The growth of emerging economies and global macroeconomic stability

Vincenzo Quadrini
University of Southern California and CEPR

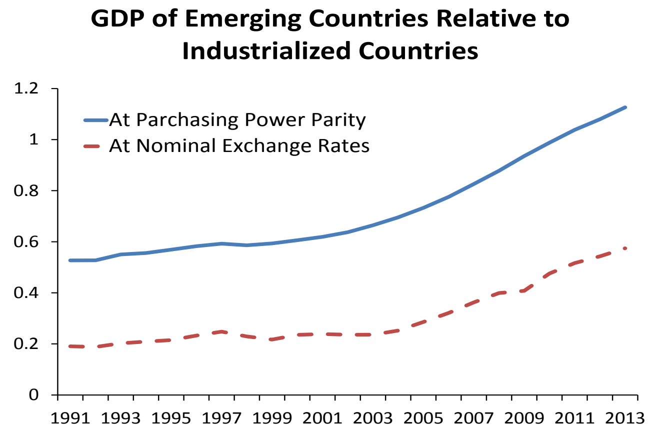
Abstract

This paper studies how the unprecedent growth within emerging countries during the last two decades has affected global macroeconomic stability in both emerging and industrialized countries. To address this question I develop a two-country model (representative of industrialized and emerging economies) where financial intermediaries play a central role in the domestic and international intermediation of funds. The main finding is that the growth of emerging countries has increased the worldwide demand for safe financial assets. This has enhanced the incentive of banks to leverage which in turn has contributed to greater financial and macroeconomic instability in both industrialized and emerging economies.

1 Introduction

During the last two decades we have witnessed unprecedent growth within emerging countries. As a result of the sustained growth, the size of these economies has increased dramatically compared to industrialized countries. The top panel of Figure 1 shows that, in PPP terms, the GDP of emerging countries at the beginning of the 1990s was 46 percent the GDP of industrialized countries. This number has increased to 90 percent by 2011. When the GDP comparison is based on nominal exchange rates, the relative size of emerging economies has increased from 17 to 52 percent.

During the same period, emerging countries have increased the foreign holdings of safe financial 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



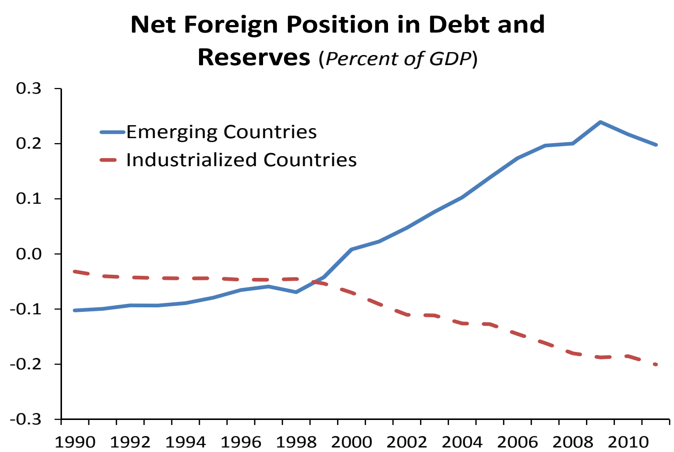


Figure 1: Gross domestic product and net foreign positions in debt instruments and international reserves of emerging and industrialized countries. **Emerging countries**: Argentina, Brazil, Bulgaria, Chile, China, Hong.Kong, Colombia, Estonia, Hungary, India, Indonesia, South Korea, Latvia, Lithuania, 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)).

Gourinchas and Rey (2007) and Lane and Milesi-Ferretti (2007)). The net foreign position in the first class of assets—debt and international reserves—

is plotted in the bottom panel of Figure 1 separately for industrialized and emerging economies. Since the early 1990s, emerging countries have accumulated 'positive' net positions while industrialized countries have accumulated 'negative' net positions.

There are several theories proposed in the literature to explain why emerging countries accumulate safe assets issued by industrialized countries. One explanation posits that emerging countries have pursued policies aimed at keeping their currencies undervalued and, to achieve this goal, they have been purchasing large volumes of foreign financial assets. Another explanation is based on differences in the characteristics of financial markets. The idea is that lower financial development in emerging countries 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, they turn to industrialized countries for the acquisition of these assets. A third explanation is based on greater idiosyncratic uncertainty faced by consumers and firms in emerging countries due, for example, to higher idiosyncratic risk or lower safety net provided by the public sector.

Independently of the particular mechanism, the existing literature emphasizes the tendency of emerging economies to have an excess demand for safe financial assets. Then, as the relative size of these countries increases, so does the global demand for these assets. The goal of this paper is to study how this affects financial and macroeconomic stability in both emerging and industrialized countries.

To address this question I develop a two-country model where financial intermediaries play a central role in the intermediation of funds from agents in excess of funds (lenders) to agents in need of funds (borrowers). Financial intermediaries issue liabilities and make loans. Differently from recent macroeconomic models proposed in the literature,[1] I emphasize the central role of banks in issuing liabilities (or facilitating the issuance of liabilities) rather than its lending role for macroeconomic dynamics.

An important role played by bank liabilities is that they can be held by other sectors of the economy for insurance purposes. Then, when the stock of bank liabilities increases, agents are better insured and willing to

[1] See, for example, Van den Heuvel (2008), Meh and Moran (2010), Brunnermeier and Sannikov (2010), Gertler and Kiyotaki (2010), Mendoza and Quadrini (2010), De Fiore and Uhlig (2011), Gertler and Karadi (2011), Boissay, Collard, and Smets (2010), Corbae and D'Erasmo (2012), Rampini and Viswanathan (2012), Adrian, Colla, and Shin (2013).

engage in activities that are individually risky. In aggregate, this allows for sustained employment, production and consumption. However, when banks issue more liabilities, they also create the conditions for a liquidity crisis. A crisis generates a drop in the volume of intermediated funds and with it a fall in the stock of bank liabilities held by the nonfinancial sector. As a consequence of this, the nonfinancial sector will be less willing to engage in risky activities with a consequent macroeconomic contraction.

The probability and macroeconomic consequences of a liquidity crisis depend on the leverage chosen by banks, which in turn depends on the interest rate paid on their liabilities (funding cost). When the interest rate is low, banks have more incentives to leverage, which in turn increases the likelihood of a liquidity crisis. It is then easy to see how the growth of emerging countries could contribute to global economic instability. As the share of these countries in the world economy increases, the worldwide demand for financial assets (bank liabilities in the model) rises. This drives down the interest rate paid by banks on their liabilities, increasing the incentives to take more leverage. But as the banking sector becomes more leveraged, the likelihood of a crisis starts to emerge and/or the consequences of a crisis become bigger. As long as a crisis does not materialize, the economy enjoys sustained levels of financial intermediation, asset prices and economic activity. Eventually, however, a crisis does materializes inducing a reversal in financial intermediation with consequent contractions in asset prices and overall economic activity.

The organization of the paper is as follows. Section 2 describes the model and characterizes the equilibrium. Section 3 applies the model to study the central question addressed in the paper, that is, how the growth of emerging economies affects the financial and macroeconomic stability of both emerging and industrialized countries. Section 4 concludes.

2 Model

There are two countries in the model, indexed by $j \in \{1, 2\}$. The first country is representative of industrialized economies and the second is representative of emerging economies. In each country there are two sectors: the entrepreneurial sector and the worker sector. Furthermore, there are profit-maximizing banks that operate globally in a regime of international capital mobility. The role of banks is to facilitate the transfer of resources between entrepreneurs and workers and across countries. As we will see, the ownership of banks by country 1 or country 2 is irrelevant. What is important is that banks operate globally, that is, they can issue liabilities and make loans in both countries.

Countries are heterogeneous in two dimensions: (i) economic size captured by differences in aggregate productivity $\bar{z}_{j,t}$; and (ii) financial market development captured by the parameters σ_j and η_j. While productivity is allowed to change over time, financial market development is assumed to remain constant, which explains the time subscript in $\bar{z}_{j,t}$ but not in σ_j and η_j. Although changes in the relative size of countries could also be a consequence of other factors besides productivity (for example population growth, investment, real exchange rates), we will see that in the model these additional changes are isomorphic to productivity changes. Finally, the assumption that only cross-country productivity (as a proxy for economic size) changes over time while differences in financial markets development remain constant, is consistent with the main question addressed in the paper, that is, how the increasing size of emerging economies impacts financial and macroeconomic stability in a globalized economy.

2.1 Entrepreneurial sector

In each country there is a unit mass of atomistic entrepreneurs indexed by i. Entrepreneurs are individual owners of firms with lifetime utility

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \ln(c^i_{j,t}),$$

where $c^i_{j,t}$ is the consumption of entrepreneur i in country j at time t.

Each entrepreneur operates the production function

$$y^i_{j,t} = z^i_{j,t} h^i_{j,t},$$

where $h^i_{j,t}$ is the input of labor supplied by workers in country j at the market wage $w_{j,t}$, and $z^i_{j,t}$ is an idiosyncratic productivity shock. The idiosyncratic productivity is independently and identically distributed among firms and over time, with probability distribution $\Gamma_j(z)$.

It would be convenient to assume that $\Gamma_j(z)$ is fully characterized by two country-specific parameters: the mean $\bar{z}_{j,t}$ and the standard deviation σ_j. Differences in the mean $\bar{z}_{j,t}$ captures cross-country differences in aggregate productivity while differences in the standard deviation σ_j captures cross-country differences in risk. Later I will interpret σ_j as the residual idiosyncratic risk that cannot be insured directly through financial markets (for example by selling a share of the business to external investors). Thus, differences in this parameter can be interpreted as capturing cross-country differences in financial markets development.

As in Arellano, Bai, and Kehoe (2011), the input of labor $h^i_{j,t}$ is chosen before observing $z^i_{j,t}$, and therefore, labor is risky. To insure the risk, entrepreneurs have access to a market for non-contingent bonds at price q_t. As we will see, bonds held by entrepreneurs are the liabilities issued by banks. Notice that the market price of bonds does not have the subscript j because capital mobility implies that the price is equalized across countries. Since the bonds cannot be contingent on the realization of the idiosyncratic shock $z^i_{j,t}$, they provide only partial insurance.

An entrepreneur i in country j enters period t with bonds $b^i_{j,t}$ and chooses the labor input $h^i_{j,t}$. After the realization of the idiosyncratic shock $z^i_{j,t}$, he/she chooses consumption $c^i_{j,t}$ and next period bonds $b^i_{j,t+1}$, facing the budget constraint

$$c^i_{j,t} + q_t b^i_{j,t+1} = (z^i_{j,t} - w_{j,t})h^i_{j,t} + b^i_{j,t}. \tag{1}$$

Because labor $h^i_{j,t}$ is chosen before the realization of $z^i_{j,t}$, while the saving decision is made after the observation of $z^i_{j,t}$, it will be convenient to define $a^i_{j,t} = b^i_{j,t} + (z^i_{j,t} - w_{j,t})h^i_{j,t}$ the entrepreneur's wealth after production. Given the timing assumption, the input of labor $h^i_{j,t}$ depends on $b^i_{j,t}$ while the saving decision $b^i_{j,t+1}$ depends on $a^i_{j,t}$. The optimal entrepreneur's policies are characterized by the following lemma.

Lemma 2.1 *Let $\phi_{j,t}$ satisfy the condition* $\displaystyle\int_z \left\{\frac{z - w_{j,t}}{1 + (z - w_{j,t})\phi_{j,t}}\right\}\Gamma_j(z) = 0.$ *The optimal entrepreneur's policies are*

$$\begin{aligned} h^i_{j,t} &= \phi_{j,t} b^i_{j,t}, \\ c^i_{j,t} &= (1-\beta)a^i_{j,t}, \\ q_t b^i_{j,t+1} &= \beta a^i_{j,t}. \end{aligned}$$

Proof 2.1 *See Appendix A.*

The demand for labor is linear in the wealth of the entrepreneur $b^i_{j,t}$, with the proportional factor $\phi_{j,t}$ defined by the condition $\int_z \left\{\frac{z-w_{j,t}}{1+(z-w_{j,t})\phi_{j,t}}\right\}\Gamma_j(z) =$

0. Notice that the wage rate $w_{j,t}$ and the distribution of the shock $\Gamma_j(z)$ are country-specific. This implies that the value of $\phi_{j,t}$ differs across countries but is the same for all entrepreneurs of the same country. Since the distribution of the shock is fixed in the model, the only endogenous variable that affects $\phi_{j,t}$ is the wage rate $w_{j,t}$. Therefore, I denote it by the function $\phi_j(w_{j,t})$, which is strictly decreasing in the (country) wage rate.

