Global Banks and Systemic Debt Crises*

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Abstract. We study the role of global financial intermediaries in international lending. We construct a model of the world economy, in which heterogeneous borrowers issue risky securities purchased by financial intermediaries. Aggregate shocks transmit internationally through financial intermediaries' net worth. The strength of this transmission is governed by the degree of frictions intermediaries face in financing their risky investments. We provide direct empirical evidence on this mechanism showing that around Lehman Brothers' collapse, emerging-market bonds held by more distressed global banks experienced larger price contractions. A quantitative analysis of the model shows that global financial intermediaries play a relevant role in driving borrowing-cost and consumption fluctuations in emerging-market economies, during both debt crises and regular business cycles. The portfolio of financial intermediaries and the distribution of bond holdings in the world economy are key to determine aggregate dynamics.

Keywords: Financial intermediaries, international lending, external debt crises, sovereign default, sudden stops, heterogeneous-agent models

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1. Introduction

Debt crises in emerging-market economies are global in nature, affecting multiple economies in a synchronized fashion and involving 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 late 1990s, linked to the collapse of the LTCM fund; and the recent global financial crisis, linked to U.S. and European banks and affecting most emerging-market 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.

In this paper, we reassess this long-held view in policy circles by studying the role of global financial intermediaries in international lending. We do so by developing a heterogeneous-agent model of the world economy with risky lending, and provide new empirical evidence on the relationship between global financial intermediaries and emerging-market debt prices. In the model, borrowers issue risky securities purchased by financial intermediaries, and aggregate shocks transmit internationally through financial intermediaries' net worth. The strength of this mechanism is governed by the degree of financial frictions that intermediaries face in financing their risky investments. We then provide empirical evidence on this mechanism, showing that well-identified shocks to financial intermediaries' net worth affect bond prices in emerging-market economies. We exploit variation in the prices of emerging-market bonds with similar observed characteristics during a short window around Lehman Brothers' bankruptcy, and document larger price drops in bonds held by more affected financial intermediaries. Finally, we conduct a quantitative analysis of the model, which uses the empirical evidence as well as other key data, and show that global financial intermediaries play a relevant role in driving fluctuations of borrowing costs and consumption in emerging-market economies, during both debt crises and regular business cycles.

We begin by laying out a model of risky international lending. We model a world economy composed of a set of heterogeneous emerging economies that face systemic and idiosyncratic income shocks and borrow from developed economies without commitment. Global financial firms intermediate in this lending process, but face financial frictions in linking investments in risky securities to their net worth. The model, while rich enough to be quantified and mapped to the data, hinges on critical 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 equate global supply and demand of funds for risky assets. In this way, negative aggregate shocks lower financial intermediaries' net worth, contract the supply of funds, and increase the intermediation premium. The strength of this mechanism is governed by the financial frictions faced by intermediaries, which determine their marginal costs of external finance. When these marginal costs are large, shocks that affect intermediaries' net worth lead to large effects on emerging-market bond prices, since they require higher returns to be willing to raise external finance and purchase risky securities. In fact, in the opposite extreme case, when intermediaries face no financial frictions, debt prices do not respond to changes in intermediaries' net worth.

Motivated by the model's predictions, we analyze the empirical relationship between emerging-market bond prices and financial institutions' net worth. In the aggregate, these two variables are strongly negatively correlated, with periods such as the recent global financial crisis being characterized by spikes in emerging-market spreads. However, the main empirical challenge for drawing conclusions about this relationship is that changes in financial institutions' net worth can be linked to other factors that drive emerging-market default risk. Therefore, we propose an empirical strategy that builds on the empirical finance literature and exploits high-frequency variation in individual bond prices. We identify the effect of changes in global financial intermediaries' net worth on emerging-market bond prices by relating the average contraction in the net worth of the institutions holding a particular bond in a narrow window around the Lehman-bankruptcy episode to its subsequent price drop. The main idea of this empirical strategy is that bonds of a given country–sector with comparable observable characteristics have similar default and liquidity risk, but are held by financial intermediaries differentially affected during the Lehman-bankruptcy episode. To measure the average contraction in the net worth of the financial intermediaries holding a particular bond, we collect data on each financial intermediary's holdings 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 suffered a contraction in net worth one standard deviation higher than the mean experienced a price contraction 50% larger than that of the average bond.

We then use a quantitative version of the model, disciplined by our empirical estimates as well as other key data, to assess the relevance of global financial intermediaries in international lending. The model, solved with a combination of global methods and an approximation of the distribution of assets in the world economy, is consistent with important comovements of international asset prices, as well as with individual emerging-economy business cycles. Our first main quantitative result is that global banks play a central role in the emerging economies' borrowing costs and consumption dynamics, during both debt crises and in regular business cycles. In debt crises, we show that a contraction in the net worth of global financial intermediaries similar to that observed during 2007–2009 can explain more than two-thirds of the increase in borrowing costs and more than one-third of the consumption adjustment, or "sudden stop," observed in emerging economies during this period. Moreover, global financial intermediaries are also relevant in regular business cycles, accounting for 40% of the fluctuations in emerging economies' borrowing costs, with the remainder explained by fluctuations in the default risk.

