Global Banks and Systemic Debt Crises*

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Abstract. This paper studies the role of financial intermediaries in the global market of risky external debt. We first provide empirical evidence measuring the effect of global banks' net worth on bond prices of emerging-market economies. We exploit within-borrower bond variation and show that, around the collapse of Lehman Brothers, bonds held by more distressed global banks saw larger price contractions. We then construct a model of global banks' lending to emerging economies and quantify their role using our empirical estimates and other key data. In the model, banks' net worths affect bond prices by the combination of a form of market segmentation and banks' financial frictions. We show that these banks' exposure to emerging economies is the key to determine their role in propagating shocks. With the current observed exposure, global banks generally play an important role transmitting shocks originating in developed economies, accounting for the bulk of the variation of spreads in emerging economies during the recent global financial crisis. Global banks help explain key patterns of debt prices observed in the data, and the evolution of their exposure over the last decades can explain the changing nature of systemic debt crises in emerging economies.

Keywords: Financial intermediaries, external debt, debt crises, world economy

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1. Introduction

Debt crises in emerging–market economies are global in nature. They affect multiple economies in a synchronized fashion and compromise the stability of global financial intermediaries. Salient examples of these events include the Latin American debt crises of the 1980s, linked to major U.S. banks; the Russian/East Asian crises in the 1990s, linked to the collapse of the LTCM fund; and the recent global financial crisis, linked to U.S. and European banks, which affected most emerging economies. Based on the recurrent nature of these episodes, a commonly held view in policy circles is that "global banks" (i.e., financial intermediaries operating in the world economy) play an important role in shaping systemic debt crises. However, most academic literature analyses debt crises in isolation (i.e., from the perspective of individual economies), and abstracts from any explicit role of global financial intermediaries.

In this paper, we reassess this long-held view in policy circles by studying the role of global banks in systemic debt crises. We do so by providing new empirical evidence complemented with a framework to study the global nature of these phenomena. Our empirical analysis studies whether well-identified shocks to global banks' net worth affect bond prices in emerging economies. For this, we exploit within-country variation in bond prices during a short window around the Lehman episode and document larger price drops in bonds held by more-affected global banks. We then construct a model of global banks' lending to emerging economies, and quantify their role using our empirical estimates as well as other key data. In the model, the reason banks' net worths affect bond prices is the combination of a form of market segmentation, which prevents the equalization of expected returns across asset classes, and banks' financial frictions, which link the banks' abilities to supply funds to their net worths. We find that these banks' exposure to emerging economies is the key to determine their role in propagating shocks. With the current observed relatively low exposure, global banks play a major role in transmitting shocks originating in developed economies. In fact, we show that the bulk of the variation of spreads in emerging economies during the recent global financial crisis can be explained by negative shocks to risky assets in developed economies that affected global banks' net worths. In addition, we show that global banks help explain key patterns of debt prices, including the large comovement observed within emerging economies and with other risky securities, and that the evolution of banks' exposure over recent decades can explain the changing nature of systemic debt crises in emerging economies.

Our empirical analysis seeks to measure the effect of global banks' net worth on emerging-market bond prices. The main empirical challenge for this task is that changes in global banks'

net worths are linked to other factors driving emerging-market default risk. The key idea of our empirical strategy is that bonds of a given country and sector have similar default risk, but are held by different financial intermediaries. We can then identify the effect of global banks' net worth on emerging-market bond prices by relating the average contraction in the net worth of the financial intermediaries holding a particular bond in a narrow window around the Lehman episode to its subsequent price drop. To measure the average contraction in the net worth of the financial intermediaries holding a particular bond, we collect data on the holdings of each financial intermediary of each individual bond, as well as data on the stock price drop of each publicly traded financial intermediary. We document that bonds held by more severely affected banks during this episode experienced more severe price drops in the two subsequent months. The estimated elasticity is quantitatively large: Bonds whose holders suffer a contraction in net worth one standard deviation higher than the mean experienced a price contraction twice as large as that of the average bond.

We then construct a model of global banks' lending to emerging economies, and use the model together with our empirical estimates to analyze their role in systemic debt crises. We model the world economy as composed by a set of heterogeneous emerging economies facing systemic and idiosyncratic income shocks, which borrow from developed economies using risky debt. Global banks intermediate in this international lending process, but face financing frictions linking investments in risky securities to their net worth. The model, while rich enough to be quantified to explain the data, hinges on key forces that can be characterized in a stylized way. Required returns on emerging-economy debt are determined endogenously and include an intermediation premium and a default-risk component. The intermediation premium is determined to equilibrate aggregate supply and demand of funds for risky assets. This way, shocks that contract the supply of funds, like lower realized returns on global banks' investments, increase the intermediation premium. The default premium is determined by borrowers' incentives to default.

One of our model's main takeaways is that the type of role played by global banks crucially depends on their exposure to emerging-market risky debt. On the one hand, when their exposure is high, global banks play a key role amplifying shocks originating in emerging economies, through a feedback effect between the supply of funds and emerging economies' default rates. On the other hand, when the exposure is low, global banks play a key role in transmitting shocks originating in other risky asset classes.

To quantitatively assess this role we measure this exposure and inform the model with the estimated elasticity from our empirical analysis. We find that, with the current observed exposure (around ten percent of risky assets), global banks mostly play a role in transmitting shocks originating in developed economies. We illustrate the relevance of their role by showing that the bulk of the variation of emerging-market spreads during the global financial crises can be explained by negative shocks in developed economies that affected the net worth of global banks. In addition, global banks can help explain why bond spreads in the data are highly correlated within emerging economies, and also highly correlated with the returns of other risky securities in developed economies, such as U.S. corporate bonds. In our model, an important part of the fluctuations in debt prices are driven by changes in banks' net worth and the aggregate supply of funds, leading to large comovements similar to those observed in the data.

Finally, our global-bank model sheds light on the history of systemic debt crises in emerging economies. For instance, a common narrative of why the Latin American debt crisis of the 1980s was so pronounced, is that U.S. banks had a very large exposure to these economies, and when their default rates increased banks had to significantly contract credit, further affecting the ability of Latin American economies to repay. Our model captures exactly this mechanism, and shows that the dynamics observed in this crisis are what would have been predicted in our quantitative model when global banks' exposure is large. Our model can also explain why, over recent decades, when financial lenders were more diversified in their portfolios, most of the swings in emerging-market debt prices were linked to changes in realized returns of risky securities in developed economies, as illustrated for instance by the 2008 Lehman episode.

Related literature

Our paper contributes to several strands of the literature. First, to the literature that studies external debt crises and sovereign default. This literature has shown how the dynamics of external borrowing in emerging economies can be linked to frictions in international credit markets (see, for example, Mendoza, 2002, 2010; Bianchi, 2011) and default risk (see, for example, Arellano, 2008; Aguiar and Gopinath, 2006). Motivated by the high synchronization of debt crises, a recent part of this literature has analyzed the role of lenders in the debt market (see, for example, Aguiar et al., 2016; Tourre, 2017; Arellano et al., 2017; Bai et al., 2018). Our paper contributes to this literature by analyzing debt crises from a global perspective and focusing on the role of financial intermediaries in this market.

Second, our paper contributes to the literature on the history of debt crises (see, for example, Calvo and Mendoza, 1996; Reinhart and Rogoff, 2009; Kaminsky and Reinhart, 1999; Sachs, 1989). A relevant takeaway from this literature is that financial intermediaries play a key role in emerging economies' debt crises. We contribute to this literature by constructing a model of the world economy with global financial intermediaries that allows us to further understand the channels through which global banks can play an important role in these crises.

Third, our paper is related to the literature on international asset prices and the global financial cycle. This literature has documented a large comovement in debt prices across emerging economies (see, for example, Longstaff et al., 2011; Borri and Verdelhan, 2011), and a strong link between international capital flows and lending in emerging economies (see, for example, Gourinchas and Rey, 2007; Devereux and Yetman, 2010; Rey, 2015; Baskaya et al., 2017; Avdjiev et al., 2018). Our paper shows that global banks can play a key role in these patterns. In this sense, our paper is also related to Gabaix and Maggiori (2015), who study the role of global financial intermediaries in asset markets.

Finally, our paper contributes to the literature on the role of financial intermediaries in the macroeconomy (see, for example, Gertler and Karadi, 2011; Gertler and Kiyotaki, 2010). The closest contributions are Gennaioli et al. (2014), Bocola (2016), and Perez (2018), which analyze the role of banks as lenders to risky governments. We contribute to this literature by stressing that the same frictions that help understand financial frictions domestically are relevant in the synchronization of global debt crises and debt prices.

The rest of the paper is organized as follows. Section 2 presents the empirical evidence measuring the effect of global banks' net worth on bond prices of emerging-market economies. Section 3 lays out the model. Section 4 discusses the channels through which global banks amplify and transmit shocks in the risky debt market. Section 5 presents the calibration. We perform the main quantitative exercises in Section 6, and conclude in Section 7.

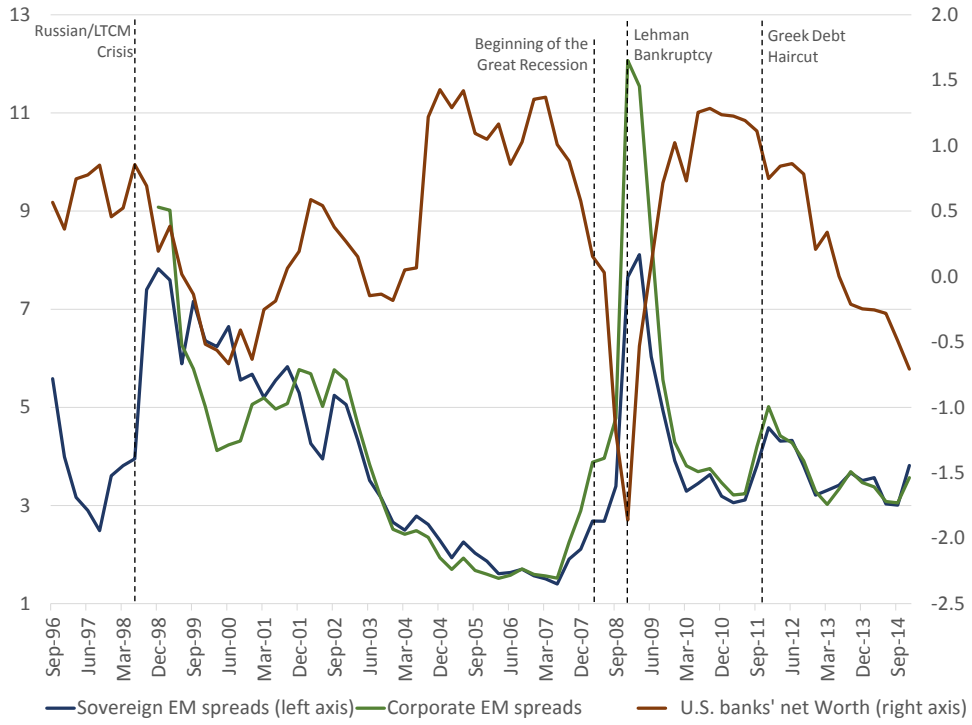
2. Empirical Evidence

In this section we provide empirical evidence of the effect of global banks' net worth on EMs debt prices. The estimates obtained constitute new evidence on the role of global banks in EM debt prices, and are also helpful to discipline the quantify aggregate effects of global banks in the debt market in the next sections.