The aggregate demand for labor in country j is

$$H_{j,t} = \phi_j(w_{j,t}) \int_i b^i_{j,t} = \phi_j(w_{j,t}) B_{j,t},$$

where capital letters denote aggregate variables.

The aggregate demand for labor depends negatively on the wage rate—which is a standard property—and positively on the aggregate financial wealth of entrepreneurs even if they are not financially constrained—which is a special property of this model. This property derives from the risk associated with hiring: entrepreneurs are willing to hire more labor when they hold more financial wealth as an insurance buffer.

Also linear is the consumption policy which follows from the logarithmic utility. This property allows for linear aggregation. Another property worth emphasizing is that in a stationary equilibrium with constant $B_{j,t}$, the interest rate (the inverse of the price of bonds q_t) must be lower than the intertemporal discount rate, that is, $q_t > \beta$.[2]

2.2 Worker sector

In each country there is a unit mass of atomistic workers that maximize the lifetime utility

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(c_{j,t} - \alpha \bar{z}_{j,t} \frac{h_{j,t}^{1+\frac{1}{\nu}}}{1+\frac{1}{\nu}} \right),$$

where $c_{j,t}$ is consumption and $h_{j,t}$ is the supply of labor.

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

The assumption that workers have linear utility in consumption simplifies the characterization of the equilibrium (with some of the results derived analytically) without affecting the key properties of the model. As I will discuss below, as long as workers do not face idiosyncratic risks (or the idiosyncratic risk faced by workers is significantly lower than entrepreneurs), the model will display similar properties even if workers were risk averse.

Another special feature of the utility function is that the dis-utility from working depends on country-specific productivity $\bar{z}_{j,t}$. This is necessary for the model to display balanced growth.

Workers can trade a non-reproducible asset available in fixed supply $\overline{K}_j$. Each unit of the asset produces $\bar{z}_{j,t}$ units of consumption goods. The variable $\bar{z}_{j,t}$ is also the average productivity of entrepreneurs. Therefore, the two countries are characterized by the same productivity differentials in entrepreneurial and worker sectors. The asset is divisible and can be traded at the market price $p_{j,t}$. I will interpret the fixed asset as housing and $\bar{z}_{j,t}$ as housing services.

Workers can borrow at the gross interest rate R_t and face the individual budget constraint

$$c_{j,t} + l_{j,t} + (k_{j,t+1} - k_{j,t})p_{j,t} = \frac{l_{j,t+1}}{R_t} + w_{j,t}h_{j,t} + \bar{z}_{j,t}k_{j,t},$$

where $l_{j,t}$ is the loan contracted in period $t-1$ and due in the current period t, and $l_{j,t+1}$ is the new loan that will be repaid in the next period $t+1$. The interest rate on loans does not have the country subscript j because, thanks to capital mobility, it will be equalized across countries.

Debt is constrained by a borrowing limit. I will consider two specifications of the borrowing limit. The first specification takes the form

$$l_{j,t+1} \leq \eta_j \bar{z}_{j,t}, \tag{2}$$

where η_j is a parameter that could differ across countries.

The advantage of this simple specification of the borrowing constraint is that it allows me to characterize the equilibrium analytically with simple intuitions for the key results of the paper. The disadvantage, however, is that the equilibrium asset price $p_{j,t}$ will be only a function of the exogenous productivity $\bar{z}_{j,t}$ and will not be affected by financial markets conditions. I will then consider a second specification of the borrowing limit of the form

$$l_{j,t+1} \leq \eta_j \mathbb{E}_t p_{j,t+1} k_{j,t+1}. \tag{3}$$

The dependence of the borrowing limit from the collateral value of assets introduces a mechanism through which borrowing affects the equilibrium price of the asset, $p_{j,t}$, and the model provides some predictions about the dynamics of this price that depend on financial markets conditions. The full characterization of the equilibrium, however, can be done only numerically.

Appendix B writes down the workers' problem and derives the first order conditions. When the borrowing limit takes the form specified in (2), the optimality conditions are

$$\alpha \bar{z}_{j,t} h_{j,t}^{\frac{1}{\nu}} = w_{j,t}, \quad (4)$$

$$1 = \beta R_t (1 + \mu_{j,t}), \quad (5)$$

$$p_{j,t} = \beta \mathbb{E}_t (\bar{z}_{j,t} + p_{j,t+1}), \quad (6)$$

where $\beta\mu_{j,t}$ is the Lagrange multiplier associated with the borrowing constraint. As can be seen from equation (6), the price $p_{j,t}$ only depends on the exogenous productivity $\bar{z}_{j,t}$.

When the borrowing limit takes the form specified in (3), the first order conditions with respect to $h_{j,t}$ and $l_{j,t+1}$ are still (4) and (5) but the first order condition with respect to $k_{j,t+1}$ becomes

$$p_{j,t} = \beta \mathbb{E}_t \Big[\bar{z}_{j,t} + (1 + \eta_j \mu_{j,t}) p_{j,t+1} \Big]. \quad (7)$$

In this case the price $p_{j,t}$ also depends on the multiplier $\mu_{j,t}$, which captures the tightness of the borrowing constraint for borrowers. Therefore, changes in financial market conditions affect the market price of the asset.

2.3 Equilibrium with direct borrowing and lending

Before introducing the financial intermediation sector it would be instructive to characterize the equilibrium with direct borrowing and lending. In equilibrium, the worldwide bonds held by entrepreneurs are equal to the loans taken by workers, that is,

$$B_{1,t} + B_{2,t} = L_{1,t} + L_{2,t},$$

and the interest rate on bonds is equal to the interest rate on loans, that is, $1/q_t = R_t$. Because of capital mobility and cross-country heterogeneity, the net foreign asset positions of the two countries will be in general different from zero, that is, $B_{j,t} \neq L_{j,t}$.

Proposition 2.1 *Suppose that productivity $\bar{z}_{j,t}$ is constant. Then the economy converges to a steady state in which workers borrow from entrepreneurs and $q = 1/R > \beta$.*

Proof 2.1 *See Appendix C*

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. If $q = \beta$, entrepreneurs would continue to accumulate bonds without limit as an insurance for the idiosyncratic risk. The supply of bonds from workers, however, is limited by the borrowing limit. To insure that entrepreneurs do not accumulate an infinite amount of bonds, the interest rate has to fall below the intertemporal discount rate.

The equilibrium in the labor market in each country is depicted in Figure 2. The aggregate demand in country j was derived in the previous subsection and takes the form $H^D_{j,t} = \phi_j(w_{j,t})B_{j,t}$. It depends negatively on the wage rate $w_{j,t}$ and positively on the aggregate wealth (bonds) of entrepreneurs, $B_{j,t}$. The supply of labor is derived from the households' first order condition (4) and takes the form $H^S_{j,t} = \left(\frac{w_{j,t}}{\alpha\bar{z}_j}\right)^{\nu}$.

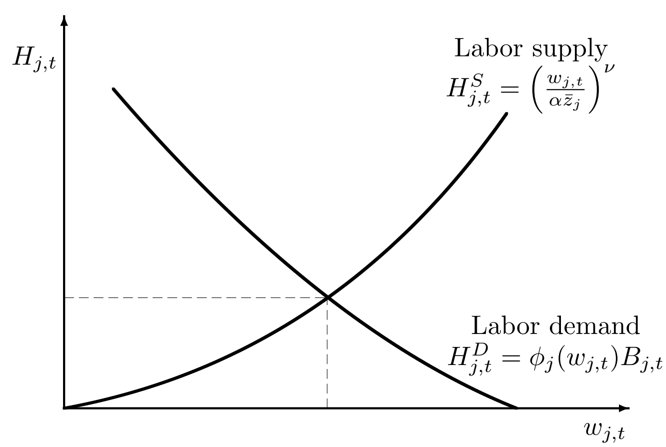


Figure 2: Labor market equilibrium.

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 $B_{j,t}$, the demand for labor declines and in equilibrium there is lower employment and production. Importantly, the reason lower values of $B_{j,t}$ 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 the model, employers do not need any financing to hire and produce. Instead, the transmission mechanism is based on the lower insurance of 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.

The next step is to introduce financial intermediaries and show that a fall in $B_{j,t}$ could result from a crisis that originates in the financial sector.

Discussion and remarks The equilibrium described above is characterized by producers (entrepreneurs) that are net savers and workers that are net borrowers. This structure differs from the financial structure of several models proposed in the literature where producers are typically net borrowers. Although this property may appear counterfactual at first, it is not inconsistent with the recent changes in the financial structure of US corporations. It is well known that during the last two and half decades, US corporations have increased their holdings of financial assets. This suggests that the proportion of financially dependent firms has declined significantly over time, which is consistent with the study of Shourideh and Zetlin-Jones (2012) and Eisfeldt and Muir (2012). The large accumulation of financial assets by firms (often referred to as cash) is also observed in emerging countries (for example, in China). The model developed here then captures the growing importance of firms that are no longer dependent on external financing.

The second remark is that this particular property of the model (firms as net lenders) does not derive from the assumption that entrepreneurs are risk-averse while workers are risk-neutral. Instead, it follows from the assumption that only entrepreneurs are exposed to uninsurable risks. As long as producers face more risk than workers, entrepreneurs would continue to be net lenders even if workers were risk averse.

The final remark relates to the assumption that the idiosyncratic risk faced by entrepreneurs cannot be insured away (market incompleteness). Since workers are risk neutral, it would be optimal to offer wages that are contingent on the output of the firm. Although this is excluded by assumption, it is not difficult to extend the model so that the lack of insurance from workers is an endogenous outcome of information asymmetries. The idea is that, when the wage is state-contingent, firms could use their information advantage to gain opportunistically from workers. Since this is well known in the contract literature, to keep the model simple I have directly assumed that state contingent wages are not feasible.[3]

2.4 Financial intermediation sector

If direct borrowing is not feasible or inefficient, financial intermediaries become important for transferring funds from lenders to borrowers and to create financial assets that could be held for insurance purposes.

To formalize this idea, suppose that direct borrowing implies a cost $\tilde{\tau}$. The analysis of the previous section can be trivially extended with this cost. Financial intermediaries could then play an important role because, by specializing in financial intermediation, they have a comparative advantage (lower cost) in transferring funds from lenders to borrowers. It is under this premise that I introduce the financial intermediation sector.

Financial intermediaries are infinitely lived, profit-maximizing firms owned by workers. The assumption that they are owned by workers, as opposed to entrepreneurs, is motivated by two considerations. The first is for analytical simplicity. The risk neutrality of shareholders implies that the operation of banks is not affected by the ownership structure (domestic versus foreign workers). The second consideration is more substantive and relates to the redistributive consequences of a financial crisis. As we will see, the ownership assumption guarantees that a financial crisis generates wealth losses for entrepreneurs. It is important to point out that, even if I use the term 'banks', it should be clear that the financial sector is representative of all financial firms, not only commercial banks or typical depository institutions.

Banks operate globally, that is, they sell liabilities and make loans to domestic and foreign agents. As observed above, the ownership of banks by domestic or foreign workers is irrelevant for the equilibrium.

A bank starts the period with loans made to workers, l_t, and liabilities held by entrepreneurs, b_t. These loans and liabilities were made in the previous period $t-1$. Since the interest rates on loans will be equalized across countries, banks are indifferent about the nationality of their costumers (besides making sure that the borrowing constraints are not violated). Similarly,

[3] It could be claimed that in reality there are markets where some contingent claims are traded. For example, the sale of corporate shares. The model accounts for this by interpreting σ_j as the residual risk that cannot be eliminated by trading in these markets.

the interest rate paid by banks on their liabilities will be equalized across countries. Therefore, I will use the notation l_t and b_t without subscript j to denote the loans and liabilities of an individual bank. The difference between loans and liabilities is the bank's equity $e_t = l_t - b_t$.