We then conduct a set of exercises that highlight the value of modeling risky lending and borrowing in the global economy, relative to assuming an exogenous stochastic discount factor in an otherwise standard model of sovereign debt, which is a common practice in the literature. First, we identify elements that matter for the transmission and amplification of aggregate shocks: the exposure of global financial intermediaries to emerging economies and the distribution of debt in the world economy. With the current observed exposure (around 10% of risky assets), global financial intermediaries mostly play a role in transmitting shocks that originate in developed economies. However, when this exposure is higher, around the levels observed in the 1980s (three times the current levels), global financial intermediaries also amplify shocks that originate in emerging economies, through a feedback effect between the supply of funds and emerging economies' default rates. In this case, the distribution of debt shapes the feedback effect, with more dispersion in debt positions leading to higher default rates for a given negative output shock. Second, we assess the effects of global policies of liquidity provision to financial intermediaries on emerging economies' borrowing costs and consumption dynamics during debt crises. We show that policies that reduce funding rates for global banks during recessions in developed economies attenuate the transmission of the shock to emerging economies, with borrowing costs increasing by half of what they would in the absence of these policies.

Related literature

Our paper contributes to several strands of the literature. First, a growing body of research on financial intermediaries and asset prices argues that financial intermediaries are likely to be the marginal investor in several asset markets, and links asset-price dynamics to frictions in financial intermediation. For examples of theories, see Gertler and Kiyotaki (2010); He and Krishnamurthy (2011, 2013); Brunnermeier and Sannikov (2014); for examples of empirical evidence, see Adrian et al. (2014); He et al. (2017); Du et al. (2019); see also He and Krishnamurthy (2018) for a recent survey.[1] The closest papers on the role of financial intermediaries in international asset prices are Gabaix and Maggiori (2015) and Maggiori (2017), who study exchange-rate determination in imperfect financial markets. Our contribution to this literature is twofold. First, our empirical analysis provides direct evidence on the intermediary-based asset pricing channel for emerging-market debt. Second, the analysis of our world-economy model shows that the wealth dynamics of global financial intermediaries are central in determining aggregate emerging-market borrowing and consumption dynamics.

Second, our paper is related to the literature on sovereign debt and default. This literature argues that default risk is an important driver of the dynamics of external borrowing and consumption in emerging economies (see, for example, Aguiar and Gopinath, 2006; Arellano, 2008). In a recent survey, Aguiar et al. (2016) suggest the relevance of enriching the lender side in sovereign-debt models. To date, this has been done by introducing more flexible stochastic discount factors in the pricing of debt (see, for example, Borri and Verdelhan, 2011; Lizarazo, 2013; Tourre, 2017; Bianchi et al., 2018; Bocola and Dovis, 2019; Bai et al., 2019) and analyzing amplification and contagion through lenders (see Park, 2014; Bocola, 2016; Arellano et al., 2019). Our paper contributes to this literature by quantifying a theory that links the balance

[1] Other related papers study intermediaries-driven fire sales in the context of CDS and corporate bonds (Coval and Stafford, 2007; Mitchell et al., 2007; Siriwardane, 2019).

sheets of global financial intermediaries to the behavior of asset prices and risky borrowing in the world economy.

Third, the paper is related to the literature on international capital flows and the global financial cycle. This literature has documented a large comovement in debt and equity prices across countries (see, for example, Forbes and Rigobon, 2002; Longstaff et al., 2011; Borri and Verdelhan, 2011), a strong link between international capital flows, domestic lending, and the occurrence of "sudden stops" in emerging economies (examples include Calvo, 1998; Mendoza, 2010; Rey, 2015; Kalemli-Özcan, 2019), and a relevant role of global banks in the transmission of international shocks (see, for example, Devereux and Yetman, 2010; Cetorelli and Goldberg, 2011; Bruno and Shin, 2015b; Baskaya et al., 2017; Cao et al., 2020; Correa et al., 2020). Our paper shows that global financial intermediaries can play a central role in these patterns. In this sense, our results provide a micro foundation for exogenous fluctuations in external borrowing costs, which have been identified as important drivers of consumption, output, and exchange-rate dynamics (see Neumeyer and Perri, 2005; García-Cicco et al., 2010).

Finally, our paper is related to the growing body of research that studies the role of agents' heterogeneity in the transmission of aggregate shocks. Most of the advances in this literature occurred in the context of closed economies (prominent examples include Krusell and Smith, 1998; Khan and Thomas, 2008; Kaplan et al., 2018). We contribute to this literature by analyzing the role of agent heterogeneity and the composition of financial intermediaries' balance sheets in the the transmission of international shocks. Methodologically, our work is related to a set of papers that use microlevel moments to discipline macro theories (see the work surveyed in Nakamura and Steinsson 2018 and Arellano et al. (2019) for examples in the context of sovereign debt).

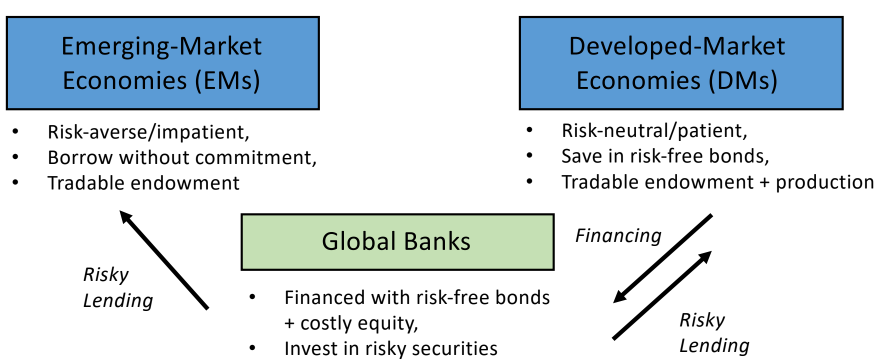
The rest of the paper is organized as follows. Section 2 lays out the model and discusses the channels through which global banks amplify and transmit shocks in the risky-debt market. Section 3 presents the empirical evidence. Section 4 presents the calibration and performs the main quantitative exercises, and Section 5 concludes.

