

BANK LIABILITIES CHANNEL

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Abstract

The financial intermediation sector is important not only for channeling resources from agents in excess of funds to agents in need of funds (lending channel). By issuing liabilities they also create financial assets that can be held by other sectors for insurance purpose. Then, when the intermediation sector creates less liabilities or their value falls, agents are less willing to engage in activities that are individually risky but efficient in aggregate. The first goal of this paper is to illustrate this “bank liabilities channel”. The second goal is to show that fluctuations in bank liabilities could be driven by self-fulfilling expectations about the liquidity of the financial sector (multiple equilibria). The third goal is to apply the model to study the impact of two recent trends: the growth of emerging economies and financial innovation. A finding of the paper is that both trends have contributed to greater financial and macroeconomic instability.

1 Introduction

There is a well established tradition in macroeconomics that adds financial market frictions to standard macroeconomic models. The seminal work of Bernanke and Gertler (1989) and Kiyotaki and Moore (1997) are the classic references for most of the work done in this area during the last three decades. Although these contributions differ in many details ranging from the micro-foundation of market incompleteness to the scope of the application, they typically share two common features. The first is that the role played by financial frictions in the propagation of shocks to the real sector

of the economy is based on the typical ‘credit channel’. The idea is that various shocks can affect the financing capability of borrowers—either in the available credit or in the cost—which in turn affects their economic decisions (consumption, investment, employment, etc.).

The second feature of these models is that they assign a limited role to the financial intermediation sector. This is not to say that there are not studies that emphasize the role of banks for business cycle dynamics. Holmstrom and Tirole (1997) provided a theoretical foundation for the central roles of banks in general equilibrium, inspiring subsequent contributions such as Van den Heuvel (2008) and Meh and Moran (2010). However, it is only after the recent crisis that the role of financial intermediaries became central to the research agenda in macroeconomics. Recent contributions include Boissay, Collard, and Smets (2010), Brunnermeier and Sannikov (2010), Corbae and D’Erasmus (2012), De Fiore and Uhlig (2011), Gertler and Karadi (2011), Gertler and Kiyotaki (2010), Mendoza and Quadrini (2010), Rampini and Viswanathan (2012).

In most of the recent studies, the primary role of the intermediation sector is to channel funds to investors (borrowers). Because of frictions, the funds that can be intermediated depends on the financial conditions of banks. When these conditions deteriorate, the volume of intermediated funds declines, which in turn forces borrowers to cut investments and other economic activities. Therefore, the primary channel through which the financial intermediation sector affects real economic activities is still the typical ‘credit or lending channel’. One of the goals of this paper is to emphasize a second channel through which financial intermediation affects real economic activity.

This second channel is based on the observation that the financial intermediation sector is important not only for channeling resources from agents in excess of funds to agents in need of funds (credit channel). By issuing liabilities, it also creates financial assets that can be held by other sectors of the economy for insurance purposes. Then, when the supply or the value of bank liabilities decline, the holders of these liabilities (being them households or firms) are less willing to engage in activities that are individually risky because of lower insurance.

This mechanism can be illustrated with an example. Suppose that a bank issues 1 dollar liability and sells it to agent *A* (this represents an asset for agent *A*). The dollar is then used by the bank to make a loan to agent *B*. By doing so the bank facilitates a more efficient allocation of resources because, typically, agent *B* is in a condition to create more value than agent

A (because of higher productivity or higher marginal utility of consumption). However, if the bank is unable to issue the dollar liability, the bank will not make the loan and, as a consequence, agent B is forced to cut investment and/or consumption. This example illustrates the standard ‘credit or lending channel’ of financial intermediation.

In addition to the credit channel, there is another channel through which the intermediation of funds affects real economic activity. When the bank issues the 1 dollar liability, it creates a financial asset that will be held by agent A . For this agent, the bank liability represents a financial asset that can be used to insure against the idiosyncratic outcome of various economic activities including investment, hiring, consumption. Then, when the holdings of bank liabilities decline, agent A is discouraged from engaging in the above economic activities that are individually risky but efficient in aggregate. Therefore, it is through the supply of bank liabilities that the financial intermediation sector also plays an important role for the real sector of the economy. I refer to this channel as the ‘bank liabilities channel’.

The example illustrates the insurance role played by financial intermediaries in a simple fashion: issuance of traditional bank deposits. However, the complexity of assets and liabilities issued by the intermediation sector has grown over time and many of these activities are important for providing insurance. In some cases, the assets and liabilities issued by the financial sector do not involve significant intermediation of funds in the current period but they create the conditions for future payments as in the case of derivatives. In other cases, intermediaries simply facilitate the direct issuance of assets and liabilities in the non-financial sector as in the case of public offering of corporate bonds and shares or the issuance of mortgage-backed securities. Even though these securities do not remain in the balance sheet of financial institutions, banks still play an important role in facilitating the creation of these securities and, later on, in affecting their value in the secondary market. Corporate mergers and acquisitions can also be seen in this logic since, in addition to promote operational efficiency, they also allow for corporate diversification (*i.e.*, insurance). Still, the direct involvement of banks is crucial for the success of these operations. When the health of financial intermediaries deteriorates, the volume of these activities contracts, which is another way of thinking about the importance of the ‘bank liabilities channel’.

The second goal of this paper is to explore a possible mechanism that affects the value of bank liabilities. The mechanism is based on self-fulfilling expectations about the liquidity of the intermediation sector: when the mar-

ket expects the intermediation sector to be liquid, banks have the capability of issuing additional liabilities and, therefore, they are liquid. On the other hand, when the market expects the intermediation sector to be illiquid, banks are unable to issue additional liabilities and, as a result, they end up being illiquid. Through this mechanism the model could generate multiple equilibria: a ‘good’ equilibrium characterized by expanded financial intermediation, sustained economic activity and high asset prices, and a ‘bad’ equilibrium characterized by reduced financial intermediation, lower economic activity and depressed asset prices. I refer to the switch from good to bad equilibria as a financial crisis.

In the model, the existence of multiple equilibria and, therefore, the emergence of a crisis is possible only when banks are highly leveraged. This implies that structural changes that increase the incentives of banks to take on more leverage, may create the conditions for greater financial and macroeconomic instability. In the application of the model I will consider two trends observed in the last three decades: the growth of emerging countries and financial innovations.

Emerging countries tend to accumulate safe assets issued by industrialized countries. As the share of these countries in the world economy increases, so does the world demand for safe assets with subsequent decline in the equilibrium interest rate. The lower interest rate reduces the funding cost of banks and increases their incentive to leverage. The higher leverage, however, could move the economy to a state in which multiple equilibria become possible, exposing the economy to the possibility of a financial crisis.

Financial innovation is another mechanism that could induce banks to take more leverage. In the model financial innovation is captured by a reduction in the operation cost of banks. This reduces the funding cost for banks and encourages them to take more leverage. On the one hand, this facilitates greater financial intermediation and higher economic activity. On the other, however, it creates the conditions for the emergence of a crisis and increases its macroeconomic consequences.

The organization of the paper is as follows. Section 2 describes the theoretical framework and characterizes the equilibrium. Section 3 applies the model to study how the growth of emerging countries and financial innovations have affected the stability of the economy. Section 4 concludes.

2 Model

There are three sectors in the economy: the entrepreneurial sector, the worker sector and the financial intermediation sector.

2.1 Entrepreneurial sector

In the entrepreneurial sector there is a unit mass of entrepreneurs with lifetime utility $E_0 \sum_{t=0}^{\infty} \beta^t \ln(c_t)$. Entrepreneurs are individual owners of firms, each operating the production function $F(z_t, h_t) = z_t h_t$, where h_t is the input of labor supplied by workers at the market wage w_t , and z_t is an idiosyncratic productivity shock. The productivity shock is independently and identically distributed among firms and over time, with probability distribution $\Gamma(z)$. As in Arellano, Bai, and Kehoe (2011), the input of labor h_t is chosen before observing z_t , and therefore, labor is risky.

Entrepreneurs have access to a market for non-contingent bonds with gross interest rate R_t^b . For the moment I refer to the financial assets held by entrepreneurs as bonds. When I introduce the financial intermediation sector, the bonds held by entrepreneurs are the liabilities issued by banks.

An entrepreneur i enters period t with bonds b_t^i and chooses the labor input h_t^i . After the realization of the idiosyncratic shock z_t^i , he/she chooses consumption c_t^i and next period bonds b_{t+1}^i . The budget constraint is

$$c_t^i + \frac{b_{t+1}^i}{R_t^b} = (z_t^i - w_t)h_t^i + b_t^i. \quad (1)$$

Because labor h_t^i is chosen before the realization of z_t^i , while the saving decision is made after the observation of z_t^i , it will be convenient to denote by $a_t^i = b_t^i + (z_t^i - w_t)h_t^i$ the entrepreneur's wealth after production. Given the timing structure, the input of labor h_t^i depends on b_t^i while the saving choice b_{t+1}^i depends on a_t^i . The following lemma provides a characterization of the optimal entrepreneur's policies.

