while some empirical papers (Dell'Ariccia and Garibaldi, 2005, and Craig and Haubrich, 2006) have supported this representation of credit market frictions.

Three major advantages of this approach have been revealed here. On practical grounds, it has allowed for a particularly tractable model while introducing a financial market and considering a two-country model where both home and foreign variables are endogenized. Second, it has pointed out that liquidity market disruptions are sudden while restoring confidence between investors and banks as well as between banks and credit borrowers is time consuming, due to heterogeneity and informational asymmetries, thus creating a period of time in which the reinforcement between financial, credit and labor market frictions is economically painful. Third, this modeling has permitted to depart from traditional monetary shocks to represent shocks of a different nature, for which interest rate adjustments cannot immediately clear the market. The study of non walrasian financial shocks has provided new interesting insights in terms of financial tightness and exchange rate dynamics conducive to crisis propagations.

5 Conclusion

This paper has constructed a tractable multi-frictional model whereby an asymmetric financial shock is transmitted between major economic areas with com-

plete financial markets and within a floating exchange rate regime.

On the one hand, it nests a standard result of the literature — from the early Mundell-Fleming models to the DSGE recently used by Central Banks — by predicting a negative correlation between home and foreign outputs following asymmetric liquidity supply shocks, even in the presence of internal financial accelerators. Therefore, it provides plausible reasons why the international macroeconomic literature — whether neoclassic or including real markets imperfections — has not been integrated into the literature on financial frictions and sophisticated monetary transmission mechanisms, and *vice versa*, so far.

On the other hand, it argues that another type of financial shocks, namely confidence shocks, does generate international propagation in otherwise similar contexts. This is permitted via the application of the search and matching approach, that allows representing perfectly efficient financial markets in normal times but frozen financial markets when heterogeneity and information asymmetry create mistrust about the solvency of fund-raising credit intermediaries. Thus it helps understanding how financial market integration forms an international transmission channel of financial shocks, without resorting to fixed exchange rates or to portfolio effects.

Several improvements to this framework could constitute further research. First, the model could be inserted in a fully dynamic setup whereby the resources of financial investors are no more an exogenous endowment but are driven by saving decisions of the different agents. This is likely to make entrepreneurs less dependent from financial intermediaries for recruitment when the credit constraint is binding, but also to amplify the impact and the persistence of unexpected financial shocks by reducing the willingness to save and invest in risky assets. Second, it would be interesting to allow for more than one-to-one relationships and study size effects on different agent types, whether firms or financiers. In particular, crossed financial relationships between countries could add to the propagation of financial shocks.

Finally, monetary policy implications will be of main interest. The financial contagion studied here is basically the one that prevails before policy interventions, and Central Banks are not given a proper role besides being liquidity providers through quantitative easing operations. Introducing an interbank market along with the present frictional financial market would both diversify liquidity access to banks and confer a more realistic role to monetary authorities. In a two-country framework, positive externalities could then emerge and replace the standard 'beggar-thy-neighbor' monetary policy instruments.

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A Optimal Consumptions and the Price Index

Utility is derived from consumption

$$U = \mathbb{E}_0 \int_{t=0}^{\infty} \beta^t C_{i,t}$$

where $C_{i,t}$ denotes the individual consumption level in country i ($i = h, f$) at time t, $\mathbb{E}_0$ is the mathematical expectation conditional on information available

at time 0, and $0 < \beta = (1+r)^{-1} < 1$ is the common discount factor. Utility is assumed linear in consumption in order to analyze specific financial transmission channels independently of risk aversion effects. The consumption level $C_{i,t}$ is a Dixit-Stiglitz composite index of home and foreign goods

$$C_{i,t} = [\alpha^{\frac{1}{\lambda}} C_{h_{i,t}}^{\frac{\lambda-1}{\lambda}} + (1-\alpha)^{\frac{1}{\lambda}} C_{f_{i,t}}^{\frac{\lambda-1}{\lambda}}]^{\frac{\lambda}{\lambda-1}}$$

where $C_{j_{i,t}}$ stands for the consumption level of good j $(j = h, f)$ in country i $(i = h, f)$ at time t, and λ is the elasticity of intratemporal substitution between home and foreign goods. Note that the results hold for any particular value for this degree of substitution between home and foreign aggregate outputs.