Renegotiation of bank liabilities Given the beginning of period balance sheet position, banks could default on their liabilities. In case of default, creditors have the right to liquidate the assets of the bank l_t. However, they may not be able to recover the full value of the assets. More specifically, with probability λ_t creditors recover only the fraction $\underline{\xi} < 1$ of the liquidated assets (and with probability $1 - \lambda_t$ they recover the full value). The recovery fraction, denoted by $\xi_t \in \{\underline{\xi}, 1\}$, is an aggregate stochastic variable (same for all banks) that is realized at the beginning of period t. Therefore, ξ_t was unknown at $t - 1$ when banks issued the liabilities b_t and made the loans l_t.

The probability λ_t will be derived endogenously in the model. For the moment, however, it will be convenient to think of this probability as exogenously fixed at $\bar{\lambda}$.

Once the value of ξ_t becomes known at the beginning of period t, banks could use the threat of default to renegotiate the outstanding liabilities b_t. Under the assumption that banks have the whole bargaining power, the outstanding liabilities could be renegotiated to the liquidation value of assets $\xi_t l_t$. Of course, banks will renegotiate only if the liabilities are bigger than the liquidation value, that is, $b_t > \xi_t l_t$. Therefore, after renegotiation, the residual liabilities of the bank are

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

Interest rate The possibility that a bank renegotiates its liabilities implies potential losses for investors (entrepreneurs). This is fully internalized by the market when a bank issues new liabilities b_{t+1} and makes new loans l_{t+1}.

Denote by $\overline{R}_t^b$ the expected gross return from holding the market portfolio of bank liabilities issued in period t and repaid in period $t+1$ (that is, for the liabilities issued by the whole banking sector). Since banks are competitive, the expected return on the liabilities issued by an individual bank must be equal to the aggregate expected return $\overline{R}_t^b$. Therefore, the price of liabilities

$q_t(b_{t+1}, l_{t+1})$ issued by an individual bank at time t satisfies

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

The left-hand-side is the payment made by investors for the purchase of b_{t+1}. The term on the right-hand-side is the expected repayment in the next period, discounted by $\overline{R}_t^b$ (the expected market return). Since the bank could renegotiate in the next period if $\xi_{t+1} = \underline{\xi}$, the actual repayment $\tilde{b}_{t+1}(b_{t+1}, l_{t+1})$ could differ from b_{t+1}. Arbitrage requires that the cost of purchasing b_{t+1} for investors (the left-hand-side of (9)) is equal to the discounted value of the expected repayment (the right-hand-side of (9)).

Intermediation cost Financial intermediation implies an operational cost that depends on the leverage chosen by the bank. Denoting by $\omega_{t+1} = b_{t+1}/l_{t+1}$ the leverage, the cost takes the form

$$\varphi\left(\omega_{t+1}\right) q_t b_{t+1}. \tag{10}$$

The operational cost is proportional to the funds raised by the bank, $q_t b_{t+1}$, and the unit cost $\varphi(\omega_{t+1})$ is a function of the leverage.

Assumption 1 *The cost function $\varphi(\omega_{t+1})$ is positive and twice continuously differentiable with $\varphi'(\omega_{t+1}), \varphi''(\omega_{t+1}) = 0$ if $\omega_{t+1} \leq \underline{\xi}$ and $\varphi'(\omega_{t+1}), \varphi''(\omega_{t+1}) > 0$ if $\omega_{t+1} > \underline{\xi}$.*

The fact that the derivative of the cost function becomes positive when the leverage exceeds the threshold $\underline{\xi}$ captures, in reduced form, the potential agency frictions that become more severe when banks choose high leverages.

Bank problem The budget constraint of the bank, after the renegotiation of the liabilities at the beginning of the period, can be written as

$$\tilde{b}_t(b_t, l_t) + \frac{l_{t+1}}{R_t^l} + d_t = l_t + q_t(b_{t+1}, l_{t+1})b_{t+1}\left[1 - \varphi\left(\frac{b_{t+1}}{l_{t+1}}\right)\right], \tag{11}$$

The left-hand-side of the budget contains the residual liabilities after renegotiation, the cost of issuing new loans, and the dividends paid to shareholders (workers). The right-hand-side contains the initial loans and the funds raised by issuing new liabilities net of the operational cost. Using the arbitrage condition (9), the funds raised with new debt are equal to $\mathbb{E}_t \tilde{b}_{t+1}(b_{t+1}, l_{t+1})/\overline{R}^b_t$.

The optimization problem of the bank can be written recursively as

$$V_t(b_t, l_t) \;=\; \max_{d_t, b_{t+1}, l_{t+1}} \left\{ d_t + \beta \mathbb{E}_t V_{t+1}(b_{t+1}, l_{t+1}) \right\} \tag{12}$$

subject to (8), (9), (11).

The leverage chosen by the bank will never exceed 1 since the liabilities will be renegotiated with certainty. Once the probability of renegotiation is 1, a further increase in b_{t+1} does not increase the borrowed funds but raises the renegotiation cost. Therefore, the optimization problem of the bank is also subject to the constraint $b_{t+1} \leq l_{t+1}$.

Denote by $\omega_{t+1} = b_{t+1}/l_{t+1}$ the bank leverage. Appendix D shows that the first order conditions with respect to b_{t+1} and l_{t+1} can be expressed as

$$\frac{1}{\overline{R}^b_t} \;\geq\; \beta \Big[1 + \Phi(\omega_{t+1}) \Big] \tag{13}$$

$$\frac{1}{R^l_t} \;\geq\; \beta \Big[1 + \Psi(\omega_{t+1}) \Big], \tag{14}$$

where $\Phi(\omega_{t+1})$ and $\Psi(\omega_{t+1})$ are increasing functions of the leverage. The first order conditions are satisfied with equality if $\omega_{t+1} < 1$ and with inequality if $\omega_{t+1} = 1$ given the constraint $\omega_{t+1} \leq 1$.

Conditions (13) and (14) make clear that it is the leverage of the bank $\omega_{t+1} = b_{t+1}/l_{t+1}$ that matters, not the scale of operation b_{t+1} or l_{t+1}. This follows from the linearity of the intermediation technology and the risk neutrality of banks. These properties imply that in equilibrium all banks choose the same leverage (although they could chose different scales of operation).[4]

Further exploration of the first order conditions reveals that the funding cost $\overline{R}^b_t$ is smaller than the interest rate on loans R^l_t, which is necessary to

[4] Because the first order conditions (13) and (14) depend only on one individual variable—the leverage ω_{t+1}—there is no guarantee that these conditions are both satisfied for arbitrary values of $\overline{R}^b_t$ and R^l_t. In the general equilibrium, however, these rates adjust to clear the markets for bank liabilities and loans and both conditions will be satisfied.

cover the operational cost of the bank. This property is stated formally in the next lemma.

Lemma 2.2 *If $\omega_{t+1} > \underline{\xi}$, then $\overline{R}_t^b < R_t^l < \frac{1}{\beta}$. Furthermore, the return spread $R_t^l/\overline{R}_t^b$ increases with ω_{t+1}.*

Proof 2.2 *See Appendix E*

Therefore, there is a spread between the funding rate and the lending rate. Intuitively, the choice of a positive leverage increases the operational cost. The bank will choose to do so only if there is a spread between the cost of funds and the return on the investment. As the spread increases so does the leverage chosen by banks. When the leverage exceeds $\underline{\xi}$, banks could default with positive probability. This generates a loss of financial wealth for entrepreneurs, causing a macroeconomic contraction through the 'bank liabilities channel' as described earlier.

2.5 Banking liquidity and endogenous ξ_t

To make ξ_t endogenous, I now interpret this variable as the liquidation price of bank assets. This price will be determined in equilibrium and the liquidity of the banking sector plays a central role in determining this price. I start specifying the assumptions that set the conditions for making ξ_t endogenous.

Assumption 2 *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 sectors can recover only a fraction $\underline{\xi} < 1$.*

This assumption implies that it is more efficient to sell the assets of a liquidated bank to other banks since they have the ability to recover the whole value l_t while other sectors can recover only $\underline{\xi} l_t$. This is a natural assumption since banks are likely to have a comparative advantage in the management of financial investments. However, in order for other banks to purchase the assets, they need to be liquid.

Assumption 3 *Banks can purchase the assets of a liquidated bank only if they are liquid, that is, $b_t < \xi_t l_t$.*

A bank is liquid if it can issue new liabilities at the beginning of the period without renegotiating. Obviously, if a bank starts with a stock of liabilities bigger than the liquidation value of its assets, that is, $b_t > \xi_t l_t$, the bank will be unable to raise additional funds. Potential investors know that the new liabilities (as well as the outstanding liabilities) are not collateralized and the bank will renegotiate immediately after receiving the new funds.

To better understand Assumptions 2 and 3, consider the condition for not renegotiating, $b_t \leq \xi_t l_t$. Now the variable $\xi_t \in \{\underline{\xi}, 1\}$ is the liquidation price of bank assets at the beginning of the period. If this condition is satisfied, banks have the ability 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 $\xi_t = 1$. However, if $b_t > \xi_t l_t$ for all banks, there will be no bank with credit capacity. As a result, the liquidated assets can only be sold to non-banks. But then 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.[5]

Proposition 2.2 *There exists multiple equilibria if and only if the leverage of the bank is within the two liquidation prices, that is,* $\underline{\xi} \leq \omega_t \leq 1$.

Proof 2.2 *See appendix F.*

Denote by ε a sunspot variable that takes the value of 0 with probability $\bar{\lambda}$ and 1 with probability $1 - \bar{\lambda}$. The probability of a low liquidation price, denoted by $\theta(\omega_t)$, is equal to

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

If the leverage is sufficiently small ($\omega_t < \underline{\xi}$), banks do not renegotiate even if the liquidation price is low. But then the price cannot be low since banks remain liquid for any expectation of the liquidation price ξ_t, and therefore,

[5] Assumptions 2 and 3 are similar to the assumptions made in Perri and Quadrini (2011) but in a model without banks.

for any draw of the sunspot variable ε. Instead, when the leverage is between the two liquidation prices ($\underline{\xi} \leq \omega_t \leq 1$), the liquidity of banks depends on the expectation of this price. The realization of the sunspot variable ε then becomes important for selecting one of the two equilibria. When $\varepsilon = 0$—which happens with probability $\bar{\lambda}$—the market expects that the liquidation price is $\xi_t = \underline{\xi}$, making the banking sector illiquid. On the other hand, when $\varepsilon = 1$—which happens with probability $1 - \bar{\lambda}$—the market expects that the liquidation price is $\xi_t = 1$, and the banking sector remains liquid.

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 of liabilities by consolidating the demand of loans from 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 characterize the equilibrium analytically. Furthermore, I assume that aggregate productivity $\bar{z}_{j,t}$ stays constant in both countries.

Deriving the demand for bank liabilities As shown in Lemma 2.1, the optimal saving of entrepreneurs takes the form $q_t b^i_{j,t+1} = \beta a^i_{j,t}$, where $a^i_{j,t}$ is the end-of-period wealth $a^i_{j,t} = \tilde{b}^i_t + (z^i_{j,t} - w_{j,t})h^i_{j,t}$. This lemma continues to hold even if the return from bank liabilities is now stochastic (since the actual return depends on the realization of the sunspot shock).[6]

Since $h^i_{j,t} = \phi_j(w_{j,t})\tilde{b}^i_{j,t}$ (see Lemma 2.1), the end-of-period wealth can be rewritten as $a^i_{j,t} = [1 + (z^i_{j,t} - w_{j,t})\phi(w_{j,t})]\tilde{b}^i_{j,t}$. Substituting into the optimal saving and aggregating over all entrepreneurs we obtain

$$q_t B_{j,t+1} = \beta \Big[1 + (\bar{z}_j - w_{j,t})\phi_j(w_{j,t})\Big] \tilde{B}_{j,t}. \tag{15}$$

This equation defines the aggregate demand for bank liabilities in country j as a function of its price q_t, the wage rate $w_{j,t}$, and the beginning-of-period

[6]Lemma 2.1 was derived under the assumption that the bonds purchased by the entrepreneurs were not risky, that is, entrepreneurs receive $b_{j,t+1}$ units of consumption goods with certainty at $t + 1$. In the extension with financial intermediation, however, bank liabilities are risky since banks may renege on these liabilities. Because of the logarithmic utility, however, the lemma continues to hold. The proof requires only a trivial extension of the proof of Lemma 2.1.

aggregate wealth of entrepreneurs $\tilde{B}_{j,t}$. Remember that the tilde sign denotes the financial wealth of entrepreneurs 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, $H^D_{j,t} = \phi_j(w_{j,t})\tilde{B}_{j,t}$, to the supply from workers, $H^S_{j,t} = (w_{j,t}/\alpha\bar{z}_j)^\nu$, the wage becomes a function of only $\tilde{B}_{j,t}$. We can then use this function to rewrite equation (15) more compactly as

$$q_t B_{j,t+1} = s_j(\tilde{B}_{j,t}).$$

The total demand for bank liabilities is the sum of the demands from the two countries. Therefore, we can write the worldwide demand as

$$B_{t+1} = \Big[s_1(\tilde{B}_{1,t}) + s_1(\tilde{B}_{2,t})\Big]\frac{1}{q_t}. \tag{16}$$

Figure 3 plots this function for given values of $\tilde{B}_{1,t}$ and $\tilde{B}_{2,t}$. It relates the demand for bank liabilities B_{t+1} to the inverse of its price q_t. The slope of this function is determined by the entrepreneurs' wealth $\tilde{B}_{1,t}$ and $\tilde{B}_{2,t}$.