Lemma 2.1 *Let ϕ_t satisfy the condition $\mathbb{E}_z \left\{ \frac{z - w_t}{1 + (z - w_t)\phi_t} \right\} = 0$. The entrepreneur's policies take the form*

$$\begin{aligned} h_t^i &= \phi_t b_t^i, \\ c_t^i &= (1 - \beta)a_t^i, \\ \frac{b_{t+1}^i}{R_t^b} &= \beta a_t^i. \end{aligned}$$

The demand for labor is linear in the initial wealth of the entrepreneur b_t^i . The term ϕ_t —which is defined by condition $\mathbb{E}_z \left\{ \frac{z-w_t}{1+(z-w_t)\phi_t} \right\} = 0$ —is only a function of the wage rate. Therefore, from now on, I will denote this term with the function $\phi(w_t)$, which is strictly decreasing in w_t .

Since $\phi(w_t)$ is the same for all entrepreneurs, I can derive the aggregate demand for labor as

$$H_t = \phi(w_t) \int_i b_t^i = \phi(w_t) B_t,$$

where capital letters denote average (per-capita) variables. The aggregate demand for labor depends negatively on the wage rate—which is a standard property—and positively on the financial wealth of entrepreneurs—which is a special property of this model.

Also linear is the consumption policy which follows from the logarithmic specification of the utility function. This property allows for linear aggregation making the characterization of the equilibrium extremely tractable. Another property worth emphasizing is that in a stationary equilibrium with constant B_t , the interest rate must be lower than the intertemporal discount rate,¹ that is, $R^b < 1/\beta - 1$.

2.2 Worker sector

There is a unit mass of workers with lifetime utility $\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(c_t - \alpha \frac{h_t^{1+\frac{1}{\nu}}}{1+\frac{1}{\nu}} \right)$, where c_t is consumption and h_t is the supply of labor. Workers do not face idiosyncratic risks and the assumption of risk neutrality is not important for the key results of the paper. It only makes the analysis simpler.

Each worker holds a non-reproducible asset available in fixed supply \bar{K} , with each unit producing χ units of consumption goods. The asset is divisible and can be traded at the market price p_t . We can think of the asset as housing and χ as the services from one unit of housing. Workers can borrow at the

¹To see this, consider the first order condition of an individual entrepreneur for the choice of b_{t+1}^i . This is the typical euler equation that, with log preferences, takes the form $1/c_t^i = \beta R^b \mathbb{E}_t(1/c_{t+1}^i)$. Because individual consumption c_{t+1}^i is stochastic, $\mathbb{E}_t(1/c_{t+1}^i) > 1/\mathbb{E}_t c_{t+1}^i$. Therefore, if $\beta R^b = 1$, we would have that $\mathbb{E}_t c_{t+1}^i > c_t^i$, implying that individual consumption would grow on average. But then aggregate consumption would not be bounded, which violates the hypothesis of a stationary equilibrium. I will come back to this property later.

gross interest rate R_t^l and face the budget constraint

$$c_t + l_t + (k_{t+1} - k_t)p_t = \frac{l_{t+1}}{R_t^l} + w_t h_t + \chi k_t,$$

where l_t is the loan contracted in the previous period $t - 1$ and due in the current period t , and l_{t+1} is the new debt repaid in the next period $t + 1$.

Borrowing is constrained by a borrowing limit. I will consider two specifications of this limit. In the first specification the borrowing limit is exogenous and takes the form

$$l_{t+1} \leq \eta, \tag{2}$$

where η is constant. Later I will also consider a borrowing constraint that depends on the collateral value of assets,

$$l_{t+1} \leq \eta E_t p_{t+1} k_{t+1}. \tag{3}$$

The simpler form of the borrowing constraint specified in (2) allows me to characterize the equilibrium analytically. The downside, however, is that the asset price p_t is always constant. With the borrowing constraint (3), instead, the model also provides interesting predictions for the asset price p_t but the full characterization of the equilibrium need to be derived numerically. I first characterize the properties of the model analytically using the first constraint. In the numerical simulation of the model, however, I will use the second specification.

When the borrowing constraint takes the form specified in (2), the first order conditions for the optimization problem of workers are

$$\alpha h_t^{\frac{1}{\nu}} = w_t, \tag{4}$$

$$1 = \beta R_t^l (1 + \mu_t), \tag{5}$$

$$p_t = \beta \mathbb{E}_t (\chi + p_{t+1}), \tag{6}$$

where $\beta \mu_t$ is the Lagrange multiplier associated with the borrowing constraint. When the borrowing constraint takes the form specified in (3), the first order condition with respect to k_{t+1} becomes

$$p_t = \beta \mathbb{E}_t \left[\chi + (1 + \eta \mu_t) p_{t+1} \right]. \tag{7}$$

2.3 Equilibrium with direct borrowing and lending

Before introducing financial intermediation it would be instructive to characterize the equilibrium with direct borrowing and lending. In this case market clearing implies $R_t^l = R_t^b = R_t$.

Proposition 2.1 *In absence of aggregate shocks, the economy converges to a steady state in which workers borrow up to the limit and $\beta R < 1$.*

The fact that the steady state interest rate is lower than the intertemporal discount rate is a consequence of the uninsurable risk faced by entrepreneurs. Because of the precautionary motive, if $\beta R = 1$ entrepreneurs would continue to accumulate bonds without limit. The supply, however, is limited by the borrowing constraint of workers. To insure that the bond market clears, the interest rate has to fall below the intertemporal discount rate.

The equilibrium in the labor market can be characterized as the simple intersection of aggregate demand and supply as depicted in Figure 1. The aggregate demand has been derived in the previous subsection and takes the form $H_t^D = \phi(w_t)B_t$, where w_t is the wage rate and B_t is the aggregate wealth (bonds) owned by entrepreneurs. The supply of labor is derived from the households' first order condition (4) and takes the form $H_t^S = \left(\frac{w_t}{\alpha}\right)^\nu$.

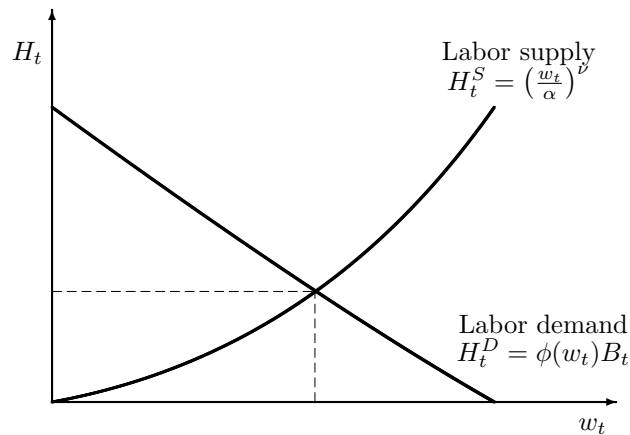


Figure 1: Labor market equilibrium.

The dependence of the demand of labor from the financial wealth of entrepreneurs is a key property of this model. When entrepreneurs hold a

lower value of B_t , the demand for labor declines and in equilibrium there is lower employment and production. Importantly, the reason lower values of B_t decreases the demand of labor is not because employers do not have funds to finance hiring or because they face a higher financing cost. In fact, employers do not need any financing to hire and produce. Instead, the transmission mechanism is based on the shortage of financial assets held by entrepreneurs to insure the idiosyncratic risk. This mechanism is clearly distinct from the traditional ‘credit channel’ where firms are in need of funds to finance employment (for example, because wages are paid in advance) or to finance investment.

2.4 Financial intermediation and banking crises

If workers could borrow directly from entrepreneurs, there is no need of financial intermediaries. However, if direct borrowing is not feasible or inefficient, the presence of financial intermediaries become central for transferring funds from lenders (entrepreneurs) to borrowers (workers) and to create financial assets that could be held for insurance purposes. It is under this assumption that I extend the model by adding a financial intermediation sector. I will then show that a decline in B_t could be the result of difficulties experienced by financial intermediaries.