2.1. *Identification*

Figure 1 shows the comovement between EM sovereign and corporate bond spreads and U.S. global banks' net worth over the last decades, characterized by a strong negative correlation of roughly -55%. Periods of spikes in bond spreads, such at the Russian/East Asian crises of the late 1990s or around the Lehman Brothers bankruptcy in 2008, tend to be periods of declines in U.S. bank's net worth. Our goal is to measure the effect of global banks' net worth in bond prices. The main empirical challenge is that changes in the net worth of U.S. banks are correlated with drivers of EM default risk. In addition, change in net worth are themselves affected by EM returns.

FIGURE 1. EM Bond Spreads and U.S. Banks' Net Worth



Notes: This figure shows emerging market sovereign and corporate bond spreads and the net worth of U.S. banks. Bond spreads are expressed in percent and are computed as the average spreads across countries included in the EMBI (for sovereign spreads) and CEMBI (for corporate spreads). Data source: Bloomberg. The net worth of U.S. global banks refer to the difference between the real value of assets and liabilities reported by U.S. chartered depository institutions. Data expressed as percentages relative to a log-linear trend. Data source: Federal Reserve Board, Flow of Funds, L.111.

Our empirical strategy to estimate the effect of global banks' net worth on EM bond prices is to exploit within country–sector variation in EM bond prices in a narrow window around the Lehman episode. The key idea of this identification strategy is that within an EM country-sector, bonds have similar default risk but different holders. For instance, all foreign currency sovereign bonds issued by Brazil in foreign markets have the same default risk (e.g., due to cross-default clauses), but are held by different global banks. Moreover, in a narrow window around Lehman episode, global banks experienced differential changes in their net worth primarily driven by DM factors. We can therefore exploit this episode to identify the effect of global banks in bond prices by relating the within country-sector variation in bond prices to a measure of their holder's change in net worth.

2.2. *Data*

We collect data for sovereign and corporate bonds issued by countries that are part of JP Morgan's EMBI before 2008 and maturing after 2010. We restrict attention to bonds issued in foreign markets and in foreign currency, which are arguably more comparable in terms of their default risk. Our variable of interest is the price of these bonds, which we measure with daily data from Bloomberg and Datastream. For each bond in our sample we construct a measure of the change in bond holders' average net worth around Lehman's episode, defined as $\Delta n_i = \sum_{j=1}^{J} \theta_{ij} \Delta n_j$, where θ_{ij} is the share held by bank j of bond i at 2008.q2, Δn_j bank j's change in market value of net worth around Lehman's bankruptcy (ten days before and three days after September 15th 2008), and J denotes the set of banks with available data. For the variable θ_{ij} we use data on holdings reported for each bond in Bloomberg. Within these holders, we focus on publicly traded financial institutions and measure Δn_j as the log change in its stock price, with data also from Bloomberg and Datastream. Appendix Table A1 details the 52 global banks included in the empirical analysis from this selection criteria.

Table 1 provides a set of summary statistics of the data used in the empirical analysis. The first column reports descriptive statistics at the bank level. The average contraction in banks' net worth in the narrow window around Lehman's episode is 19% the median contraction 3%. The other three columns report statistics at the bond level: the average share of reported holdings held by global banks, the change in bond holders' average net worth around Lehman's episode, and the change in bond prices. On average, global banks included in our sample hold 37% of reported bond holdings. After weighting global banks by their holdings prior to Lehman episode, the average contraction in net worth of lenders for the bonds included in our sample is 12%. The standard deviation of this variable is 22% which suggest that there is enough

variation is lenders' net worth across bonds to exploit in the empirical analysis. Finally, the last column shows that on average EM bond prices contracted by 3% in a narrow window around Lehman. This contraction is relatively small compared to global bank's contraction in net worth, providing support to the view that most of the change in global banks' net worth in this episode was primarily driven by DM factors.

TABLE 1. Global Banks' Net Worth and EM Bond Prices during Lehman: Summary Statistics

	Δn_j	$\sum_j \theta_{ij}$	Δn_i	Δq_i
	Bank level	Bond coverage	Bond level	Bond price
Mean	-19%	37%	-12%	-3%
Median	-3%	34%	-8%	-2%
Std Deviation	85%	24%	22%	4%
5th percentile	-61%	5%	-33%	-12%
95th percentile	20%	88%	6%	1%
Num. Obs.	52	410	409	462

Notes: This table shows descriptive statistics for the change in global banks' net worth and bond prices around Lehman's bankruptcy (ten days before and three days after September 15th 2008). The first column (Δn_j) reports summary statistics of the log change in stock prices of global banks with reported holdings of EM bonds included in the sample. The second column ($\sum_j \theta_{ij}$) reports summary statistics of the shares held by these banks for the EM bonds included in the sample. The third column reports (Δn_i) reports summary statistics of change in bond holders' average net worth around Lehman's episode (defined as $\Delta n_i = \sum_{j=1}^{J} \theta_{ij} \Delta n_j$). The fourth column ($\Delta q_i$) reports log changes in EM bond prices during this episode.

2.3. *Empirical Model and Results*

Our empirical model studies the dynamic effects of global banks' net worth on bond prices using Jorda (2005)'s local projections

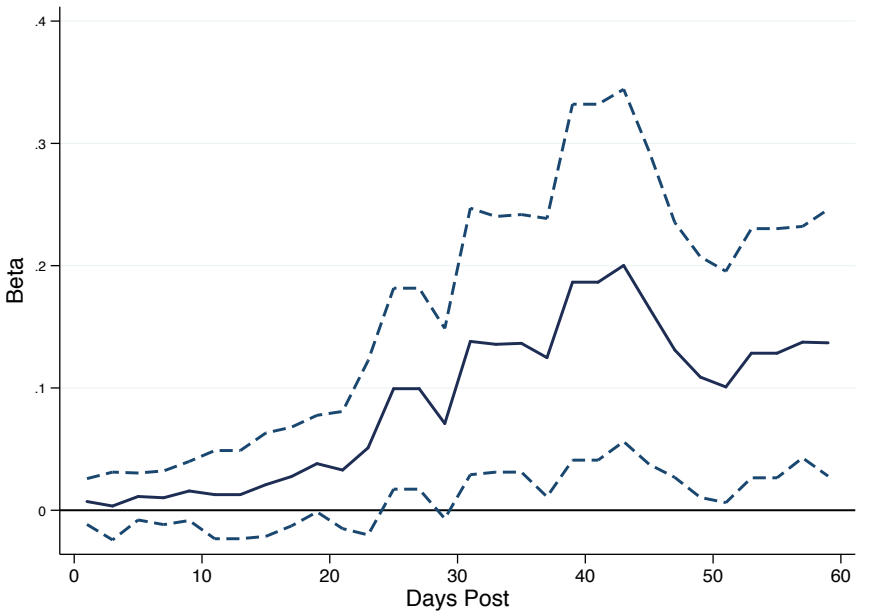
$$\Delta_h q_{iks} = \alpha_{ks} + \beta_h \Delta n_i + \gamma' X_i + \varepsilon_{iks}, \tag{1}$$

where $\Delta_h q_{ik}$ denotes the log change in the price of bond i, issued by country k in sector s between Lehman's episode and h days after the episode, Δn_i denotes the change in bond i's holders net worth around Lehman's episode (defined in the previous subsection), α_{ks} denote country-sector fixed effects, X_i is a vector of controls at the bond level (including the total

reported share $\sum_{j=1}^{J} \theta_{ij}$), and ε_{iks} a random error term. The coefficient of interest, β_h measures the elasticity of bond prices to changes in holder' net worth at horizon h. We estimate a separate regression for each horizon h, clustering standard errors at the country-sector level.

Figure 2 presents the results from estimating at different horizons. Results indicate a positive estimated elasticity β_h, indicating that bonds whose lender's net worth contracted more during Lehman's episode experienced significantly lower prices in the two months after the episode. The estimated elasticity indicates that a one percent lower net worth in lender translates into $0.1 - 0.2\%$ lower prices. To put this estimated coefficient into perspective note that if the net worth associated to a bond would be 10% lower than the mean (half of standard deviation in the cross-section of different bonds) the bond would be traded at $1 - 2\%$ lower prices, which is between one and two thirds of the average drop in bond prices during Lehman's episode.

FIGURE 2. The Effect of Global Banks' Net Worth on EM Bond Prices



Notes: This figure shows the estimated elasticity of bond prices to changes in holder' net worth at horizon h, β_h, from estimating the regression 2.3. Solid lines represent the point estimate of the regression at each horizon, and dotted lines 90% confidence intervals.

As shall be seen in the next sections, this estimated coefficient can be used to discipline key aspects of the general equilibrium model. For instance, under the assumption that EMs do not arbitrate out price differences across bonds and that the feedback effects from bond prices into back net worth are small, the estimated elasticity can be interpreted as the price

effect given a shift in the supply due to changes in net worth.[1] Under this interpretation, the estimated coefficient can be expressed as the product of the inverse of the supply elasticity and the "portfolio elasticity":

$$\hat{\beta} \simeq \left(\underbrace{\frac{\partial \log A_i^s}{\partial \log q_i}}_{\text{supply elasticity}} \right)^{-1} \underbrace{\frac{\partial \log A_i^s}{\partial \log N_i}}_{\text{portfolio elasticity}} .$$

The estimated elasticity is therefore informative the supply elasticity, which is one of the main elements governing the role played by global banks in the EM debt market.

3. A Model of the Global Economy

3.1. *Environment*

The global economy is composed by a continuum of developed-market economies (DMs) and a continuum of heterogeneous emerging-market economies (EMs). Households in these two type of economies differ in their preferences, giving rise to international lending. In DMs households are risk-neutral and patient, while in EMs households are risk-averse and impatient.

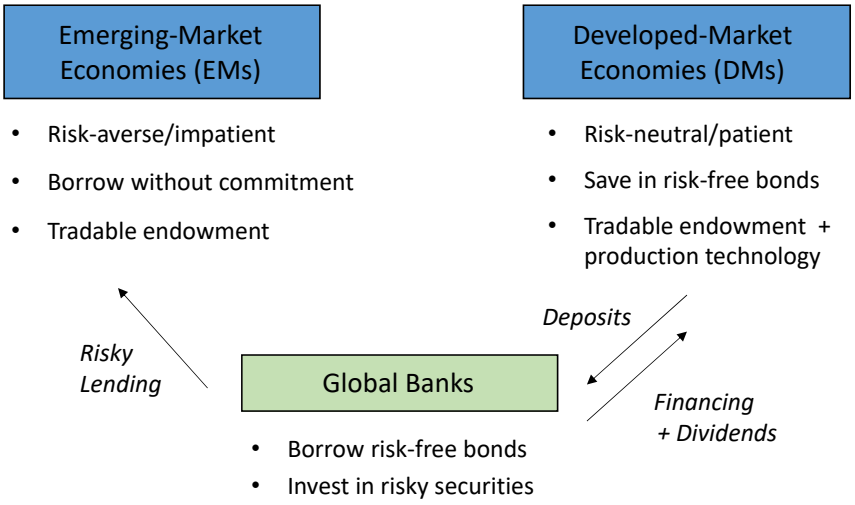
The key feature of the model is that international lending is intermediated by global banks. Households in DMs lend to global banks using a risk-free bond ("deposits"). Global banks, in turn, lend to EMs using risky bonds. Global banks face frictions in their intermediation activity, that limit their ability to rise funds from DMs. As alternative investment opportunities, global banks can also invest in risky technologies operated in DMs.