Deriving the 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.

According to Lemma 2.2, when banks are leveraged, the interest rate on loans must be smaller than the intertemporal discount rate, that is, $R^l_t < 1/\beta$. From the workers' first order condition (5) we can see that the lagrange multiplier associated with the borrowing constraint $\mu_{j,t}$ is greater than zero if $R^l_t < 1/\beta$. Therefore, the borrowing constraint of workers is binding. This implies that the aggregate loans received by workers in country j are equal to the borrowing limit, that is, $L_{j,t+1} = \eta_j\bar{z}_j$. The total loans made by banks is the sum of the loans to both countries, that is, $L_{t+1} = \eta_1\bar{z}_1 + \eta_2\bar{z}_2$.

By definition, $B_{t+1} = \omega_{t+1}L_{t+1}$. We can then express the total supply of bank liabilities as

$$B_{t+1} = (\eta_1\bar{z}_1 + \eta_2\bar{z}_2)\omega_{t+1}. \tag{17}$$

So far I have derived the supply of bank liabilities as a function of the bank leverage ω_{t+1}. However, the leverage is endogenously chosen by banks and the choice depends on the cost of borrowing $\overline{R}^b_t$ (see the optimality condition

(13)). The expected return $\overline{R}_t^b$ is in turn related to the price of bank liabilities q_t through the condition

$$q_t = \frac{1}{\overline{R}_t^b}\left[1 - \theta(\omega_{t+1}) + \theta(\omega_{t+1})\left(\frac{\underline{\xi}}{\omega_{t+1}}\right)\right]. \tag{18}$$

The term in square brackets on the left-hand-side is the expected payment at time $t+1$ from holding one unit of bank liabilities. With probability $1-\theta(\omega_{t+1})$ banks do not renegotiate and pay back 1. With probability $\theta(\omega_{t+1})$ banks renegotiate and investors receive only the fraction $\underline{\xi}/\omega_{t+1}$. The current value of the expected repayment, discounted by the market return $\overline{R}_t^b$, must be equal to the price q_t.

Using (18) to replace $\overline{R}_t^b$ in equation (13), we obtain a function that relates the price of bank liabilities q_t to the leverage ω_{t+1}. Finally, using (17) to substitute for ω_{t+1}, we obtain the supply of liabilities as a function of q_t. The derived supply is plotted in Figure 3. The supply is decreasing in $1/q_t$ until it reaches the maximum volume of loans that can be made to workers, that is, $L_{Max} = \eta_1\bar{z}_1 + \eta_2\bar{z}_2$.

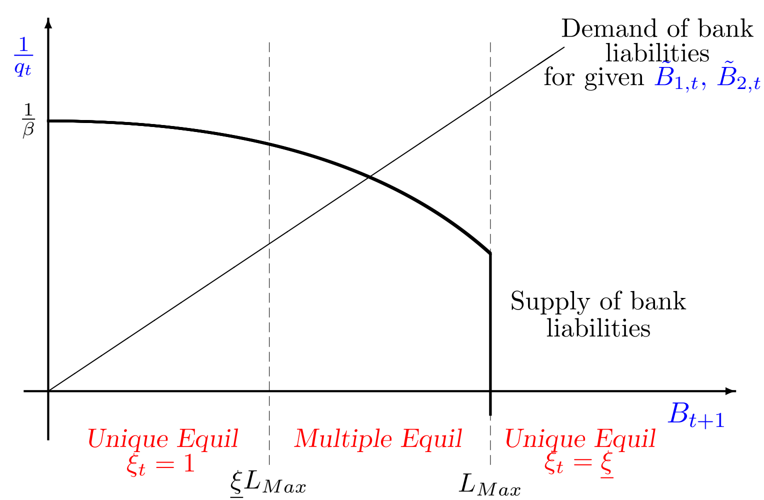


Figure 3: Demand and supply of bank liabilities.

General equilibrium The intersection of aggregate demand and supply for bank liabilities characterizes the general equilibrium. As shown in Figure 3, the supply (from banks) is decreasing in $1/q_t$ while the demand (from entrepreneurs) is increasing in $1/q_t$. The demand is plotted for a particular value of outstanding post-renegotiation liabilities $\tilde{B}_t = \tilde{B}_{1,t} + \tilde{B}_{2,t}$. By changing the outstanding liabilities, the slope of the demand function would also change and would result in different equilibrium price and stock of liabilities.

The figure also indicates the regions with unique or multiple equilibria. When the liabilities exceed $\underline{\xi} L_{Max}$, multiple equilibria are possible. In this case the economy is subject to stochastic fluctuations induced by the realization of the sunspot shock. Whether the economy is in the region with unique or multiple equilibria depends on the initial state $\tilde{B}_t$, which evolves endogenously over time. In this respect the model shares some similarities with the sovereign default model of Cole and Kehoe (2000).

Solving for the dynamics of the model is simple. Given the initial aggregate wealth of entrepreneurs $\tilde{B}_t$, we can solve for q_t and B_{t+1} by equalizing the aggregate demand and supply of bank liabilities as shown in Figure 3. This in turn allows us to determine the next period wealth $\tilde{B}_{t+1}$. In absence of renegotiation we have $\tilde{B}_{t+1} = B_{t+1}$, where B_{t+1} is determined by equation (16). In the event of renegotiation (if 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, new values of q_t and B_{t+1}.

Depending on the parameters, the economy may or may not reach a steady state. In order to reach a steady state the economy must converge to a state $B_t < \underline{\xi} L_{Max}$ (region with a unique equilibrium). However, if the economy does not converge to this region, it will experience stochastic fluctuations associated with the realization of the sunspot shock. The operational cost $\varphi(\omega_{t+1})$ plays an important role in determining the type of equilibria (unique or multiple) that are possible in the long-run.

Bank leverage and crises Figure 3 illustrates how the type of equilibria depends on leverage. When banks increase their leverage, the economy switches from a state in which the equilibrium is unique (no crises) to a state with multiple equilibria (with the possibility of financial crises). But even if the economy was already in a state with multiple equilibria, the increase in leverage implies that the consequences of a crisis are more severe. In fact, when the economy switches from the non-renegotiation equilibrium (no crisis) to the equilibrium with renegotiation (financial crisis), the bank liabilities are renegotiated to $\underline{\xi} L_{Max}$. Therefore, bigger are the liabilities B_t

issued by banks and larger are the losses incurred by entrepreneurs holding these liabilities. Larger financial losses incurred by entrepreneurs imply larger declines in the demand for labor in both countries, which cause larger macroeconomic contractions.

3 Quantitative analysis

The goal of this section is to study quantitatively how the growth of emerging countries has affected financial and macroeconomic stability in both industrialized and emerging economies. To address this question, I calibrate the model using data for the period 1991-2013. In the model, country 1 is representative of industrialized economies and country 2 of emerging economies. Starting in 1991 I will then simulate the model until 2013. The list of industrialized and emerging countries is provided in Table 1.

For the quantitative exercise I will use the borrowing limit specified in (3). As observed earlier, this specification allows the model to generate interesting predictions about the dynamics of the price of the fixed asset p_t, interpreted as the price of housing.[7]

Productivity sequence The change in relative economic size of the two countries are captured in the model by the relative productivity $\bar{z}_{2,t}/\bar{z}_{1,t}$. Therefore, an important part of the calibration is to pin down the sequence of relative productivity which will then be used as an input for the simulation.

Production in the model is the sum of entrepreneurial production, $\bar{z}_{j,t}H_{j,t}$, and the services produced by the fixed asset $\bar{z}_{j,t}\overline{K}$, which are interpreted as housing services. Therefore, aggregate production in country j is equal to $Y_{j,t} = \bar{z}_{j,t}(H_{j,t} + \overline{K})$. Becasue in the model there is no capital accumulation, the empirical counterpart for this variable is Gross Domestic Product minus investment (capital formation).

Taking into account that the goal of the exercise is to study how the change in relative size of the two countries affects the world demand for financial assets, the sequence of $\bar{z}_{2,t}/\bar{z}_{1,t}$ should replicate the relative economic

[7] As observed earlier, the borrowing limit (2) used in the theoretical section of the paper allows for the derivation of analytical solutions. However, the price p_t only depends on the exogenous productivity and it is not affected by financial crises. With the specification used here, instead, the price p_t will change in response to financial crises. The model, however, needs to be solved numerically.

size of the two countries measured at nominal exchange rates.[8] This implies that changes in $\bar{z}_{2,t}/\bar{z}_{1,t}$ should also reflect changes in relative prices between the two countries, which are not formally modelled. Another factor that contributes to generate differences in economic size but is not explicitly modelled is population growth. Therefore, changes in $\bar{z}_{2,t}/\bar{z}_{1,t}$ should also reflect not only actual productivity but also changes in population and nominal prices.

To illustrate this point, define the nominal output of country j as

$$P_{j,t}Y_{j,t} \;=\; P_{j,t}A_{j,t}(H_{j,t} + \overline{K})N_{j,t},$$

where $A_{j,t}$ is actual productivity, $H_{j,t}$ is labor supply per worker, $\overline{K}$ is the endowment of houses per worker and $P_{j,t}$ is the nominal price of country j expressed in the same currency unit for all countries. Notice that the above definition of output assumes that the endowment of houses increases with population. This is necessary to maintain balanced growth.

The size of country 2 relative to the size of country 1 is

$$\begin{aligned} \frac{P_{2,t}Y_{2,t}}{P_{1,t}Y_{1,t}} &= \frac{A_{2,t}N_{2,t}P_{2,t}}{A_{1,t}N_{1,t}P_{1,t}}\left(\frac{H_{2,t}+\overline{K}}{H_{1,t}+\overline{K}}\right) \\ &\equiv \frac{\bar{z}_{2,t}}{\bar{z}_{1,t}}\left(\frac{H_{2,t}+\overline{K}}{H_{1,t}+\overline{K}}\right). \end{aligned} \tag{19}$$

Therefore, the productivity ratio in the model, $\bar{z}_{2,t}/\bar{z}_{1,t}$, captures differences in actual productivity, population and prices.

Before I can use Equation (19) to back up $\bar{z}_{2,t}/\bar{z}_{1,t}$, I need to pin down the value of $\overline{K}$. This is done by using the share of housing services in GDP (net of investment), which in the model is equal to $\overline{K}/(H_{j,t}+\overline{K})$. Unfortunately, data for the share of housing services is not available for many countries. To obviate this problem, I impose that all countries have the same share of housing services in output (GDP minus investment in the data) and use the US share as the calibration target for both countries. Therefore, $\overline{K}$ is calibrated using the condition

$$\frac{\overline{K}}{\overline{H}+\overline{K}} = \text{US share of housing services},$$

[8]Nominal exchange rates affect the purchasing power of a country in the acquisition of foreign financial assets. Therefore, movements in the exchange rates should be taken into account in the measurement of the relative size of countries.

where $\overline{H}$ is the average employment-population ratio over the sample period 1991-2013 for all countries (both emerging and industrialized). Employment and population data is from the World Development Indicators (WDI) and the share of US financial services is from NIPA.