The financial intermediation sector is populated by a continuum of infinitely lived banks held by workers. Banks start the period with loans to workers, l_t , and liabilities held by entrepreneurs, b_t .² The difference between loans and liabilities represents the bank equity $e_t = l_t - b_t$. Given the beginning of period balance sheet position, the bank could choose to default on its liabilities. In this case the creditors have the right to liquidate the bank but they can recover only a fraction ξ_t of its assets l_t . The variable ξ_t is an aggregate stochastic variable whose value was unknown when the bank issued the liabilities b_t and made the loans l_t in the previous period $t - 1$. Once ξ_t becomes known at the beginning of period t , the bank could use the threat of default to renegotiate the liabilities b_t to the liquidation value of its assets, that is, $\xi_t l_t$. Therefore, after renegotiating, the liabilities of the bank

²It is important to point out that the fact that entrepreneurs hold bank liabilities (they are net savers) while workers hold bank loans (they are net borrowers) is an equilibrium outcome. This follows from the assumption that only entrepreneurs are exposed to idiosyncratic risks and, therefore, they are willing to hold financial assets that pay a return that is lower than their intertemporal discount rate.

become

$$\tilde{b}_t(b_t, l_t) = \begin{cases} b_t, & \text{if } b_t \leq \xi_t l_t \\ \xi_t l_t & \text{if } b_t > \xi_t l_t \end{cases} \quad (8)$$

The variable ξ_t will be derived endogenously in the model. For the moment, however, it will be convenient to think of this variables as an exogenous stochastic variable that takes only two values, $\xi_t \in \{\underline{\xi}, \bar{\xi}\}$, with probabilities λ and $1 - \lambda$, respectively.

Since the liabilities of the bank could be renegotiated, the price of new liabilities b_{t+1} will reflect the potential losses that creditors could incur in period $t + 1$ in the event of renegotiation. Denote by \bar{R}_t^b the expected gross return of bank liabilities for the whole economy. Since banks are atomistic, the expected return on the liabilities issued by an individual bank must be equal to the aggregate expected return for the whole banking sector. Therefore, the price of new liabilities issued by an individual bank—denoted by $q(b_{t+1}, l_{t+1})$ —must satisfy

$$q(b_{t+1}, l_{t+1})b_{t+1} = \frac{1}{\bar{R}_t^b} \mathbb{E}_t \tilde{b}_{t+1}(b_{t+1}, l_{t+1}). \quad (9)$$

The term on the left-hand-side is the payment made by investors (entrepreneurs) to subscribe the liabilities b_{t+1} issued by an individual bank. The term on the right-hand-side is the repayment that investors expect in the next period, discounted by \bar{R}_t^b . Arbitrage imposes that these two terms are equalized in equilibrium.

Renegotiation, however, is not costless but it involves the following cost paid by the bank

$$\tilde{\varphi}_t(b_t, l_t) = \begin{cases} 0, & \text{if } b_t \leq \xi_t l_t \\ \varphi\left(\frac{b_t - \xi_t l_t}{l_t}\right) l_t & \text{if } b_t > \xi_t l_t \end{cases}. \quad (10)$$

The function $\varphi(\cdot)$ is strictly increasing and convex, differentiable and satisfies $\varphi(0) = \varphi'(0) = 0$. The final assumption is that banks incur an operation cost τ per unit of raised funds.

The budget constraint, after renegotiation, can be written as

$$\tilde{b}_t(b_t, l_t) + \tilde{\varphi}_t(b_t, l_t) + \frac{l_{t+1}}{R_t^l} + d_t = l_t + \frac{1 - \tau}{\bar{R}_t^b} \mathbb{E}_t \tilde{b}_{t+1}(b_{t+1}, l_{t+1}), \quad (11)$$

where d_t are the dividends paid to shareholders (workers) and the functions $\tilde{b}_t(b_t, l_t)$ and $\tilde{\varphi}_t(b_t, l_t)$ are defined in (8) and (10). The last term in the budget constraint denotes the funds raised by issuing new liabilities b_{t+1} . According to (9), these funds are equal to $\mathbb{E}_t \tilde{b}_{t+1}(b_{t+1}, l_{t+1}) / \bar{R}_t^b$, and are multiplied by $1 - \tau$ because of the operation cost.

The problem solved by the bank can be written recursively as

$$V_t(b_t, l_t) = \max_{d_t, b_{t+1}, l_{t+1}} \left\{ d_t + \beta \mathbb{E}_t V_{t+1}(b_{t+1}, l_{t+1}) \right\}$$

subject to (8), (10), (11).

In this problem the decision to renegotiate existing liabilities is implicitly accounted in the budget constraint by the functions $\tilde{b}_t(b_t, l_t)$ and $\tilde{\varphi}_t(b_t, l_t)$.

Lemma 2.2 *Define $\omega_{t+1} = b_{t+1}/l_{t+1} \leq \bar{\xi}$ the bank leverage. The optimal policies b_{t+1} and l_{t+1} satisfy*

$$\frac{1 - \tau}{R_t^b} \geq \beta \left[1 + \Phi(\omega_{t+1}) \right], \quad (12)$$

$$\frac{1}{R_t^l} \geq \beta \left[1 + \Psi(\omega_{t+1}) \right], \quad (13)$$

where $\Phi(\omega_{t+1})$ and $\Psi(\omega_{t+1})$ are continuous functions equal to zero for $\omega_{t+1} \leq \underline{\xi}$ and strictly increasing for $\omega_{t+1} > \underline{\xi}$. The two conditions are satisfied with equality if $\omega_{t+1} < \bar{\xi}$ and with inequality if $\omega_{t+1} = \bar{\xi}$.

A bank will never choose $b_{t+1} > \bar{\xi} l_{t+1}$ or, equivalently, $\omega_{t+1} > \bar{\xi}$, because this would trigger costly renegotiation with probability 1. Once the probability of renegotiation is 1, a further increase in b_{t+1} does not increase the borrowed funds $[(1 - \tau) / \bar{R}_t^b] \mathbb{E}_t \tilde{b}_{t+1}(b_{t+1}, l_{t+1})$ but raises the renegotiation cost. The optimal policy is then $b_{t+1} = \bar{\xi} l_{t+1}$.

Conditions (12) and (13) are derived from re-arranging the first order conditions of the bank with respect to b_{t+1} and l_{t+1} . The functions $\Phi(\omega_{t+1})$ and $\Psi(\omega_{t+1})$ depend on the renegotiation cost. They are equal to zero when the leverage is very low because in this case the liquidation value of the bank

assets is bigger than its liabilities even if $\xi_{t+1} = \underline{\xi}$. Once the leverage reaches a certain level, however, renegotiation arises with some probability. The inequality signs in (12) and (13) arise if the solution is at the corner $b_{t+1} = \bar{\xi}l_{t+1}$. Since we have two conditions that depend only on one variable—the leverage ω_{t+1} —there is no guarantee that these two conditions are both satisfied for arbitrary values of \bar{R}_t^b and R_t^l . In the general equilibrium, however, the interest rates adjust to clear the market and both conditions will be satisfied.

2.5 Banking liquidity and endogenous ξ_t

To make ξ_t endogenous, I assume that this variable represents the liquidation price of bank assets and the liquidity of the the whole banking sector plays a central role in the determination of this price. More specifically, I will make the following assumptions:

Assumption 1 *If a bank is liquidated, the assets l_t are divisible and can be sold either to other banks or to other sectors (workers and entrepreneurs). However, other banks have the ability to recover a fraction $\bar{\xi}$ of the liquidated assets while other sectors can recover the smaller fraction $\underline{\xi} < \bar{\xi}$.*

Assumption 2 *Banks can purchase the assets of a liquidated bank only if they are liquid, that is, $b_t < \xi_t l_t$.*

Based on the first assumption, in the event of liquidation it is more efficient to sell the liquidated assets to other banks. According to the second assumption, however, the sale to other banks can arise only if there are banks with liquidity to purchase the liquidated assets. A bank is liquid if it can issue new liabilities at the beginning of the period without renegotiating. Obviously, if the bank starts with $b_t > \xi_t l_t$, it will be unable to raise additional funds because investors know that the new liabilities (as well as the outstanding liabilities) are not collateralized and the bank will renegotiate immediately after receiving the funds.

To better understand these assumptions, consider the condition for not renegotiating, $b_t \leq \xi_t l_t$, where now ξ_t is the liquidation price of bank assets at the beginning of the period. If this condition is satisfied, banks have the option to raise additional funds at the beginning of the period to purchase the assets of a defaulting bank. This insures that the market price of the

liquidated assets is $\xi_t = \bar{\xi}$. However, if $b_t > \xi_t l_t$ for all banks, there will not be any bank with unused credit. As a result, the liquidated assets can only be sold to non-banks and the price will be $\xi_t = \underline{\xi}$. Therefore, the value of liquidated assets depends on the financial decision of banks, which in turn depends on the expected liquidation value of their assets. This interdependence creates the conditions for multiple self-fulfilling equilibria.

