Global demand for financial assets, falling real interest rates and macroeconomic instability

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Abstract

The sharp, secular decline in the world real interest rate of the past thirty years suggests that the observed surge in global demand for financial assets outpaced the growth in the supply. We argue that (a) this phenomenon was driven by faster growth of emerging market economies (EMs) and changes in the financial structure of both emerging and advanced countries, and (b) the low-interest-rate environment made the world economy more vulnerable to financial crises. A two-region model in which financial assets provide productive services and private debt can be defaulted on, predicts that faster growth in EMs and financial structural change cause a sharp rise in demand for financial assets and a drop in the world interest rate. This, in turn, increases financial and macroeconomic instability worldwide.

1 Introduction

Four key facts illustrated in Figure 1 highlight major changes in the world economy during the last three decades. First, emerging economies grew significantly relative to advanced economies. As shown in the first panel of the Figure, GDP in PPP units of emerging countries relative to that of advanced economies rose from 57 to 125 percent between 1990 and 2020. Valuing GDP in U.S. dollars instead of PPP units yields an increase from 28 to 68 percent. Thus, the growth in the relative size of EMs is evident even setting aside real-exchange-rate movements.

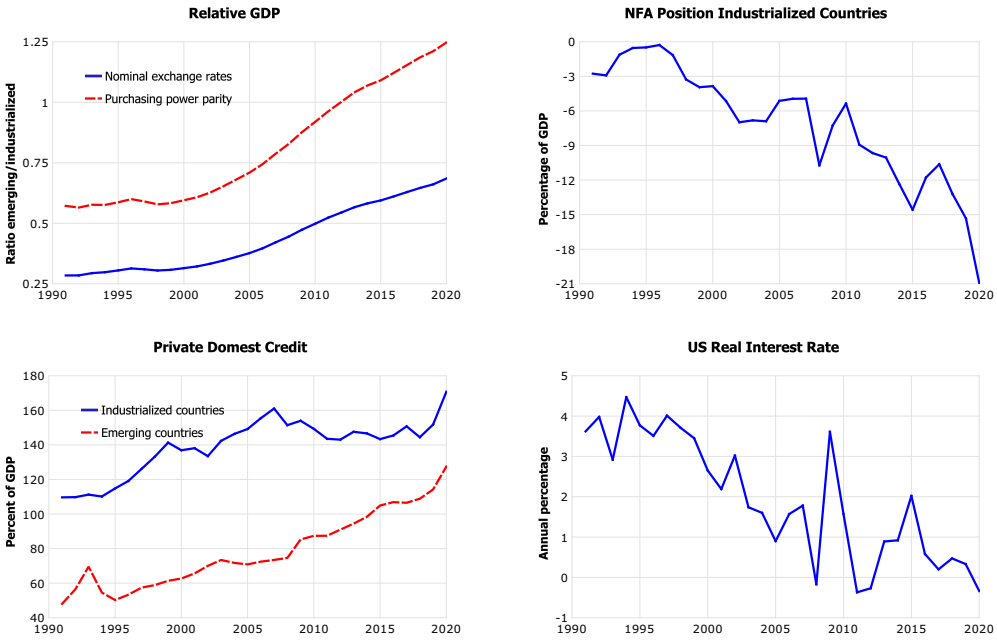


Figure 1: Real and Financial Trends in Advanced and Emerging Countries.

Note: **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 database (Lane and Milesi-Ferretti (2018)).

The second fact, often labeled the 'global imbalances phenomenon', is that the net foreign liabilities of industrialized countries increased significantly. As the second panel of the Figure shows, the net foreign assets (NFA) of advanced economies as a share of their collective GDP fell from close to zero at the beginning of the 1990s to about -20 percent in 2020.

The third fact is that the financial structure of both emerging and advanced economies changed so as to produce significant growth in credit to the private sector. The third panel of the Figure shows that private domestic credit as a percentage of GDP roughly tripled in EMs in the last 30 years and grew about half as much (by a factor of 1.5) in advanced economies. Thus, although domestic credit as a share of GDP in EMs remains below that of industrialized countries, the gap has narrowed markedly.

This significant growth in financial intermediation worldwide could be driven by both the growth in demand for financial assets and/or the growth in the supply (i.e., issuance of liabilities). But whether the growth in demand outpaces the growth in supply or vice-versa is important for determining the direction of the response of the equilibrium interest rate, which brings us to the last key fact.

The fourth panel of Figure 1 plots the ex-post real interest rate on U.S. long-term public debt, a proxy for the world interest rate. Starting from about 4 percent at the beginning of the 1990s, the real interest rate followed a declining trend reaching values of around half of a percent at the end of 2020. Measures of expected real interest rates based on inflation expectations embedded in the pricing of inflation-indexed treasury bills or derived from econometric models also show significant declines. The market yield on 10-year U.S. TIPS at constant maturity fell from 2.29 percent in January 2003 to -1 percent at the end of 2020. The Cleveland Fed's estimate of the 10-year expected real interest rate fell from 4.1 percent in January 1990 to -0.2 percent at the end of 2020.[1] These sharp drops in ex-ante and ex-post world real interest rates suggest that the global demand for financial assets increased at a faster pace than the supply.

The trends in the world economy documented in Figure 1 emerged during a period marked by financial globalization and a surge in the occurrence of financial crises. Well-established measures of de-jure and de-facto

[1]The market yield is from FRED available at fred.stlouisfed.org/series/DFII10. The Cleveland Fed's expected real interest rate is available at www.clevelandfed.org/our-research/indicators-and-data/inflation-expectations.aspx

international capital mobility show the rapid progress of financial globalization as barriers to capital mobility were sharply reduced (see Chinn and Ito (2006)) and both gross external assets and liabilities grew in a large number of countries (see Lane and Milesi-Ferretti (2007)).[2] The increase in the frequency of financial crises is documented in well-known empirical studies (e.g. Reinhart and Rogoff (2009)). They show that there were no financial crises in advanced economies between 1940 and 1973 and only a handful between 1973 and 1990. Since then, between 15 and 20 crises have occurred, depending on the study one considers. Crises in emerging economies were also rare between 1940 and the onset of the sovereign debt crises of the 1980s, and the number of crises rose sharply after 1990 (see the survey by Sufi and Taylor (2021)).

This paper has two main goals. The first is to identify and measure the factors that caused the rise in net demand for financial assets and the drop in the world real interest rate shown in Figure 1 through the lens of a macroeconomic model. The second is to use the model to investigate the effects of these changes on global financial and macroeconomic volatility.

To achieve these goals, we develop a two-region model—one representative of emerging countries and one representative of advanced economies. In each region, there is a borrowing sector and a lending sector. Financial assets have features that make them akin to 'inside money' or to assets that embody a 'convenience yield' to the creditors that hold them. In particular, they can be used as productive inputs in the production of final goods at a cost. On the other hand, debtors (i.e. issuers of these assets) cannot commit to repay and thus private debts can be defaulted on. Debtors can renegotiate their debts at an increasing, convex cost.

A financial crisis occurs when the debt repayment is lower than the liquidation value of the debtors' real assets, and when this happens these assets are sold to creditors who can liquidate them with a haircut relative to their market price. As a result, a financial crisis causes wealth redistribution from creditors to debtors. This redistribution of wealth is essential to the mechanism by which the financial crisis generates real macroeconomic effects. Importantly, these effects depend on the changing structure of financial intermediation, which in the model is driven by changes in ex-

[2]The latest update of the Chinn-Ito Index of financial openness is available at web.pdx.edu/ĩto/Chinn-Ito_website.htm and the latest update of the Lane-Milesi-Ferretti External Wealth of Nations database is available at www.brookings.edu/research/the-external-wealth-of-nations-database.

ogenous factors as well as endogenous general equilibrium adjustments.

We consider three exogenous factors: (i) productivity, (ii) a structural parameter that affects the demand for financial assets, and (iii) another parameter that affects the supply of financial assets. We then use the model in conjunction with the data shown in Figure 1 to identify and measure the changes over time of these factors in both regions. The final step is to assess their contribution to macroeconomic and financial volatility through counterfactual simulations.

We find that the measured changes in productivity and financial structure both contributed to increase macroeconomic and financial volatility over the 1991-2020 period. These changes raised the demand for financial assets relatively to the supply, causing the decline in the interest rate. The lower interest rate then encouraged higher borrowing and led to higher effective leverage ratios. This, in turn, raised financial and macroeconomic volatility in both regions.

The observed reduction in the interest rate and the dynamics of the NFA positions are key for the identification of the financial changes. As mentioned above, the expansion of the financial sector could be driven by both a higher demand for financial assets or a higher supply. The reduction in the interest rate implies, however, that the worldwide growth in demand exceeded the growth in supply (at a fixed interest rate). NFA dynamics are important for determining in which country the demand for financial assets grew more than the supply. In particular, the fact that the net liabilities of advanced economies widened over time indicates that the net demand for assets in these countries increased less than in emerging countries.

The organization of the paper is as follows. Section 2 describes the model and characterizes the equilibrium. Section 3 uses the model in conjunction with the data shown in Figure 1 to construct empirical series for productivity and exogenous variables that affect the demand and supply of assets in the two countries. We then show the separate quantitative implications of these changes. Section 4 concludes.

Related literature. Our work is related to three important strands of the literature. On the side of international macroeconomics, there is the literature on global imbalances and the literature on financial crises or Sudden Stops. On the side of corporate finance, there is the literature on the growth of financial assets or cash held by nonfinancial corporations.