Households in EMs receive each period a stochastic endowment of tradable goods, which has a systemic component (common across all EMs) and an idiosyncratic component (whose realizations differ across EMs). EMs households lack commitment to repay their debt. We interpret household borrowing in a broad sense, capturing direct international borrowing, sovereign borrowing, or borrowing through other agents (e.g., local banks). Figure 3 provides a graphical representation of the global economy.

Time is discrete and infinite. Within each period, the timing is as follows. At the beginning of each period exogenous variables are realized. EM households choose repayment. Global

[1] We consider this a plausible interpretation because: (i) EMs did not issue debt or conducted buybacks during this period –see Figure A.1– and (ii) As will be show in detail in the next section, the exposure of global banks to EMs is relatively small. In the quantitative analysis we conduct alternative interpretations of this estimate including both demand and net worth channels.

FIGURE 3. The Global Economy



banks choose their portfolio, DM households their savings, and EMs household their borrowing. Appendix C provides details of these state vectors and the recursive representation of the model.

3.2. *Developed Economies*

Households. The representative household in DMs has preferences described by the lifetime expected utility

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_{DM}^t c_{DMt} \tag{2}$$

where c_{DMt} denotes consumption and $\beta_{DM} \in (0,1)$ the subjective discount factor of DM households.

Each period households receive an endowment of tradable goods y_{DM} and time to work $\overline{h}$. They can save in deposits in the global banks that pay a return R_{dt} for every unit of deposit in $t+1$. Their sequential budget constraint is given by

$$c_{DMt} = y_{DM} + w_t \overline{h} + R_{dt} d_t - d_{t+1} + \pi_t \tag{3}$$

where w_t denotes wages in period t, d_{t+1} the amount of deposits in t to be repaid in $t+1$, and π_t denotes net payouts from global banks and non-financial firms.

The DM household's problem is to choose state-contingent plans $\{c_{DMt}, d_{t+1}\}_{t=0}^{\infty}$ to maximize (12) subject to (3), taking as given prices $\{R_{dt}, w_t\}_{t=0}^{\infty}$ and transfers $\{\pi_t\}_{t=0}^{\infty}$. Household's optimization delivers a constant equilibrium interest rate for deposits, $R_{dt} = \beta_{DM}^{-1}$.

Firms. The DM economy is also populated by a representative non-financial firm, which has access to technologies to produce tradable goods and accumulate capital given, respectively, by

$$F_t(k_t, h_t) = z_{DMt} k_t^{\alpha} h_t^{(1-\alpha)}, \tag{4}$$

$$k_{t+1} = (1-\delta)\, k_t + i_t, \tag{5}$$

with $\alpha, \delta \in (0,1)$, where k_t is the stock of capital at the beginning of period t, h_t is hours of work hired by the firm, i_t is investment, and z_{DMt} is an exogenous productivity process. Firms are owned by global banks, as we describe later.

3.3. *Global Banks*

Global banks are financial firms owned by households in DM. Their objective is to maximize the lifetime discounted dividends transfered to DM households

$$\max \mathbb{E}_t \sum_{s=0}^{\infty} \beta_{DM}^{s-t} div_{jt+s}, \tag{6}$$

where div_{jt} denotes dividend payments of bank j in period t. Global banks engage in financial intermediation in the global economy. They can invest in two types of risky securities, claims on non-financial firms from the DM economy a_{DMjt} and bonds issued by EM economies $\{a^i_{EMjt}\}_{i\in\mathcal{I}_t}$, where i indexes a particular EM economy and $\mathcal{I}_t$ the set of EM economies that issue bonds in period t. The amount of final goods that the global bank obtains from these investments, or net worth is given by

$$n_{jt} = \int_{i\in\mathcal{I}_{t-1}} R^i_{EMt} a_{EMjt-1} \mathrm{d}i + R_{DM} a_{DM,jt-1} - R_d d_{jt-1} \tag{7}$$

where $\{R^i_{EMt}\}_{i\in\mathcal{I}_{t-1}}$ is the set of returns of EM bonds in period t and $R_{DM,t}$ the return of the claims of non-financial firms in the DM economy in period t. Then banks use their net worth, as well as risk-free deposits from DM households, to finance investments in risky securities and dividend payments

$$n_{jt} + d_{jt} = \int_{i\in\mathcal{I}_t} a^i_{EMjt} \mathrm{d}i + a_{DMjt} + div_{jt}. \tag{8}$$

Banks face frictions to finance their investments. First, they face a borrowing constraint, linking their risky their investment to their net worth

$$\kappa \left(\int_{i\in\mathcal{I}_t} a_{iEMt} \mathrm{d}i + a_{DMt} \right) \leq n_t, \tag{9}$$

where $\kappa > 0$. In addition, we assume that banks cannot raise new equity, i.e., $div_{jt} \geq 0$.[2] Finally, to ensure that banks to not outgrow their financial frictions we assume that they exit with an exogenous i.i.d. probability $(1 - \sigma)$. New banks are endowed with net worth $\overline{n}$, and total mass of global banks is always fixed at one.

The global bank's problem is to choose state-contingent plans $\{\{a_{EMjt}\}, a_{DMjt}, d_{jt}, div_{jt} \geq 0\}$ to maximize (6) subject to (7) and (9). Appendix C shows the bank's recursive problem. Our formulation gives rise to a problem that is linear in net worth, and whose solution is characterized by constraints (9) and $div_{jt} \geq 0$ holding with equality and

$$R^e_{EMit} = R^e_{DMt} \tag{10}$$

$$R^e_{DMt} = R^e_{dt} + \mu_t \kappa \tag{11}$$

for any solution with $a_{iEM} > 0, a_{jEM} > 0$, where $R^e_{EMit} \equiv \mathbb{E}_t[v_{t+1} R_{EMit+1}]$, $R^e_{DMt} \equiv \mathbb{E}_t[v_{t+1} R_{DMt+1}]$, $R^e_{dt} \equiv R_d \mathbb{E}_t[v_{t+1}]$, v_t is the marginal value of net worth for global banks, and $\mu_t \geq 0$ the Lagrange mutiplier associated with the borrowing constraint (9). Equation (10) implies that the global bank equates expected returns across asset classes, while equation (11) implies that the borrowing constraint prevents global banks from equalizing expected returns between risky and risk-free assets.

3.4. *Emerging Economies*

Each emerging economy is populated by a mass one of identical households with preferences described by the lifetime utility

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t_{EM} u(c_{it}) \tag{12}$$

where $u(\cdot)$ is increasing and concave, c_{it} denotes consumption of the representative household of emerging economy i in period t and $\beta_{EM} \in (0, \beta_{DM})$ the subjective discount factor of EM households. Each period households in EMs receive a stochastic endowment of tradable goods, with a systemic component $y_{EM,t}$, common across all EMs, and an idiosyncratic component z_{it}. After observing the realization of their endowment households choose to repay debt they inherited from previous period ($\iota_{it} = 0$) or to default ($\iota_{it} = 1$). Households that default loose access to external credit markets and re-enter when the random variable $\zeta_{it} \sim Bernouli(\theta)$ equals one. This implies that households remain in financial autarky for a stochastic number

[2] As standard, for financial frictions to play a meaningful role, they have to be present both in debt and equity markets. Our assumption in the equity market is a frequent modeling choice in the corporate finance literature due to its tractability and the fact that firms, in the data, raise equity only infrequently.

of periods. Households that repay their previous promises can issue one-period bonds, whose promised payments are not state contingent, facing a bond price schedule $q_{it}(b_{it+1})$ that depends on the EM characteristics and borrowing choices. Their sequential budget constraint is given by

$$c_{it} = y_{EMt} + z_{it} + q_{it}(b_{it+1})b_{it+1} - b_{it} \tag{13}$$

While households are excluded from global capital markets they simply consume their endowments

$$c_{it} = \mathcal{H}(y_{EMt} + z_{it}) \tag{14}$$

where $\mathcal{H}(x) \leq x$ captures the output losses associated with the default decision. The household problem in recursive form is detailed in Appendix C.

In partial equilibrium, this problem is equivalent to a standard borrowing problem in a small open economy with default. However, the bond price scheduled faced by EM households this this economy will be affected by the interaction between global banks, the distribution of debt positions across EMs, and systemic variables introduced by our framework.

3.5. *Equilibrium*

A competitive equilibrium in the global economy can be defined as follows:

DEFINITION **1.** *Given initial global banks portfolios* $\left(\left(a^i_{EMj-1}\right)_{i\in[0,1]}, a_{DMj-1}, d_{j,-1}\right)_{j\in[0,1]}$*, initial debt positions in EM households* $(b_{it})_{i\in[0,1]}$*, and state-contingent processes* $\{z_{DM}, y_{EMt}, (z_{it}, \zeta_{it})_{i\in[0,1]}\}$*, a competitive equilibrium in the global economy is a sequence of allocations for DM households* $\{c_{DMt}, d_{t+1}\}_{t=0}^{\infty}$*, non-financial firms* $\{h_t, k_{t+1}\}_{t=0}^{\infty}$*, global banks* $\{\left(\left(a^i_{EMjt}\right)_{i\in[0,1]}, a_{DMjt}, d_{j,t}\right)_{j\in[0,1]}\}_{t=0}^{\infty}$*, and EM households* $\{(c_{it}, b_{it+1}, \iota_{it})_{i\in[0,1]}\}_{t=0}^{\infty}$ *and prices* $\{w_t, (q_{it}(b_{t+1}))_{i\in(0,1)}\}_{t=0}^{\infty}$ *such that*

i. Allocations solve agents problems at the equilibrium prices,

ii. Assets and labor markets clear.

In equilibrium, asset markets clearing implies that global bank's investment in each risky security traded in the global economy equalizes the amount of that type of securities issued:

$$A_{EMit} \equiv \int_{j\in[0,1]} a^i_{EMjt}\,\mathrm{d}j = b_{it+1},$$

$$A_{DMt} \equiv \int_{j\in[0,1]} a_{DMjt}\,\mathrm{d}j = k_{t+1}.$$

The return for each type of security is given by $R_{EMit+1} = \frac{\iota_{it+1}}{q_{it}(b_{it+1})}$ and $R_{DMt+1} = z_{DMt}\alpha A_{DMt}^{\alpha-1} + (1-\delta)$.

4. Global Supply and Demand for EM Debt

We now conduct a theoretical discussion of the channels through which global banks affect EMs' debt. For this, we consider an economy without aggregate uncertainty, and study the effects of fully unanticipated aggregate shocks, with a perfect foresight transitional dynamics back to steady state. We incorporate a stochastic structure for aggregate shocks in the next section, analyzing the quantitative version of our model.