Proposition 2.2 *There exists multiple equilibria if and only if the leverage of the bank is within the two liquidation prices, that is, $\underline{\xi} \leq \omega_t \leq \bar{\xi}$.*

Given the multiplicity, equilibrium selection takes place stochastically through sunspots. Denote by ε a stochastic variable that takes the value of 0 with probability λ and 1 with probability $1 - \lambda$. The probability of a low liquidation price, denoted by $\theta(\omega_t)$, is a function of the banks' leverage as follows:

$$\theta(\omega_t) = \begin{cases} 0, & \text{if } \omega_t < \underline{\xi} \\ \lambda, & \text{if } \underline{\xi} \leq \omega_t \leq \bar{\xi} \\ 1, & \text{if } \omega_t > \bar{\xi} \end{cases}$$

If the leverage is sufficiently small ($\omega_t < \underline{\xi}$), banks do not default even if the liquidation price is low. But then the liquidation price cannot be low since banks remain liquid for any expectation of the liquidation price ξ_t and, therefore, for any draw of the sunspot variable ε . Instead, when the leverage is between the two liquidation prices ($\underline{\xi} \leq \omega_t \leq \bar{\xi}$), the liquidity of banks depends on the expectation of this price. Therefore, the equilibrium outcome depends on the realization of the sunspot variable ε . When $\varepsilon = 0$ —which happens with probability λ —the market expectation is for a low liquidation price $\xi_t = \underline{\xi}$, making the banking sector illiquid. On the other hand, when $\varepsilon = 1$ —which happens with probability $1 - \lambda$ —the market expectation is for a high liquidation price $\xi_t = \bar{\xi}$ so that the banking sector remains liquid. The dependence of the probability $\theta(\omega_t)$ from the leverage of the banking sector plays an important role for the results of the paper.

2.6 General equilibrium

To characterize the general equilibrium I first derive the aggregate demand for bank liabilities from the optimal saving of entrepreneurs. I then derive

the supply by consolidating the demand of loans of workers with the optimal policy of banks. In this section I assume that the borrowing limit for workers takes the simpler form specified in (2), which allows me to derive analytical characterizations.

Demand for bank liabilities As shown in Lemma 2.1, the optimal saving of entrepreneurs takes the form $b_{t+1}^i/R_t^b = \beta a_t^i$, where a_t^i is the end-of-period wealth defined as $a_t^i = \tilde{b}_t^i + (z_t^i - w_t)h_t^i$. Since $h_t^i = \phi(w_t)\tilde{b}_t^i$ (see Lemma 2.1), the end-of-period wealth can be rewritten as $a_t^i = [1 + (z_t^i - w_t)\phi(w_t)]\tilde{b}_t^i$. Substituting into the optimal saving and aggregating over all entrepreneurs we obtain

$$B_{t+1} = \beta R_t^b [1 + (\bar{z} - w_t)\phi(w_t)] \tilde{B}_t. \quad (14)$$

This equation defines the aggregate demand for bank liabilities as a function of the interest rate R_t^b , the wage rate w_t , and the beginning-of-period aggregate wealth of entrepreneurs \tilde{B}_t . Remember that the tilde sign denotes the entrepreneurs' wealth after renegotiation.

Using the equilibrium condition in the labor market, we can express the wage rate as a function of \tilde{B}_t . In particular, equalizing the demand for labor, $H_t^D = \phi(w_t)\tilde{B}_t$, to the supply from workers, $H_t^D = (w_t/\alpha)^\nu$, we can express the wage w_t as a function of only \tilde{B}_t . We can then use this function to replace w_t in (14) and express the demand for bank liabilities as a function of only \tilde{B}_t and R_t^b , that is, $B_{t+1} = D(\tilde{B}_t, R_t^b)$. Figure 2 plots this function for a given value of \tilde{B}_t . As we increase \tilde{B}_t , the demand function becomes flatter.

Supply of bank liabilities The supply of bank liabilities is derived from consolidating the borrowing decisions of workers with the investment and funding decisions of banks.

The lending policy of banks satisfies condition (13). This condition implies that the lending rate is smaller than the intertemporal discount rate if $\omega_{t+1} > \underline{\xi}$, that is, when banks are highly leveraged. From the workers' first order condition (5) we can see that $\mu_t > 0$ if $R_t^l < 1/\beta$. Therefore, when $\omega_{t+1} > \underline{\xi}$, the borrowing constraint for workers is binding, which implies $L_{t+1} = \eta$. Since $B_{t+1} = \omega_{t+1}L_{t+1}$, the supply of bank liabilities is $B_{t+1} = \eta\omega_{t+1}$. When the lending rate is equal to the intertemporal discount rate, instead, the demand for loans from workers is undetermined, which in turn implies indeterminacy in the supply of bank liabilities. In this case the liabilities of banks are demand determined.

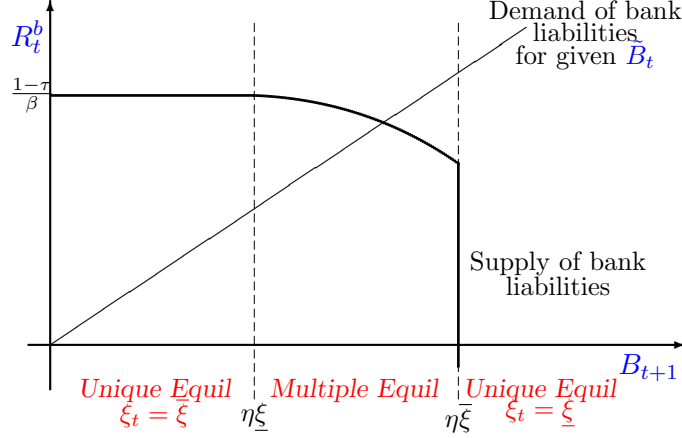


Figure 2: Demand and supply of bank liabilities.

So far I have derived the supply of bank liabilities as a function of the bank leverage ω_{t+1} . However, the leverage of banks is related to the borrowing rate R_t^b through condition (12). We can then use this condition to express the supply of bank liabilities as a function of R_t^b . This is plotted in Figure 2. As can be seen, the supply is undetermined when the interest rate is equal to $(1 - \tau)/\beta$ but increases for lower values of the interest rate until it reaches $\eta\bar{\xi}$. Further declines no longer changes the supply.

Equilibrium The general equilibrium can be characterized as the intersection of the demand and supply of bank liabilities as plotted in Figure 2. The supply (from banks) is decreasing in the funding rate R_t^b while the demand (from entrepreneurs) is increasing in R_t^b . The demand is plotted for a particular value of outstanding liabilities \tilde{B}_t . By changing the outstanding liabilities, the slope of the demand function changes.

The figure also indicates the regions with unique or multiple equilibria. When the interest rate is $(1 - \tau)/\beta$, banks are indifferent in the choice of leverage $\omega_{t+1} \leq \underline{\xi}$. When the funding rate falls below this value, however, the optimal leverage starts to increase above $\underline{\xi}$ and the economy enters in the region with multiple equilibria. Once the leverage reaches $\omega_{t+1} = \bar{\xi}$, a further decline in the interest rate paid by banks on their liabilities does not lead to higher leverages since the choice of $\omega_{t+1} > \bar{\xi}$ would cause renegotiation with

probability 1.³

Given the initial entrepreneurial wealth \tilde{B}_t , the intersection of demand and supply of bank liabilities determines the interest rate R_t^b , which in turn allows me to determine the next period wealth of entrepreneurs \tilde{B}_{t+1} . In absence of renegotiation we have $\tilde{B}_{t+1} = B_{t+1}$, where B_{t+1} is determined by equation (14). In the event of renegotiation (assuming that we are in a region with multiple equilibria) we have $\tilde{B}_{t+1} = (\underline{\xi}/\omega_{t+1})B_{t+1}$. The new \tilde{B}_{t+1} will determine a new slope for the demand of bank liabilities, and therefore, a new equilibrium value of R_t^b and B_{t+1} . Depending on the parameter values, the economy may or may not reach a steady state. A key parameter determining the convergence to a steady state is the intermediation cost τ .

Proposition 2.3 *There exists $\hat{\tau} > 0$ such that: If $\tau \geq \hat{\tau}$, the economy converges to a steady state without renegotiation. If $\tau < \hat{\tau}$, the economy never converges to a steady state but switches stochastically between equilibria with and without renegotiation according to the realization of the sunspot ε .*

In order to converge to a steady state, the economy has to reach an equilibrium in which renegotiation never arises. This requires that the interest rate paid on bank liabilities is equal to $R_t^b = (1 - \tau)/\beta$. With this interest rate banks do not have incentive to leverage because the funding cost equals the return on loans and renegotiation never arises. For this to be an equilibrium, however, the demand for bank liabilities must be sufficiently low which cannot be the case when $\tau = 0$. With $\tau = 0$, in fact, the steady state interest rate must be equal to $1/\beta$. But then entrepreneurs will increase over time the holding of bank liabilities without bound for precautionary reasons. The demand for bank liabilities will eventually become bigger than the supply (which is bounded by the borrowing constraint of workers), driving the interest rate below $1/\beta$. As the interest rate falls, multiple equilibria become possible.

3 Recent trends and macroeconomic stability

In this section I use the model to illustrate the impact of two recent trends: the growth of emerging economies (Subsection 3.1) and financial innovation

³The dependence of the existence of multiple equilibria from the state of the economy is also a feature of the sovereign default model of Cole and Kehoe (2000).