The global imbalances literature proposes several theories that provide explanations for the positive NFA positions of emerging countries. One explanation is based on the idea that emerging countries have a lower ability to create viable saving instruments for inter-temporal smoothing (Caballero, Farhi, and Gourinchas (2008)). Another explanation is based on the idea that emerging countries have a higher demand for assets due to lower insurance, or lower financial development related to weaker enforcement (Mendoza, Quadrini, and Ríos-Rull (2009)) or because of higher idiosyncratic uncertainty (Carroll and Jeanne (2009), Angeletos and Panousi (2011), Song, Storesletten, and Zilibotti (2011), Sandri (2014), Bacchetta and Benhima (2015), Fogli and Perri (2015)). The first theory emphasizes cross-country heterogeneity in the supply of assets while the second emphasizes heterogeneity in the demand. In both cases, though, because of the lower domestic supply of assets or higher demand, emerging countries turn to industrialized countries for the acquisition of saving instruments.

Our model incorporates both types of heterogeneity between industrialized and emerging countries. Importantly, the aim of our paper is not to examine why industrialized countries have been borrowing from emerging countries, which is the focus of the above referenced studies. Instead, our focus is on two issues that are new to this literature: First, examining and measuring how the heterogeneity in both demand and supply has changed over time. Second, how the change has affected macroeconomic and financial instability.

Various studies in the Sudden Stops literature examine the role of financial globalization, credit booms and high leverage as causing factors of financial crises (for example, Calvo and Mendoza (1996), Caballero and Krishnamurthy (2001), Gertler, Gilchrist, and Natalucci (2007), Edwards (2004), Mendoza and Quadrini (2010), Mendoza and Smith (2014), Fornaro (2018)).[3] Some of these studies emphasize mechanisms that cause financial crises because of equilibrium multiplicity due to self-fulfilling expectations (e.g., Aghion, Bacchetta, and Banerjee (2001), Perri and Quadrini (2018)). Crises in our model also follow from periods of fast credit growth and rising leverage and they are also the result of self-fulfilling expectations, but the mechanism driving our model differs in that it relies on a novel interaction between the inside-money-like role of financial assets for creditors with the debtors' lack of commitment to repay and ability to rene-

[3]See Bianchi and Mendoza (2020) for a survey of the literature.

gotiate debts.

In the corporate finance literature, several studies document and provide explanations for the raising demand for financial assets. An example is the literature on the growing cash holdings of nonfinancial businesses (e.g., Busso, Fernández, and Tamayo (2016) and Bebczuk and Cavallo (2016)). Our model has a similar feature in that entrepreneurs hold positive positions in financial assets that expand as a result of faster growth and changes in financial structure, but our focus is on its macroeconomic implications when it interacts with debt renegotiation and lack of commitment to repay on the side of debtors. In particular, we aim to quantify the implications of the increased net demand for financial assets for global financial and macroeconomic stability. We explore this through the lens of the structural model where the increased net demand for financial assets depresses the interest rate which in turn increases the incentives to leverage. While the higher leverage allows for sustained levels of financial intermediation and economic activity, it also makes the economies of emerging and industrialized countries more vulnerable to crises (global macroeconomic instability).

2 Model

There are two countries/regions 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 household sector.

Countries are heterogeneous in two dimensions: (i) economic size captured by differences in aggregate productivity, $z_{j,t}$; and (ii) financial market structure captured by two time-varying parameters, $\phi_{j,t}$ and $\kappa_{j,t}$. Although differences in economic size could be generated in the model by other factors besides productivity (for example, population, real exchange rates, etc.), heterogeneity in these factors are isomorphic to productivity differences. This will become clear in the quantitative section. Productivity $z_{j,t}$ and financial parameters $\phi_{j,t}$ and $\kappa_{j,t}$ are time varying but not stochastic. Their changes over time are fully anticipated.

2.1 Entrepreneurial sector

In each country there is a unit mass of atomistic entrepreneurs with lifetime utility

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

where $c_{j,t}$ is entrepreneur's consumption in country j at time t.

Entrepreneurs are business owners producing a single good with technology described below. Although the model is presented as if all firms are privately owned, we should think of the entrepreneurial sector broadly including public companies. Then, entrepreneurial consumption can be interpreted as dividend payments and the concavity of the utility function reflects the risk aversion of managers and/or major shareholders. The concavity could also reflect, in reduced form, the cost associated with financial distress: even if shareholders and managers are risk-neutral, a convex cost of financial distress would make the objective of the firm concave. Since entrepreneurs are homogeneous, we can focus on the representative entrepreneur.

The production technology operated by entrepreneurs takes the form

$$y_{j,t} = z_{j,t}^{\gamma} m_{j,t}^{\alpha} l_{j,t}^{\gamma} h_{j,t}^{1-\alpha-\gamma}, \tag{1}$$

where $z_{j,t}$ is productivity, $m_{j,t}$ is the financial wealth of the entrepreneur, $l_{j,t}$ is the input of labor, and $h_{j,t}$ is a non-produced factor rented from households. Financial wealth provides working capital that is complementary to other production factors. Productivity in each country fluctuates around a common long-run deterministic trend that grows at the constant gross growth rate g. This will also be the average long-run growth for both countries. In the short-run, however, the two countries could experience significant deviations from the long-run trend.

Production also implies a cost $\phi_{j,t} m_{j,t}$. The cost captures expenses that increase with the production scale as determined by the input $m_{j,t}$. One way to think about this cost is that it derives from the depreciation of the fixed factor: larger is the scale of production and larger are the expenses required to replenish the depreciated part of the fixed factor. The parameter $\phi_{j,t}$, will be important for determining the demand of financial assets.

Entrepreneurs have access to a market for bonds traded at price $q_{j,t}$. We will see that in equilibrium the bonds held by entrepreneurs are liabilities

issued by households. Even if there is capital mobility, the prices of bonds issued by the two countries differ because they are characterized by repayment risks that are specific to each country as we will describe below.

The representative entrepreneur in country j enters period t with bonds issued by country 1, $b_{1j,t}$, and bonds issued by country 2, $b_{2j,t}$. The first subscript denotes the country that issued the bond while the second subscript denotes the residency of the entrepreneur. In the event of a financial crisis, the entrepreneur incurs financial losses proportional to the owned bonds.

Denote by $\delta_{1,t}$ and $\delta_{2,t}$ the unit repayments realized at the beginning of the period on bonds issued, respectively, by country 1 and country 2. The residual values of the two bonds are then $\delta_{1,t}b_{1j,t}$ and $\delta_{2,t}b^i_{2j,t}$. The unit repayments $\delta_{1,t}$ and $\delta_{2,t}$ are endogenous stochastic variables that are determined in the general equilibrium. Given the realization of the unit losses, the after-default wealth of the entrepreneur is

$$m_{j,t} = \delta_{1,t}b_{1j,t} + \delta_{2,t}b_{2j,t}.$$

This is the financial wealth that enters the production function (1). In addition, the entrepreneur hires labor at the wage rate $w_{j,t}$ and rents the non-produced factor at the rental rate $r_{j,t}$. The end-of-period wealth, after production, is

$$a_{j,t} = (1-\phi_{j,t})m_{j,t} + z^{\gamma}_{j,t}m^{\alpha}_{j,t}l^{\gamma}_{j,t}h^{1-\alpha-\gamma}_{j,t} - w_{j,t}l_{j,t} - r_{j,t}h_{j,t}.$$

Wealth is in part allocated to consumption, $c^i_{j,t}$, and in part to purchase new bonds, $b_{1j,t+1}$ and $b_{2j,t+1}$ at prices, respectively, $q_{1,t}$ and $q_{2,t}$. The budget constraint can be written as

$$c_{j,t} + q_{1,t}b_{1j,t+1} + q_{2,t}b_{2j,t+1} = a_{j,t}. \tag{2}$$

While the input of labor $l_{j,t}$ depends on $m_{j,t}$, the portfolio decisions, $b_{1j,t+1}$ and $b_{2j,t+1}$, are functions of $a_{j,t}$. To make the timing of the model precise, we can think of the period as divided in three subperiods:

1. **Subperiod 1**: Entrepreneurs enter the period with financial assets $b_{1j,t}$ and $b_{2j,t}$, and observe the country-specific repayment ratios $\delta_{1,t}$ and $\delta_{2,t}$. The repayments bring the residual value of the entrepreneurs' wealth to $m_{j,t} = \delta_{1,t}b_{1j,t} + \delta_{2,t}b_{2j,t}$.

2. **Subperiod 2**: Given residual wealth $m_{j,t}$, the entrepreneur chooses the inputs of labor $l_{j,t}$ and fixed factor $h_{j,t}$. Market clearing determines the wage and rental rates $w_{j,t}$ and $r_{j,t}$.

3. **Subperiod 3**: The end-of-period wealth $a_{j,t}$ is in part consumed, $c_{j,t}$, and in part saved in bonds of country 1, $q_{1,t}b_{1j,t+1}$, and in bonds of country 2, $q_{2,t}b_{2j,t+1}$.

The following lemma characterizes the production decision (Subperiod 2) and the optimal portfolio decision (Subperiod 3).