Given the value of $\overline{K}$, I can now compute the sequence of $\bar{z}_{2,t}/\bar{z}_{1,t}$ using (19). The variable $P_{j,t}Y_{j,t}$ is measured in the data as GDP minus investment in current US dollars from the WDI. The variable $H_{j,t}$ is measured as the ratio of employment over total population also from the WDI. Since the model is calibrated quarterly while WDI data is available annually, the series for $\bar{z}_{2,t}/\bar{z}_{1,t}$ is converted to a quarterly frequency by linearly interpolating the annual series. The resulting sequence of relative productivity is plotted in the first panel of Figure 4.

Other parameters 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 6%. The parameter ν in the utility function of workers is the elasticity of labor supply which I set to the high value of 50. The reason to use this high value is to capture, in simple form, possible wage rigidities. 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 utility parameter α_j is chosen for each country j so that the average labor in the model is equal to the average ratio of employment over population computed from the WDI over the period 1991-2013.

The parameter η_j determines the fraction of the fixed asset used as a collateral in country j. Cross-country differences in this parameter captures differences in the ability of countries to create financial assets in the spirit of (Caballero et al. (2008)) and it is calibrated by targeting the ratio of private credit over output. More specifically, I choose η_1 so that the average value of $L_{1,t}/Y_{1,t}$ before the growth of the emerging economies is equal to the value of domestic credit to the private sector in industrialized countries in 1991 (from the WDI). Similarly, I choose η_2 so that the average value of $L_{2,t}/Y_{2,t}$ in the model before the growth of emerging economies is equal to the value of domestic credit to the private sector for emerging countries in 1991 observed in the data (also from the WDI).

The idiosyncratic productivity shock z follows a truncated normal distribution with mean $\bar{z}_j$ and standard deviation of $\bar{z}_j\sigma_j$. The parameter σ_j is the residual risk that cannot be insured through state-contingent financial contracts. More developed financial markets allow for better insurance, and therefore, lower residual risk σ_j. Thus, I interpret cross-country differences in σ_j as capturing differences in financial markets as in Mendoza et al. (2009). I set $\sigma_1 = 0.3$ (for industrialized countries) and $\sigma_2 = 0.6$ (for emerging economies).

The last set of parameters pertain to the banking sector. The operational cost function is specified as

$$\varphi(\omega_{t+1}) = \tau + \begin{cases} 0, & \text{if} \quad \omega_{t+1} \leq \underline{\xi} \\ \bar{\lambda}(\omega_{t+1} - \underline{\xi})^2, & \text{if} \quad \omega_{t+1} > \underline{\xi} \end{cases}.$$

The idea is that, as long as the leverage of the bank does not exceed the renegotiation threshold $\underline{\xi}$, the agency frictions are independent of leverage and the operational cost is constant at τ. However, once the leverage reaches the threshold $\underline{\xi}$, the agency frictions start to rise generating an additional convex cost. This cost is multiplied by the sunspot probability $\bar{\lambda}$ since the cost is likely to increase with this probability.

Given the specification of the cost function, I need to calibrate three parameters: τ, $\underline{\xi}$ and the sunspot probability $\bar{\lambda}$. The probability that the sunspot takes the value $\varepsilon = 0$ is set to $\bar{\lambda} = 0.02$. Therefore, provided that the economy is in a state that admits multiple equilibria, a crisis is a low probability event that arises, on average, every fifty quarters. Next I choose the values of τ and $\underline{\xi}$ so that the average operation cost for banks is 0.4 percent the value of liabilities and their leverage (liabilities over assets) is 0.82. These numbers implies that the intermediation cost is about 6 percent the value of total production, which is about the share of value added of the financial sector in the US economy in the 1990s.

Numerical exercise Given the parameter values described above, I simulate the model for 700 quarters (175 years) using a random sequence of draws of the sunspot shock. In the first 500 quarters the relative productivity of country 2 (emerging economies) is constant at the 1991 level. Starting at quarter 501 (which corresponds to the first quarter of 1992), agents learn that the relative productivity of emerging economies will change during the next 88 quarters (from 1992 to 2013) after which it stabilizes at the level observed in 2013.

Since there are sunspot shocks that could shift the economy from one type of equilibrium to the other, the dynamics of the economy depend on the actual realizations of the shock. To better illustrate the stochastic nature of the model, I repeat the simulation 1,000 times (with each simulation performed over 700 periods as described above).

Simulation results Figure 4 plots the average as well as the 5th and 95th percentiles of the realizations of the 1,000 repeated simulations in each quarter. The range of variation between the 5th and 95th percentiles provides information about the potential volatility of the economy at any point in time.

The first panel shows the relative productivity $\bar{z}_{2,t}/\bar{z}_{1,t}$. Productivity is exogenous in the model and the changes that start in 1991 represent a structural break for the simulation of the model. The next three panels plot bank leverage and the interest rates paid by banks on liabilities and earned on loans. The remaining panels show the dynamics of asset prices (the prices for the fixed asset interpreted as housing) and labor in each of the two countries.

The first point to notice is that, following the increase in relative productivity of emerging countries, the interval delimited by the 5th and 95th percentiles for the repeated simulations widens significantly. This means that 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 in 1991. However, after the structural break, the consequence of a bank crisis could be much bigger since the distance between the 5th and 95th percentiles widens. This is especially true in the second half of 2000s.

Besides the increase in financial and macroeconomic volatility, the figure reveals other interesting patterns. First, as the relative size of emerging economies increases, banks raise their leverage while the interest rate on their liabilities declines. The economy also experiences a decline in the interest rate on loans which in turn allows for a boom in asset prices. This is a direct consequence of the interest rate decline on loans. Since part of the holding of real assets can be financed with loans issued by banks, the decline in the interest rate makes the financing of these assets cheaper for workers, raising their price.

Labor, however, declines on average, which can be explained as follows. As emerging countries become bigger, relatively to industrialized countries, they demand more financial liabilities issued by banks. Banks increase the supply but not enough to compensate for the overall increase in demand. As

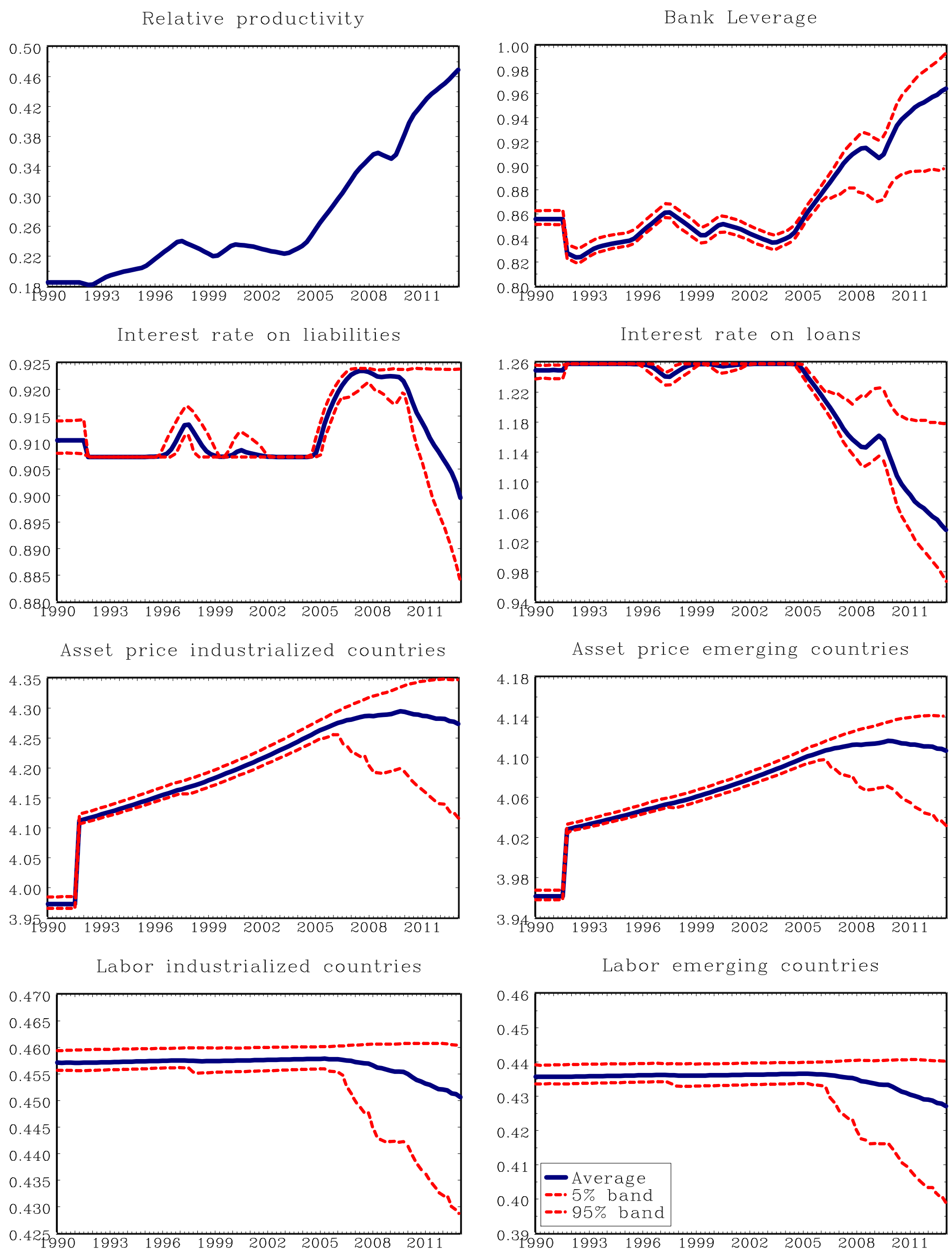


Figure 4: Change in productivity of emerging countries 1992-2013. Responses of 1,000 simulations.

a result, in equilibrium entrepreneurs will hold less financial assets relatively to their production scale. This implies lower insurance and, therefore, less demand for labor.

It is important to point out that, although the underlying financial and macroeconomic volatility has increased in recent years, this does not mean that we can observe it in the actual data. It is conceivable that the recent crisis is the only negative sunspot shock realized during the last 20 years. Then, the dynamics of the economy observed during the last two decades would appear quite stable until 2008 even if the underlying volatility has increased substantially. Because the probability of a negative sunspot shock is very low (calibrated to only 2% per quarter), the probability of a sequence of positive realizations from 1991 to 2008 is about 25 percent. Therefore, the hypothesized scenario is quite plausible. It also fits with anecdotal evidence for which 2008 is the only truly worldwide financial crisis observed during the last 20 years.

A second remark is that, although labor falls on average for all repeated simulations, the actual dynamics of labor during the 20 years that followed the 1992 break could be increasing or decreasing depending on the actual realizations of the sunspot shocks.

To show this point, I repeat the simulation of the model but for a particular sequence of sunspot shocks. More specifically, I assume 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 fourth quarter of 2008 the draw of the sunspot becomes $\varepsilon = 0$ but returns to $\varepsilon = 1$ in the first quarter of 2009 and in all subsequent quarters. This particular sequence of sunspots captures the idea that expectations may have turned pessimistic in the fourth quarter of 2008 leading to a sudden financial crisis. The simulated variables are plotted in Figure 5.

As we can seen from Figure 5, as long as the draws of the sunspot variable are $\varepsilon = 1$, asset prices continue to increase and the input of labor does not drop. However, a single realization $\varepsilon = 0$ 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 very 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 rebuilt the lost wealth through savings.