(Subsection 3.2). As we will see, both trends have increased financial and macroeconomic instability. I describe first the parametrization of the model which, for the application, will use the borrowing limit specified in 3. As discussed earlier, this specification of the borrowing constraint allows for the price of the fixed asset to move over time so that I can also study how the two trends affect the dynamics of asset prices.

The period in the model is a quarter and the discount factor is set to $\beta = 0.9825$, implying an annual intertemporal discount rate of about 7%. The parameter ν in the utility function of workers is the elasticity of the labor supply. I set this elasticity to the high value of 50. The reason to use this high value is to capture, in a simple way, possible wage rigidities. In fact, with a very high elasticity of the labor supply, wages are almost constant. The alternative would be to model explicitly downward wage rigidities but this requires an additional state variable and would make the computation of the model more demanding. The parameter α is chosen so that the average labor supply is about 0.3.

The average productivity of entrepreneurs is normalized to $\bar{z} = 1$. Since the average input of labor is about 0.3, the average production is also about 0.3. The supply of the fixed asset is normalized to $\bar{k} = 1$ and its production flow is set to $\chi = 0.05$. Total production is the sum of entrepreneurial production plus the production from the fixed asset which is about 0.35 per quarter (about 1.4 per year).

The parameter η determines the fraction of the fixed asset that can be used as a collateral and it is set to 0.6. The productivity shock follows a truncated normal distribution with standard deviation of 0.3. In equilibrium this implies that the standard deviation of entrepreneurial wealth is about 20%. Therefore, entrepreneurs face substantial risk.

The last parameters pertain to the banking sector. The two values of ξ are set to $\underline{\xi} = 0.75$ and $\bar{\xi} = 0.95$. This implies that the maximum leverage of the banking sector is 95%. The sunspot probability (which could lead to a bank crisis) is set to 2%. Therefore, provided that the economy is in a region that admits multiple equilibria, a crisis arises on average every fifty quarters. The renegotiation cost is assumed to be quadratic, that is, $\varphi(\cdot) = (\cdot)^2$. Finally, the operation cost for banks is set to $\tau = 0.0045$.

3.1 The growth of emerging countries

During the last three decades we have witnessed an unprecedented growth of emerging countries. As a result of the sustained growth, the size of these economies has increased dramatically compared to industrialized countries, as shown in the top panel of Figure 3. In PPP terms, at the beginning of the 1990s the GDP of emerging countries was less 46 percent the GDP of industrialized countries. This number increased to almost 90 percent by 2011. When the GDP comparison is based on nominal exchange rates, the relative size of the emerging economies increased from 17 to 52 percent.

During the same period emerging countries have increased the foreign holdings of safer assets. It is customary to divide foreign assets in four classes: (i) debt instruments and international reserves; (ii) portfolio investments; (iii) foreign direct investments; (iv) other investments. See Gourinchas and Rey (2007) and Lane and Milesi-Ferretti (2007). The first class of assets—debt and international reserves—is typically considered safer. The net foreign position in this asset class for emerging and industrialized countries is plotted in the bottom panel of Figure 3. Since the early 1990s, emerging countries have accumulated ‘positive’ net positions while industrialized countries have experienced the opposite pattern with the accumulation of ‘negative’ net positions. Therefore, the increase in the relative size of emerging economies has been associated with a significant accumulation by these countries of safer financial assets issued by industrialized countries.

There are several theories proposed in the literature to explain why emerging countries accumulate safer assets issued by industrialized countries. One explanation is based on the view that emerging countries have pursued policies aimed at keeping their currencies undervalued relatively to the currencies of industrialized countries. To achieve this goal, they have purchased large volumes of foreign financial assets such as US treasury bills together with the imposition of capital controls. Another explanation is based on differences in the characteristics of financial markets in emerging and industrialized countries. The idea is that lower financial development in emerging economies impairs the ability of these countries to create viable saving instruments for intertemporal smoothing (Caballero, Farhi, and Gourinchas (2008)) or for insurance purpose (Mendoza, Quadrini, and Ríos-Rull (2009)). Because of this, emerging economies turn to industrialized countries in to purchase these assets. A third explanation is based on a higher idiosyncratic uncertainty faced by consumers and firms in emerging countries due, for example,

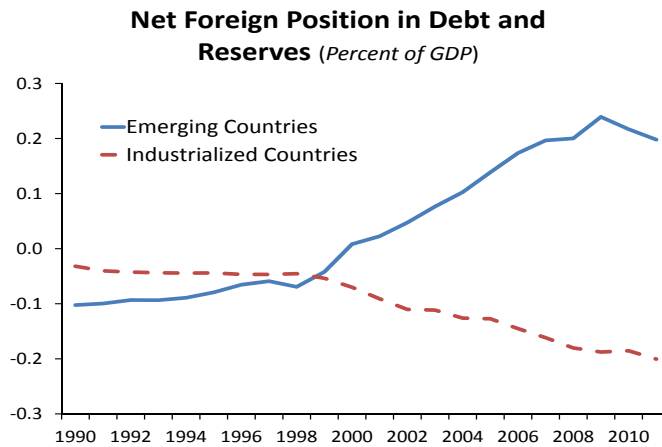
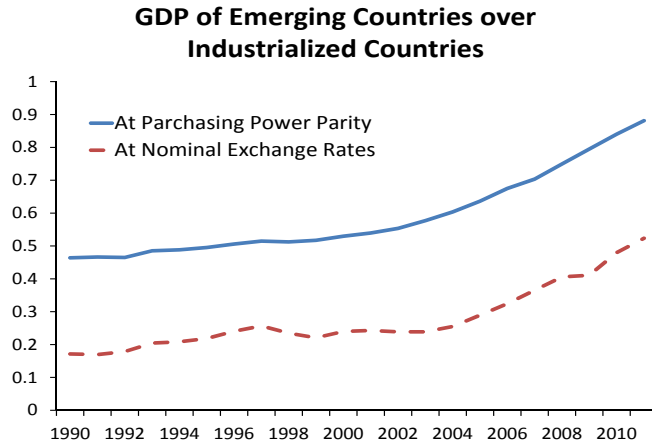


Figure 3: Gross domestic product and net foreign positions in debt instruments and international reserves of emerging and industrialized countries. **Emerging countries:** Argentina, Brazil, Bulgaria, Chile, China, Hong.Kong, Colombia, Estonia, Hungary, India, Indonesia, South Korea, Latvia, Lithuania, Malaysia, Mexico, Pakistan, Peru, Philippines, Poland, Romania, Russia, South Africa, Thailand, Turkey, Ukraine, Venezuela. **Industrialized countries:** Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United.Kingdom, United.States. **Sources:** World Development Indicators (World Bank) and External Wealth of Nations Mark II database (Lane and Milesi-Ferretti (2007)).

to the greater idiosyncratic risk associated with fast structural changes or lower safety nets provided by the public sector.

The above explanations point to an excess demand for safe financial assets from emerging countries. As the relative size of these countries increases, so does the global demand for safe assets issued by industrialized countries.

Extended model and numerical simulation To study how the increase in the demand for safe assets from emerging countries affects the stability of the globalized economy, I extend the model by assuming that in addition to the demand for bank liabilities from domestic entrepreneurs, there is also a demand for these liabilities from the foreign sector. To keep the model simple I assume that the foreign demand is purely exogenous, and therefore, it is insensitive to the equilibrium interest rate.

Denoting by B_t the domestic demand and by B_t^F the foreign demand, the total demand of bank liabilities is equal to $B_t + B_t^F$ and the renegotiation condition for banks becomes $B_t + B_t^F > \xi_t L_t$. Besides this, the description and equilibrium conditions are the same as for the model studied earlier.

The next step is to use the extended model to study the impact of the growth of emerging economies numerically. To this end I conduct the following experiment. I assume that the country in the model is representative of the industrialized countries. I then interpret the negative of the foreign position in debt and foreign reserves of industrialized countries as the demand for foreign liabilities coming from emerging economies.

The net position in debt and foreign reserves is shown in Figure 3 for the period 1990-2011. Before 1990, I assume that the net position is constant at the 1990 level, that is, -3.2% of GDP. Then during the subsequent period 1991-2011 it follows the exact pattern shown in the data. Since the period in the model is a quarter while the data on net foreign asset positions is available annually, the inter-quarter values are assumed to be equal to the annual levels. Then, starting in 2012, I assume that the net position remains at the 2011 level, that is, -20% of GDP. Of course, we do not know what will be the pattern in the future and I could make alternative assumptions as I will do later. I assume further that until 1990, the growth in the external demand for bank liabilities is not anticipated. Starting in 1991, however, the future pattern is fully anticipated.