2. A Model of the Global Debt Market

We construct a framework to study the role of financial intermediaries in global lending markets. The world economy consists of a set of emerging-market economies (EMs) and a set of developed-market economies (DMs). Households in these two types of economies differ in their preferences, which gives rise to international lending. EM households are risk-averse and impatient, while DM households are risk-neutral and patient. Households in EMs are endowed with a stochastic stream of tradable goods with systemic and idiosyncratic components that lead to heterogeneity across EMs. We interpret household borrowing in a broad sense and capture direct international borrowing, sovereign borrowing, and borrowing through other agents (e.g., local banks). EMs lack commitment to repay their debt and can default.

The model's key feature is that international lending is mediated by financial intermediaries (*global banks*). DM households provide finance to global banks using a risk-free bond (*deposits*) and equity. Intermediaries face frictions in their intermediation activity that limit their ability to raise funds from DMs. They lend these funds to EM households using risky bonds or invest them in risky DM technologies. Figure 1 graphically represents the global economy.

Figure 1. The World Economy



2.1. *Emerging Economies*

There is a continuum of mass μ_{EM} of heterogeneous emerging economies, indexed by $i \in [0, \mu_{\text{EM}}]$. Each emerging economy is populated by a unit mass of identical households with preferences described by the lifetime utility

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_{\text{EM}}^t u(c_{it}), \tag{1}$$

where $u(\cdot)$ is increasing and concave, c_{it} denotes consumption of the representative EM household i in period t, and $\beta_{\text{EM}} \in (0,1)$ is the EM household's subjective discount factor. Each period, EM households receive a stochastic endowment of tradable goods, with a systemic component $y_{\text{EM}t}$, common across all EMs, and an idiosyncratic component z_{it}. After observing the realization of their endowment, households choose to repay the debt they inherited from the previous period ($\iota_{it} = 1$) or default ($\iota_{it} = 0$). Defaulting households lose access to external credit markets and reenter when the random variable $\psi_{it} \sim \text{Bernoulli}(\theta)$ equals one. This implies that households remain in financial autarky for a stochastic number of periods. Households that have access to external credit markets can issue long-term bonds with a deterministic decay rate. In particular, by issuing one unit of the bond in period t, the government promises to repay one unit of goods in period $t+1$, ξ in period $t+2$, ξ^2 in period $t+3$, and so on, and in exchange receives $q_{\text{EM}t}^i$ units of goods in period t.[2] Denoting by b_t the amount of coupons to be paid in period t, the law of motion of these coupons is given by $b_{t+1} = \xi b_t + i_t$, where i_t denotes the period t issuance of new bonds. Households' sequential budget constraint in periods with access to international markets is then

$$c_{it} = y_{\text{EM}t} + z_{it} + q_{\text{EM}t}^i \left(b_{it+1} - \xi b_{it}\right) - b_{it}. \tag{2}$$

Households excluded from global capital markets simply consume their endowments $c_{it} = \mathcal{H}(y_{\text{EM}t} + z_{it})$, 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 A. As is standard in default problems, the price $q_{\text{EM}t}^i$ depends on the aggregate and individual states of the households as well as on their borrowing choices, b_{it+1}.

In partial equilibrium, this problem is equivalent to a standard borrowing problem in a small open economy with default (e.g., Aguiar and Gopinath, 2006; Arellano, 2008). However, the bond-price schedule faced by EM households in this economy will be affected by the interaction

[2]The convenience of this type of contract, frequently used in the sovereign-debt and corporate finance literature, is its recursive structure. The case of $\xi = 0$ corresponds to short-term debt, and as ξ increases, so does the maturity of the bond.

between global banks, the distribution of debt positions across EMs, and systemic variables introduced by our framework.

2.2. *Developed Economies*

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

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_{\text{DM}}^{t} c_{\text{DM}t}, \tag{3}$$

where $c_{\text{DM}t}$ denotes consumption and $\beta_{\text{DM}} \in (\beta_{\text{EM}}, 1)$ the DM household's subjective discount factor. Each period, households receive an endowment of tradable goods y_{DM} and time to work $\overline{h}$.[3] They can save in risk-free bonds issued by global banks (i.e., deposits) that pay a return R_{dt} for every unit of deposit in $t+1$. Their sequential budget constraint is given by

$$c_{\text{DM}t} = y_{\text{DM}} + w_t \overline{h} + R_{dt} d_t - d_{t+1} + \pi_t, \tag{4}$$

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

The DM household's problem is to choose state-contingent plans $\{c_{\text{DM}t}, d_{t+1}\}_{t=0}^{\infty}$ to maximize (3) subject to (4), taking as given prices $\{R_{dt}, w_t\}_{t=0}^{\infty}$ and transfers $\{\pi_t\}_{t=0}^{\infty}$. Households' optimization delivers a constant equilibrium interest rate for deposits, $R_{dt} = \beta_{\text{DM}}^{-1} \equiv R_d$.