Workers' budget constraint in the home country is simply $w = p_{h_h} C_{h_h} + p_{f_h} C_{f_h}$, where w is the wage. For tractability, it is considered that only workers consume but all types of agents could equally consume with similar results. The intratemporal first-order conditions in the home country are therefore

$$(C_{h_h}) : \alpha^{\frac{1}{\lambda}} C_{h_h}^{-\frac{1}{\lambda}} [\alpha^{\frac{1}{\lambda}} C_{h_h}^{\frac{\lambda-1}{\lambda}} + (1-\alpha)^{\frac{1}{\lambda}} C_{f_h}^{\frac{\lambda-1}{\lambda}}]^{\frac{1}{\lambda-1}} = \Lambda p_{h_h}$$

$$(C_{f_h}) : (1-\alpha)^{\frac{1}{\lambda}} C_{f_h}^{-\frac{1}{\lambda}} [\alpha^{\frac{1}{\lambda}} C_{h_h}^{\frac{\lambda-1}{\lambda}} + (1-\alpha)^{\frac{1}{\lambda}} C_{f_h}^{\frac{\lambda-1}{\lambda}}]^{\frac{1}{\lambda-1}} = \Lambda p_{f_h}$$

$$(\Lambda) : w = p_{h_h} C_{h_h} + p_{f_h} C_{f_h}$$

where Λ is the Lagrangian multiplier. Solving gives

$$\bar{C}_{h_h} = \frac{\alpha w (p_{h_h})^{-\lambda}}{\alpha (p_{h_h})^{1-\lambda} + (1-\alpha)(p_{f_h})^{1-\lambda}} \quad \text{and} \quad \bar{C}_{f_h} = \frac{(1-\alpha) w (p_{f_h})^{-\lambda}}{\alpha (p_{h_h})^{1-\lambda} + (1-\alpha)(p_{f_h})^{1-\lambda}}$$

The Consumption-Based Price Index is defined as the least expenditure that buys a unit of the consumption index on which period utility depends (Obstfeld and Rogoff, 1996). It is computed here by first substituting these optimal consumption levels in the initial consumption function, and then replacing the instantaneous available income w by the index, denoted P, while equalizing C to 1 as the index is the minimum expenditure per single unit of consumption

$$\Big[\alpha^{\frac{1}{\lambda}} \Big(\frac{\alpha P_h (p_{h_h})^{-\lambda}}{\alpha p_{h_h}^{1-\lambda} + (1-\alpha)(p_{f_h})^{1-\lambda}}\Big)^{\frac{\lambda-1}{\lambda}} + (1-\alpha)^{\frac{1}{\lambda}} \Big(\frac{(1-\alpha) P_h (p_{f_h})^{-\lambda}}{\alpha p_{h_h}^{1-\lambda} + (1-\alpha)(p_{f_h})^{1-\lambda}}\Big)^{\frac{\lambda-1}{\lambda}}\Big]^{\frac{\lambda}{\lambda-1}} = 1$$

Rearranging gives the solution for P in the home country

$$P_h = [\alpha p_{h_h}^{1-\lambda} + (1-\alpha)(p_{f_h})^{1-\lambda}]^{\frac{1}{1-\lambda}}$$

The foreign price index expressed in domestic currency, $S_t P_{f,t}$, is constructed similarly but does not need to equal $P_{h,t}$ as preferences parameters (α and λ) are allowed to differ from one country to another. Note that the consumption-based price index is taken as given by a particular consumer since markets for

final goods are competitive, but is endogenous at the aggregate level.

B Individual behaviors and domestic equilibrium

B.1 Workers-Consumers

The worker-consumer problem is given here for general equilibrium understanding but the international propagation mechanisms are primarily driven by interactions between investors, bankers and entrepreneurs in the simplified sequential representation. In each period, workers are either unemployed and earn no revenue (in stage 2) or working for a given wage w that allows for consumption (in stage 3).[10] When an unemployed worker encounters an entrepreneur whose job offer matches his or her characteristics, he or she can either reject the offer and wait for a new job opportunity or accept the offer and earn w until an adverse shock arrives. Worker-entrepreneur relationships end at the exogenous separation rate s. Hence, the optimal stochastic value function $W_{i,t}$ of an unemployed worker of country i at time t satisfies the following recursive problem