Given the parameter values described above, I simulate the model for 2,000 quarters (500 years). In the first 1,000 quarters the foreign demand for bank liabilities is fixed at the 1990 level and agents do not anticipate the future growth in demand. Starting at quarter 1,001, which corresponds to

the first quarter of 1991, agents learn that the foreign demand has changed and will continue to change during the next 80 quarters (from 1991 to 2011) after which it stabilizes at the level observed in 2011. Therefore, the break period is the first quarter of 1991.

Numerical results Since there are sunspot shocks that could shift the economy from one type of equilibrium to the other, the dynamics depend on the actual realizations of the shock. To better illustrate the stochastic nature of the economy, I repeat the simulation of the model 1,000 times (with each simulation performed over 2,000 periods as described above). Figure 4 plots the average of the 1,000 repeated simulations as well as the 5th and 95th percentiles in each quarter over the period 1981-2020. This corresponds to periods 960 to 1,120 in each simulation. The range of variation between the 5th and 95th percentiles provides information about the volatility of the economy at any point in time.

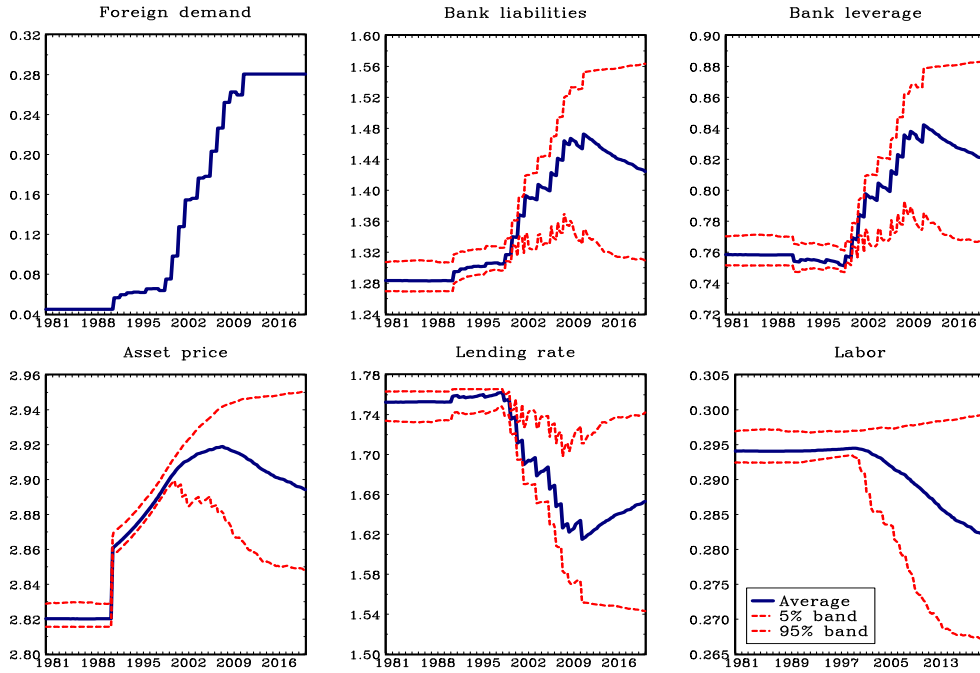


Figure 4: Change in foreign demand for bank liabilities. Responses of 1,000 simulations.

The first panel plots the foreign demand for bank liabilities. The foreign demand is exogenous in the model and the 1991 change determines a

structural break. The next five panels plot five endogenous variables: the total liabilities of banks (domestically and foreign owned), their leverage, the lending rate, the price of the fixed asset and the input of labor.

The first point to notice is that, following the increase in foreign demand, the interval delimited by the 5th and 95th percentiles of the repeated simulations widens dramatically. Therefore, financial and macroeconomic volatility increases substantially as we move to the 2000s. In this particular simulation, the probability of a bank crisis is always positive, even before the structural break induced by the change in foreign demand for bank liabilities in the early 1990s. However, after the structural change, the consequences of a bank crisis could be much bigger since the distance between the 5th and 95th percentiles is wider.

Besides the increase in financial and macroeconomic volatility, the figure reveals other interesting patterns. First, as the foreign demand increases, banks raise their leverage while the interest rate on loans decreases. The economy also experiences an increase in asset prices (the price of the fixed asset) but labor declines on average. This is a consequence of the decline in labor demand. As the foreign demand for bank liabilities increases, part of the increase is filled with lower holdings of bank liabilities by domestic entrepreneurs (in addition to higher bank leverage). But as domestic entrepreneurs hold less financial wealth, they become more averse to risk and hire less labor.

It is important to point out that, although labor falls in the average of all repeated simulations, the actual dynamics of labor during the 20 years that followed the 1991 break could be increasing or decreasing depending on the actual realizations of the sunspot shocks. To show this point, I repeat the experiment shown in Figure 4 but for a particular sequence of sunspot shocks. In particular, I simulate the model under the assumption that, starting in the first quarter of 1991, the economy experiences a sequence of draws of the sunspot variable $\varepsilon = 1$ until the second quarter of 2008. Then in the third quarter of 2008 the draw of the sunspot shock becomes $\varepsilon = 0$ but returns to $\varepsilon = 1$ from the fourth quarter of 2008 and in all subsequent quarters.

This particular sequence of draws captures the idea that expectations may have turned pessimistic in the fourth quarter of 2008 leading to a sudden financial and macroeconomic crisis. The statistics for the resulting simulation is reported in Figure 5. The continuous line is still the average at time t of the 1,000 simulations. However, differently from the previous graph, starting from the first quarter of 1991 the sequences of draws for the sunspot variable

is always the same for all 1,000 repeated simulations.

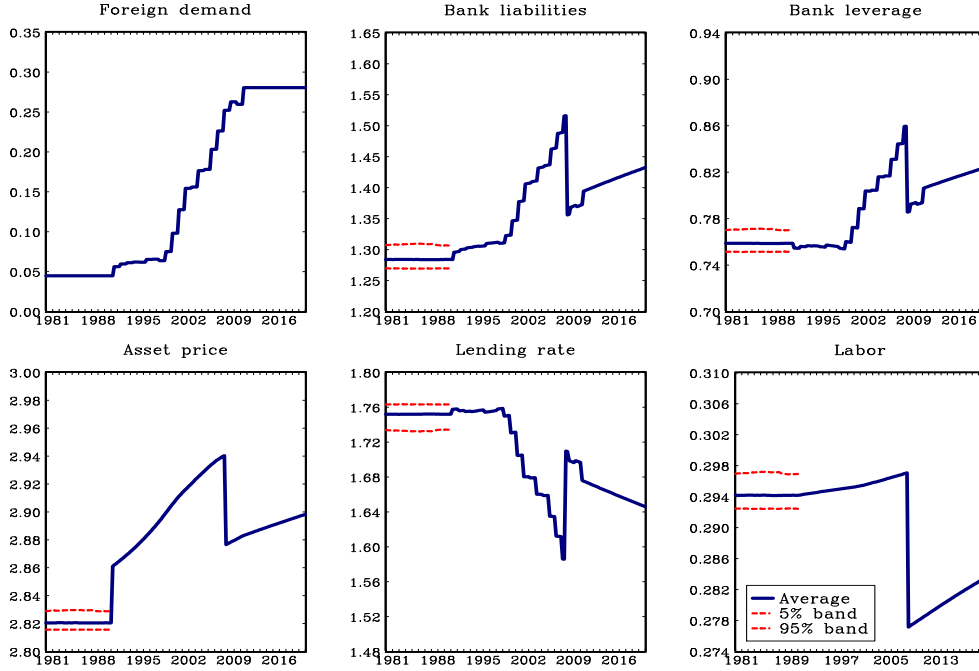


Figure 5: Change in foreign demand for bank liabilities. Responses of 1,000 simulations with same draws of the sunspot variable starting in 1991.

As we can see from Figure 5, even if the demand for bank liabilities from the foreign sector increases, as long as the draws of the sunspot variable is $\varepsilon = 1$, asset prices continue to increase and the input of labor does not drop. However, a single realization $\varepsilon = 1$ of the sunspot shock can trigger a large decline in labor. Furthermore, even if the negative shock is only for one period and there are no crises afterwards, the recovery in the labor market is extremely slow. This is because the crisis generates a large decline in the financial wealth of employers and it will take a long time for them to rebuild the lost wealth through savings.

Another way of showing the importance of the growth of emerging countries for macroeconomic stability in industrialized countries, is by conducting the following counterfactual exercise. I repeat the simulation shown in Figure 5 but under the assumption that the foreign demand for bank liabilities remains at the pre-1991 level for the whole simulation period. This counterfactual exercise tells us how the financial and macroeconomic dynamics in

response to the same shocks would have changed in absence of the observed increase in foreign demand for bank liabilities. The resulting simulation is shown in Figure 6.