Lemma 2.1 *The optimal entrepreneur's policies are*

$$\begin{aligned}
l_{j,t} &= z_{j,t}^{\frac{\gamma}{\alpha}} \left(\frac{\gamma}{w_{j,t}}\right)^{\frac{\alpha+\gamma}{\alpha}} \left(\frac{1-\alpha-\gamma}{r_{j,t}}\right)^{\frac{1-\alpha-\gamma}{\alpha}} m_{j,t}, \\
h_{j,t} &= z_{j,t}^{\frac{\gamma}{\alpha}} \left(\frac{\gamma}{w_{j,t}}\right)^{\frac{\gamma}{\alpha}} \left(\frac{1-\alpha-\gamma}{r_{j,t}}\right)^{\frac{1-\gamma}{\alpha}} m_{j,t}, \\
c_{j,t} &= (1-\beta) a_{j,t}^{i}, \\
q_{1,t}b_{1j,t+1} &= \beta\theta_t a_{j,t}, \\
q_{2,t}b_{2j,t+1} &= \beta(1-\theta_t) a_{j,t},
\end{aligned}$$

where θ_t solves the first order condition

$$1 = \mathbb{E}_t \left\{ \frac{\frac{\delta_{1,t+1}}{q_{1,t}}}{\theta_t \frac{\delta_{1,t+1}}{q_{1,t}} + (1-\theta_t)\frac{\delta_{2,t+1}}{q_{2,t}}} \right\}. \tag{3}$$

Proof 2.1 *See Appendix* **??**.

The demand for labor is linear in financial wealth $m_{j,t}^{i}$. The proportional term depends positively on productivity, $z_{j,t}$, and negatively on the wage rate, $w_{j,t}$. Similarly, the demand for the non-producible factor is linear in financial wealth $m_{j,t}^{i}$, with the proportional term increasing in productivity $z_{j,t}$, and decreasing in the rental rate $r_{j,t}$.

Lemma 2.1 also indicates that entrepreneurs allocate their end-of-period wealth between consumption and savings according to the fixed factor β.

This property derives from the log specification of the utility function. Finally, a fraction θ_t of savings is allocated to bonds issued by country 1 and the remaining fraction $1-\theta_t$ to bonds issued by country 2. The fraction θ_t changes over time. However, it is the same for entrepreneurs of country 1 and 2, which is indicated by the fact that θ_t does not have the j subscript. Essentially, entrepreneurs in both countries choose the same portfolio allocation between bonds issued by country 1 and country 2.

2.2 Household sector

In each country there is a unit mass of atomistic and homogeneous households with utility

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(c_{j,t} - z_{j,t} \frac{l_{j,t}^{1+\frac{1}{\nu}}}{1+\frac{1}{\nu}} \right),$$

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

The assumption that households have linear utility in consumption simplifies the characterization of the equilibrium, allowing for some analytical results, without affecting the key properties of the model. The dependence of the dis-utility from country-specific productivity $z_{j,t}$ guarantees balanced growth, and could be justified by the assumption that productivity affects both market and homework productions.

Households hold $h_{j,t}$ units of the non-produced asset which is available in total supply $H_{j,t}$. The asset is rented to domestic entrepreneurs at rate $r_{j,t}$ and can be traded among households at the market price $p_{j,t}$.

We assume that the supply of the non-produced asset grows exogenously at the same rate as the average long-run growth of the economy. Therefore, denoting by g the constant gross growth rate of the economy, the assets evolves over time according to $H_{j,t} = \bar{H} g^t$. This guarantees that in the long-run the model displays balanced growth around the non-stochastic trend. We interpret the asset as residential houses and its production as housing services. An important assumption is that houses are held only by households, not entrepreneurs.

Debt and default. At the end of period $t-1$, households can borrow $d_{j,t}/R_{j,t-1}$ where $R_{j,t-1}$ is the gross interest rate and $d_{j,t}$ is the 'promised'

repayment at time t. At the beginning of time t, however, when the debt $d_{j,t}$ is due, households could default. In the event of default creditors have the right to liquidate the $h_{j,t}$ units of houses owned by a defaulting household. However, the liquidation value at the beginning of period t, when the repayment is due, could be smaller than the loan.

Denote by $\tilde{p}_{j,t}$ the liquidation price at the beginning of period t. The condition that the loan exceeds the liquidation value of the owned house is $\tilde{p}_{j,t}h_{j,t} \leq d_{j,t}$. This could happen because the economy ends up in a state in which the housing market freezes and the liquidation price drops. The mechanism that generates a housing market freeze at the beginning of the period will be described in the next subsection. For the moment we should think of the liquidation price $\tilde{p}_t$ as a stochastic variable with probability distribution $f_{j,t}(\tilde{p}_{j,t})$. The probability distribution is endogenous in the model and will be determined in the general equilibrium.

It is important to point out that the liquidation price $\tilde{p}_t$ is formed at the beginning of the period and could differ from the market price at the end of the period which we denote by p_t. This will become clear in the next subsection.

Once the value of $\tilde{p}_{j,t}$ becomes known at the beginning of period t, households could use the threat of default to renegotiate the outstanding debt $d_{j,t}$. Of course, renegotiation takes place only if the debt is bigger than the liquidation value of the collateral, that is, $d_{j,t} > \tilde{p}_t h_{j,t}$. Under the assumption that borrowers have the whole bargaining power, the debt will be renegotiated to the liquidation value. Thus, the post-renegotiation debt is

$$\tilde{d}(d_{j,t}, \tilde{p}_{j,t}h_{j,t}) = \min \left\{ d_{j,t} \ , \ \tilde{p}_t h_{j,t} \right\} \tag{4}$$

Renegotiation carries a cost that is increasing and convex in the magnitude of the renegotiation, that is, the difference between the nominal value of the debt and its repayment. Specifically, it takes the form,

$$\varphi \left(d_{j,t}, \tilde{p}_{j,t}h_{j,t} \right) = \eta \left(\frac{d_{j,t} - \tilde{d}(d_{j,t}, \tilde{p}_{j,t}h_{j,t})}{d_{j,t}} \right)^2 d_{j,t}. \tag{5}$$

The cost is zero in absence of renegotiation, that is, the debt is fully repaid, $\tilde{d}(d_{j,t}, \tilde{p}_{j,t}h_{j,t}) = d_t$. It becomes positive if the borrower renegotiates the debt and repays less than the nominal value, that is, $\tilde{d}(d_{j,t}, \tilde{p}_{j,t}h_{j,t}) < d_{j,t}$.

After renegotiation the housing market returns to normal at the end of the period and the equilibrium price p_t could differ from the liquidation price $\tilde{p}_t$. Subsection 2.3 provides the micro-foundation for this particular structure.

The assumption of an immediate fresh-start is a simplification that makes the model tractable. Under this assumption, the households' budget constraint, after renegotiation, is

$$\tilde{d}(d_{j,t}, \tilde{p}_{j,t}h_{j,t}) + \varphi(d_{j,t}, \tilde{p}_{j,t}h_{j,t}) + p_{j,t}h_{j,t+1} + c_{j,t} = \\ w_{j,t}l_{j,t} + r_{j,t}h_{j,t} + p_{j,t}h_{j,t}g + \frac{d_{j,t+1}}{R_{j,t}}.$$

The term g is the growth rate in non-produced assets (houses) which corresponds to the long-run growth of productivity.

The gross interest rate $R_{j,t}$ paid by a household depends on the borrowing decision. If the household borrows more, relatively to the ownership of the house, the expected repayment rate could be lower in the next period. This will be reflected in a higher interest rate on the loan.

Denote by $\overline{R}_{j,t}$ the expected gross return from holding the debt issued in period t by all households in country j, which is due at $t+1$. This is the expected market return. Since households are atomistic and financial markets are competitive, the expected return on the debt issued by an 'individual' household must be equal to the aggregate expected return $\overline{R}_{j,t}$. Thus, the interest rate on the debt issued by an individual household satisfies

$$\frac{d_{j,t+1}}{R_{j,t}} = \frac{1}{\overline{R}_{j,t}} \mathbb{E}_t \tilde{d}(d_{j,t+1}, \tilde{p}_{j,t+1}h_{j,t+1}). \tag{6}$$

The left-hand-side is the amount borrowed in period t while the right-hand-side is the expected repayment in period $t+1$, discounted by the market return $\overline{R}_{j,t}$. Since the household renegotiates the debt if $d_{j,t+1} > \tilde{p}_{j,t+1}h_{j,t+1}$, the actual repayment $\tilde{d}(d_{j,t+1}, \tilde{p}_{j,t+1}h_{j,t+1})$ could differ from $d_{j,t+1}$. Competition in financial intermediation requires that the left-hand-side of (6) is equal to the right-hand-side.

Equation (6) is the condition that determines the interest rate $R_{j,t}$ for an individual household. In equilibrium all households will make the same decisions and they all borrow at the same rate. However, in order to characterize the optimal decision, we need to allow an individual household to deviate from other households, which causes a deviation of the individual borrowing rate as determined by equation (6).

First order conditions. As for entrepreneurs, households' decisions are made sequentially. At the beginning of the period (Subperiod 1) households decide whether to default and ask for the renegotiation of the debt. After that (Subperiod 2), they chose the supply of labor. Finally, at the end of the period (Subperiod 3), they choose the new debt. Appendix A describes the households' problem and derives the first order conditions

$$w_{j,t} = z_{j,t} l_{j,t}^{\frac{1}{\nu}}, \tag{7}$$

$$\frac{1}{\bar{R}_{j,t}} = \beta \mathbb{E}_t \left[1 + \Phi \left(\frac{d_{j,t+1}}{\tilde{p}_{j,t+1} h_{j,t+1}} \right) \right], \tag{8}$$

$$p_{j,t} = \beta \mathbb{E}_t \left[r_{j,t+1} + g p_{j,t+1} + \Psi \left(\frac{d_{j,t+1}}{\tilde{p}_{j,t+1} h_{j,t+1}} \right) \right]. \tag{9}$$

The detailed functional forms for the functions $\Phi(.)$ and $\Psi(.)$ are derived in the appendix. They are increasing in the ratio $d_{j,t+1}/\tilde{p}_{j,t+1}h_{j,t+1}$, which is a measure of leverage.