Nonfinancial firms. DM economies are also populated by representative nonfinancial firms with access to technologies to produce tradable goods $y_{\text{F}t}$ and accumulate capital k_{t+1}:

$$y_{\text{F}t} = \omega_t k_t^{\alpha} h_t^{(1-\alpha)}, \tag{5}$$

$$k_{t+1} = \omega_t \left(1-\delta\right) k_t + i_t, \tag{6}$$

[3]We introduce the endowment y_{DM} to make explicit that our framework can accommodate production sectors in DMs that are not financed by global banks—for instance, small firms financed by regional U.S. banks. Due to the risk-neutrality of DM households, making this process stochastic would not play any role in equilibrium.

with $\alpha, \delta \in (0,1)$, where h_t are hours of work, i_t is firm investment, and ω_t is an aggregate shock that affects productivity and capital quality with a bounded support.[4] The shock to DM firms is potentially correlated with the aggregate shock to EMs, y_{EM}, with the correlation between the two shocks given by the parameter $\rho_{\text{EM,DM}} \in [-1,1]$. Nonfinancial DM firms are owned by global banks, which we describe next.

2.3. *Global Banks*

Global banks—financial firms owned by DM households—engage in financial intermediation in the world economy. Their objective is to maximize the lifetime discounted payouts transferred to DM households,

$$\max \mathbb{E}_t \sum_{s=0}^{\infty} \beta_{\text{DM}}^{s-t} \pi_{jt+s}, \tag{7}$$

where π_{jt} denotes the net payments of bank j to households in period t. Each bank can invest in two types of risky securities: claims on nonfinancial firms from DM economies, $a_{\text{DM}jt}$, and bonds issued by EMs, $\{a^i_{\text{EM}jt}\}_{i\in\mathcal{I}_t}$, where i indexes a particular EM economy and $\mathcal{I}_t$ the set of EMs that issue bonds in period t. The amount of final goods each bank obtains from these investments, or net worth, is given by

$$n_{jt} = \int_{i\in\mathcal{I}_{t-1}} R^i_{\text{EM}t} q^i_{\text{EM}t-1} a^i_{\text{EM}jt-1}\,\mathrm{d}i + R_{\text{DM}t} q_{\text{DM}t-1} a_{\text{DM}jt-1} - R_d d_{jt-1}, \tag{8}$$

where $\{R^i_{\text{EM}t}\}_{i\in\mathcal{I}_{t-1}}$ is the set of returns of EM bonds in period t, $R_{\text{DM}t}$ is the return of the claims of nonfinancial firms in DM economies in period t, and $q_{\text{DM}t}$ is its price. Banks use their net worth, as well as risk-free deposits from DM households, to finance investments in risky securities and dividend payments, div_{jt}:

$$n_{jt} + d_{jt} = \int_{i\in\mathcal{I}_t} q^i_{\text{EM}t} a^i_{\text{EM}jt}\,\mathrm{d}i + q_{\text{DM}t} a_{\text{DM}jt} + div_{jt}. \tag{9}$$

Banks face frictions in financing their investments. First, they face a borrowing constraint that links their deposits to their net worth,

$$d_{jt} \leq \kappa n_{jt}, \tag{10}$$

[4]Shocks to the quality of capital are frequently used in the macrofinance literature (see, for example, Bernanke et al., 1999; Gertler and Kiyotaki, 2010) as a stylized disturbance that can generate realistic variations in investment returns.

where $\kappa > 0$.[5] In addition, although banks can raise equity to finance the purchase of their risky assets (i.e., $div_{jt} < 0$), we assume that raising equity is a costly source of financing, entailing a cost of $\mathcal{C}(-div_{jt}, n_{jt})$ units of final goods per unit raised, with $\mathcal{C}(div, n) = \phi\left(\frac{-div}{n}\right)$. Following the quantitative corporate finance literature (e.g., Gomes, 2001; Hennessy and Whited, 2007), these costs are designed to capture flotation costs and adverse-selection premia associated with raising external equity. We interpret ϕ in a broad sense, as capturing the marginal cost of raising external finance, which includes outside equity and other sources of external finance such as issuing costly risky debt or expanding the customer base in the case of asset managers.

The net payouts to DM households in a given period are then given by

$$\pi_{jt} = div_{jt}(1 + \mathbb{I}_{div_{jt}<0}\mathcal{C}(div_{jt}, n_{jt})). \tag{11}$$

Finally, to ensure that banks do not outgrow their financial frictions, we assume that they exit with an exogenous i.i.d. probability $(1 - \sigma)$ (see, for example, Gertler and Kiyotaki, 2010). Each period, a mass of $(1 - \sigma)$ new banks enter the economy, so that the total mass of global banks is always fixed at one. New banks are endowed with net worth $\overline{n}$.

The bank's problem is to choose state-contingent plans $\{\{a^i_{\text{EM}jt}\}, a_{\text{DM}jt}, d_{jt}, div_{jt}\}$ to maximize (7) subject to (8), (9), (10), and (11). Appendix A shows the bank's recursive problem, which is linear in its net worth. Define the expected risk-adjusted returns on EM and DM assets, and deposits as $R^e_{\text{EM}it} \equiv \mathbb{E}_t[\sigma\beta_{\text{DM}}v_{t+1}R^i_{\text{EM}t+1}]$, $R^e_{\text{DM}t} \equiv \mathbb{E}_t[\sigma\beta_{\text{DM}}v_{t+1}R_{\text{DM}t+1}]$, $R^e_{dt} = \mathbb{E}\left[\sigma\beta_{\text{DM}}v_{t+1}\right]R_d$, where v_t is the marginal value of net worth for global banks, formally defined in Appendix A; and let $\zeta_t \geq 0$ be the Lagrange multiplier associated to the borrowing constraint. Focusing on an equilibrium in which banks always issue equity and invest in all securities, the solution of the bank's portfolio problem is characterized by the following