Another way of showing the importance of the growth of emerging countries for macroeconomic stability is by conducting the following counterfac-

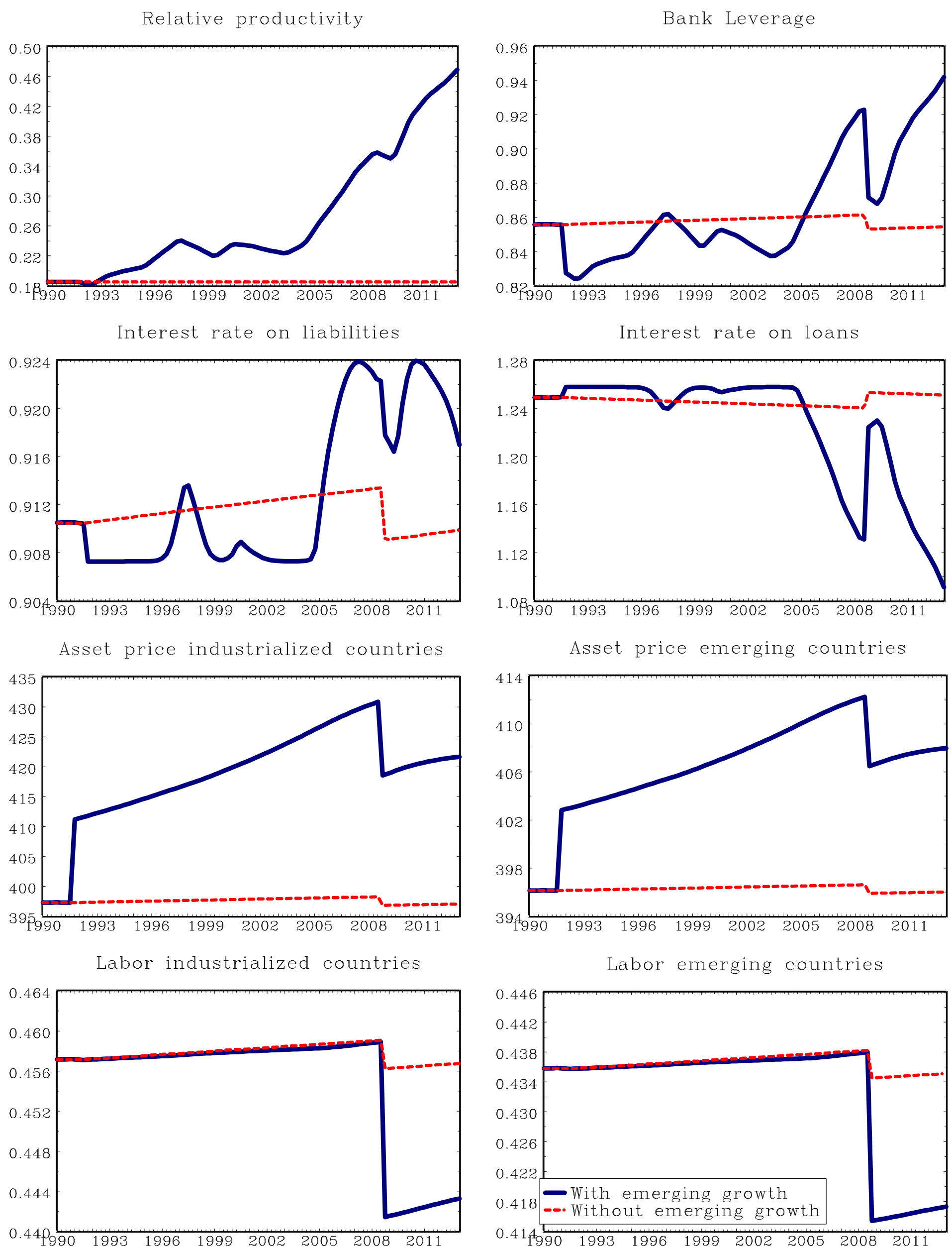


Figure 5: Change in productivity of emerging countries 1992-2013. Responses of 1,000 simulations with same draws of the sunspot variable starting in 1992, with the exception of fourth quarter of 2008.

tual exercise. I repeat the simulation under the assumption that the relative productivity of emerging countries does not growth but remains at the pre-1992 level for the whole simulation period. This counterfactual exercise tells us how the financial and macroeconomic dynamics in response to the same sequence of shocks would have changed without the growth of emerging countries. The resulting simulation is shown by the dashed line in Figure 5.

Without the growth of emerging countries, 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. This became evident only after the crisis materialized.

4 Discussion and conclusion

An implication of the sustained high growth of emerging economies and their consequent increase in the share of the world economy, is that the economic performance of these countries is becoming more important for the performance of industrialized countries. The view that emerging countries are a collection of small open economies whose dynamics is of negligible importance for the economic performance of industrialized countries is no longer a valid approximation.

Of course, there are many channels through which emerging economies could affect industrialized countries. In this paper I emphasized one of these channels: the increased demand for financial assets traded in a globalized capital market. In particular, I have shown that the increased demand for financial assets raises the incentives of financial intermediaries to leverage. On the one had, this allows for the expansion of the financial sector with positive effects on real macroeconomic variables. On the other, it increases the fragility of the financial system, raising the probability and/or the consequences of a crisis.

These results are illustrated with a model in which the banking sector plays a central role in the intermediation of funds, and therefore, in the creation of financial assets. The paper emphasizes a special channel through which banks can affect the real sector of the economy: the issuance of liabilities held by the nonfinancial sector for insurance purposes. When the supply of bank liabilities or their value are low, agents are less willing to engage in risky activities and this causes a macroeconomic contraction.

The analysis of 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 allows for an economic boom. But as leverage increases, the banking sector becomes vulnerable to pessimistic expectations about the liquidity of the overall banking sector, creating the conditions for a financial crisis. The increase in the demand for financial assets from emerging economies amplifies this mechanism because, by reducing the funding cost, it increases the incentive of banks to leverage.

In reality, financial assets held for precautionary reasons are also created directly by nonfinancial sectors. For example, firms and governments issue liabilities that are directly held by nonfinancial sectors. Still, financial intermediaries play an important role in the direct issuance of these securities. Financial intermediaries also play an important role in the secondary market for these securities. Therefore, difficulties in financial intermediation is likely to affect the functioning and valuation of all financial markets. It is for this reason that in this paper I focused on the operation of financial intermediaries.

An important feature of the model economy studied here is that the expansion of the financial sector improves the allocation efficiency. This is because the issuance of bank liabilities provides insurance instruments for entrepreneurs, encouraging them to hire labor. Another way to say this is that risk creates a wedge in the demand of labor. The creation of financial assets that can be used for insurance purposes mitigates the labor wedge. However, the creation of more financial assets is often associated with higher leverage, making the financial system more vulnerable to a crisis. From a policy perspective, there is a trade-off: the benefit of an expanded financial system and the potential cost of deeper crises. The study of optimal policies in the context of this model will be the subject of future research.

Appendix

A Proof of Lemma 2.1

Ignoring the agent superscript i and the country subscript j, the optimization problem of an entrepreneur can be written recursively as

$$\begin{aligned} V_t(b_t) &= \max_{h_t} \mathbb{E}_t \tilde{V}_t(a_t) \\ & \text{subject to} \\ & a_t = b_t + (z_t - w_t)h_t \end{aligned} \tag{20}$$

$$\begin{aligned} \tilde{V}_t(a_t) &= \max_{b_{t+1}} \Big\{ \ln(c_t) + \beta \mathbb{E}_t V_{t+1}(b_{t+1}) \Big\} \\ & \text{subject to} \\ & c_t = a_t - q_t b_{t+1} \end{aligned} \tag{21}$$

Since the information set changes from the beginning of the period to the end of the period, the optimization problem has been separated according to the available information. In sub-problem (20) the entrepreneur chooses the input of labor without knowing the productivity z_t. In sub-problem (21) the entrepreneur allocates the end of period wealth in consumption and savings after observing z_t.

The first order condition for sub-problem (20) is

$$\mathbb{E}_t \frac{\partial \tilde{V}_t}{\partial a_t}(z_t - w_t) = 0.$$

The envelope condition from sub-problem (21) gives

$$\frac{\partial \tilde{V}_t}{\partial a_t} = \frac{1}{c_t}.$$

Substituting in the first order condition we obtain

$$\mathbb{E}_t \left(\frac{z_t - w_t}{c_t} \right) = 0. \tag{22}$$

At this point we proceed by guessing and verifying the optimal policies for employment and savings. The guessed policies take the form:

$$h_t = \phi_t b_t \tag{23}$$
$$c_t = (1 - \beta) a_t \tag{24}$$

Since $a_t = b_t + (z_t - w_t)h_t$ and the employment policy is $h_t = \phi_t b_t$, the end of period wealth can be written as $a_t = [1 + (z_t - w_t)\phi_t]b_t$. Substituting in the guessed consumption policy we obtain

$$c_t = (1-\beta)\Big[1 + (z_t - w_t)\phi_t\Big]b_t. \tag{25}$$

This expression is used to replace c_t in the first order condition (22) to obtain

$$\mathbb{E}_t\left[\frac{z_t - w_t}{1 + (z_t - w_t)\phi_t}\right] = 0, \tag{26}$$

which is the condition stated in Lemma 2.1.

To complete the proof, we need to show that the guessed policies (23) and (24) satisfy the optimality condition for the choice of consumption and saving. This is characterized by the first order condition of sub-problem (21), which is equal to

$$-\frac{q_t}{c_t} + \beta\mathbb{E}_t\frac{\partial V_{t+1}}{\partial b_{t+1}} = 0.$$

From sub-problem (20) we derive the envelope condition $\partial V_t/\partial b_t = 1/c_t$ which can be used in the first order condition to obtain

$$\frac{q_t}{c_t} = \beta\mathbb{E}_t\frac{1}{c_{t+1}}.$$

We have to verify that the guessed policies satisfy this condition. Using the guessed policy (24) and equation (25) updated one period, the first order condition can be rewritten as

$$\frac{q_t}{a_t} = \beta\mathbb{E}_t\frac{1}{[1 + (z_{t+1} - w_{t+1})\phi_{t+1}]b_{t+1}}.$$

Using the guessed policy (24) we have that $q_t b_{t+1} = \beta a_t$. Substituting and rearranging we obtain

$$1 = \mathbb{E}_t\left[\frac{1}{1 + (z_{t+1} - w_{t+1})\phi_{t+1}}\right]. \tag{27}$$

The final step is to show that, if condition (26) is satisfied, then condition (27) is also satisfied. Let's start with condition (26), updated by one period. Multiplying both sides by ϕ_{t+1} and then subtracting 1 in both sides we obtain

$$\mathbb{E}_{t+1}\left[\frac{(z_{t+1} - w_{t+1})\phi_{t+1}}{1 + (z_{t+1} - w_{t+1})\phi_{t+1}} - 1\right] = -1.$$

Multiplying both sides by -1 and taking expectations at time t we obtain (27).

B First order conditions for workers

Ignoring country subscript j, the optimization problem of a worker is

$$\begin{aligned} V_t(l_t, k_t) &= \max_{h_t, l_{t+1}, k_{t+1}} \left\{ c_t - \alpha \bar{z}_t \frac{h_t^{1+\frac{1}{\nu}}}{1+\frac{1}{\nu}} + \beta V_{t+1}(l_{t+1}, k_{t+1}) \right\} \\ & \text{subject to} \\ & c_t = w_t h_t + \bar{z}_t k_t + \frac{l_{t+1}}{R_t} - l_t - (k_{t+1} - k_t) p_t \\ & l_{t+1} \geq \eta \bar{z}_t. \end{aligned}$$

Given $\beta\mu_t$ the lagrange multiplier associated with the borrowing constraint, the first order conditions with respect to h_t, l_{t+1}, k_{t+1} are, respectively,

$$\begin{aligned} & -\alpha \bar{z}_t h_t^{\frac{1}{\nu}} + w_t = 0, \\ & \frac{1}{R_t} + \beta \frac{\partial V_{t+1}(l_{t+1}, k_{t+1})}{\partial l_{t+1}} - \beta \mu_t = 0, \\ & -p_t + \beta \frac{\partial V_{t+1}(l_{t+1}, k_{t+1})}{\partial k_{t+1}} = 0. \end{aligned}$$

The envelope conditions are

$$\begin{aligned} \frac{\partial V_t(l_{t+1}, k_{t+1})}{\partial l_{t+1}} &= -1, \\ \frac{\partial V_t(l_{t+1}, k_{t+1})}{\partial k_{t+1}} &= \bar{z}_t + p_t. \end{aligned}$$

Updating by one period and substituting in the first order conditions we obtain (4), (5), (6). When the borrowing constraint takes the form $\eta \mathbb{E}_t p_{t+1} k_{t+1} \geq l_{t+1}$, the first order condition with respect to k_{t+1} becomes

$$-p_t + \beta \frac{\partial V_{t+1}(l_{t+1}, k_{t+1}}{\partial k_{t+1}} + \eta \beta \mu_t \mathbb{E}_t p_{t+1} = 0,$$

Substituting the envelope condition we obtain (7).