$$W_{i,t}(\theta_{i,t}, S_t) = \max_{accept,reject} \left\{ \max_{C_{h_{i,t}}, C_{f_{i,t}}} \left\{ U_{(*)} + \beta(1-s) W_{3_{i,t+1}} + \beta s W_{2_{i,t+1}} \right\}; \right.$$
$$\left. \beta \left[1 - \theta_{i,t} q_L(\theta_{i,t})\right] W_{2_{i,t+1}} + \beta\, \theta_{i,t} q_L(\theta_{i,t})\, W_{3_{i,t+1}} \right\}$$

$$(*) \quad \text{s.t.} \quad w_i = p_{h_{h,t}} C_{h_{i,t}} + S_t\, p_{f_{f,t}} C_{f_{i,t}}$$

where W_2 and W_3 are the value functions of workers in the respective stages 2 and 3 of the process described above, and where $p_{j_{i,t}}$ is the price of good j in country i and expressed in country i currency at time t.

The consumption index obtained above (Appendix A) allows re-expressing the individual budget constraint as $w_{i,t} = P_{i,t} \bar{C}_{i,t}$, where $\bar{C}_{i,t}$ is the optimal consumption basket in country i at date t. Therefore, dropping time and country subscripts, the simplified Bellman equations for a worker in the successive stages of the sequential process are

$$rW_2 = \theta q_L(\theta)(W_3 - W_2)$$

$$rW_3 = \frac{w}{P} + s(W_2 - W_3)$$

[10] Unemployment benefits, minimal consumption levels while being unemployed, job search costs for workers or valuation of leisure activities could have been added to the framework but none is critical for the current purpose.

B.2 Entrepreneurs

A similar problem for the entrepreneurs gives the following Bellman equations

$$rE_1 = -c_E + q_C(\phi)(E_2 - E_1)$$
$$rE_2 = -\gamma_L + \gamma_L + q_L(\theta)(E_3 - E_2)$$
$$rE_3 = p - w - \rho_C + s(E_4 - E_3)$$

with E_1, E_2, E_3 the respective intertemporal values of entrepreneurs in stages 1, 2 and 3, c_E the search cost in stage 1, and γ_L the search cost in the recruitment stage (offset by the amount borrowed from the bank).

B.3 Bankers

Similarly, for the commercial banks,

$$rB_0 = -c_B + q_F(\xi)(B_1 - B_0)$$
$$rB_1 = -\gamma_C + \gamma_C + \phi\, q_C(\phi)(B_2 - B_1)$$
$$rB_2 = -\gamma_L + \gamma_L + q_L(\theta)(B_3 - B_2)$$
$$rB_3 = \rho_C - \rho_F + s(B_4 - B_3)$$

where c_B and γ_C stand for bankers' search costs in stage 0 and stage 1 respectively, and where γ_L is offset by the capital provided by the investor.

B.4 Investors

Similarly, for the financial investors, with c_I their search cost in stage 0,

$$rI_0 = -c_I + \xi\, q_F(\xi)(I_1 - I_0)$$
$$rI_1 = -\gamma_C + \phi\, q_C(\phi)(I_2 - I_1)$$
$$rI_2 = -\gamma_L + q_L(\theta)(I_3 - I_2)$$
$$rI_3 = \rho_F + s(I_4 - I_3)$$

B.5 Domestic Equilibrium

Free entry implies that, in equilibrium, $E_1 = 0$, $B_0 = 0$, and $I_0 = 0$. The first Bellman equation for each agent therefore gives their respective *backward* value one stage after entering the process as follows

$$\text{For entrepreneurs} \quad E_2 = \frac{c_E}{q_C(\phi)};$$

$$\text{For bankers} \quad B_1 = \frac{c_B}{q_F(\xi)};$$

$$\text{For investors} \quad I_1 = \frac{c_I}{\xi q_F(\xi)};$$

Free exit ($E_4 = 0$, $B_4 = 0$, and $I_4 = 0$) similarly gives the value in stage 3 from the last Bellman equation in each group. *Forward* values for stages 1 and 2 are then obtained recursively as

$$\text{For entrepreneurs} \quad E_3 = \frac{p - w - \rho_C}{r + s}, \quad E_2 = \frac{q_L(\theta)}{r + q_L(\theta)} E_3;$$