[5] This borrowing constraint can emerge from an agency friction by which the banker can use the funds raised from deposits to start a new franchise. Alternatively, the constraint can be interpreted as the presence of regulatory capital requirements.

equations:

$$R^e_{\text{EM}it} = R^e_{\text{DM}t} \equiv R^e_{At}, \tag{12}$$

$$\sigma\left(1 - 2\phi\left(\frac{div_{jt}}{n_{jt}}\right)\right) = R^e_{dt} + \zeta_{jt} \equiv R^e_{jXt}, \tag{13}$$

$$R^e_{At} = R^e_{jXt}, \tag{14}$$

and the complementary slackness condition $\zeta_{jt}(\kappa n_{jt} - d_{jt}) = 0$, for $i \in \mathcal{I}_t$ and $j \in [0,1]$. Equation (12) implies that the global bank equates expected returns across asset classes. Equation (13) implies equal marginal costs of the two sources of finance: the bank equates its marginal cost of equity to its shadow marginal cost of deposits. Finally, equation (14) equates its marginal cost of finance, R^e_{jXt}, to the expected return on risky assets, R^e_{At}. Equations (12)-(14) also imply that there exists a global banks' stochastic discount factor m_{t+1} that prices risky EM assets, i.e., $\mathbb{E}\left[m_{t+1}R^i_{\text{EM}t+1}\right] = 1$ for all i. This discount factor is given by $m_{t+1} = \frac{\beta_{\text{DM}}\nu_{t+1}}{1+2\phi x_t}$, where $x_t \equiv \frac{-div_{jt}}{n_{jt}}$ is the banks' optimal equity issuance relative to their net worth, which is the same for all banks j. This indicates that states with a higher marginal cost of external finance are associated with a lower stochastic discount factor, all else equal.

2.4. *Equilibrium*

Appendix A defines a competitive equilibrium in the global economy. In equilibrium, the clearing of asset markets implies that global banks' investment in each risky security traded in the global economy equalizes the amount of that type of security issued:

$$A^i_{\text{EM}t} \equiv \int_{j\in[0,1]} q^i_{\text{EM}t} a^i_{\text{EM}jt}\,\mathrm{d}j = q^i_{\text{EM}t} b_{it+1}, \qquad A_{\text{DM}t} \equiv \int_{j\in[0,1]} a_{\text{DM}jt}\,\mathrm{d}j = k_{t+1}.$$

This equation implicitly normalizes the aggregate amount of DM securities to the aggregate capital stock. A consequence of this normalization is that the equilibrium price of DM securities is one, $q_{\text{DM}t} = 1$. The returns of securities are given by $R^i_{\text{EM}t+1} = \frac{\iota_{it+1}\left(1+\xi q^i_{EMt+1}\right)}{q^i_{EMt}}$ and $R_{\text{DM}t+1} = \omega_{t+1}\left[\alpha A^{\alpha-1}_{\text{DM}t} + 1 - \delta\right]$.

2.5. *The Role of Global Banks in International Lending*

We now discuss the main channels through which global banks affect EM debt by considering an economy without aggregate uncertainty and studying the effects of fully unanticipated aggregate shocks. These channels are the main driving forces in the quantitative analysis of the model with aggregate shocks, which we study in Section 4. The equilibrium determination of EM required returns and borrowing can be illustrated with a demand–supply-of-funds scheme. On the lender side, combining optimal portfolio and financing choices across banks, we obtain a positive relationship between the generic required returns on any EM bond, $R^e_{\text{EM}t}$, and the aggregate EM bonds acquired by global banks, which we label *aggregate supply* of funds to EMs:

$$\mathcal{A}^s_t(R^e_{\text{EM}t}, N_t) = \underbrace{N_t(1+\kappa)}_{\substack{\text{Net worth}\\ +\text{New deposits}}} + \underbrace{\mathcal{X}(R^e_{\text{EM}t}, \phi)N_t}_{\text{Equity issuance}} - \underbrace{\mathcal{A}_{\text{DM}t}(R^e_{\text{EM}t}, \alpha)}_{\text{Investment in DM firms}}, \tag{15}$$

where $\mathcal{A}^s_t(R^e_{\text{EM}t}, N_t) \equiv \int_{i\in\mathcal{I}_t}\int_{j\in[0,1]} q^i_{\text{EM}t} a^i_{\text{EM}jt}\,\mathrm{d}j\,\mathrm{d}i$; $N_t \equiv \int_{j\in[0,1]} n_{jt}\,\mathrm{d}j$ is banks' aggregate net worth at t; $\mathcal{X}(R^e_{\text{DM}t}, \phi) \equiv \int_{j\in[0,1]}\left(\frac{-div_{jt}}{n_{jt}}\right)\mathrm{d}j = x_t$ denotes the aggregate equity raised by banks per unit of net worth, which, as indicated in the last equality, is the same for all banks; and $\mathcal{A}_{\text{DM}t}(R^e_{\text{EM}t}, \alpha) \equiv A_{\text{DM}t}$ denotes banks' investments in DM firms.[6] This relationship between funds supplied and required returns is increasing (i.e., $\frac{\partial A^s_t}{\partial R^e_{\text{EM}t}} > 0$). To increase the amount of funds supplied when banks are borrowing-constrained, banks must either issue more equity or decrease their DM investments, both of which require higher EM returns. Issuing more equity is costly due to its increasing marginal costs, and decreasing investments in DM firms is costly because it depresses the aggregate level of capital and increases its marginal product. Note that equation (15) assumes a binding borrowing constraint. If the borrowing constraint does not bind, equations (13) and (14) imply a perfectly elastic supply curve, in which banks are willing to supply any amount of funds to EMs at the deposit rate.