4.1. *Equilibrium in the Risky Debt Market*

We begin by constructing a simple demand-supply scheme representing the equilibrium in the global debt market. On the lender side, combining optimal portfolio choices and borrowing constrains holding with equality across banks, we obtain a positive relationship between EMs required returns and aggregate funds invested in EMs, which we label "aggregate supply:"

$$A_{EMt} = \mathcal{A}_t^s(R^e_{EMt}, N_t) \equiv \frac{1}{\kappa} N_t - \left\{ \left[R^e_{DMt} - (1-\delta) \right] (\alpha z_{DMt})^{-1} \right\}^{\frac{1}{\alpha-1}} \tag{15}$$

with $\frac{\partial A_t^s}{\partial R^e_{EMt}} > 0$ and $\frac{\partial A_t^s}{\partial N_t} > 0$. This equilibrium condition represents the fact that when EM returns are high, global banks require also higher returns for DM securities, which occurs with a higher marginal product of capital and a lower aggregate funds allocated to DMs. The aggregate net worth of global banks acts a a shifter on the aggregate supply: For a given level of EM returns, the higher the net worth of global banks, the higher the amount of funds invested in EMs.

On the borrowers side, aggregating borrowing across EMs and using the definition of returns, we obtain a relationship between required return and borrowing in EMs, which we label "aggregate demand:"

$$A_{EMt} = \mathcal{A}_t^d(R^e_{EMt}) = \int_{i \in \mathcal{I}_t} \frac{1}{R^e_t} \iota_{it+1} b_{it+1} \, \mathrm{d}i. \tag{16}$$

The slope of aggregate demand is given by $\frac{\partial \mathcal{A}_t^d(R^e_{EMt})}{\partial R^e_{EMt}} = -\frac{1}{R^{e2}_t} \iota_{it+1} b_{it+1} + \frac{1}{R^e_t} \partial \frac{\partial \iota_{t+1} b_{t+1}}{\partial R^e_t}$. The first term of this expression is negative, reflecting that higher required returns are associated with lower debt prices, and a smaller amount of borrowing for given repayments. The second term reflects the effect that required return has on next period's repayment choices. Although this term cannot be signed analytically, we focus here on a case in which it is negative, as will be in our quantitative model, reflecting that higher required reduces borrowing and makes repayments less likely.

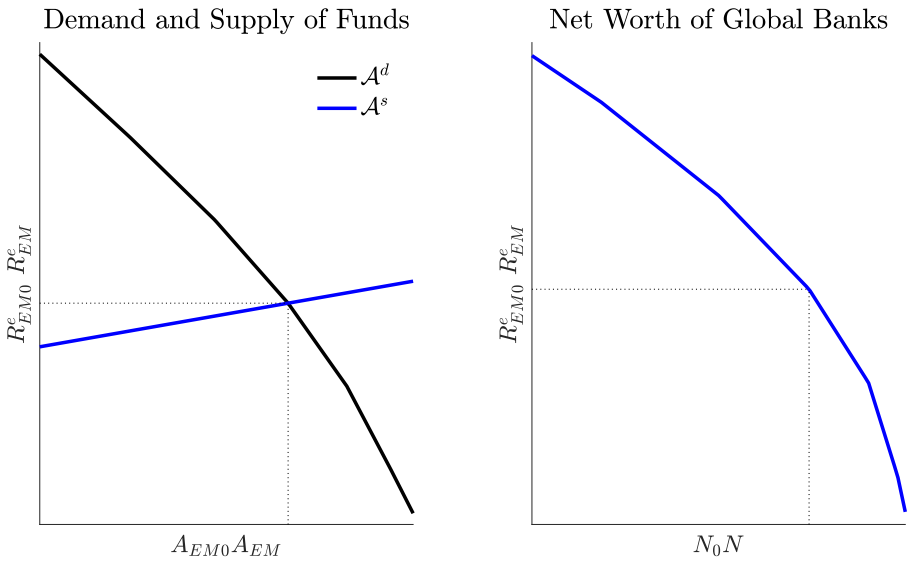
Figure 4 depicts the equilibrium aggregate borrowing and required returns as the intersection between aggregate demand and supply of funds, for given levels of global bank's net worth.

Net worth, however, is also endogenous in this system, as required returns affect borrowers' repayments and realized returns. To obtain this relationship, we integrate the evolution of net worth (7) across banks to obtain:

$$N_t = \int_{i \in \mathcal{I}_{t-1}} \iota_{it} A_{EMit-1} \mathrm{d}i + R_{DMt} A_{DMt-1} - R_d D_{t-1}. \tag{17}$$

Given previous period investments $\{(A_{EMit-1})_{i\in[0,1]}, A_{DMt-1}, D_{t-1}\}$, the slope of net worth with respect to required returns is given by $\frac{\partial N_t}{\partial R^e_{EMt}} = \int_{i\in\mathcal{I}_{t-1}} \frac{\partial \iota_{it}}{\partial R^e_{EMt}} A_{EMit-1} \mathrm{d}i$. We focus in the case in which this slope is negative, as will be in our quantitative model, reflecting that higher required returns decrease the value of repayment and leads to more default in EMs. This relationship is depicted in the right panel of Figure 4. Together, aggregate supply, aggregate demand, and evolution of net worth constitute a system of three equations determining aggregate EM borrowing A_{EMt}, required returns R^e_{EMt}, and global bank's aggregate net worth N_t.

FIGURE 4. The Global Debt Market Equilibrium

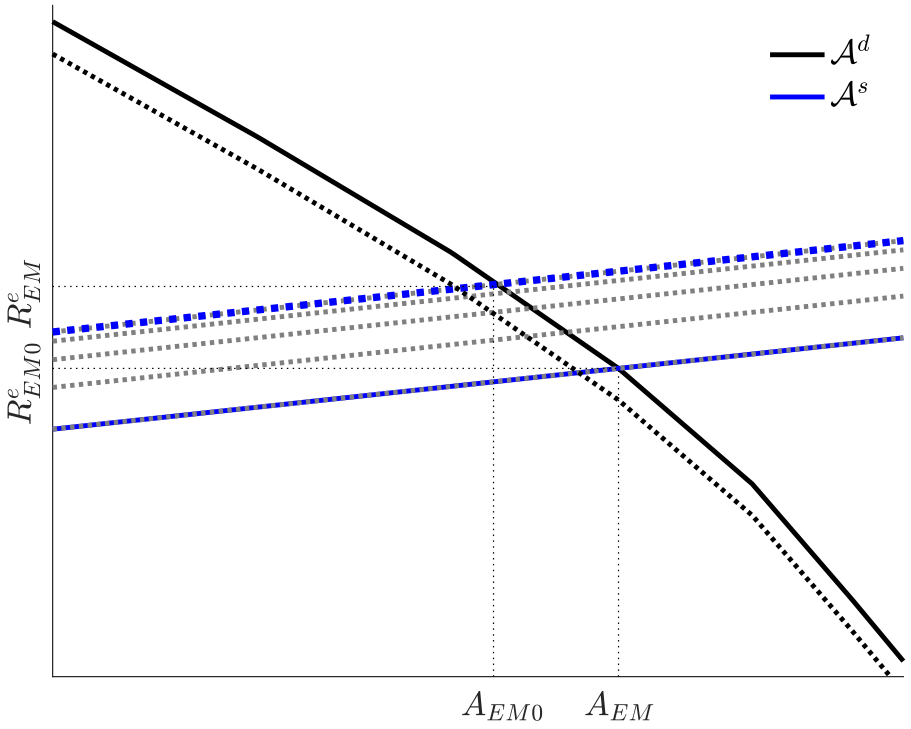


4.2. *Aggregate shocks*

We now use our equilibrium scheme to analyze the role of global banks propagating aggregate shocks. First, consider the effect of an unexpected negative shock to the return of the DM security. This shock affects global banks' net worth and, through this channel, the aggregate supply of funds (see equations (15) and (17)). This initial effect of this shock is represented in Figure 5 as a shift of the net worth and aggregate supply curves, indicating less net worth and supply of funds for any given level of EM required returns, leading to an increase of EM required returns. In addition to this initial effect of the shock, there is an amplification effect

that operates through global banks' net worth: Higher required returns in EM lead to more EM economies to default, further contracting bank's net worth and the aggregate supply of funds and further increasing EM required returns.

FIGURE 5. Aggregate Shocks and Global Debt Market Equilibrium



Through a similar mechanism, global banks also amplify systemic shocks originated in EMs. For this, consider now the effect of an unexpected negative shock to systemic EM income. The negative income shock leads to more EM economies to default, affecting banks' net worth and the supply of funds in a similar fashion than analyzed above for the shock to the realized return of DM securities. The negative income shock also affects the demand of funds. In Figure 5, this is represented as a downward shift in the aggregate demand of funds, as typically occurs in models of risky external borrowing. If the increase in required returns driven by the contraction in aggregate supply is not fully offset by a weaker demand, global banks trigger the amplification trough net worth explained below.

The amplification through global banks is a key difference between systemic and idiosyncratic EM income shocks. When income shocks are idiosyncratic, they do not affect global bank's net worth and have a smaller effect in debt prices. This result is important because it implies that our model can provide a theoretical explanation of the fact that EM spreads are more sensitive

to systemic than to idiosyncratic changes income, documented in Section 2. In the next section we show that this explanation of our model is also quantitatively consistent with the data.

5. Quantitative Analysis

In this section we calibrate the model to match the salient features of global banks and the market of EM risky debt. Importantly, the calibration is informed by the empirical results from section 2. We then use our quantified model to assess the relevance of global banks as lenders of emerging economies.

5.1. *Calibration*

One period corresponds to one year. The period utility function of EM households is given by

$$u(c) = \frac{c^{1-\gamma}}{1-\gamma}.$$

The endowment processes of EM households follow

$$\ln y_{EM,t} = \rho_{y_{EM}} \ln y_{EM,t-1} + \sigma\epsilon_{EM,t}, \quad \epsilon_{EM,t} \sim N(0,1),$$
$$\ln z_{i,t} = \rho_{z_i} \ln z_{i,t-1} + \sigma\epsilon_{i,t}, \quad \epsilon_{i,t} \sim N(0,1).$$

Similarly, the productivity process of firms in the DM economy is given by

$$\ln z_{DM,t} = (1-\rho_{z_i})\mu_{z_DM} + \rho_{z_i} \ln z_{DM,t-1} + \sigma\epsilon_{DM,t}, \quad \epsilon_{DM,t} \sim N(0,1).$$

Finally, the output net of default costs is parametrized by

$$\mathcal{H}(y) = y\left(1 - d_0 y^{d_1}\right)$$

where $d_0, d_1 \geq 0$. This functional form delivers non-linear costs of default that are higher for higher values of y, as in Arellano (2008) and Chatterjee and Eyigungor (2012).