$$\text{For bankers} \quad B_3 = \frac{\rho_C - \rho_F}{r + s}, \quad B_2 = \frac{q_L(\theta)}{r + q_L(\theta)} B_3, \quad B_1 = \frac{\phi q_C(\phi)}{r + \phi q_C(\phi)} B_2;$$

$$\text{For investors} \quad I_3 = \frac{\rho_F}{r + s}, \quad I_2 = \frac{-\gamma_L + q_L(\theta) I_3}{r + q_L(\theta)}, \quad I_1 = \frac{-\gamma_C + \phi q_C(\phi) I_2}{r + \phi q_C; (\phi)}$$

Equalizing the backward and forward values for each agent finally gives their respective *equilibrium condition* (1) to (3). The Nash bargaining rule for the repayment ρ_F, $(1 - \delta_F)(I_1 - I_0) = \delta_F(B_1 - B_0)$, together with the *backward* values for B_1 and I_1 then gives the equilibrium financial market tightness as

$$\bar{\xi} = \frac{1 - \delta_F}{\delta_F} \frac{c_I}{c_B}$$

Recursively, the second Nash bargaining rule for the repayment ρ_C, $(1-\delta_C)(B_2 - B_1) = \delta_C(E_2 - E_1)$, together with the values of the agents at the time they meet and the previous value for $\bar{\xi}$, gives the equilibrium credit market tightness as

$$\bar{\phi} = \frac{1 - \delta_C}{\delta_C} r \frac{c_B}{c_E} \frac{1}{q_F(\bar{\xi})}$$

Solving (1) to (5) gives the equilibrium labor market tightness $\bar{\theta}$ in (7)

B.6 Impact of Financial Shocks (Closed Economy)

The three equilibrium market tightnesses (4), (5), and (7) are loglinearized as

$$\hat{\xi} = \hat{c}_I - \hat{c}_B$$

$$\hat{\phi} = (1 - \eta_F)\hat{c}_B + \eta_F \hat{c}_I - \hat{c}_E$$

$$\hat{\theta} \approx \frac{q_L(\bar{\theta})}{\eta_L \bar{\gamma_L}} \Big\{ \frac{p\hat{p}}{s} - [(1 - \eta_F)\hat{c}_B + \eta_F \hat{c}_I]\bar{\kappa} - \frac{\bar{\gamma}_C \hat{\gamma}_C}{\bar{\phi} q_C(\bar{\phi})} - \hat{c}_E(1 - \eta_C)\Big[\frac{\bar{\gamma}_C}{\bar{\phi} q_c(\bar{\phi})} + \frac{\bar{c}_E}{q_c(\bar{\phi})}\Big]\Big\} - \frac{\hat{\gamma}_L}{\eta_L}$$

$$\text{where} \quad \bar{\kappa} = \frac{\bar{c}_B}{q_F(\bar{\xi})} + \frac{\bar{c}_I}{\bar{\xi} q_F(\bar{\xi})} + \frac{\eta_C \bar{c}_E}{q_C(\bar{\phi})} - \frac{(1 - \eta_C)\bar{\gamma}_C}{\bar{\phi} q_C(\bar{\phi})} \quad \text{and with} \quad \bar{r} = 0$$

where a hatted variable denotes the loglinear deviation from its steady-state value ($\hat{x} = \frac{x-\bar{x}}{\bar{x}}$), and where $\eta_L, \eta_C, \eta_F \in (0,1)$ are the respective matching function elasticities at equilibrium ($\eta_L \equiv -q_L'(\bar{\theta})\bar{\theta}/q_L(\bar{\theta})$, $\eta_C \equiv -q_C'(\bar{\phi})\bar{\phi}/q_C(\bar{\phi})$, and $\eta_F \equiv -q_F'(\bar{\xi})\bar{\xi}/q_F(\bar{\xi})$). Loglinearizing (6) further gives the unemployment rate response as $\hat{u} \approx -(1-\eta_L)(1-\bar{u})\hat{\theta}$. Note that $\bar{\kappa}$ is assumed positive with plausible values of the parameters henceforth so that negative financial shocks realistically raise the unemployment rate in the closed economy.