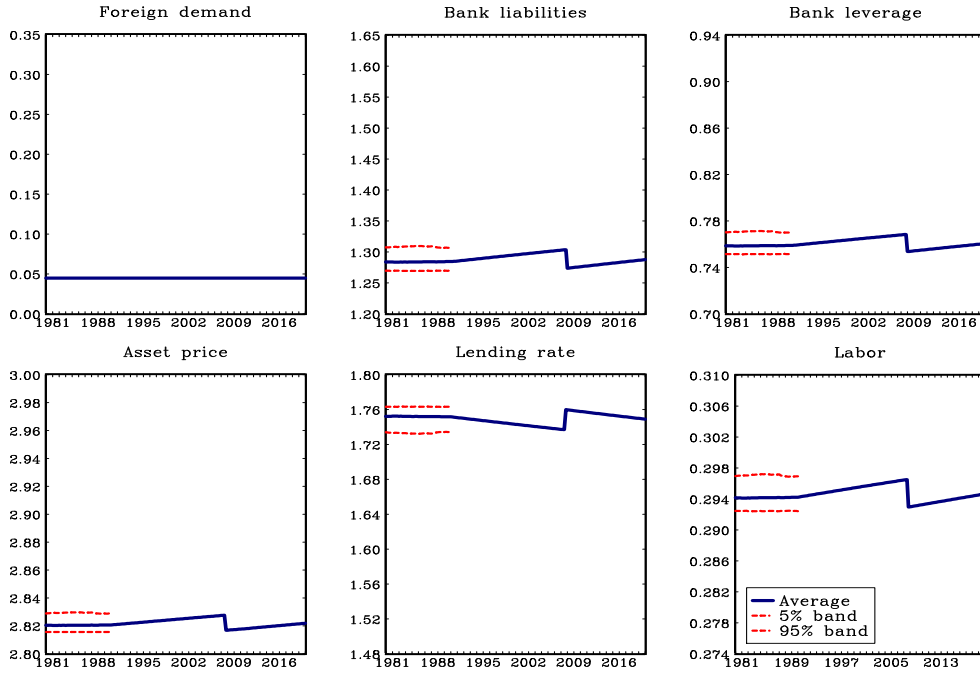


Figure 6: Counterfactual exercise with constant foreign demand for bank liabilities. Responses of 1,000 simulations with same draws of the sunspot variable starting in 1991.

As shown in the figure, without the increase in foreign demand for bank liabilities, the same sequence of sunspot shocks would have generated a much smaller financial and macroeconomic expansion before 2008 as well as a much smaller contraction in the third quarter of 2008. Therefore, the increase in foreign demand for financial assets issued by industrialized countries could have contributed to the observed expansion of the financial sector in industrialized countries but it also created the conditions for greater financial and macroeconomic fragility that became evident once the crisis materialized.

3.2 Financial innovation

The financial sector has gone through a significant process of innovations. Some of the innovations were allowed by institutional liberalization while

others were allowed by technological innovations. One way of thinking about innovations in the financial sector is that they reduce the operational cost of this sector. In the context of the model studied in this paper this is captured by a reduction in the parameter τ , that is, the funding cost for banks. The idea is that, thanks to financial liberalization and/or the introduction of new technologies and financial products, banks have been able to simplify their funding activity. In reduced form this is captured by a reduction in the operation cost τ .

From Proposition 2.3 we know that the cost τ determines the existence of multiple equilibria. For a sufficiently high τ , the economy converges to a state with a unique equilibrium without crises. With a sufficiently low τ , instead, the economy will eventually reaches a state with multiple equilibria. As a result, the economy experiences stochastic fluctuations where gradual booms are reversed by sudden crises. Therefore, as the operational cost τ declines, the economy could move from a state with unique equilibria to states with multiple equilibria.

Consider again the parameterized version of the model where I set $\tau = 0.0045$. With this value of the operational cost, the states of the economy are in the region with multiple equilibria, experiencing stochastic fluctuations. But now suppose that, starting in 1991, the cost decreases permanently to $\tau = 0.0035$. Figure 7 shows the simulation statistics associated with the structural change in τ . As for the analysis of the growth in foreign demand for bank liabilities, the change in τ is unexpected.

Starting in 1991, the distance between the 5th and 95th percentiles increases for all endogenous variables. Therefore, the decline in τ increases financial and macroeconomic volatility. On average, the economic experiences an expansion characterized by higher banking leverage and higher employment. As long as the draws of the sunspot shock are $\varepsilon = 1$, the financial and macroeconomic boom are even bigger. But a single reversal of the sunspot shock to $\varepsilon = 0$ generates a large and persistent crisis as shown in Figure 8. This figure is constructed using the same methodology used in the construction of Figure 5, that is, starting in 1991 the repeated simulations use the same sequence of sunspot shocks $\varepsilon = 1$, except in the third quarter of 2008 (financial crisis). In the graph shown here, however, the 1991 structural break is the change in τ rather than the change in foreign demand for bank liabilities.

Finally, I conduct the counterfactual exercise in which I construct the response to the particular sequence of sunspot shocks used in the previous

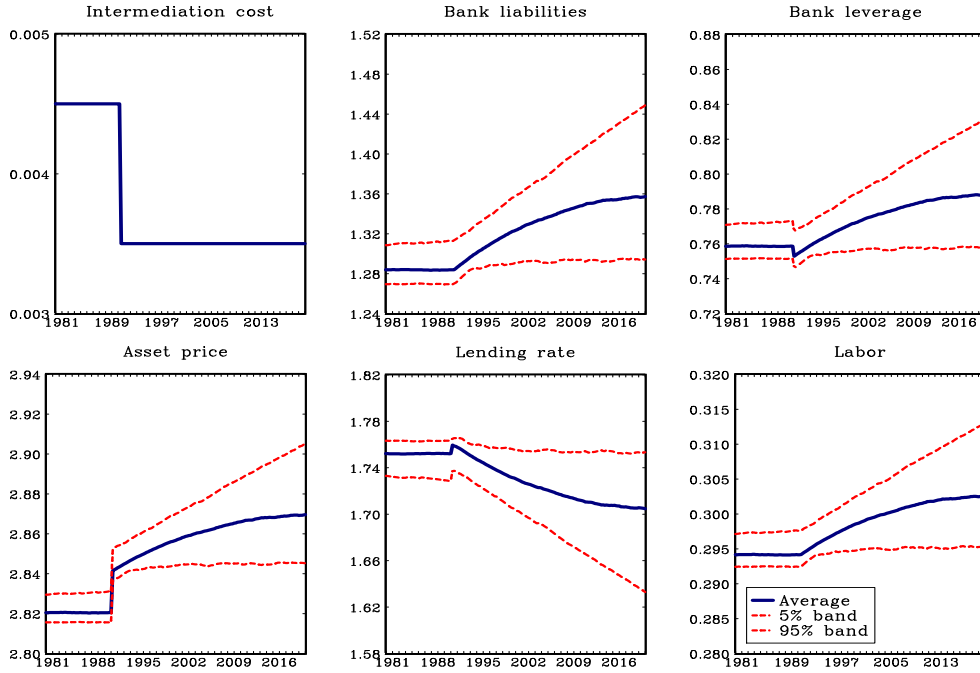


Figure 7: Change in bank operation cost τ . Responses of 1,000 simulations.

figure but without changing the value of τ in 1991. This shows how the dynamic of the economy would change without financial innovations. As shown in the Figure 9, without financial innovations the same sequence of sunspot shocks would generate a much smaller financial and macroeconomic expansion before 2008 as well as a much smaller contraction in the third quarter of 2008. Therefore, financial innovations could have contributed to the observed expansion of the financial sector in industrialized countries but it also created the conditions for greater financial and macroeconomic fragility that became evident once the crisis materialized.