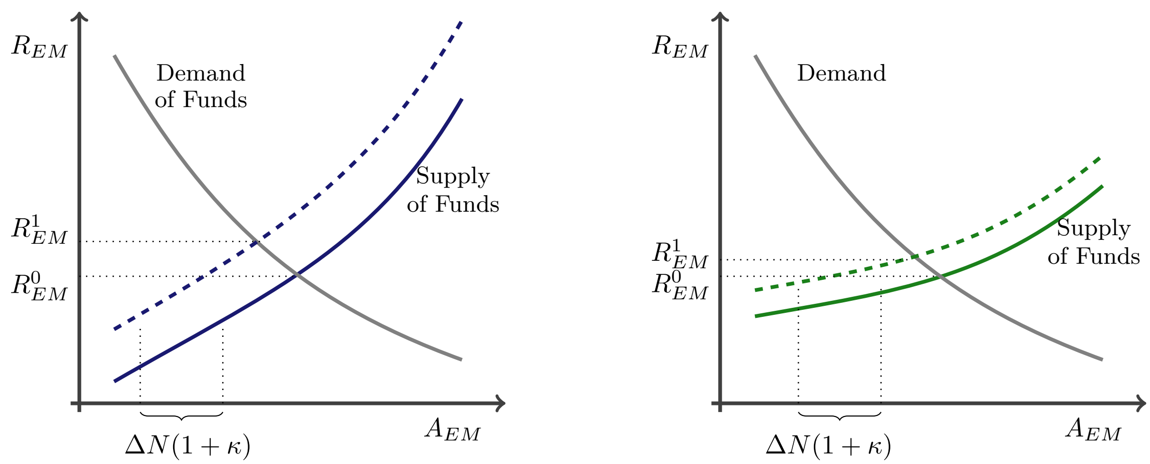
The supply elasticity is governed by two key parameters: the marginal cost of raising external finance, governed by ϕ, and the degree of decreasing returns in DM firms, α. Figure 2 graphically represents the aggregate supply of funds for high and low costs of raising equity.

[6] This supply is obtained by aggregating the supply of funds of each global bank to each EM economy. The analysis allows for aggregation at the banks' level because global banks' optimal portfolio allocation implies policies that are linear in their net worth. We also use the equilibrium condition $R^e_{\text{EM}it} \equiv R^e_{\text{EM}t} = R^e_{\text{DM}t}$; hence, the supply of funds depicts the relationship between funds allocated to EMs and required returns on all EM and DM assets. The function $\mathcal{X}(R^e_{\text{DM}t}, \phi)$ can be obtained from (12)-(14). The function $\mathcal{A}_{\text{DM}t}(R^e_{\text{EM}t}, \alpha)$ can be obtained by combining banks' optimality condition (12) and the definition of return $R_{\text{DM}t}$. Solving for $A_{\text{DM}t}$ yields $A_{\text{DM}t} = \left\{\left[R^e_{\text{EM}t} - (1-\delta)\right](\omega_{t+1}\alpha)^{-1}\right\}^{\frac{1}{\alpha-1}}$. Finally, equation (15) also assumes a binding borrowing constraint.

Lower marginal costs of issuing equity yield greater sensitivity of the supply of funds to changes in required returns. When the marginal costs of equity are low, an increase in required returns not only attracts more funds that were initially allocated to the DM productive sector, but also increases the desired level of capitalization of the aggregate banking system. In the extreme case in which equity costs become negligible ($\phi \to 0$), the aggregate supply curve becomes flat in the plane $(A_{\text{EM}t}, R^e_{\text{EM}t})$.

Figure 2. Intermediaries' Financial Frictions and the EM Debt Market

(a) High Costs of Equity Issuance (b) Low Costs of Equity Issuance



On the borrower side, aggregating borrowing policies across EMs for given required returns, we obtain a relationship between required returns and borrowing by EMs, which we label *aggregate demand* of funds: $\mathcal{A}^d_t(R^e_{\text{EM}t}) = \int_{i\in\mathcal{I}_t} \frac{1}{R^e_{\text{EM}t}} \iota_{it+1} \left(1+\xi q^i_{EMt+1}\right) b_{it+1}\,\mathrm{d}i$. The aggregate demand is also depicted in Figure 2 with a decreasing relationship between returns and quantities. Although the slope of the aggregate demand cannot be signed analytically, we focus here on a case in which it is negative, as it will be in our quantitative model, reflecting the fact that higher required returns reduce borrowing and render repayment less likely.