C International Set-up and Financial Spillovers

C.1 Aggregate constraints

Each firm of country i produces one unit of the good in which the economy is specialized ($i = h, f$) and maximizes profits by determining the optimal division of this output unit between domestic sales $C_{i_{h,t}}$ and exports $C_{i_{f,t}}$, taking prices $p_{i_{h,t}}$ and $p_{i_{f,t}}$ and the exchange rate S_t as given.

In the two-country case, the equilibrium condition (1) for entrepreneurs in country i (expressed in domestic currency) is thus rewritten as

$$\frac{c_{E_i}}{q_C(\phi_i)} = \frac{q_L(\theta_i)}{r + q_L(\theta_i)} \frac{p_{i_h} C_{i_h} + S p_{i_f} C_{i_f} - w_i - \rho_{C_i}}{r + s_i}$$

With a labor force normalized to one and one unit produced per firm, the instantaneous output of country i is merely its contemporaneous employment rate $(1 - u_{i,t})$. This gives four aggregate constraints on goods as

$$(1 - u_{i,t}) = C_{i_{h,t}} + C_{i_{f,t}}, \quad i = h, f$$

Moreover, in each period the country-specific income is either devoted to the pecuniary costs induced by search activities or consumed in the home and foreign goods. Assuming for simplicity that output and search costs are constant through time, the resource constraints expressed in domestic currency are

$$p_{i_{h,t}} C_{i_{h,t}} + S_t p_{i_{f,t}} C_{i_{f,t}} - \gamma_C N_{C_{i,t}} - \gamma_L N_{E_{i,t}} = p_{h_{h,t}} C_{h_{i,t}} + S_t p_{f_{f,t}} C_{f_{i,t}}$$

where the equilibrium values of N_C and N_E are respectively obtained when flows of bankers and entrepreneurs into and out of the search process are equalized

$$(1 - N_{C_i}) s_i = \phi_i q_C(\phi_i) N_{C_i} \quad \text{and} \quad (1 - N_{E_i}) s_i = q_L(\theta_i) N_{E_i}$$

Similarly, the ratio of unmatched global financial investors at equilibrium is thus

$$\bar{N}_I = \frac{\bar{s}_h + \bar{s}_f}{\bar{s}_h + \bar{s}_f + \bar{\xi}_h q_F(\bar{\xi}_h) + \bar{\xi}_f q_F(\bar{\xi}_f)}$$

and roughly captures the amount of global excess liquidity at time t.

C.2 Impact of Financial Shocks (Two-Country case)

Just as in the closed economy case, solving loglinear (open-economy) versions of equations (1)–(3), replacing $\hat{\xi}_i = \hat{c}_{I_i} - \hat{c}_{B_i}$ and $\hat{\phi}_i = (1-\eta_F)\hat{c}_{B_i} + \eta_F \hat{c}_{I_i}$, and further simplifying $\hat{\gamma}_{C_i} = \hat{\gamma}_{L_i} = \hat{c}_{E_i} = \hat{w}_i = \hat{s} = \hat{r} = 0$, give the following expression for the domestic labor market tightness

$$\hat{\theta}_h \approx \frac{q_L(\bar{\theta}_h)}{\eta_L \bar{\gamma}_{L_h}} \Big\{ \bar{p}_{h_h} \bar{C}_{h_h} (\hat{p}_{h_h} + \hat{C}_{h_h}) + \bar{S} \bar{p}_{h_f} \bar{C}_{h_f} (\hat{S} + \hat{p}_{h_f} + \hat{C}_{h_f}) - [(1-\eta_F)\hat{c}_{B_h} + \eta_F \hat{c}_{I_h}] \bar{\kappa}_h \Big\}$$

$$\text{where} \quad \bar{\kappa}_h = \bar{s}_h \Big[\frac{\bar{c}_{B_h}}{q_F(\bar{\xi}_h)} + \frac{\bar{c}_{I_h}}{\bar{\xi}_h q_F(\bar{\xi}_h)} + \frac{\eta_C \bar{c}_{E_h}}{q_C(\bar{\phi}_h)} - \frac{(1-\eta_C)\bar{\gamma}_{C_h}}{\bar{\phi}_h q_C(\bar{\phi}_h)} \Big]$$