According to equation (8) there is a negative relation between the expected return on household debt (the interest rate) and leverage. Equation (9) establishes a positive relation between leverage and the return from owning houses, which in turn raises its price. The two equations then imply that a decline in the interest rate increases leverage and the price of houses.

2.3 Housing market freeze and liquidation price

The market for liquidated houses is characterized by two assumptions.

Assumption 1 *Houses can be sold to domestic households or entrepreneurs. If sold to entrepreneurs, houses lose their functionality and will be converted to consumption goods at rate* $\kappa_{j,t}$.

This assumption formalizes the idea that houses may lose value when reallocated to owners that do not use them directly, provided that $\kappa_{j,t}$ is sufficiently low. In the model this is obtained by assuming that entrepreneurs convert houses in consumption goods at rate $\kappa_{j,t}$, which we assume to be lower than $p_{j,t}$.

Notice that, in order for houses not to lose their functionality, they need to be purchased by domestic households, not foreign households. With

this assumption a housing market crisis could be local, that is, it could take place in one country without spreading to the other country.

The second assumption that characterizes the liquidation market is:

Assumption 2 *Households can buy liquidated houses only if* $d_{j,t} < \tilde{p}_{j,t} h_{j,t}$.

If a household starts with liabilities that are bigger than the liquidation value of the owned house, that is, $d_{j,t} > \tilde{p}_{j,t} h_{j,t}$, it will be unable to raise additional funds to purchase liquidated houses. Potential investors know that the new liabilities (as well as the outstanding liabilities) are not collateralized and the household would renegotiate immediately after taking the new debt. We refer to a household with $d_{j,t} < \tilde{p}_{j,t} h_{j,t}$ as 'liquid' since it can raise extra funds. A household with $d_{j,t} > \tilde{p}_{j,t} h_{j,t}$, instead, is 'illiquid'.

To better understand Assumptions 1 and 2, consider the condition for not renegotiating, $d_{j,t} \leq \tilde{p}_{j,t} h_{j,t}$. Furthermore, assume that $p_{j,t} > \kappa_{j,t}$, that is, the price at the end of the period is bigger than the liquidation price when the market freezes. If this condition is satisfied, households have the ability to raise funds to purchase other houses. This insures that the liquidation price is $\tilde{p}_{j,t} = p_{j,t}$, that is, the end-of-period price. However, if $d_{j,t} > \kappa_{j,t} h_{j,t}$ for all households, there will be no household capable of buying liquidated houses. As a result, liquidated houses can only be sold to entrepreneurs at price $\tilde{p}_{j,t} = \kappa_{j,t}$.

This shows that the market price for liquidated houses depends on the financial decision of households, which in turn depends on the liquidation price of houses. This interdependence could create the conditions for multiple self-fulfilling equilibria.

Proposition 2.1 *There exists multiple equilibria only if* $d_{j,t} > \kappa_{j,t} h_{j,t}$.

Proof 2.1 *See appendix E.*

When multiple equilibria are possible, the equilibrium is selected with the random draw of sunspot shocks.

Let $\varepsilon_{j,t}$ be a variable that takes the value of 0 with probability λ and 1 with probability $1 - \lambda$. If the condition for multiplicity is satisfied, agents coordinate their expectations on the low liquidation price $\kappa_{j,t}$ when $\varepsilon_{j,t} = 0$. Thus, the probability distribution of the low liquidation price is

$$f_{j,t}\left(\tilde{p}_{j,t} = \kappa_{j,t}\right) = \begin{cases} 0, & \text{if} \quad d_{j,t} \leq \kappa_{j,t} h_{j,t} \\ \\ \lambda, & \text{if} \quad d_{j,t} > \kappa_{j,t} h_{j,t} \end{cases}$$

The ratio $d_{j,t}/\kappa_{j,t}h_{j,t}$ is a measure of leverage. If leverage is sufficiently small, households remain liquid even if the (expected) liquidation price is $\kappa_{j,t}$. But then the liquidation price cannot be low and the realization of the sunspot shock is irrelevant for the equilibrium. Instead, when leverage is high, households' liquidity depends on the liquidation price. The realization of the sunspot shock $\varepsilon_{j,t}$ then becomes important for selecting one of the two equilibria. When $\varepsilon_{j,t} = 0$—which happens with probability λ—the market expects that the liquidation price is $\kappa_{j,t}$, making the household's sector illiquid. On the other hand, when $\varepsilon_{j,t} = 1$—which happens with probability $1 - \lambda$—the market expects that households participate in the liquidation market, validating the expectation of a higher liquidation price.[4]

Notice that the argument is based on the assumption that $\kappa_{j,t}$ is sufficiently low (implying a sufficiently low liquidation price if the housing market freezes). Also, the equilibrium value of houses without a freeze, $p_{j,t}h_{j,t}$, is always bigger than the debt $d_{j,t}$. Otherwise, households would be illiquid with probability 1 and the equilibrium price is always $\kappa_{j,t}$. Condition (6) guarantees that this does not happen in equilibrium: if the probability of default is 1, the anticipation of the renegotiation cost will increase the interest rate, which deters households from borrowing too much.

2.4 General equilibrium

Using capital letters to denote aggregate variables, the aggregate states are given by bonds held by entrepreneurs, $B_{11,t}$, $B_{21,t}$, $B_{12,t}$, $B_{22,t}$, and sunspot shocks $\varepsilon_{1,t}$ and $\varepsilon_{2,t}$. The aggregate debts issued by households in the previous period are $D_{1,t} = B_{11,t} + B_{12,t}$ and $D_{2,t} = B_{21,t} + B_{22,t}$. In addition, we also have productivity $z_{1,t}$ and $z_{2,t}$, and financial variables $\phi_{1,t}, \phi_{2,t}, \kappa_{1,t}, \kappa_{2,t}$. Even if the changes in these variables are deterministic and perfectly anticipated, they are part of the state space. To use a compact notation we denote the state vector by

$$\mathbf{s}_t \equiv (z_{1,t}, z_{2,t}, \phi_{1,t}, \phi_{2,t}, \kappa_{1,t}, \kappa_{2,t}, B_{11,t}, B_{21,t}, B_{12,t}, B_{22,t}, \varepsilon_{1,t}, \varepsilon_{2,t}).$$

[4]The assumption that houses lose their functionality if sold to foreign households allows the model to generate equilibria in which default happens only in one country. If houses could maintain their functionality when sold to foreign households, default in one country could arise only if the other country also defaults. Even if default takes place only in one country, it will have a real economic impact also in the other country due to portfolio diversification.

The equilibrium is determined sequentially in the three subperiods as shown in Figure 2.

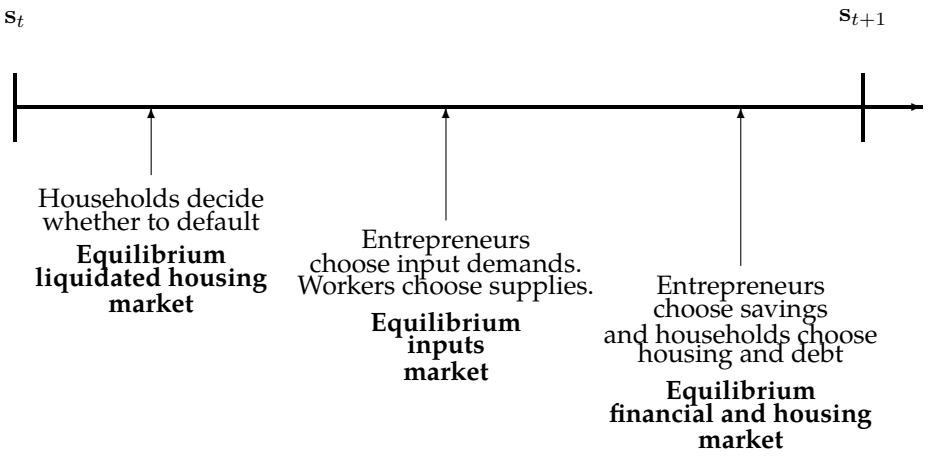


Figure 2: Timing within period t.

1. **Subperiod 1**: Given the sunspot shock $\varepsilon_{j,t}$ in country j, agents form (self-fulfilling) expectations about the liquidation price $\tilde{p}_{j,t}$. Given the liquidation price, households choose whether to default. The renegotiated debt is

$$\tilde{D}_{j,t} = \begin{cases} \kappa_{j,t} H_{j,t}, & \text{if} \quad D_{j,t} \geq \kappa_{j,t} H_{j,t} \text{ and } \varepsilon_{j,t} = 0 \\ D_{j,t}, & \text{otherwise} \end{cases}.$$

   The post-default wealth held by entrepreneurs in each country is proportional to their holdings prior to default, that is,

$$M_{j,t} = \left(\frac{\tilde{D}_{1,t}}{D_{1,t}}\right) B_{1j,t} + \left(\frac{\tilde{D}_{2,t}}{D_{2,t}}\right) B_{2j,t}$$

2. **Subperiod 2**: Given the post-default wealth $M_{j,t}$, entrepreneurs in country j choose the inputs of labor and housing, and households

choose the supplies. The aggregate input demands in country j are obtained from the individual demands derived in Lemma 2.1,

$$\begin{aligned} L_{j,t} &= z_{j,t}^{\frac{\gamma}{\alpha}} \left(\frac{\gamma}{w_{j,t}}\right)^{\frac{\alpha+\gamma}{\alpha}} \left(\frac{1-\alpha-\gamma}{r_{j,t}}\right)^{\frac{1-\alpha-\gamma}{\alpha}} M_{j,t}, \\ H_{j,t} &= z_{j,t}^{\frac{\gamma}{\alpha}} \left(\frac{\gamma}{w_{j,t}}\right)^{\frac{\gamma}{\alpha}} \left(\frac{1-\alpha-\gamma}{r_{j,t}}\right)^{\frac{1-\gamma}{\alpha}} M_{j,t}. \end{aligned}$$

The aggregate supply of labor is derived from the household's first order condition (7). Imposing $l_{j,t} = L_{j,t}$ and inverting we obtain

$$L_{j,t} = \left(\frac{w_{j,t}}{z_{j,t}}\right)^{\nu}.$$

The supply of housing is exogenous and equal to $H_{j,t} = \bar{H} g^t$. Market clearing will then determine the wage rate $w_{j,t}$, the rental rate $r_{j,t}$, and employment $L_{j,t}$ in each country.