The model calibration features a set of parameters which we set exogenously and another set which we calibrate to match relevant moments. We stress the role of two key parameters (α and $\mu_{z_{DM}}$) that are relevant in determining the role played by global banks in the EM risky debt market. We first describe the set of predetermined parameters that reported in the first column of Table 2. We follow the literature on quantitative macroeconomic models to set values for the exogenous parameters. The coefficient of risk aversion of EM households is set to $\gamma = 2$. The probability of re-entering credit markets is set to $\theta = 0.25$, so that the average exclusion period is of 4 years, in line with empirical evidence (Gelos et al. (2011) and Dias and Richmond (2008)). The parameters of the endowment process of EM households are estimated using data on output

for the sample of countries analyzed in section 2. We restrict the systemic and idiosyncratic component of output to have the same stochastic process, i.e. $\rho_{y_{EM}} = \rho_{z_{EM}}$ and $\sigma_{y_{EM}} = \sigma_{z_{EM}}$. We make this parametric restriction to study the differential effects of these shocks that arise due to endogenous amplification, rather than due to having different stochastic processes. The estimated values of the autocorrelation and standard deviation are $\rho_{y_{EM}} = \rho_{z_{EM}} = 0.66$ and $\sigma_{y_{EM}} = \sigma_{z_{EM}} = 0.048$. The discount factor of DM households is $\beta_{DM} = 0.98$ which implies an annual risk-free interest rate of 2%. The depreciation rate is set at $\delta = 0.08$.

TABLE 2. Model Calibration

Parameter	Description	Value
Exogenous Parameters		
γ	risk aversion	2.00
θ	re-entry probability	0.25
$\rho_{y_{EM}}$	systemic endowment autocorrelation	0.656
$\sigma_{y_{EM}}$	systemic endowment shock volatility	0.048
$\rho_{z_{EM}}$	idiosyncratic endowment autocorrelation	0.656
$\sigma_{z_{EM}}$	idiosyncratic endowment shock volatility	0.048
β_{DM}	discount rate of DM	0.98
α	share of capital	0.35
δ	depreciation	0.08
κ	leverage ratio	0.10
Calibrated Parameters		
β_{EM}	discount rate of EMs	0.85
d_0	default cost - level	0.05
d_1	default cost - curvature	1.50
σ	bank survival rate	0.42
$\bar{n}$	level of net worth	0.100
$\mathbb{E}z_{DM}$	unconditional mean of DM shock	0.37
$\sigma_{z_{DM}}$	volatility of DM shock	0.15
$\rho_{z_{DM}}$	autocorrelation of DM shock	0.07

The remaining predetermined parameters (κ and α) directly influence moments associated to global banks. The parameter on the borrowing constraint of global banks is set to $\kappa = 0.1$, so that the leverage (defined as the ratio of net worth to assets) is set to 10%. This leverage ratio

is obtained by analyzing the balance-sheet of seven major global banks, namely, Santander, HSBC, Citi, Bank of America, JP Mogran and Wells Fargo. In Figure A2 we report this and other relevant statistics regarding the balance-sheets of those banks. Finally, the share of capital in the production function of DM firms α is a relevant parameter that governs the elasticity of supply of funds to EMs. In turn, this elasticity is directly related to the estimated effect of global banks' net worth on bond prices from section 2.[3] A lower value of α has associated more decreasing returns to scale in the aggregate production technology of DM firms, which in turn implies a more inelastic supply of funds for EMs, and a larger price effect of drops in the net worth of banks. The value of $\alpha = 0.21$ is set so that the elasticity of banks' aggregate net-worth to EM bond prices is 0.1, which is our estimated effect from section 2.

The remaining parameters are calibrated to match specific data moments. A subset of these parameters are related EM households (β_{EM}, d_0, d_1), others to global banks $(\sigma, \overline{n})$, and others to DM firms $(\mu_{z_{DM}}, d_0, d_1)$. We target a set of moments related to EM debt and default and another set of moments related to global banks and other risky assets. Related to EM debt we target the average level of external debt, the annual rate of default, the average spread, the average correlation of spreads and output, and the average volatility of spreads. Related to global banks and other risky assets we target the average exposure of global banks to DM risky assets, and the volatility and autocorrelation of spread of the DM risky asset.[4] The calibrated

[3]To see this recall that the aggregate supply is given by (15), which implies that the elasticity of EMs bond prices to the aggregate net worth of banks, holding constant the aggregate demand A_{EM}, is given by

$$\frac{\partial q_t}{\partial N_t} = (1-\alpha)\theta_{DM}\left(\frac{R^e_{EM,t} - (1-\delta)}{R^e_{EM,t}}\right),$$

where $\theta_{DM} = \frac{A_{DM}}{A_{DM}+A_{EM}}$ is the share of DM risky assets on global banks' risky asset portfolio. The estimated value from section 2 of this elasticity is 0.1. Additionally, the observed value of the share of DM risky assets on global banks' risky asset portfolio is $\theta_{DM} = 0.9$ (see Figure A2) and, given the average required return on EM bonds we can back out a value of $\alpha = 0.21$.

[4]The average level of debt in the data is computed as the average level of external debt of the countries in our sample for the period Sep-96 to Dec-14. The annual rate of default is computed as the average share of EM defaults that occurred in our sample period. The average level and volatility of spreads is computed as the country-time average of sovereign spreads. Its correlation with output is computed as the average correlation of sovereign spreads and the cyclical component of output for each country in our sample. We compute the average exposure of global banks to DM risky assets as the exposure to all risky assets that are not EM debt as a fraction of total assets. We use the spreads on the US High Yield corporate bonds to compute the volatility and autocorrelation of the DM risky asset. See Appendix B for data sources and further details in the computation of moments.

values are shown in Table 2. While in the joint calibration all moments can be affected by all parameters, we find that the parameters related to EM households mostly affect the EM spread and debt moments, the parameters related to global banks and DM firms affect the price moments of both types of risky assets as well as the portfolio composition of global banks. One important parameter is the average productivity of DM firms $\mu_{z_{DM}}$, which directly affects the average return on DM risky debt and, through a general equilibrium effect, the share of banks assets invested in DM risky assets. When $\mu_{z_{DM}}$ is high, the return on DM assets is high and this increases investment by global banks to DM firms thereby increasing their exposure to DM risky assets. Finally, it is also worth noting that, in order to match the levels of debt in EM economies, we obtain a low calibrated value of $\beta_{EM} = 0.85$ which is in line with previous literature on quantitative models of sovereign default.

Table 3 shows the data moments and the model moments. Almost all of the moments are well approximated, with the exception of the frequency of default which in the model is lower than in the data. The average spread in the model is composed of a component that is due to compensation for default risk and another component that comes from the fact EM borrowing is done via financial intermediaries that require a premium for doing so.

5.2. *Untargeted Moments*

We evaluate the model's ability to reproduce untargeted moments regarding the synchronization of asset prices. In particular, we ask to what extent is the model able to generate the high synchronization of debt prices within EM economies and with other risky assets. These exercises provide a source of validation of the model since matching these data facts was not part of the calibration target. Second, they help shed light into the role that global banks play in explaining the facts regarding debt prices. We compute all exercises for the calibration and for another version of the model without global banks. This version of the model corresponds to an economy in which global banks do not face financial frictions (i.e. $\kappa = \infty$ in the borrrowing constraint) or equivalently, to an economy in which there is no financial intermediation and DM households directly lend to EM households. To parametrize this economy we set the same values for the exogenous parameters and re-calibrate the remaining parameters to match the same moments as baseline economy.

We simulated data from both versions of the model and compute the average correlation of individual spreads with the average spread and with required returns from risky DM debt. We compare the model correlations with those of the data. As shown in Table 4, the average correlation of each country's spread with the average EM spread is 69% in the data. In the baseline

TABLE 3. Model Calibration

Target	Data	Model
Average debt	15.0%	13.6%
Yearly default rate	1.6%	0.1%
Correlation of spread and GDP	-31.0%	-30.0%
Average spread	395bp	330bp
Spreads volatility	170bp	305bp
Portfolio weight on DM	90.0%	92.4%
Volatility of DM Spread	255bp	246bp
Autocorrelation of DM Spread	0.16	0.19

Notes: The first column describes the targeted moments for the calibration of the model. The second column presents the empirical estimation of the moment. The third column shows the simulated moments from the calibrated model. Average debt is external public sector debt. Yearly default rate is the average of each country's default frequency in the sample. The time span for average debt, default rate, spread-GDP correlation, average spread and volatility of spread is Sep-96 to Dec-14. The portfolio weight on DM comes from the 2017 balance-sheets of Citibank, HSBC, JPMorgan, Bank of America, Wells Fargo and Banco Santander. The autocorrelation and volatility of DM Spread were computed from US BB corporate bonds at annual frequency, for the period 1997 to 2014. Source: World Bank, St Louis FRED and banks' balance-sheet statements.

model economy this correlation is 77%, while in model without global banks the correlation is 60%. The correlation in the model without global banks is lower than the one in the data and in the baseline model since there is zero amplification of the systemic component of outupt. The baseline model is also able to reproduce a large average correlation between individual EM spreads and the required return on risky assets. In particular the average correlation in the data (measured by the correlation between EM spreads and US high yield spread) is 50% and the one in the model is 69%. In the model without global banks there is no correlation between these asset prices since there is no transmission of shocks.

6. Systemic Debt Crises and the Role of Global Banks

In this section we use the calibrated model to assess quantitatively the role of global banks in the transmission and amplification of shocks in the market of EM risky debt. We first analyze

TABLE 4. Comovement in Asset Prices: Model and Data

	Correlation	
	Within EMs	High Yield
Data	0.69	0.50
Model	0.77	0.69
No Global Banks	0.60	N.A.

Notes: The correlation variable refers to the correlation of each country's spread with the mean across countries, excluding the treated country. In the model the High Yield refers to the DM risky debt. The *No Global Banks* version excludes financial frictions on global banks, thus there is no comovement between EM debt and risky DM debt.

the dynamics of spreads during the global financial crisis through the lens of the model and conclude that global banks played an important role transmitting shocks originated in DMs. Second, we analyze whether global banks play a role amplifying EM-originated systemic shocks.

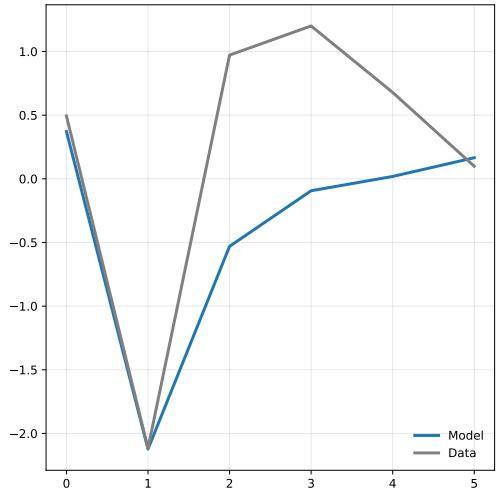
6.1. *EMs Spread Dynamics during the Global Financial Crisis*

We first use the model to shed light into the dynamics of EM spreads during the global financial crisis. For this we simulate the model for 1,000,000 periods and identify episodes in which the systemic output of EMs fell by the same amount it fell in the data, and in which the aggregate net worth of global banks fell like it did in the data. In particular, we look for simulations in which: *i.* y_{EM} fell by 4% (which is the peak to trough fall of average EM output during 2007-09), and *ii.* z_{DM} fell such that the net worth of aggregate banks falls like it did in the data. The dynamics of the aggregate net worth of global banks and EM output, both in the model and in the data, are shown in Figure 6. While the on-impact effects are targeted, the recovery dynamics emerge endogenously from the model and are roughly consistent with those observed in the data. The dynamics of the exogenous shock to z_{DM} that induce the dynamics of net worth are shown in Figure 8a in the appendix.