Then, loglinearizing the expression for the exchange rate (8) and given that $\bar{\xi}_h q_F(\bar{\xi}_h) \bar{N}_I = (1-\bar{N}_I)\bar{s}_h$, we have

$$\bar{S} \bar{p}_{h_f} \bar{C}_{h_f} (\hat{S} + \hat{p}_{h_f} + \hat{C}_{h_f}) = \bar{p}_{f_h} \bar{C}_{f_h} (\hat{p}_{f_h} + \hat{C}_{f_h}) - \bar{s}_h (1-\bar{N}_I)(1-\eta_F)(\hat{\xi}_h - \hat{\xi}_f)$$

Substituting into the previous equation thus gives

$$\hat{\theta}_h \approx \frac{q_L(\bar{\theta}_h)}{\eta_L \bar{\gamma}_{L_h}} \Big\{ \bar{p}_{h_h} \bar{C}_{h_h} (\hat{p}_{h_h} + \hat{C}_{h_h}) - \bar{s}_h (1-\bar{N}_I)(1-\eta_F)(\hat{c}_{I_h} - \hat{c}_{B_h} - \hat{c}_{I_f} + \hat{c}_{B_f}) \\ + \bar{p}_{f_h} \bar{C}_{f_h} (\hat{p}_{f_h} + \hat{C}_{f_h}) - [(1-\eta_F)\hat{c}_{B_h} + \eta_F \hat{c}_{I_h}] \bar{\kappa}_h \Big\}$$

Finally, loglinearizing consumers' budget constraint as

$$\bar{p}_{h_h} \bar{C}_{h_h} (\hat{p}_{h_h} + \hat{C}_{h_h}) + \bar{p}_{f_h} \bar{C}_{f_h} (\hat{p}_{f_h} + \hat{C}_{f_h}) = \bar{w} \hat{w}$$

and given that $\hat{w} = 0$[11], the labor market tightness simplifies to

$$\hat{\theta}_h \approx -\frac{q_L(\bar{\theta}_h)}{\eta_L \bar{\gamma}_{L_h}} \Big\{ \Big[(1-\eta_F)\hat{c}_{B_h} + \eta_F \hat{c}_{I_h} \Big] \bar{\kappa}_h + \bar{s}_h (1-\bar{N}_I)(1-\eta_F)(\hat{c}_{I_h} - \hat{c}_{B_h} - \hat{c}_{I_f} + \hat{c}_{B_f}) \Big\}$$

where the first member in curly brackets is the direct financial transmission channel while the second is the expenditure-switching channel resulting from real exchange rate variations. The labor market tightness responses to asymmetric liquidity supply shocks at home and abroad are therefore respectively

[11] This simplification stems from the fact that workers' wage is exogenous in the model. Besides composition changes due to exchange rate variations following negative financial shocks (c_{I_i} and c_{B_i}), consumption will be thus reduced via greater unemployment (direct effect). Further feedback effects on real prices will be caused by a change in firms' profits in the long run rather than via wage reductions here. This does not seem a very restrictive assumption when studying the immediate impact of financial shocks in the present sequential model, because wage adjustments are probably lagged, so that the present direct effects would probably still outweigh the indirect effects in a dynamic version of the model. Moreover, workers here supply inelastic and country-specific labor similarly to low-wage workers whose minimum wage is indeed exogenous.

given by $\partial\hat{\theta}_h/\partial\hat{c}_{I_h}$ and $\partial\hat{\theta}_h/\partial\hat{c}_{I_f}$ (subsection 3.2), while responses to asymmetric confidence shocks correspond to $\partial\hat{\theta}_h/\partial\hat{c}_{B_h}$ and $\partial\hat{\theta}_h/\partial\hat{c}_{B_f}$ (subsection 3.3).

C.3 Calibration parameters

Table 3: Calibration parameters

matching efficiency	$\mu_F = \mu_C = 1; \mu_L = 1.1, 1.355, 1.5$
tightness elasticity	$\eta_F = \eta_C = 0.5; \eta_L = 0.66$
bargaining power	$\delta_F = 0.995; \delta_F = 0.5; \delta_L = 0.66$
search costs on financial markets	$c_I = c_B = 0.1$
search costs on credit markets	$\gamma_C = 0.1$
search costs on labor markets	$\gamma_L = 0.5$
separation rate	$s = 0.1$
riskfree rate	$r = 0.05$