4 Conclusion

The traditional role of banks is to facilitate the transfer of resources from agents in excess of funds to agents in need of funds. This paper emphasizes a second important role played by banks: the issuance of liabilities that can be held by the nonfinancial sector for insurance purposes. This is similar to

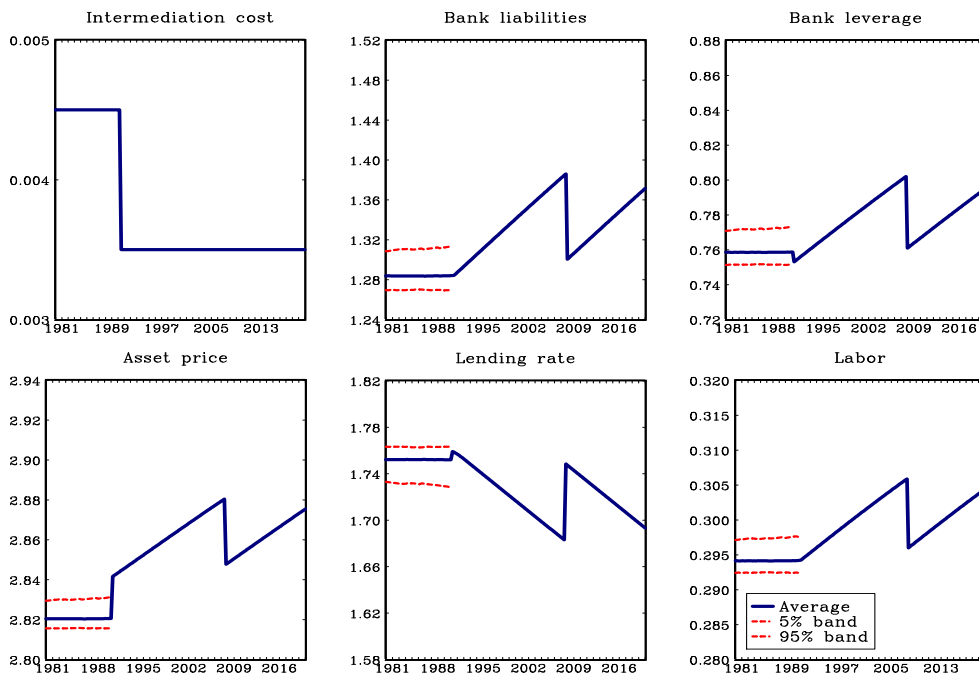


Figure 8: Change in bank operation cost τ . Responses of 1,000 simulations with same draws of the sunspot variable starting in 1991.

the role of banks in the creation of liabilities used as a mean of transaction (money). The difference is that in the current paper bank liabilities are valued not for their use as a mean of exchange but as a store of value which is important for insuring agents against idiosyncratic risks. When the liabilities of banks or their value are low, agents are less willing to engage in risky economic activities and this causes a macroeconomic downturn.

The paper also shows that booms and busts in financial intermediation can be driven by self-fulfilling expectations about the liquidity of the banking sector. When the economy expects the banking sector to be liquid, banks have an incentive to leverage and this generates a macroeconomic boom. But as the leverage increases, the banking sector becomes vulnerable to pessimistic expectations that generate self-fulfilling liquidity crises.

The model has been used to study two recent trends: the growth of emerging economies and financial innovations. Both trends have contributed to a macroeconomic expansion in industrialized countries but they have also increased the potential instability of the financial and macroeconomic systems.

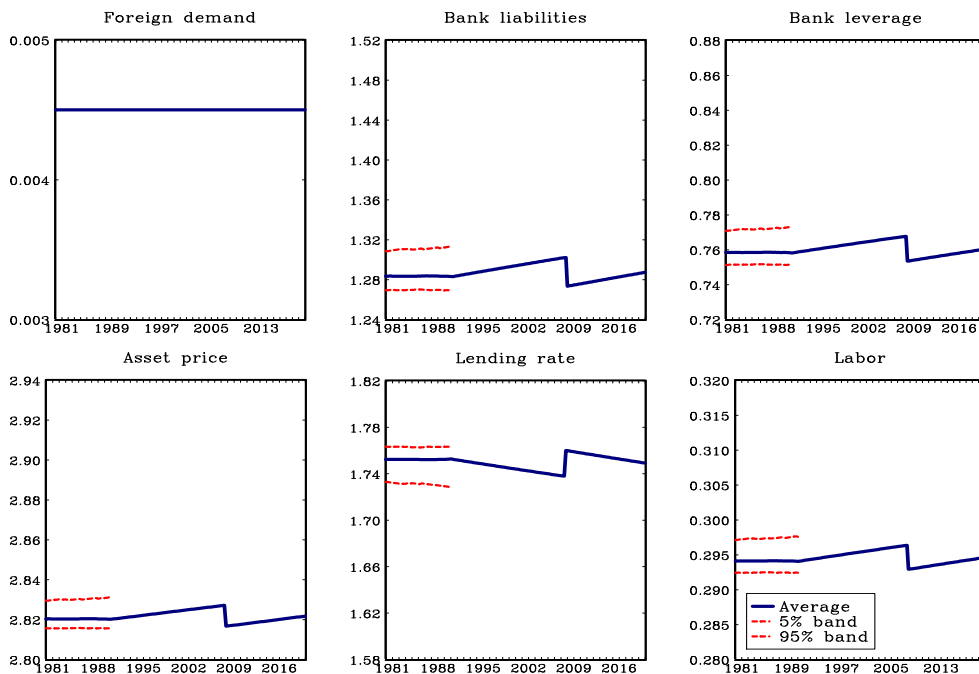


Figure 9: Counterfactual exercise with constant bank operation cost τ . Responses of 1,000 simulations with same draws of the sunspot variable starting in 1991.

As long as expectations remain optimistic, countries experience financial and macroeconomic booms in response to the growth of emerging economies and financial innovation. However, the boom also creates the conditions for more severe and long lasting macroeconomic crises.

References

- Arellano, C., Bai, Y., & Kehoe, P. (2011). Financial Markets and Fluctuations in Uncertainty. Research Department Staff Report, Federal Reserve Bank of Minneapolis.
- Bernanke, B., & Gertler, M. (1989). Agency Costs, Net Worth, and Business Fluctuations. *American Economic Review*, 79(1), 14–31.
- Boissay, F., Collard, F., & Smets, F. (2010). Booms and Systemic Banking Crises. Unpublished manuscript, European Central Bank.

- Brunnermeier, M., & Sannikov, Y. (2010). A Macroeconomic Model with a Financial Sector. Unpublished manuscript, Princeton University.
- Caballero, R. J., Farhi, E., & Gourinchas, P. O. (2008). An Equilibrium Model of Global Imbalances and Low Interest Rates. *American Economic Review*, 98(1), 358–93.
- Cole, H. L., & Kehoe, T. J. (2000). Self-Fulfilling Debt Crises. *Review of Economic Studies*, 67(1), 91–116.
- Corbae, D., & D’Erasmus, P. (2012). A Quantitative Model of Banking Industry Dynamics. Unpublished manuscript, University of Wisconsin and University of Maryland.
- De Fiore, F., & Uhlig, H. (2011). Bank Finance versus Bond Finance. *Journal of Money Credit and Banking*, 43(7), 1399–1421.
- Gertler, M., & Kiyotaki, N. (2010). Financial Intermediation and Credit Policy in Business Cycle Analysis. In Friedman, B. M., & Woodford, M. (Eds.), *Handbook of Monetary Economics*, Vol. 3, chap. 11, pp. 1341–96. Elsevier, Amsterdam: Elsevier Science.
- Gertler, M., & Karadi, P. (2011). A Model of Unconventional Monetary Policy. *Journal of Monetary Economics*, 58(1), 17–34.
- Gourinchas, P. O., & Rey, H. (2007). From World Banker to World Venture Capitalist: US External Adjustment and the Exorbitant Privilege. In Clarida, R. H. (Ed.), *G7 Current Account Imbalances: Sustainability and Adjustment*, pp. 11–66. The University of Chicago Press, Chicago, Illinois.
- Holmstrom, B., & Tirole, J. (1997). Financial Intermediation, Loanable Funds, and the Real Sector. *Quarterly Journal of Economics*, 112(3), 663–91.
- Kalemli-Ozcana, S., Papaioannou, E., & Perri, F. (2013a). Global Banks and Crisis Transmission. *Journal of International Economics*, 89(2).
- Kalemli-Ozcana, S., Sorensen, B., & Volosovych, V. (2013b). Deep Financial Integration and Macroeconomic Volatility. *Journal of European Economic Association*, forthcoming.

- Kiyotaki, N., & Moore, J. H. (1997). Credit Cycles. *Journal of Political Economy*, 105(2), 211–48.
- Lane, P. R., & Milesi-Ferretti, G. M. (2007). The External Wealth of Nations Mark II: Revised and Extended Estimates of Foreign Assets and Liabilities, 1970-2004. *Journal of International Economics*, 73(2), 223–250.
- Meh, C. A., & Moran, K. (2010). The Role of Bank Capital in the Propagation of Shocks. *Journal of Economic Dynamics and Control*, 34(3), 555–76.
- Mendoza, E., Quadrini, V., & Ríos-Rull, J. V. (2009). Financial Integration, Financial Development and Global Imbalances. *Journal of Political Economy*, 117(3), 297–323.
- Mendoza, E., & Quadrini, V. (2010). Financial Globalization, Financial Crises and Contagion. *Journal of Monetary Economics*, 57(1), 24–39.
- Perri, F., & Quadrini, V. (2011). International Recessions. NBER Working Paper No. 17201.
- Rampini, A., & Viswanathan, S. (2012). Financial Intermediary Capital. Unpublished manuscript, Duke University.
- Van den Heuvel, S. J. (2008). The Welfare Cost of Bank Capital Requirements. *Journal of Monetary Economics*, 55(2), 298–320.