3. **Subperiod 3**: The end-of-period wealth of entrepreneurs is

$$A_{j,t} = (1-\phi_j) M_{j,t} + z_{j,t}^{\gamma} M_{j,t}^{\alpha} L_{j,t}^{\gamma} H_{j,t}^{1-\alpha-\gamma} - w_{j,t} L_{j,t} - r_{j,t} H_{j,t}.$$

A fraction $1-\beta$ will be consumed while the remaining fraction β will be saved in new bonds, $q_{1,j} B_{1j,t+1}$ and $q_{2,j} B_{2j,t+1}$. Households choose new debt $D_{j,t+1}$ and new holding of houses $H_{j,t+1}$.

Market clearing in financial assets requires

$$B_{11,t+1} + B_{12,t+1} = D_{1,t+1}, \tag{10}$$

$$B_{21,t+1} + B_{22,t+1} = D_{2,t+1}. \tag{11}$$

Because of capital mobility and cross-country heterogeneity, the net foreign asset positions of the two countries could be different from zero, that is, $B_{1j,t+1} + B_{2j,t+1} \neq D_{j,t+1}$. Competition also implies that the price paid by entrepreneurs to purchase households' debt is consistent with the interest rate, that is,

$$q_{j,t} = \frac{1}{R_{j,t}}.$$

Since $\overline{R}_{j,t} = R_{j,t}\mathbb{E}_{t+1}\delta_{j,t+1}$, the above condition relates the price $q_{j,t}$ to the average return of the debt.

Using the optimal savings of entrepreneurs derived in Lemma 2.1 and aggregating, we obtain the demand for bonds in country j,

$$q_{1,j}B_{1j,t+1} + q_{2,j}B_{2j,t+1} = \beta A_{j,t}. \tag{12}$$

The supply of bonds is derived from the borrowing decisions of households. From the first order condition (8) we have

$$\frac{1}{\overline{R}_{j,t}} = \beta\left[1 + \Phi\left(\frac{D_{j,t+1}}{\kappa_{j,t+1}H_{j,t+1}}\right)\right].$$

Because in equilibrium $\overline{R}_{j,t} = R_{j,t}\mathbb{E}\delta_{j,t+1}$ and $q_{j,t} = 1/R_{j,t}$, the first order condition can be rewritten as

$$q_{j,t} = \beta\left[1 + \Phi\left(\frac{D_{j,t+1}}{\kappa_{j,t+1}H_{j,t+1}}\right)\right]\mathbb{E}\delta_{j,t+1}. \tag{13}$$

The market for housing must also clear, that is, the demand $H_{j,t+1}$ must be equal to the exogenous supply $\bar{H}g^t$. The first order condition (8) will then determine the (end-of-period) price p_t. Since this equation depends on future prices, we cannot derive a closed form expression for the housing price. We will compute it numerically in the quantitative analysis.

Proposition 2.2 *Suppose that $z_{j,t}, \phi_{t,t}, \kappa_{j,t}$ are constant and the debt is always repaid, that is, $\delta_{j,t} = 1$. The economy converges to a steady state with constant growth rate g. The steady state equilibrium is characterized by $q > 1/R = \beta$ and households borrow from entrepreneurs.*

Proof 2.2 *See Appendix B*

The reason entrepreneurs are willing to hold households' debt even if the effective price is higher than β (or equivalently, the interest rate is lower than the inter-temporal discount rate) is because bonds enter into the production function. Therefore, in addition to the interest rate, they generate a profit.

When $z_{j,t}, \phi_{t,t}, \kappa_{j,t}$ are time-varying and households can default, the economy does not reach a steady state but displays dynamics that could be stochastic due to the sunspot shocks. In particular, sunspot shocks can lead to a financial crisis with default where households' debt is repaid only partially. This redistributes wealth from lenders (entrepreneurs) to borrowers (households), reducing entrepreneurial wealth. When entrepreneurs hold less wealth $M_{j,t}$, they demand less labor and in equilibrium there will be lower employment and production. This is the main mechanism through which financial crises have real macroeconomic consequences. A lower value of $M_{j,t}$ also decreases the demand for housing which lower the rental rate $r_{j,t}$. The lower return on housing then reduces its price p_t. Therefore, a financial crises also impacts negatively on housing prices.

2.5 Discussion and remarks

Before proceeding, it would be helpful to clarify the importance of some modeling assumptions and the associated properties.

The equilibrium is characterized by producers that are net savers and households that are net borrowers. This equilibrium structure differs from other models proposed in the literature where, typically, producers are net borrowers. Although having producers with positive net financial wealth might 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, the corporate sector has increased their holdings of financial assets. This suggests that the proportion of financially dependent firms has declined significantly over time. This is consistent with the empirical findings of Shourideh and Zetlin-Jones (2012) and Eisfeldt and Muir (2016).

The large accumulation of financial assets by firms (often referred to 'cash') is related to the significance of business savings. Busso et al. (2016) document the share of savings done by firms both in advanced and emerging countries and present evidence that in Latin America this share is even larger than in industrialized economies. The importance of business savings is also documented in Bebczuk and Cavallo (2016). Using data for 47 countries over 1995–2013 they show that the contribution of businesses to national savings is on average more than 50%. The model developed here captures the growing importance of firms that are not very dependent on external financing.

The second remark is that the equilibrium property for which firms are net lenders does not rely on the assumption that households are risk neutral. What is crucial for the model to generate this property is that bonds are valuable for entrepreneurs beyond the earned interests, that is, the overall return they get from bonds is greater than the interest rate. For households, instead, bonds are valuable only because they pay interests. With risk averse households, bonds could also provide an insurance benefit. However, as long as the extra return that entrepreneurs received from holding bonds is sufficiently large, they would continue to be net lenders while households will continue to be net borrowers.

3 Quantitative analysis

In this section we calibrate the model to assess quantitatively how financial and macroeconomic stability has been affected by the unprecedented growth of emerging countries and the changes in financial structure experienced by both emerging and industrialized countries. The calibration uses data for the period 1991-2020 under the assumption that country 1 is representative of industrialized economies and country 2 is representative of emerging economies. Starting in 1991, we simulate the model until 2020. The list of countries included in the emerging and industrialized regions is provided in Figure 1.

3.1 Calibration

The model is calibrated annually and the discount factor is set to $\beta = 0.95$, implying an annual intertemporal discount rate of about 5%. The probability of a negative sunspot shock, $\varepsilon = 0$, is set to $\lambda = 0.02$. Thus, provided that leverage is sufficiently high, crises are very low probability events. On average, once every fifty years. Similar numbers have been used in the literature (see, for example, Bianchi and Mendoza (2018)). Also notice that a global crisis in which all countries experience the crisis is an extremely rare event that happens with probability $0.02 \times 0.02 = 0.0004$.

Differences in size and financial structure between the two regions and their changes over time are generated by the deterministic sequences of $z_{j,t}$, $\phi_{j,t}$, and $\kappa_{j,t}$, with $j \in \{1, 2\}$. We construct these sequences to replicate the empirical time series we showed in Figure 1 over the period 1991-2020.

The sequences of $z_{j,t}$, $\phi_{j,t}$, and $\kappa_{j,t}$ needed to replicate the data depend on the realizations of the sunspot shocks over this period. For the purpose of calibration, we select a particular sequence of these shocks and determine $z_{j,t}$, $\phi_{j,t}$, $\kappa_{j,t}$ conditional on the selected sequence. More specifically, we assume that ε_{jt} takes the value of 1 in all simulation years with only few exceptions. For emerging countries it takes the value of zero in 1997 and 2009. These two dates correspond, respectively, to the 1997 Asian crisis and the 2008 financial crisis which extended to 2009. Both crises had an impact on emerging countries. For industrialized countries it takes the value of zero only in 2009 reflecting, again, the 2008 financial crisis. It is important to point out that, even if we calibrate the model assuming a specific sequence of sunspot shocks, agents do not anticipate them and, therefore, they make decisions based on the random distribution of these shocks.

The productivity series $z_{1,t}$ and $z_{2,t}$ are constructed as Solow residuals using the production function. This requires measurements of the production inputs and of output. For output we use GDP measured at nominal exchange rates, not PPP. Since movements in nominal exchange rates affect the purchasing power of a country in the acquisition of foreign assets, productivity also reflects exchange rate movements. Another factor that contributes to differences in aggregate GDP is population growth. However, because population is not explicitly formalized in the model, $z_{1,t}$ and $z_{2,t}$ also reflect changes in population.

Denote by $P_{j,t}$ the nominal price index for country j expressed in a common currency. For example, using the US dollar as the common currency denomination, prices in US dollars are calculated by multiplying the price in local currency by the dollar exchange rate. We can then define the 'nominal' aggregate output of country j as

$$P_{j,t}Y_{j,t} \quad = \quad P_{j,t}\hat{z}_{j,t}^{\gamma}M_{j,t}^{\alpha}L_{j,t}^{\gamma}H_{j,t}^{1-\alpha-\gamma}N_{j,t},$$

where $\hat{z}_{j,t}$ is actual productivity, $M_{j,t}$ is per-capita financial assets, $L_{j,t}$ is per-capita employment, $H_{j,t}$ is per-capita houses, $N_{j,t}$ is population. Notice that the above definition of output assumes that the endowment of houses increases with population.