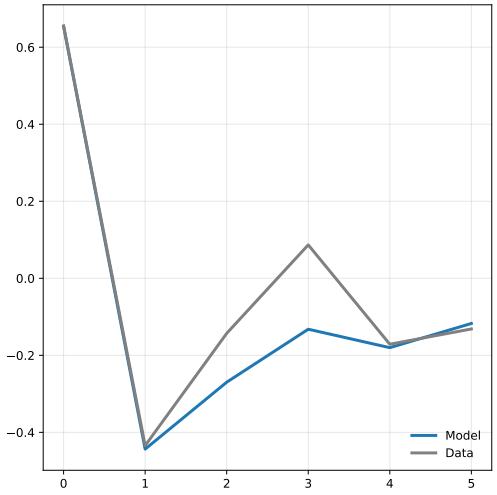
We then compare the dynamics of EM spreads from the model simulated episodes to the observed dynamics of EM spreads during the global financial crisis. This is shown in Figure 7. The dynamics of spreads in the model track closely those observed in the data, both in terms of the original spike as well as during the recovery. The model slightly overstates the increase in spreads by predicting an increase of around 650 basis points compared to the observed increase

FIGURE 6. Global Financial Crisis: Exogenous Drivers

(A) Global Banks' Net Worth



(B) EMs Output

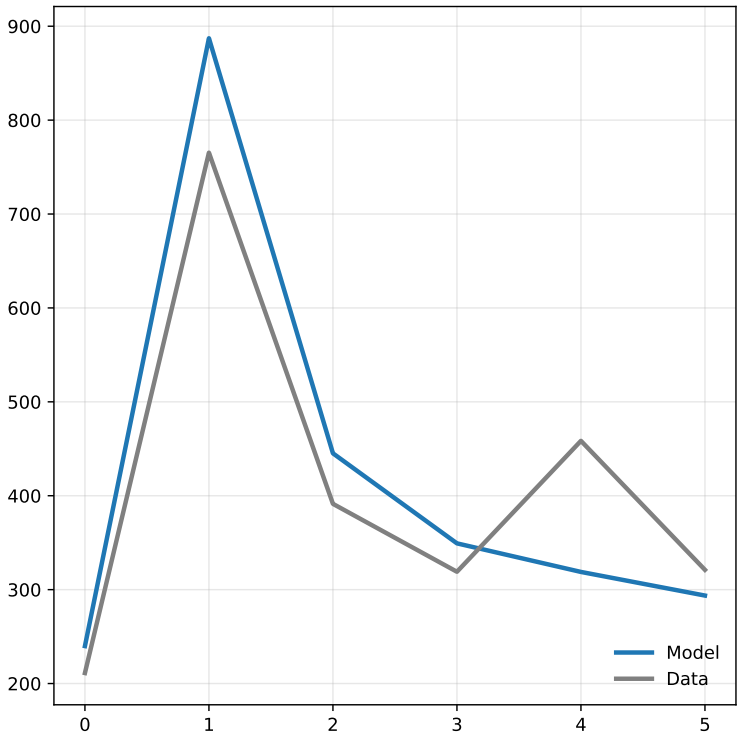


Notes: The left panel shows the observed path of detrended net worth of global banks during the global financial crisis and the model simulated path of the same variable. The right panel shows the observed average detrended output of EMs during the global financial crisis and the model simulated path from the same variable. The observed data corresponds to the average of the countries in our sample. The model simulated data from both panels show average path of the variables over episodes within the model simulations in which the net worth and the aggregate systemic output fall by an amount that is in an interval centered in the observed drop in the data. All variables are in percent deviation from a linear trend.

of around 550 basis points. The fact that the model is able to reproduce the dynamics of spreads during the global financial crisis provides an additional source of external validation of the model. In the model spreads increase due to two forces. First, the lower realizations of returns in DM risky assets has a negative impact on the aggregate net worth of global banks. With a lower net worth, global banks have to reduce their borrowing to maintain same levels of leverage, and thereby reduce their supply of funds to EMs. Given an aggregate demand of funds from EMs, this reduces bond prices and increases spreads. Second, a drop in EMs output increases spreads due to a combination of an increase in default risk and an amplification effect through the net worth of global banks.

When then use the model to disentangle the relevance of each of the two shocks in the dynamics of spreads during the global financial crisis. For this we analyze spread dynamics during episodes in which only z_{DM} drops and episodes in which only y_{EM} drops. Results, shown in Figure 8, suggest that most of the spread dynamics are due to the shock in DMs.

FIGURE 7. EMs Spread Dynamics during the Global Financial Crisis: Model and Data



Notes: This figure shows the observed path of EM bond spreads during the global financial crisis and the model simulated path of the same variable. The observed data is computed as the simple average of spreads of the countries in our sample. The model simulated data shows the average path of the same variable variables over episodes within the model simulations in which the net worth and the aggregate systemic output fall by an amount that is in an interval centered in the observed drop in the data. Spreads are annual and are expressed in basis points.

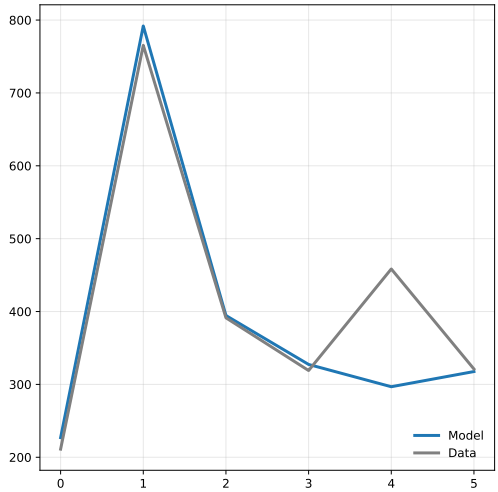
When we only consider episodes in which returns on DM risky assets fall, the spreads from EMs in the model increase as much as they do in the data. On the other hand, when we consider episodes in which only output in EMs falls, spreads modestly increase by only 100 basis points. This exercise suggests that most of the observed dynamics of EMs spreads was due to shocks in DMs, and that global banks played a key role transmitting those shocks, rather than amplifying EM-originated shocks.

6.2. *Amplification of EM-Originated Shocks*

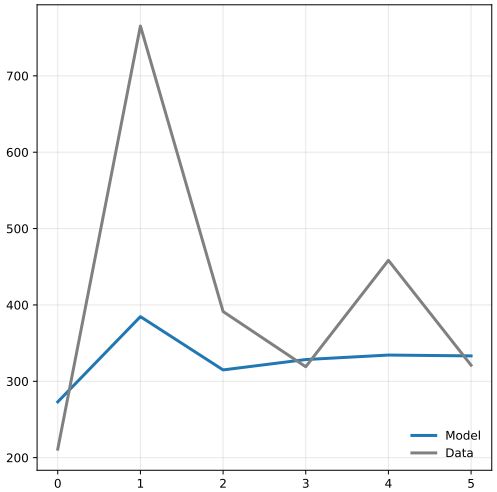
We analyze the effects of output shocks in EM households on debt prices. In particular, we analyze the impulse-response of a negative shock to the systemic and idiosyncratic component

FIGURE 8. Disentangling EMs Spread Dynamics

(A) The Role of shocks in EMs



(B) The Role of shocks in DMs



Notes: The left panel shows the observed path of EM bond spreads during the global financial crisis and the model simulated path of the same variable in episodes in which we only condition in the net worth of global banks drop as in the data. The observed data is computed as the simple average of spreads of the countries in our sample. The model simulated data shows the average path of the same variable variables over episodes within the model simulations in which the net worth fall by an amount that is in an interval centered in the observed drop in the data. The right panel shows observed spreads with model simulated path of spreads in episodes in which we only condition in aggregate output of EMs drop as in the data. The model simulated data shows the average path of the spreads over episodes within the model simulations in which the EM average output falls by an amount that is in an interval centered in the observed drop in the data. Spreads are annual and are expressed in basis points.

of output of equal magnitude.[5] The dynamics of the systemic and idiosyncratic output are shown in Figure A.5. Both negative shocks have the same negative effect on output since they follow the same stochastic process. The dynamics of spreads under both types of shocks and under both calibrations are shown in Figure 9. The left panel show the response spreads to a same negative shock to both components of output in the baseline economy. Both shocks trigger an increase in spreads. This is because a lower output increases the value of default relative to the value of repaying and thus, increases the probability of default. Interestingly, the increase

[5]To compute the responses of a shock to the systemic (idiosyncratic) component of output we simulate the calibrated economies for 1,000,000 periods and identify period in which the systemic (idiosyncratic) component falls by one standard deviation and then trace the dynamics of the variables of interest. We then compute the average response over all identified episodes.

in spreads in response to the both shocks is similar in magnitudes. This suggests the absence of any amplification of systemic shocks through global banks in the baseline calibration.

We then explore the role of the exposure of global banks to EM debt in generating amplification of systemic output shocks. For this we consider an alternative calibration in which we re-calibrate the value of $\mu_{z_{DM}}$ to obtain an exposure to EM debt of 15%, which is double the one in the baseline and is more in line to the observed exposures in 1980s (see Figure A3). In this economy we compute the same impulse-response exercise as in the baseline economy. Results are shown in the right panel of Figure 9. In this economy a negative shock to output can have a differential effect on spreads depending on the nature of the shock. A negative shock to the idiosyncratic component of output of one standard deviation triggers an increase in the spreads of that country of approximately 50bps. On the other hand, a negative shock of the same magnitude to the systemic component of output triggers an increase in spreads that is three times as large as the response to the idiosyncratic shock. We argue next that this differential response is due to the amplification effect that systemic shocks create by affecting the balance-sheets of global banks.

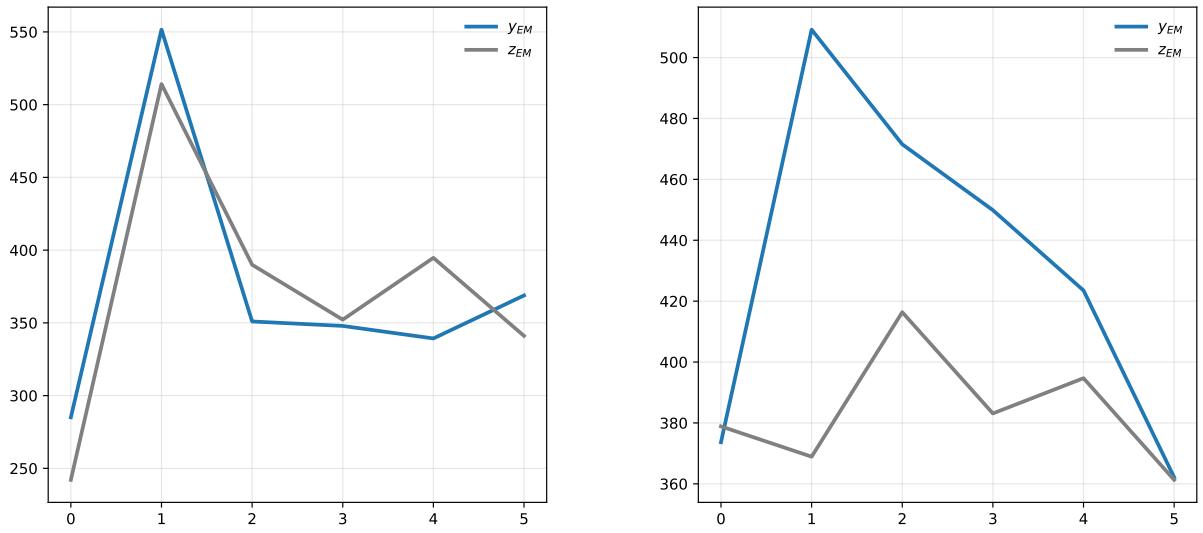
7. Conclusion

In this paper we show that global banks play an important role in the configuration of systemic debt crises in emerging economies. We first document that they hold a sizable portion of the external debt of emerging economies and that these investments represent a relevant fraction of their total assets.