C Proof of Proposition 2.1

As shown in Lemma 2.1, the optimal saving of entrepreneurs takes the form $q_t b^i_{j,t+1} = \beta a^i_{j,t}$, where $a^i_{j,t}$ is the end-of-period wealth $a^i_{j,t} = b^i_{j,t} + (z^i_{j,t} - w_{j,t}) h^i_{j,t}$. Since $h^i_{j,t} = \phi(w_{j,t}) b^i_{j,t}$ (see Lemma 2.1), the end-of-period wealth can be rewritten as $a^i_{j,t} = [1 + (z^i_{j,t} - w_{j,t})\phi_j(w_{j,t})]b^i_{j,t}$. Substituting into the optimal saving and aggregating over all entrepreneurs of country j we obtain

$$B_{j,t+1} = \frac{\beta}{q_t}\Big[1 + (\bar{z}_j - w_{j,t})\phi_j(w_{j,t})\Big]B_{j,t}. \tag{28}$$

This equation defines the aggregate demand for bonds in country j as a function of the price q_t, the wage rate $w_{j,t}$, and the beginning-of-period aggregate wealth of entrepreneurs $B_{j,t}$. Notice that the term in square brackets is bigger than 1. Therefore, in a steady state equilibrium where $B_{j,t+1} = B_{j,t}$, the condition $\beta < q_t$ must be satisfied.

Using the equilibrium condition in the labor market, I can express the wage as a function of $B_{j,t}$. In particular, equalizing the demand for labor, $H^D_{j,t} = \phi_j(w_{j,t})B_{j,t}$, to the supply from workers, $H^S_{j,t} = (w_{j,t}/\alpha\bar{z}_j)^\nu$, the wage can be expressed as a function of only $\tilde{B}_{j,t}$. We can then use this function to replace $w_{j,t}$ in (28) and express the demand for bonds as a function of only $B_{j,t}$ and q_t as follows

$$B_{j,t+1} = \frac{s_j(B_{j,t})}{q_t}. \tag{29}$$

The function $s_j(B_{j,t})$ is strictly increasing in the wealth of entrepreneurs, $B_{j,t}$.

Consider now the supply of bonds from workers. For simplicity I assume that the borrowing constraint takes the form specified in equation (2), that is, $l_{j,t+1} \leq \eta_j\bar{z}_j$. Using this limit together with the first order condition (5), we have that, either the price of bonds satisfies $q_t = \beta$ or workers are financially constrained, that is, $L_{j,t+1} = \eta_j\bar{z}_j$. When the price of bonds is equal to the inter-temporal discount factor (first case), we can see from (28) that $B_{j,t+1} > B_{j,t}$. So eventually, the global demand of bonds will reach the global supply, that is, $B_{1,t+1}+B_{2,t+1} = \eta_1\bar{z}_1+\eta_2\bar{z}_2$. At this stage the borrowing constraint of workers is binding in both countries and, therefore, the multiplier $\mu_{j,t}$ is positive. Condition (5) then implies that the price of bonds is bigger than the inter-temporal discount factor. So the economy has reached a steady state. The steady state price of bonds is determined by condition (29) after setting $B_{j,t} = B_{j,t+1}$ and $B_{1,t} + B_{2,t} = \eta_1\bar{z}_1 + \eta_2\bar{z}_2$. This is the only steady state equilibrium.

When the borrowing constraint takes the form (3), the proof is more involved but the economy also reaches a steady state with $\beta < q_t$.

D First order conditions for problem (12)

The probability of renegotiation, denoted by θ_{t+1}, is defined as

$$\theta_{t+1} = \begin{cases} 0, & \text{if} \quad \omega_{t+1} < \underline{\xi} \\ \bar{\lambda}, & \text{if} \quad \underline{\xi} \leq \omega_{t+1} \leq 1 \\ 1, & \text{if} \quad \omega_{t+1} > 1 \end{cases}$$

Define $\beta(1-\theta_{t+1})\gamma_t$ the Lagrange multiplier associated to the constraint $b_{t+1} \leq l_{t+1}$. The first order conditions for problem (12) with respect to b_{t+1} and l_{t+1} are

$$\frac{1-\varphi_t}{\overline{R}_t^b}\mathbb{E}_t\frac{\partial \tilde{b}_{t+1}}{\partial b_{t+1}} - \frac{\partial \varphi_t}{\partial b_{t+1}}\frac{\mathbb{E}_t\tilde{b}_{t+1}}{\overline{R}_t^b} - \beta\mathbb{E}_t\frac{\partial \tilde{b}_{t+1}}{\partial b_{t+1}} - \beta(1-\theta_{t+1})\gamma_t = 0, \tag{30}$$

$$-\frac{1}{R_t^l} + \frac{1-\varphi_t}{\overline{R}_t^b}\mathbb{E}_t\frac{\partial \tilde{b}_{t+1}}{\partial l_{t+1}} - \frac{\partial \varphi_t}{\partial l_{t+1}}\frac{\mathbb{E}_t\tilde{b}_{t+1}}{\overline{R}_t^b} + \beta\mathbb{E}_t\left(1 - \frac{\partial \tilde{b}_{t+1}}{\partial l_{t+1}}\right) + \beta(1-\theta_{t+1})\gamma_t = 0. \tag{31}$$

I now use the definition of φ_t and $\tilde{b}_{t+1}$ provided in equations (10) and (8) to derive the following terms

$$\begin{aligned} \frac{\partial \varphi_t}{\partial b_{t+1}} &= \varphi'_{t+1}\frac{1}{l_{t+1}}, \\ \frac{\partial \varphi_t}{\partial l_{t+1}} &= -\varphi'_{t+1}\omega_{t+1}\frac{1}{l_{t+1}}, \\ \mathbb{E}_t\frac{\partial \tilde{b}_{t+1}}{\partial b_{t+1}} &= 1-\theta_{t+1}, \\ \mathbb{E}_t\frac{\partial \tilde{b}_{t+1}}{\partial l_{t+1}} &= \theta_{t+1}\underline{\xi}, \\ \mathbb{E}_t\tilde{b}_{t+1} &= (1-\theta_{t+1})b_{t+1} + \theta_{t+1}\underline{\xi}l_{t+1}. \end{aligned}$$

Substituting in (30) and (31) and re-arranging we obtain

$$\frac{1}{\overline{R}_t^b} = \beta\left[1 + \frac{\varphi_{t+1} + \varphi'_{t+1}A_{t+1} + \gamma_t}{1 - \varphi_{t+1} - \varphi'_{t+1}A_{t+1}}\right], \tag{32}$$

$$\frac{1}{R_t^l} = \beta\left[1 + \frac{\varphi'_{t+1}A_{t+1}^2(1-\theta_{t+1})(1+\gamma_t)}{1 - \varphi_{t+1} - \varphi'_{t+1}A_{t+1}} + \left(1 - \theta_{t+1} + \theta_{t+1}\underline{\xi}\right)\gamma_t\right], \tag{33}$$

where $A_{t+1} = \omega_{t+1} + \frac{\theta_{t+1}\underline{\xi}}{1-\theta_{t+1}}$.

The multiplier γ_t is zero if $\omega_{t+1} < 1$ and positive if $\omega_{t+1} = 1$. Therefore, the first order conditions can be written as

$$\begin{aligned}\frac{1}{\overline{R}^b_t} &= \beta\left[1 + \frac{\varphi_{t+1} + \varphi'_{t+1}A_{t+1}}{1 - \varphi_{t+1} - \varphi'_{t+1}A_{t+1}}\right],\\ \frac{1}{R^l_t} &= \beta\left[1 + \frac{\varphi'_{t+1}A^2_{t+1}(1-\theta_{t+1})}{1 - \varphi_{t+1} - \varphi'_{t+1}A_{t+1}}\right],\end{aligned}$$

which are satisfied with the inequality sign if $\gamma_t > 0$. Since the right-hand-side terms are all functions of ω_{t+1}, the first order conditions can be written as in (13) and (14).

E Proof of Lemma 2.2

Let's consider the first order conditions (32) and (33) when $\omega_{t+1} < 1$. In this case the lagrange multiplier γ_t is zero. Since $A_{t+1} > 0$ and φ_{t+1} and φ'_{t+1} are both positive for $\omega_{t+1} > \underline{\xi}$, conditions (32) and (33) imply that $\overline{R}^b_t$ and R^l_t are smaller than $1/\beta$.

The next step is to derive the return spread from (32) and (33) to obtain

$$\frac{R^l_t}{\overline{R}^b_t} = \frac{1}{1 - \varphi_{t+1} - \varphi'_{t+1}A_{t+1}[1-(1-\theta_{t+1})A_{t+1}]}. \tag{34}$$

Given the properties of the cost function (Assumption 1), to show that the spread is bigger than 1 I only need to show that $(1-\theta_{t+1})A_{t+1} < 1$. Using $A_{t+1} = \omega_{t+1} + \frac{\theta_{t+1}\underline{\xi}}{1-\theta_{t+1}}$ and taking into account that $\omega_{t+1} < 1$ and $\theta_{t+1} < 1$, we can verify that $(1-\theta_{t+1})A_{t+1} < 1$. Therefore, the spread is bigger than 1.

To show that the spread is increasing in the leverage, I differentiate (34) with respect to ω_{t+1} to obtain

$$\frac{R^l_t}{\overline{R}^b_t} = \frac{(\varphi''_{t+1}A_{t+1} + 2\varphi'_{t+1})[1-(1-\theta_{t+1})A_{t+1}]}{\left[1 - \varphi_{t+1} - \varphi'_{t+1}A_{t+1}(1-(1-\theta_{t+1})A_{t+1}\right]^2}$$

Given the properties of the cost function (Assumption 1), the derivative is zero for $\omega_{t+1} \leq \underline{\xi}$. To prove that the derivative is positive for $\omega_{t+1} > \underline{\xi}$, I only need to show that $(1-\theta_{t+1})A_{t+1} < 1$, which has already been shown above. Therefore, the return spread is strictly increasing for $\omega_{t+1} > \underline{\xi}$.

F Proof of Proposition 2.2

Banks make decisions at two different stages. At the beginning of the period they choose whether to renegotiate the debt and at the end of the period they choose the funding and lending policies. Given the initial states, b_t and l_t, the renegotiation decision boils down to a take-it or leave-it offer made by each bank to its creditors for the repayment of the debt. Denote by $\tilde{b}_t = f(b_t, l_t, \xi_t^e)$ the offered repayment. This depends on the individual liabilities b_t, individual assets l_t, and the expected liquidation price of assets ξ_t^e. The superscript e is to make clear that the bank decision depends on the expected price in the eventuality of liquidation. Obviously, the best repayment offer made by the bank is

$$f(b_t, l_t, \xi_t^e) = \begin{cases} b_t, & \text{if} \quad b_t \leq \xi_t^e l_t \\ \\ \xi_t^e l_t, & \text{if} \quad b_t > \xi_t^e l_t \end{cases}, \tag{35}$$

which is accepted by creditors whenever the actual liquidation price is bigger than the expected price ξ_t^e.

After the renegotiation stage, banks choose the funding and lending policies, b_{t+1} and l_{t+1}. These policies depend on the two interest rates, $\overline{R}_t^b$ and R_l, and on the probability distribution of the next period liquidation price ξ_{t+1}. Since we could have multiple equilibria, the next period price could be stochastic. Suppose that the price takes two values, $\underline{\xi}$ and 1, with the probability of the low value defined as

$$\theta(\omega_{t+1}) = \begin{cases} 0, & \text{if} \quad \omega_{t+1} < \underline{\xi} \\ \\ \lambda, & \text{if} \quad \underline{\xi} \leq \omega_{t+1} \leq 1 \\ \\ 1, & \text{if} \quad \omega_{t+1} > 1. \end{cases}$$

The variable $\omega_{t+1} = b_{t+1}/l_{t+1}$ represents the leverage of all banks in a symmetric equilibrium, that is, they all choose the same leverage. For the moment the symmetry of the equilibrium is an assumption. I will then show below that in fact banks do not have incentives to deviate from the leverage chosen by other banks.