Figure 2 depicts the equilibrium aggregate borrowing and required returns as the intersection between aggregate demand and supply of funds. This analysis takes as given other equilibrium variables, particularly global banks' net worth. Aggregate net worth can be obtained by integrating the evolution of net worth (8) across banks:

$$N_t = \sigma \left[\int_{i\in\mathcal{I}_{t-1}} \iota_{it}\left(1+\xi q^i_{EMt}\right) A^i_{\text{EM}t-1}\,\mathrm{d}i + R_{\text{DM}t}A_{\text{DM}t-1} - R_d D_{t-1}\right] + (1-\sigma)\overline{n}. \tag{16}$$

Consider the effect of an unexpected negative shock to the return of the DM security, ω_t, which implies a low return on DM investments and negatively affects global banks' net worth. The strength of the impact on net worth depends on global banks' exposure to DM investments. Under binding borrowing constraints, a lower net worth reduces the amount of deposits banks can rollover. This implies that banks have fewer resources available to purchase securities, which reduces the aggregate supply of funds for a given required return—as depicted by the dotted line in Figure 2a—and increases the equilibrium required return.[7] The asset pricing equation $\mathbb{E}\left[m_{t+1}R^i_{\mathrm{EM}t+1}\right] = 1$, with $m_{t+1} = \frac{\beta_{\mathrm{DM}}\nu_{t+1}}{1+2\phi x_t}$, offers an alternative interpretation of the equilibrium effects on expected returns of EM debt. A lower net worth increases the marginal cost of issuing equity $1 + 2\phi x_t$, which decreases the discount factor m_{t+1}, and increases the required returns on EM debt.

Next, consider the effect of an unexpected negative shock to the systemic component of EM endowments, $y_{\mathrm{EM}t}$. This shock affects aggregate demand through the effect of lower endowments on desired individual borrowing decisions by each EM. Additionally, this shock negatively affects the aggregate supply of funds and the net worth of global banks through an increase in default risk that lowers EM debt prices and decreases returns. The strength of the impact on net worth depends on global banks' exposure to EM investment and also on the debt's distribution across EMs. If a larger fraction of EMs have high levels of debt, the increase in default risk is higher and so is the effect on banks' net worth. In Section 4, we study the quantitative role of banks' exposure to EM debt and debt distribution in the amplification of shocks to $y_{\mathrm{EM}t}$.

Finally, how EM returns respond to shocks to N_t, originating from shocks to either ω_t or $y_{\mathrm{EM}t}$, depends on the banks' ability to recapitalize. In the model, this depends on the parameter ϕ, which determines the marginal cost of issuing external finance. Consider an economy with high costs of equity issuance (high ϕ). In this economy, the excess supply of funds is steep because banks require a significant increase in returns to issue equity to finance purchases of additional risky securities. As shown in Figure 2a, a shock to N_t will have an associated large drop in prices and a large increase in required returns to induce equity issuance to purchase

[7]When borrowing constraints are not binding, banks offset the negative net worth shock by capturing deposits without affecting the required returns of EM debt.

a given stock of securities. Next, consider an economy with low ϕ. In this economy, it is less costly for banks to recapitalize, and therefore prices and returns need to respond less to a shock to N_t of the same magnitude in order to induce equity issuance to restore equilibrium (Figure 2b). In the extreme case in which banks can recapitalize costlessly, the excess supply becomes perfectly elastic, and N_t would have no effect on prices. Proposition 1 formalizes this result.

PROPOSITION **1.** *If global banks face no financial frictions (i.e., $\phi = 0$), EM debt prices are given by* $q^i_{\text{EM}t} = \mathbb{E}_t\left[\beta_{DM}\iota_{it+1}\left(1+\xi q^i_{\text{EM}t+1}\right)\right]$.

Proof. If $\phi = 0$, (12)-(14) and the definition of $R^e_{\text{EM}t}$ imply that $\frac{1}{\beta_{\text{DM}}} = \mathbb{E}_t\left[\upsilon_{t+1}\frac{\left(\iota_{it+1}+\xi q^i_{EMt+1}\right)}{q^i_{EMt}}\right]$. From banks' recursive problem (detailed in Appendix A), it follows that $\upsilon_t = 1$ for all t, leading to the stated result. □

Therefore, when global financial intermediaries can frictionlessly finance their investments in risky securities, the equilibrium for each individual economy is isomorphic to one in which debt is priced by DM households. A corollary of this result is that if, in addition, aggregate EM and DM shocks are orthogonal ($\rho_{\text{EM,DM}} = 0$), then shocks to DMs ω_t are uncorrelated with EM prices:

COROLLARY **1.** *If $\phi = 0$ and $\rho_{\text{EM,DM}} = 0$, then $\text{cov}(\omega_t, q^i_{\text{EM}t}) = 0$ for all t and i.*

This analysis suggests that the degree of price drops in response to DM shocks (if unrelated to EM shocks) are highly informative of the degree of financial frictions faced by global institutions that price EM securities. The next section analyzes the empirical evidence linked to this relationship.