Based on these observations we develop a dynamic model of the world economy in which external borrowing is intermediated by global banks. We find that banks are relevant in the generation and amplification of systemic debt crises. The nature of the role played by global banks in systemic debt crises is governed by their exposure to emerging market debt. When banks are highly exposed, they amplify systemic shocks originated in emerging economies, whereas when their exposure is low, they transmit shocks from other risky assets to the emerging debt market. Our model thus formalizes an old view in policy circles whereby banks are relevant actors in the shaping of global crises in emerging markets, and sheds light into the channels through which they operate.

FIGURE 9. Aggregate Response of Spread to EM Output Shocks

(A) Baseline Economy (B) 'High Exposure' Economy



Notes: This figure shows the evolution of spreads in episodes in which the systemic and aggregate component of EM output fall by one standard deviations. The left panel shows the evolution of spreads in under baseline parametrization. The right panel shows a parametrization that has an exposure of global banks to EM debt of 15%. Spreads are measured in basis points.

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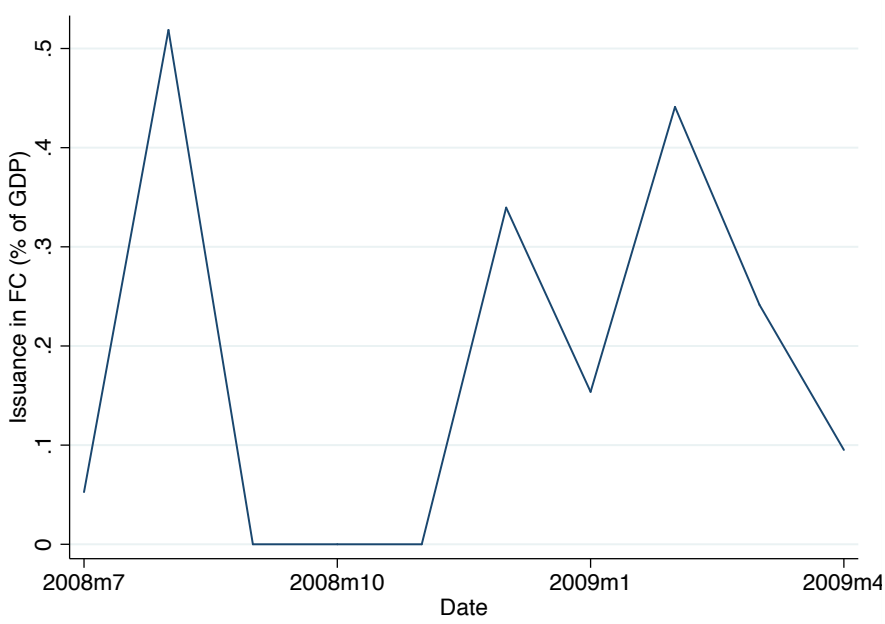
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Appendix A. Additional Figures and Tables

Table A1. Main Global Banks included in the Empirical Analysis of Section .

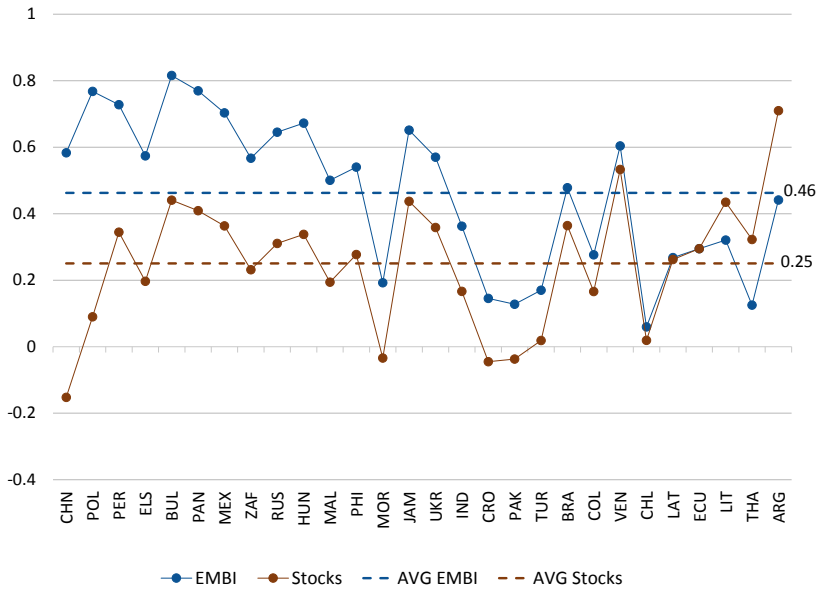
Aegon NV	Hartford	Societe Generale
Allianz SE	Intesa Sanpaolo SpA	Sovereign Bank
American International Group	JPMorgan	Suntrust Banks
Ameriprise Financial Inc	Keycorp	T Rowe Price Group Inc
BNP Paribas	Lehman Brothers	TD Bank
BNYM	M&T Bank	U.S. Bancorp
Bank of America	Merrill Lynch	UBS
Bank of Nova Scotia	MetLife Inc	Unionbancal
Barclays Bank	Mitsubishi UFJ	Wachovia
Bb&T	Morgan Stanley	Wells Fargo
Bear Stearns	NN Group NV	
BlackRock Inc	National City	
CIBC	Nikko Asset Management Co Ltd	
CIT	PNC	
Citigroup	Principal Financial Group Inc	
Comericarporated	Prudential Financial Inc	
Credit Suisse	Regions	
Deutsche Bank	Royal Bank of Canada	
Fifth Third Bancorp	Royal Bank of Scotland	
GE Capital	SVB	

FIGURE A.1. EM Debt Issuance During Lehman Episode



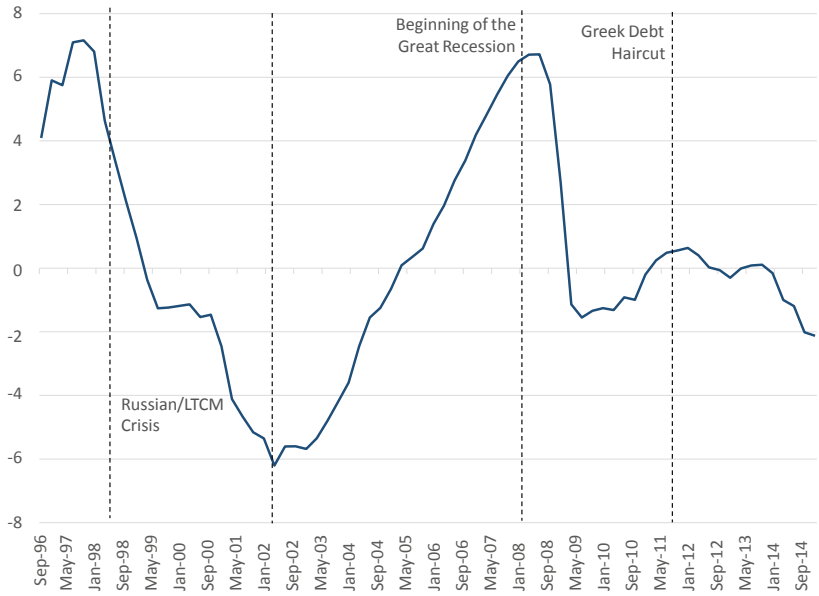
Notes: This figure shows the total amount of new debt issuance in foreign currency by EM economies during the Lehman episode. Issuance is expressed as a function of GDP and averaged across countries.

FIGURE A.2. Returns Co-movements within EMs and with US Stocks



Notes: This figure shows the empirical correlation between a country's sovereign bond total return and the total return of the US stock market, and of the simple average of all other countries' sovereign bonds total returns. We take the S&P500 to represent the US stock market, and JP Morgan EMBI for the countries total return on sovereign bonds.

FIGURE A.3. Systemic Component of Output in Emerging Markets



Notes: This figure shows the systemic component of output, defined as the simple average output of all countries in our sample. Output was log-linearly detrended.

TABLE A2. Balance-Sheets of Major Global Banks: 2017

Bank	Share Sovereign Non-U.S. Debt	Share EM Debt	Ratio Equity to Assets
Santander	25.5%	41%	7.4%
HSBC	24.9%	91.2%	7.8%
Citi	21.1%		10.9%
JPMorgan	12.6%		10.1%
BOFA	5.2%		11.7%
Wells Fargo	2%	61%	10.7%
Average	15.2%	48.3%	9.8%

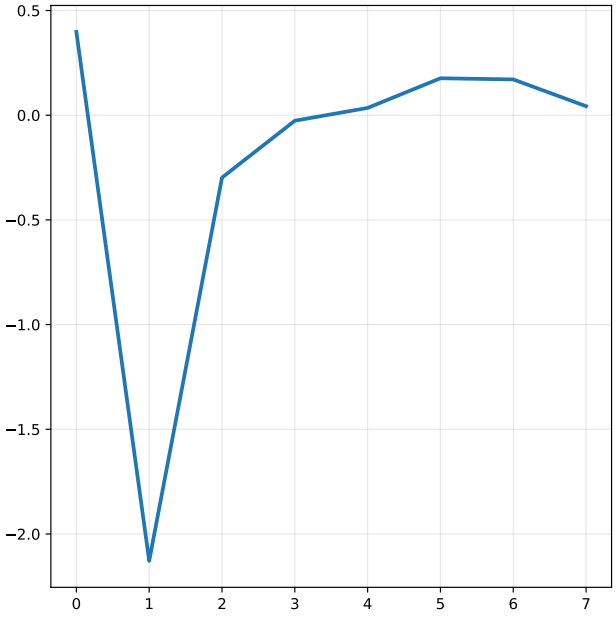
Notes: This table shows selected items of major banks' balance sheets, for 2017. The first column shows the share of banks' claims on non-US sovereigns over risky assets. The second column shows what fraction of those claims are on emerging markets. The last column shows the equity-to-assets ratio of each bank. The last row represents the simple average of each variable. Data is publicly available.