If we deflate the nominal GDP of both countries by the price index in

country 1, we obtain

$$\begin{aligned} Y_{1,t} &= \hat{z}_{1,t}^{\gamma} M_{1,t}^{\alpha} L_{1,t}^{\gamma} H_{1,t}^{1-\alpha-\gamma} N_{1,t}, \\ \frac{P_{2,t} Y_{2,t}}{P_{1,t}} &= \left(\frac{P_{2,t} \hat{z}_{2,t}^{\gamma}}{P_{1,t}} \right) M_{2,t}^{\alpha} L_{2,t}^{\gamma} H_{2,t}^{1-\alpha-\gamma} N_{2,t}, \end{aligned}$$

Aggregate productivity in the model corresponds to

$$\begin{aligned} z_{1,t} &= \hat{z}_{1,t} N_{1,t}^{\frac{1}{\gamma}}, \\ z_{2,t} &= \hat{z}_{2,t} \left(\frac{P_{2,t} N_{2,t}}{P_{1,t}} \right)^{\frac{1}{\gamma}}. \end{aligned}$$

This shows that productivity in the model also reflects cross-country differences in prices and population. The productivity series in the model can then been calculated from the data as

$$z_{1,t} = \left(\frac{Y_{1,t}}{M_{1,t}^{\alpha} L_{1,t}^{\gamma} H_{1,t}^{1-\alpha-\gamma}} \right)^{\frac{1}{\gamma}}, \tag{14}$$

$$z_{2,t} = \left(\frac{P_{2,t} Y_{2,t} / P_{1,t}}{M_{2,t}^{\alpha} L_{2,t}^{\gamma} H_{2,t}^{1-\alpha-\gamma}} \right)^{\frac{1}{\gamma}}. \tag{15}$$

The numerator is total real GDP, deflated by nominal prices in industrialized countries. If prices in emerging countries grow more than prices in industrialized countries, this will be reflected in higher relative productivity in emerging countries. Although this does not increase actual productivity, it raises the ability of emerging countries to purchase assets in industrialized countries, which is important for general equilibrium effects. Also notice that the change in relative prices could simply be the result of movements in nominal exchange rates. Still, when the currencies of emerging countries appreciate, foreign assets become cheaper for these countries.

We will use equations (14) and (15) to construct the sequences of productivity from the data. First we set the income share of labor to $\gamma = 0.6$ and the income share of housing to $1-\alpha-\gamma = 0.12$. This implies that the income share of financial wealth is $\alpha = 0.28$. At this point we need empirical counterparts for $Y_{1,t}$, $P_{2,t}Y_{2,t}/P_{1,t}$, $M_{1,t}$, $M_{2,t}$ $L_{1,t}$, $L_{2,t}$, $H_{1,t}$, and $H_{2,t}$.

The variables $Y_{1,t}$ and $P_{2,t}Y_{2,t}/P_{1,t}$ are obtained by aggregating the GDP of industrialized countries and emerging countries, respectively, both expressed at constant US dollars. To construct $M_{j,t}$ we use domestic credit and net foreign asset positions, both expressed in constant US dollars, divided by population over the age of 15. More specifically, denoting by $D_{j,t}$ domestic credit and $NFA_{j,t}$ the net foreign asset position of country j, the assets used in production are $M_{j,t} = D_{j,t} + NFA_{j,t}$.

For $L_{j,t}$ we use employment-to-population, where population is again over the age of 15. The variable $H_{j,t}$ grows in the model at the constant long-run growth $g-1$. Thus, $H_{j,t} = \bar{H}g^t$. Notice that the stock of per-capita houses grows at the same constant rate in the two regions. We set the long-run growth to the average growth rate of aggregate GDP in industrialized countries which, over the period 1991-2020, is 1.89%. We consider this the long-run growth rate for both industrialized and emerging economies (after convergence). Data is from the World Development Indicators (WDI). The resulting productivity series are plotted in the top panel of Figure 3.

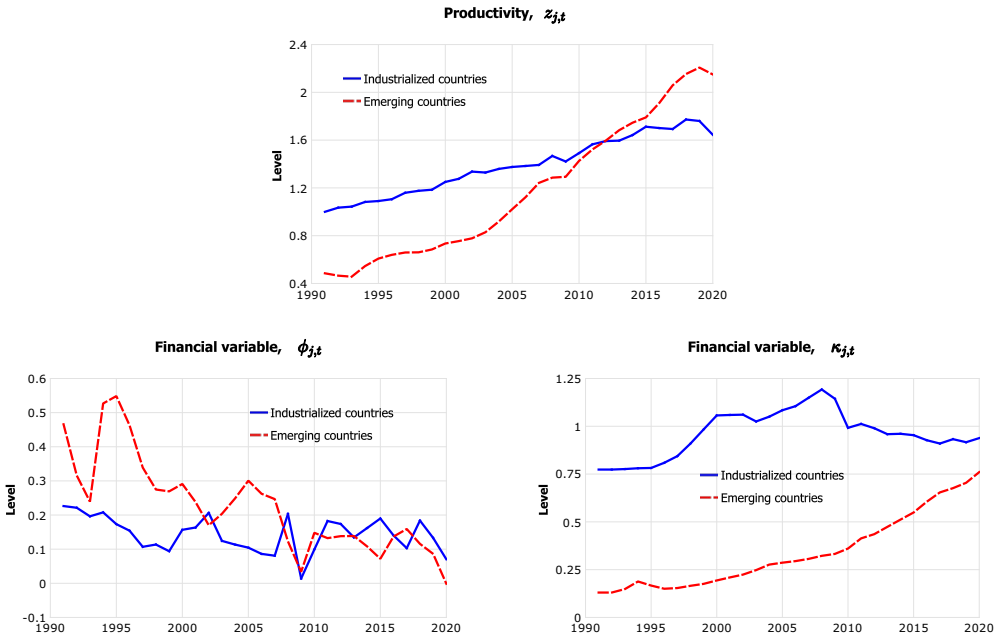


Figure 3: Computed productivity and financial variables series for industrialized and emerging countries, 1990-2020.

As expected, the productivity measure has increased faster for emerging countries. The fact that the measured productivity of emerging countries is now higher than the measured productivity of industrialized countries does not mean that they use a more efficient technology. Remember that $z_{j,t}$ also reflects the population size, which is much bigger for emerging countries.

The next step is to derive the sequence of $\phi_{j,t}$ and $\kappa_{j,t}$. The first variable, $\phi_{j,t}$, determines the 'demand' for financial assets (in the spirit of Mendoza et al. (2009)): Lower values of $\phi_{j,t}$ increase the demand for financial assets since their use in production is less costly. The parameter $\kappa_{j,t}$, instead, determines the 'supply' of financial assets (in the spirit of Caballero et al. (2008)): Higher values of $\kappa_{j,t}$ increase the households' incentive to borrow. We construct the sequences of $\phi_{1,t}$, $\phi_{2,t}$, $\kappa_{1,t}$ and $\kappa_{2,t}$ so that the model replicates four empirical series over the period 1991-2020: (i) domestic credit-to-GDP ratio in industrialized countries, (ii) domestic credit-to-GDP ratio in emerging countries, (iii) net foreign asset position of industrialized countries, (iv) US risk-free real interest rate. These empirical series are shown in the last three panels of Figure 1). The computed series are plotted in the bottom panels of Figure 3.

The first panel shows that the variable ϕ does not display any significant trend for industrialized countries while it has visibly trended downward for emerging countries. Recall that a reduction in the value of ϕ increases the demand for financial assets. Therefore, the computed series show that the real growth in emerging countries has been accompanied to a structural change that increased the demand for financial assets.

The second panel shows that the variable κ has increased for both industrialized and emerging countries. Since a higher value of κ increases the supply of assets, the computed series indicate that financial constraints have been relaxed in both regions.

3.2 Productivity growth versus structural financial changes

The use of the structural model allowed us to construct series for productivity, $z_{j,t}$, and variables that characterize the structure of the financial sectors, $\phi_{j,t}$ and $\kappa_{j,t}$ (see Figure 3). We can now explore how these two factors contributed to the real an financial dynamics. We do so by simulating the model over the sample period 1991-2020 by allowing the changes in only one factor while keeping the other fixed.

We start with productivity where emerging countries experienced much higher growth than industrialized counties. We impose that $\phi_{j,t}$ and $\kappa_{j,t}$ remain constant at the 1991 values for the whole period 1991-2020. We then simulate the model with the values of $z_{j,t}$ constructed in the calibration section. The simulated series are shown in Figure 4.

The first four panels plots domestic credit in both regions, the net foreign asset position of industrialized countries, and the real interest rate. The continuous line is the original data shown in Figure 1. This is also the series generated by the baseline model with productivity and financial variables taking the values plotted in Figure 3. The dashed line is the model generated data when only productivity changes. The dotted line also plots the data generated by the model when only productivity changes. However, we make the counterfactual assumption that productivity in emerging economies grows at the same rate as in industrialized countries. The comparison of the dashed and dotted lines illustrate the importance of the faster growth experienced by emerging countries.

The higher growth of emerging countries accounts for most of the imbalance (the dynamics of the net foreign asset position) and almost half of the decline in the real interest rate. The spike in the interest rate in 2009 is caused by the financial crisis. The growing size of emerging countries also generates an increase in the domestic credit of industrialized countries in percentage of GDP while it declines in emerging countries. However, the decline in emerging countries is due to the fact that GDP (the denominator) grows faster than credit (the numerator). In absolute terms, domestic credit increases also in industrialized countries.