Given the above assumption about the probability distribution of the liquidation price, the funding and lending policies of the bank are characterized in Lemma 2.2 and depend on $\overline{R}_t^b$ and R_t^l. In short, if $\overline{R}_t^b/(1-\tau) = R_t^l$, then the optimal policy of the bank is to choose a leverage $\omega_{t+1} \leq \underline{\xi}$. If $\overline{R}_t^b/(1-\tau) < R_t^l$, the optimal leverage is $\omega_{t+1} > \underline{\xi}$.

Given the assumption that the equilibrium is symmetric (all banks choose the same leverage ω_{t+1}), multiple equilibria arise if the chosen leverage is $\omega_{t+1} \in \{\underline{\xi}, 1\}$.

In fact, once we move to the next period, if the market expects $\xi^e_{t+1} = \underline{\xi}$, all banks are illiquid and they choose to renege on their liabilities (given the renegotiation policy (35)). As a result, there will not be any bank that can buy the liquidated assets of other banks. Then the only possible price that is consistent with the expected price is $\xi_{t+1} = \underline{\xi}$. On the other hand, if the market expects $\xi^e_{t+1} = 1$, banks are liquid and, if one bank reneges, creditors can sell the liquidated assets to other banks at the price $\xi_{t+1} = 1$. Therefore, it is optimal for banks not to renegotiate consistently with the renegotiation policy (35).

The above proof, however, assumes that the equilibrium is symmetric, that is, all banks choose the same leverage. To complete the proof, we have to show that there is no incentive for an individual bank to deviate from the leverage chosen by other banks. In particular, I need to show that, in the anticipation that the next period liquidation price could be $\xi_{t+1} = \underline{\xi}$, a bank do not find convenient to chose a lower leverage so that, in the eventuality that the next period price is $\xi_{t+1} = \underline{\xi}$, the bank could purchase the liquidated asset at a price lower than 1 and make a profit (since the unit value for the bank of the liquidated assets is 1.

If the price at $t+1$ is $\xi_{t+1} = \underline{\xi}$, a liquid bank could offer a price $\underline{\xi} + \epsilon$, where ϵ is a small but positive number. Since the repayment offered by a defaulting bank is $\underline{\xi} l_{t+1}$, creditors prefer to sell the assets rather than accepting the repayment offered by the defaulting bank. However, if this happens, the expectation of the liquidation price $\xi^e = \underline{\xi}$ turns out to be incorrect ex-post. Therefore, the presence of a single bank with liquidity will raise the expected liquidation price to $\underline{\xi} + \epsilon$. But even with this new expectation, a bank with liquidity can make a profit by offering $\underline{\xi} + 2\epsilon$. Again, this implies that the expectation turns out to be incorrect ex-post. This mechanism will continue to raise the expected price to $\xi^e_{t+1} = 1$. At this point the liquid bank will not offer a price bigger than 1 and the ex-post liquidation price is correctly predicted to be 1. Therefore, as long as there is a single bank with liquidity, the expected liquidation price must be 1. But then a bank cannot make a profit in period $t+1$ by choosing a lower leverage in period t with the goal of remaining liquid in the next period. This proves that there is no incentive to deviate from the policy chosen by other banks.

Finally, the fact that multiple equilibria cannot arise when $\omega_t < \underline{\xi}$ is obvious. Even if the price is $\underline{\xi}$, banks remain liquid.

G Numerical solution

I describe the numerical procedure to solve the model with the endogenous borrowing constraint specified in (3). I first describe the numerical procedure when the relative productivity $\bar{z}_{2,t}/\bar{z}_{1,t}$ does not change. In this case I can solve for the stochastic stationary equilibrium. I will then describe the numerical procedure when the relative productivity changes over time.

G.1 Stationary equilibrium without structural break

The states of the economy are given by the bank liabilities held in both countries, $B_{1,t}$ and $B_{2,t}$, the bank loans, $L_{1,t}$ and $L_{2,t}$, and the realization of the sunspot shock ε_t. These five variables are important in determining the renegotiation liabilities $\tilde{B}_{1,t}$ and $\tilde{B}_{2,t}$. However, once we know the renegotiated liabilities $\tilde{B}_{1,t}$ and $\tilde{B}_{2,t}$, these become the sufficient states for solving the model. Therefore, in the computation I will solve for the recursive equilibrium using $\tilde{B}_{1,t}$ and $\tilde{B}_{2,t}$ as the sufficient state variables for the dynamic system.

The equilibrium will be derived by solving the following equilibrium conditions:

$$H_{j,t} = \phi_j(w_{j,t})\tilde{B}_{j,t}, \tag{36}$$

$$\frac{B_{j,t+1}}{R^b_t} = \beta A_{j,t}, \tag{37}$$

$$A_{j,t} = \tilde{B}_{j,t} + (\bar{z}_j - w_{j,t})H_{j,t} \tag{38}$$

$$\alpha H_{j,t}^{\frac{1}{\nu}} = w_{j,t}, \tag{39}$$

$$1 = \beta R^l_t(1 + \mu_{j,t}), \tag{40}$$

$$p_{j,t} = \beta \mathbb{E}_t\Big[\bar{z}_j + (1 + \eta_j \mu_{j,t})p_{j,t+1}\Big], \tag{41}$$

$$L_{j,t+1} = \eta_t \mathbb{E}_t p_{j,t+1}, \tag{42}$$

$$\frac{1}{\overline{R}^b_t} \geq \beta\left[1 + \Phi\left(\omega_{t+1}\right)\right], \tag{43}$$

$$\frac{1}{R^l_t} \geq \beta\left[1 + \Psi\left(\omega_{t+1}\right)\right], \tag{44}$$

$$\overline{R}^b_t = \left[1 - \theta(\omega_{t+1}) + \theta(\omega_{t+1})\left(\frac{\xi}{\omega_{t+1}}\right)\right] R^b_t, \tag{45}$$

$$\omega_{t+1} = \frac{B_{1,t+1} + B_{2,t+1}}{L_{1,t+1} + L_{2,t+1}} \tag{46}$$

Equations (36)-(38) come from the aggregation of the optimal policies of entrepreneurs (labor demand, savings, end of period wealth). Equations (39)-(42) come from the optimization problem of workers (labor supply, optimal borrowing, optimal holding of the fixed asset, borrowing constraint). Notice that the borrowing constraint of workers (equation (42) is not always binding. However, when it is not binding and the multiplier is $\mu_t = 0$, workers' borrowing is not determined. Therefore, without loss of generality I assume that in this case workers borrow up to the limit. This explains why the borrowing constraint is always satisfied with equality. Equations (43)-(44) are the first order conditions of banks. They are satisfied with equality if $\omega_{t+1} < 1$ and with inequality if $\omega_{t+1} = 1$. Equation (45) defines the expected return on bank liabilities given their price, that is, the inverse of R^b_t. The final equation (46) defines leverage.

One complication in solving the dynamic system is that the expectation of the next period prices for the fixed asset, $\mathbb{E}_t p_{j,t+1}$, is unknown. All we know is that the next period price is a function of $\tilde{B}_{1,t+1}$ and $\tilde{B}_{2,t+1}$, that is, $p_{1,t+1} = P_1(\tilde{B}_{1,t+1}, \tilde{B}_{2,t+1})$ and $p_{2,t+1} = P_2(\tilde{B}_{1,t+1}, \tilde{B}_{2,t+1})$. If I knew these two functions, for any given states $\tilde{B}_{1,t}$ and $\tilde{B}_{2,t}$ the above conditions would be a system of 18 equations in 18 variables: $H_{j,t}$, $A_{j,t}$, $\mu_{j,t}$, $w_{j,t}$, $p_{j,t}$, $B_{j,t+1}$, $L_{j,t+1}$, R^b_t, R^l_t, $\overline{R}^b_t$, ω_{t+1}. Notice that $\tilde{B}_{j,t+1}$ is a known function of $B_{j,t+1}$, $L_{j,t+1}$ and the realization of the sunspot shock ε_{t+1}. Therefore, I can compute the expectation of the next period prices $p_{1,t+1}$ and $p_{2,t+1}$ if I know the price functions $P_1(\tilde{B}_{1,t+1}, \tilde{B}_{2,t+1})$ and $P_2(\tilde{B}_{1,t+1}, \tilde{B}_{2,t+1})$. We can then solve the 18 equations for the 18 variables and this would provide a solution for any given state $\tilde{B}_{1,t}$ and $\tilde{B}_{2,t}$.

The problem is that I do not know the price functions $P_1(\tilde{B}_{1,t+1}, \tilde{B}_{2,t+1})$ and $P_2(\tilde{B}_{1,t+1}, \tilde{B}_{2,t+1})$. Thus, the procedure will be based on a parametrization of these functions. In particular, I approximate $P_1(\tilde{B}_{1,t+1}, \tilde{B}_{2,t+1})$ and $P_2(\tilde{B}_{1,t+1}, \tilde{B}_{2,t+1})$ with piece-wise linear functions over a grid for the state variables $\tilde{B}_{1,t}$ and $\tilde{B}_{2,t}$. I then solve the above system of equations at all grid points for $\tilde{B}_{1,t}$ and $\tilde{B}_{2,t}$. As part of the solution I obtain the current prices $p_{1,t}$ and $p_{2,t}$. I then use the solution for the current prices to update the approximated functions $P_1(\tilde{B}_{1,t+1}, \tilde{B}_{2,t+1})$ and $P_2(\tilde{B}_{1,t+1}, \tilde{B}_{2,t+1})$ at the grid points. I repeat the iteration until convergence, that is, the values guessed for $P_1(\tilde{B}_{1,t+1}, \tilde{B}_{2,t+1})$ and $P_2(\tilde{B}_{1,t+1}, \tilde{B}_{2,t+1})$ at all grid points must be equal (up to a small rounding number) to the values of $p_{1,t}$ and $p_{2,t}$ obtained by solving the model (given the guesses for the price functions).

G.2 Equilibrium with structural break

When the relative productivity $\bar{z}_{2,t}/\bar{z}_{1,t}$ changes over time, the economy transits from a stochastic equilibrium to a new stochastic equilibrium. Therefore, I need to solve for the transition. The solution method is based on the following steps.

1. I first compute the stochastic equilibrium under the regime before the structural break (the change in relative productivity).

2. I then compute the stochastic equilibrium under the terminal regime (the relative productivity stabilized at the new (higher) level after the transition).

3. At this point I solve the model backward at any time t starting from the terminal period when the relative productivity stabilizes at the new level. At each t I solve the system (36)-(46) using the approximated functions $P_{1,t+1}(\tilde{B}_{1,t+1}, \tilde{B}_{2,t+1})$ and $P_{2,t+1}(\tilde{B}_{1,t+1}, \tilde{B}_{2,t+1})$ found at time $t+1$. In the first backward step (last period of the transition), $P_{1,t+1}(\tilde{B}_{1,t+1}, \tilde{B}_{2,t+1})$ and $P_{2,t+1}(\tilde{B}_{1,t+1}, \tilde{B}_{2,t+1})$ are the approximated price functions found in the stochastic stationary equilibrium after the break (see previous computational step).

References

Adrian, T., Colla, P., & Shin, H. S. (2013). Which Financial Frictions? Parsing the Evidence from the Financial Crisis of 2007-9. In Acemoglu, D., Parker, J., & Woodford, M. (Eds.), *NBER Macroeconomics Annual 2012*, pp. 159 – 214. MIT Press, Cambridge, Massachusetts.

Arellano, C., Bai, Y., & Kehoe, P. (2011). Financial Markets and Fluctuations in Uncertainty. Research Department Staff Report, Federal Reserve Bank of Minneapolis.

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'Erasmo, 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.

Eisfeldt, A., & Muir, T. (2012). Aggregate Issuance and Savings Waves. Unpublished manuscript, Anderson School of Management, UCLA.

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.

Kalemli-Ozcana, S., Papaioannou, E., & Perri, F. (2013). Global Banks and Crisis Transmission. *Journal of International Economics*, *89*(2), 495–510.

Kalemli-Ozcana, S., Sorensen, B., & Yesiltas, S. (2012). Leverage Across Firms, Banks, and Countries. *Journal of International Economics*, *88*(2), 284–298.

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.

Shourideh, A., & Zetlin-Jones, A. (2012). External Financing and the Role of Financial Frictions over the Business Cycle: Measurement and Theory. Unpublished manuscript, Wharton School.

Van den Heuvel, S. J. (2008). The Welfare Cost of Bank Capital Requirements. *Journal of Monetary Economics*, *55*(2), 298–320.