TABLE A3. Balance-Sheets of Major Global Banks: 1982

	1982	1984	1986
Debt-to-Capital			
All Banks	186.5%	156.6%	94.8%
Top 9	287.7%	246.3%	153.9%
Capital-to-Assets	4.8%	6.1%	7.1%
Debt-to-Assets			
All Banks	9.0%	9.6%	6.7%
Top 9	13.8%	15.0%	10.9%

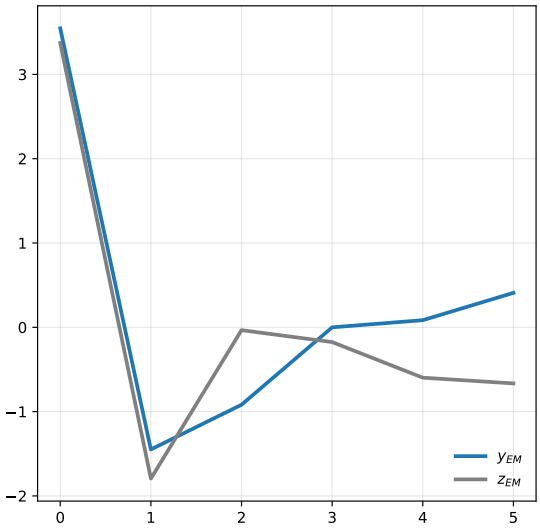
Notes: This table shows selected items of US commercial banks' balance sheets during the 1980's. Debt-to-Capital refers to the ratio of banks' claims on developing countries to banks' primary capital. The Capital-to-Assets variable is the banks' ratio of primary capital to total assets. These two variables are simple averages across banks. Debt-to-Assets is computed as Debt-to-Capital times Capital-to-Assets, and it represents banks' claims on developing countries to banks' total assets. The top nine banks refers to the top nince largest US banks during the 1980's.

FIGURE A.4. DM Productivity in the Model



Notes: This figure shows the model simulated path of DM productivity. The model simulated data shows the average path over episodes within the model simulations in which the net worth and the aggregate systemic output fall by an amount that is in an interval centered in the observed drop in the data. Productivity is measured as percent deviations from a linear trend.

FIGURE A.5. Systemic and Idiosyncratic Output Shocks in the Model



Notes: This figure shows the evolution of the systemic and aggregate component of EM output in model simulated data. The model simulated data shows the average path of the variables over episodes within the variables fall by one standard deviations. Both variables are expressed in percent deviations of a linear trend.

Appendix B. Data Description

B.1. *Data on Debt Prices and Fundamentals*

Our sample consists of those countries that have had some degree of default risk, as reflected by their credit ratings, and have sufficient data availability. In particular, we consider those countries that: (i) have ever had a credit rating that is below A in the Standard and Poor's Global Ratings scale, and (ii) have at least 10 years of available data on debt prices and output. 28 countries met the sample criteria, namely, Argentina, Brazil, Bulgaria, Chile, China, Colombia, Croatia, Ecuador, El Salvador, Hungary, Indonesia, Jamaica, Latvia, Lithuania, Malaysia, Mexico, Morocco, Pakistan, Panama, Peru, Philippines, Poland, Russia, South Africa, Thailand, Turkey, Ukraine and Venezuela. The sample period ranges from 1994 to 2014. However, data on particular countries may start later or end earlier, depending on their availability of data.

For all countries in the sample we collect data on debt prices of sovereign debt, as well as data on output. Debt price data consists on data on sovereign spreads of a synthetic basket of bonds of each country, computed by JP Morgan's Emerging Markets Bond Index (EMBI). A bond spread is the excess yield of the bond over the yield of a risk-free zero-coupon bond (i.e., a US Treasury) of the same maturity. A countrys spread is a synthetic measure of the spreads of a representative basket of bonds issued by that country. It measures the implicit interest rate premium required by investors to be willing to invest in a defaultable bond of that particular country. Spreads data was obtained from Datastream.

Data on real GDP at a quarterly frequency was obtained from national sources and IMF.

Appendix C. Model Recursive Representation

This section provides a recursive representation of the model of the global economy developed in Section 3. Within each period, the timing is as follows:

i. At the beginning of each period exogenous aggregate state, $\mathbf{s}_x \equiv \{z_{DM}, y_{EM}\}$, and exogenous idiosyncratic state, $(z_i, \zeta_i)_{i\in[0,1]}$, are realized.

ii. *Repayment stage*. EM households choose repayment. The aggregate state in this stage is given by $\mathbf{s}_- \equiv \{\mathbf{s}_x, A_{DM}, D, G_-(b,z)\}$, where $G_-(b,z)$ is the joint distribution of debt and idiosyncratic output at the repayment stage of EM economies that borrowed in the previous period. A random fraction $(1-\sigma)$ of global banks exit, and equal mass of banks enter the economy.

iii. *Borrowing stage*. Global banks choose their portfolio, DM households their savings, non-financial firms production, and EMs household their borrowing. The aggregate state at this stage is denoted by $\mathbf{s}_+ = (\mathbf{s}_x, G_n(n), G_+(b,z))$, where G_n is the distribution of net worth across global banks at the borrowing stage, and $G_+(b,z)$ is the joint distribution of debt and idiosyncratic output across EM borrowers that can borrow at the borrowing stage.

Global Banks' Recursive Problem Denoting by n the idiosyncratic net worth of a global bank at the lending stage, its recursive problem is given by

$$v(n, \mathbf{s}_+) = \max_{\{a_{EM,(b,z)} \geq 0\}, a_{DM} \geq 0, d} div + \beta_{DM}[\sigma \mathbb{E} v(n', \mathbf{s}'_+) + (1-\sigma)n'] \tag{18}$$

subject to

$$\begin{aligned}
n + d &= \int\int_{(b,z):\mathrm{d}G_+(b,z)>0} a_{EM,(b,z)} \mathrm{d}b\mathrm{d}z + a_{DM} + div \\
\kappa &\left(\int\int_{(b,z):\mathrm{d}G_+(b,z)>0} a_{EM,(b,z)} \mathrm{d}b\mathrm{d}z + a_{DM} \right) \leq n, \\
n' &= \int\int_{(b,z):\mathrm{d}G_+(b,z)>0} R_{EM,(b,z)}(\mathbf{s}_+, \mathbf{s}'_-) a_{EM,(b,z)} \mathrm{d}b\mathrm{d}z + R_{DM}(\mathbf{s}'_-) a_{DM} - \beta_{DM}^{-1} d,
\end{aligned}$$

where $a_{EM}(b,z)$ denotes the mass of securities purchased from a economies with borrowing b and idiosyncratic income z, $R_{EM,(b,z)}(\mathbf{s}_+, \mathbf{s}'_-) = \frac{\mathbb{E}_{z'|z} \iota(b'(b,z,\mathbf{s}_+), z', \mathbf{s}'_-)}{q(b,z,\mathbf{s}_+)}$, $R_{DM}(\mathbf{s}'_-) = z'_{DM} \alpha \tilde{A}_{DM}(\mathbf{s}_+)^{\alpha-1} + (1-\delta)$, and $\tilde{A}_{DM}(.)$ denotes the perceived policies for aggregate DM assets at the borrowing stage describing. The law of motion of the aggregate state $\mathbf{s}_+$ from the repayment stage is given by $\mathbf{s}_+ = \Gamma_+(\mathbf{s}_-, \tilde{\iota}(\hat{b}, \hat{z}, \mathbf{s}_-))$, where $\tilde{\iota}(b, z, \mathbf{s}'_-)$ is borrower's perceived repayment policy; the law of motion of the aggregate state $\mathbf{s}'_-$ from the borrowing stage is given by $\mathbf{s}'_- = \Gamma_-(\mathbf{s}_+, \mathbf{s}'_x, \tilde{A}_{DM}(\mathbf{s}_+), \tilde{D}(\mathbf{s}_+), \tilde{b}'(\hat{b}, \hat{z}, \mathbf{s}_+))$, and $\tilde{A}_{DM}(.), \tilde{D}(.), \tilde{b}'(.)$ denote perceived policies at the borrowing stage describing, respectively, aggregate DM assets, deposits, and EM borrowing. The laws of motion $\Gamma_+(.)$, $\Gamma_-(.)$ and perceived policies are equilibrium objects in the model, taken as given by global banks and EM borrowers. Note that this formulation uses the equilibrium deposit rate obtained from DM household's problem $R_{dt} = \beta_{DM}^{-1}$.

EMs' Recursive Problem. At the repayment state, borrower's repayment decision is characterized by the following problem:

$$V(b, z, \mathbf{s}_-) = \max_{\iota} \iota V^r(b, z, \mathbf{s}_+) + (1-\iota) V^d(z, \mathbf{s}_+) \tag{19}$$

where $V^r(b, z, \mathbf{s}_+)$ and $V^d(z, \mathbf{s}_+)$ denote, respectively, the value of repayment and value of default, described below.

At the borrowing stage, borrower's debt issuance decision is characterized by the problem

$$V^r(b,z,\mathbf{s}_+) = \max_{b'} u(c) + \beta \mathbb{E}\left[V(b',z',\mathbf{s}'_-)\right] \tag{20}$$

$$\text{s.t. } c = y_{EM} + z + q(b',z,\mathbf{s}_+)b' - b.$$

Finally, the value of default is given by

$$V^d(z,\mathbf{s}_+) = \max_{b'} u(c) + \beta \mathbb{E}\left[\phi V^r(0,z',\mathbf{s}'_+) + (1-\phi)V^d(z',\mathbf{s}'_+)\right] \tag{21}$$

$$\text{s.t. } c = \mathcal{H}(y_{EM} + z).$$

Equilibrium Definition. We can now define a recursive equilibrium as follows:

DEFINITION **2.** *A Recursive Equilibrium consists of global banks' policies* $\left\{a_{EM,(b,z)}(n,\mathbf{s}'_+), a'_{DM}(n,\mathbf{s}'_+), d'_{DM}(n,\mathbf{s}'_+)\right\}$ *and value function* $v(n,\mathbf{s}'_+)$*, borrowers' policies* $\{\iota(b,z,\mathbf{s}'_-), b'(b,z,\mathbf{s}'_+)\}$ *and value functions* $\{V(b,z,\mathbf{s}_-), V^r(b,z,\mathbf{s}_+), V^d(z,\mathbf{s}_+)\}$*, prices schedules* $q(b',z,\mathbf{s}_+)$*, laws of motion of aggregate states* $\Gamma_+(\mathbf{s}'_-, \tilde{\iota}(\hat{b},\hat{z},\mathbf{s}'_-)), \Gamma_-(\mathbf{s}_+,\mathbf{s}'_x,\tilde{A}'_{DM}(\mathbf{s}_+),\tilde{D}'(\mathbf{s}_+),\tilde{b}'(b,z,\mathbf{s}_+))$ *and perceived policies* $\{\tilde{\iota}(b,z,\mathbf{s}'_-),\tilde{b}'(b,z,\mathbf{s}_+),\tilde{A}'_{DM}(\mathbf{s}_+),\tilde{D}'(\mathbf{s}_+)\}$ *such that:*

1. *Given prices, laws of motion, and perceived policies, global banks policies and value function solve their recursive problem* (18)*.*
2. *Given prices, laws of motion, and perceived policies, borrowers' policies and value functions solve their recursive problem* (19) - (21)*.*
3. *Asset markets clear.*
4. *Law of motion of aggregate state are consistent with individual policies.*
5. *Perceived policies coincide with optimal policies.*