The last two panels show what we define 'effective leverage'. This is the ratio between the debt, $d_{j,t+1}$, and the recovery value of the debt in the eventuality of a crisis, $\kappa_{j,t+1}$. Besides the temporary drop in leverage after the financial crisis, the model generates an increasing trend in effective leverage in response to the change in productivity (dashed line). This is directly related to the change in the interest rate: a lower interest rate is always associated with a higher effective leverage. Remember that the interest rate satisfies condition (8).

We will see later that the increase in effective leverage is key for understanding the change in aggregate volatility. However, the upward trend would not arise if emerging countries grew at the same (and lower) rate experienced by industrialized countries (dotted line).

The main take out from the counterfactual exercise shown in Figure 4 is

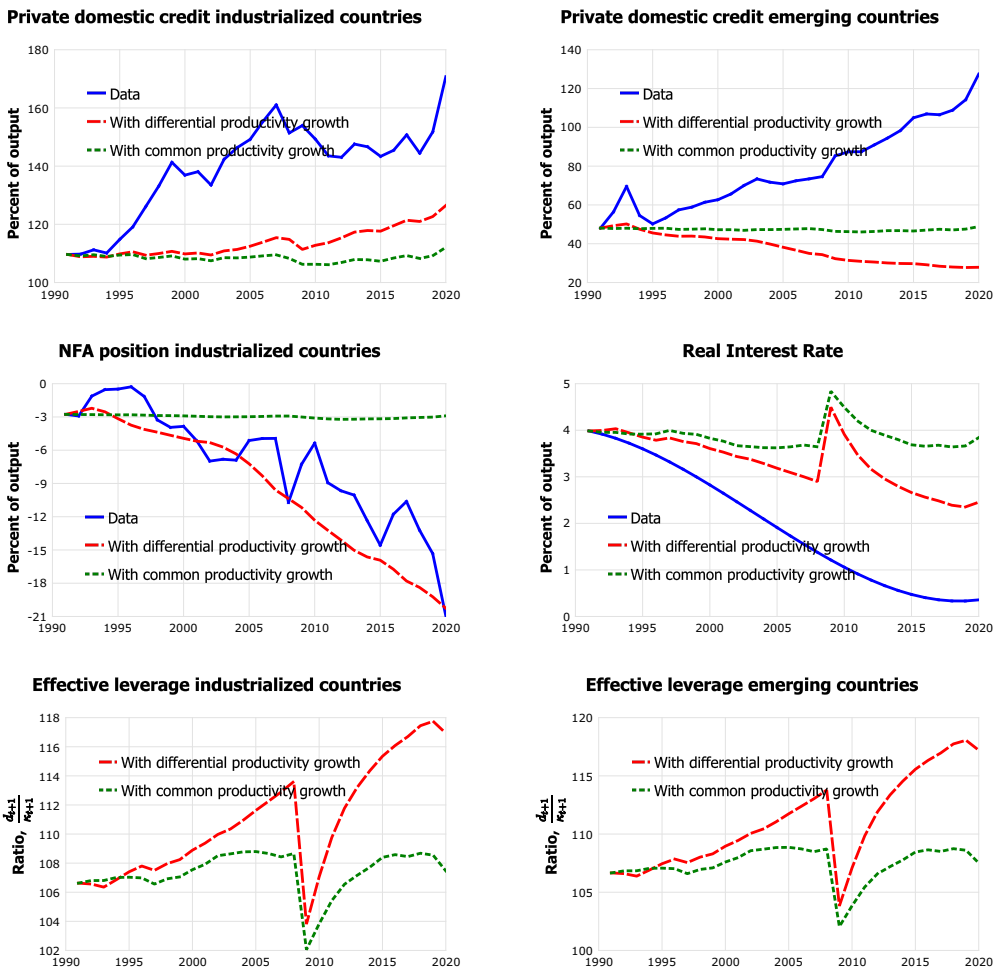


Figure 4: Computed productivity series for industrialized and emerging countries, 1990-2020.

that the faster growth of emerging countries has been an important force for the global imbalance and the declining worldwide interest rate. The mechanism that leads to this result is that faster growth generates profits that increase entrepreneurial wealth and, therefore, the demand for financial assets. But when $\kappa_{j,t}$ does not change, the supply of assets remains the same. To clear the market, then, the interest rate has to decline. The faster growth of entrepreneurial wealth in emerging economies also implies that part of that wealth is invested abroad, which explains the imbalance.

We now repeat a similar exercise to explore the importance of the changes in financial structure. We fix the productivities of the two countries and then explore the implications of the changes in financial variables $\phi_{j,t}$ and $\kappa_{j,t}$. More specifically, we assume that, starting from the 1991 values, $z_{1,t}$ and $z_{2,t}$ both grow at the long-run rate $g - 1 = 0.0189$. Remember that this is the average GDP growth of industrialized countries over the sample period 1991-2020. The simulated variables are plotted in Figure 5).

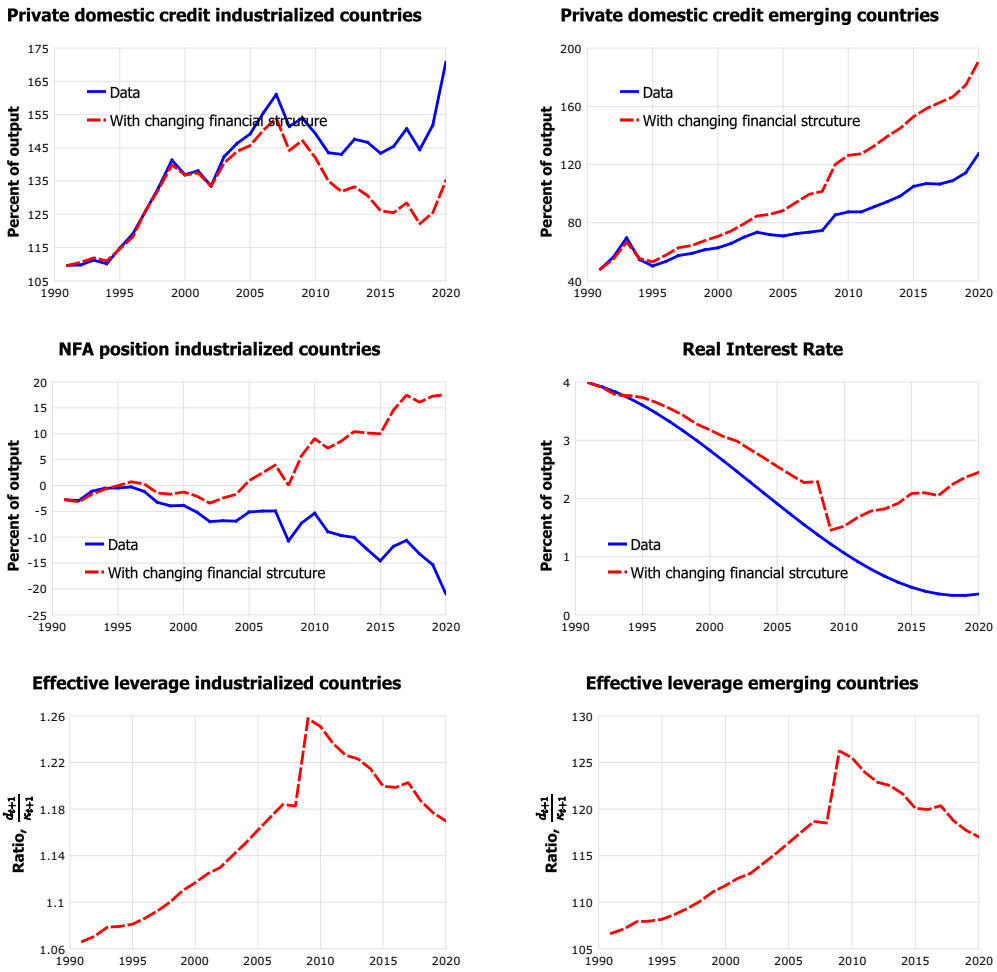


Figure 5: Computed productivity series for industrialized and emerging countries, 1990-2020.

The changes in financial structure driven by $\phi_{j,t}$ and $\kappa_{j,t}$ are important

for capturing the growing size of financial intermediation (higher credit-to-GDP ratios). It is also important for generating a large decline in the real interest rate. However, they do not explain the observed imbalance. In fact, in absence of productivity growth (beyond the common long-term growth), industrialized countries would have accumulated positive net foreign asset positions.

The last two panels plot the effective leverage. Again, this is the ratio between the debt, $d_{j,t+1}$, and the recovery value $\kappa_{j,t+1}$ of the debt. Also the change in the financial structure leads to an increase in effective leverage. As observed earlier, effective leverage is directly related to the interest rate: a lower interest rate is always associated to higher effective leverage (see condition (8)). This is important for understanding the impact on aggregate volatility.

3.3 Macroeconomic volatility

We now explore how the faster growth of emerging countries and the changes in the financial structure in both regions impacted on macroeconomic and financial volatility.

To compute measures of volatility, we simulate the model for 130 years using a random sequence of draws of the sunspot shocks: $\varepsilon_{j,t} = 0$ with probability $\lambda = 0.02$ and $\varepsilon_{j,t} = 1$ with probability $1 - \lambda = 0.98$. We then repeat the simulation (over 130 years) 10,000 times, each time with a new random draw of shocks.

The first 100 periods of each simulation are used to derive the invariant distribution when both countries grow at the same long-run rate and the financial structure does not change. The common long-run growth is the average growth rate of GDP for industrialized countries over the period 1991-2020. During the first 100 periods, the variables $\phi_{j,t}$ and $\kappa_{j,t}$ remain constant at their 1991 values. The remaining 30 periods of simulation correspond to 1991-2020 with the variables $z_{j,t}$, $\phi_{j,t}$ and $\kappa_{j,t}$ taking the values shown in Figure 3.

The first two columns of Figure 6 plot the mean and volatility of aggregate output computed over the 10,000 repeated simulations. By repeating the simulation, we obtain 10,000 data points for every year. The mean in year t is the average of the 10,000 points for the particular year t. More specifically, denoting by $x_{i,t}$ the value of output generated by the model in

year t by simulation i, the mean is computed as

$$\bar{x}_t = \frac{1}{10,000} \sum_{i=1}^{10,000} x_{i,t}.$$

The volatility is computed as the difference between the 5th and 95th percentile of the 10,000 points generated by the repeated simulation in year t, as a percentage of the mean for the same year. More specifically, denoting by $p_t(5)$ the threshold for the 5th percentile of the 10,000 points in year t and $p_t(95)$ the threshold for the 95th percentile, the output volatility at time t is computed as

$$Vol_t = \left(\frac{p_t(95) - p_t(5)}{\bar{x}_t} \right) \times 100.$$

The top panels are for the baseline model where both productivity and financial structure change over time (as shown in Figure 3). Both regions experience an increase in volatility. The last panel plots the average value of the effective leverage and shows that the increase in volatility is directly related to the increase in average leverage. The next panels illustrates the factors that contributed to the growth in volatility.

The graphs in the middle rows show the importance of faster productivity growth in emerging countries. The growth in productivity, keeping $\phi_{j,t}$ and $\kappa_{j,t}$ unchanged, contributed about 40 percent to the increase in volatility. It is important to emphasize that the increase in volatility would not arise if emerging countries experienced the same productivity growth as industrialized countries. This is shown in the third row of the figure which is constructed under the counterfactual assumption that emerging countries experience the same productivity growth as industrialized countries, which is significantly lower. In this case volatility does not change significantly over the simulated period. This is again related to the fact that the effective leverage remains almost unchanged (see the panel in the third column). Therefore, the faster growth of emerging countries contributed in an important way to higher volatility.

The last row of Figure 6 is based on the counterfactual simulation in which productivities in both regions grow at the long-run rate of $g - 1 = 0.0189$. What change are the variables $\phi_{j,t}$ and $\kappa_{j,t}$. We interpret this as reflecting structural changes in the financial sector. As can be seen, these changes contributed about 60 percent to the increase in volatility. Also in

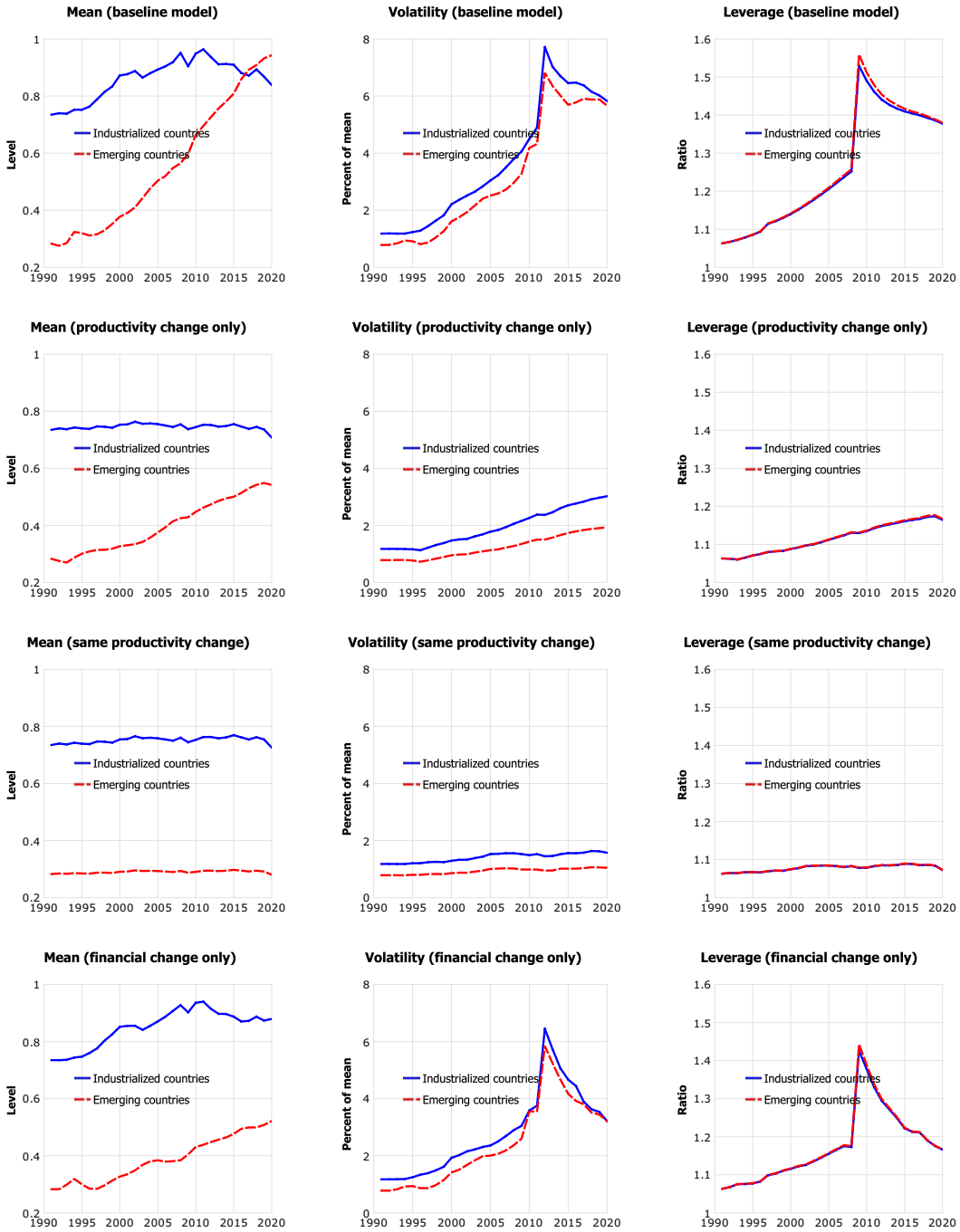


Figure 6: Simulated mean and volatility of output over the period 1991-2020. The mean is the average in every year over the 10,000 repeated simulation. The volatility is the difference between the 5th and 95th percentile as a percentage of the mean.

this case we can see from the last panel that the increase in volatility is related to the increase in effective leverage. Essentially, the structural changes led to a worldwide increase in net demand for financial assets. This led to a decline in interest rate which in turn increase effective leverage.

Notice that the changes in financial structure affected not only volatility but also the level of output. As can be seen, the output mean for industrial countries did not change significantly in absence of the changes in financial structure, while the growth of emerging countries is significantly smaller. This is because the expansion of the financial sector allowed by the changes in $\phi_{j,t}$ and $\kappa_{j,t}$ created more financial assets that in the model enter the production function and increase output.

4 Discussion and conclusion

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

There are many channels through which emerging countries could affect the industrialized world. In this paper we emphasized one of these channels: the increased demand for financial assets traded in globalized capital markets. In particular, we have shown that the worldwide increase in the demand for financial assets raises the incentives to leverage. On the one hand, this allows for the expansion of the financial sector with positive effects on real macroeconomic activity. On the other, it increases the fragility of the financial system, raising the probability and/or the consequences of a crisis.

An important feature of the model is that the expansion of the financial structure improves allocation efficiency. However, the creation of more financial assets is often associated with higher leverage, making the financial system more vulnerable to crises. From a policy perspective there is a trade-off: the benefit of an expanded financial system versus the potential cost of deeper crises. A similar mechanism also arises in models with asset price bubbles and borrowing constraints as in Miao and Wang (2011).

Appendix

A First order conditions for households

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

$$\begin{aligned} W_t(l_t, k_t) &= \max_{h_t} \mathbb{E}_t \tilde{W}_t(a_t) \\ &\quad \text{subject to} \\ &\quad a_t = w_t h_t + (A_t + p_t)k_t - l_t \end{aligned}$$

$$\begin{aligned} \tilde{W}_t(a_t) &= \max_{l_{t+1}, k_{t+1}} \left\{ c_t - \alpha z_t \frac{h_t^{1+\frac{1}{\nu}}}{1+\frac{1}{\nu}} + \beta \mathbb{E}_t W_{t+1}(l_{t+1}, k_{t+1}) \right\} \\ &\quad \text{subject to} \\ &\quad c_t = a_t + \frac{l_{t+1}}{R_t} - k_{t+1} p_t \\ &\quad l_{t+1} \geq \eta A_t. \end{aligned}$$

Also for households, the optimization problem has been separated before the realization of the aggregate productivity (when labor supply is decided) and after (when consumption, housing and borrowing are decided).

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,

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

The envelope conditions are

$$\begin{aligned} \frac{\partial W_t(l_t, k_t)}{\partial l_t} &= -1, \\ \frac{\partial W_t(l_t, k_t)}{\partial k_t} &= A_t + p_t. \end{aligned}$$

Updating by one period and substituting in the first order conditions we obtain (7), (8), (9). 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

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

Substituting the envelope condition we obtain (**??**).

B Proof of Proposition 2.2

To be written.

C First order conditions for problem (??)

To be written.

D Proof of Lemma ??

To be written.

E Proof of Proposition 2.1

To be written.

F Numerical solution

To be written.

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