3. Empirical Evidence

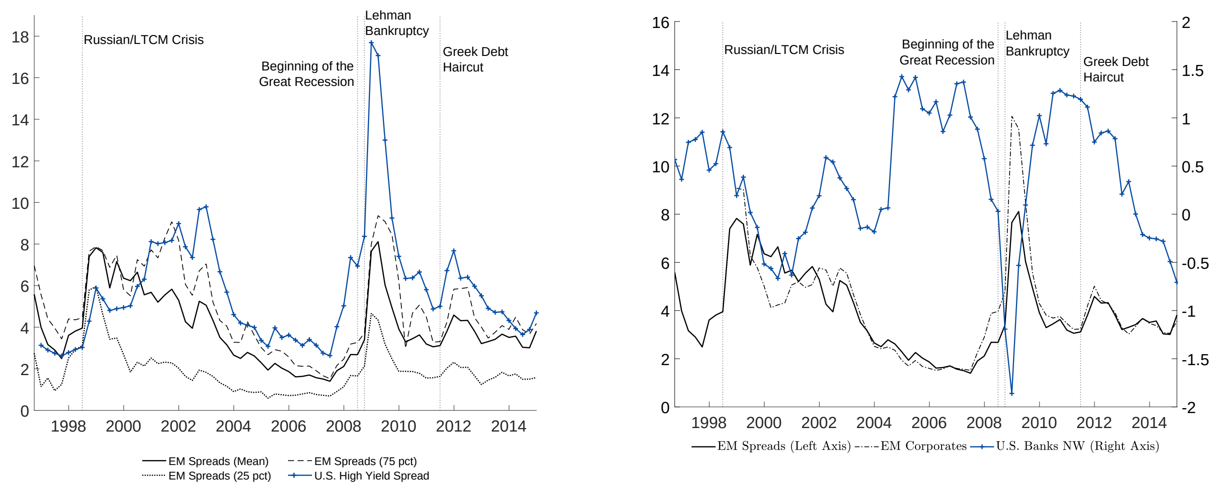
3.1. *Background: Aggregate Patterns*

EM debt prices have a strong common component that has a tight link with global factors (Longstaff et al., 2011). We illustrate this in Figure 3a, which shows fluctuations of different percentiles of the distribution of EM-bond spreads and their correlation with U.S. corporate spreads. The average correlation between the spread of an individual EM economy and the

Figure 3. Aggregate Patterns in the Global Debt Market

(A) Comovement of Bond Spreads

(B) EM Spreads and U.S. Banks' Net Worth



Notes: Panel (A) shows the mean and 25th and 75th percentiles of country EM sovereign bond spreads and U.S. high-yield corporate bonds, expressed in percentages. Panel (B) shows EM sovereign and corporate bond spreads and U.S. banks' net worth (expressed as percentages relative to a log-linear trend). For details on the data sources, see Appendix B1.

average EM-bond spread is 69%. Additionally, the correlation between average EM-bond spreads and U.S. corporate spreads is 50%. Furthermore, EM bond spreads comove negatively with global banks' net worth over recent decades, as shown in Figure 3b. The correlation between average EM-bond spreads and U.S. global banks' aggregate net worth is −55%. Spikes in bond spreads, such as the Russian and East Asian crises of the late 1990s or around Lehman Brothers' bankruptcy in 2008, tend to mark periods of declines in U.S. banks' net worth. These patterns are also consistent with the concept of the "global financial cycle" (Gourinchas and Rey, 2007; Rey, 2015).

In principle, these aggregate patterns can be informative of underlying frictions in the intermediation of risky EM debt. However, retrieving the degree of financial frictions faced by intermediaries out of aggregate data would be challenging, due to the potential presence of common factors that drive both spreads and intermediaries' net worth. Based on this concern, in the next subsections, we propose an empirical strategy that isolates the role of shocks that affect EM returns through their effect on global financial intermediaries' net worth.

This strategy is based on exploiting cross-sectional price differences in bonds held by global financial institutions differentially hit by a negative aggregate shock.[8] Our main analysis focuses on a narrow window around Lehman Brothers' bankruptcy on September 15, 2008, which constituted a large shock that affected financial institutions differentially and that, as we show below, was followed by dispersion in the yields of EM bonds with similar characteristics (default risk, maturity, liquidity). We next describe the data used in the empirical analysis, the empirical model, and results. As an additional exercise, we perform the same empirical analysis in a narrow window around Russia's default in August 1998.

3.2. *Data and Descriptive Statistics*

This section summarizes the data sets used in the empirical analysis and describes our construction of the main variables of interest for our main episode of analysis, which centers on Lehman Brothers' bankruptcy. Further details on our description of the data can be found in Appendix B.

EM bond prices. We collect data on daily prices for risky sovereign and corporate bonds issued by countries that at some point were part of the EMBI. To capture risky bonds in our sample, we focus on the set of 30 countries whose sovereign credit rating (from Standard & Poor's) is below A. We restrict attention to bonds issued in international markets, for which global financial intermediaries are more likely to be the marginal investor (see Maggiori et al., 2017; Coppola et al., 2020). The data sources are Bloomberg and Datastream, from which we obtain a sample of over 600 EM bonds (identified with different CUSIPs) with available daily price data. For each bond, we have information on its issuer, currency of denomination, maturity, bid–ask spread, seniority, and whether the bond is subject to collective action clauses. We use these variables in the empirical analysis to compare the prices of bonds with similar

[8]Note that the source of variation in this empirical analysis is across bonds with different holders. In our model, which features aggregation across intermediaries, we abstract from such sources of variation to highlight the aggregate mechanism. We refer the interested reader to Supplementary Material A, in which we enrich our model to allow for the same source of variation as in the data by introducing secondary markets and heterogeneous banks. In this model, the cross-sectional variation of EM bond prices in response to a DM shock that differentially affects intermediaries is also informative of the degree of financial frictions faced by intermediaries.

characteristics. We compute the yield to maturities of bond prices using information on the coupons and maturities of each individual bond. Around half of the bonds in our sample are sovereign bonds and half are corporate bonds, which span different sectors. In Appendix B, we report descriptive statistics of our sample of bonds per country and sector.

Our variable of interest is the change in yield to maturity in EM bonds following the Lehman episode. Appendix Figure C1a shows that EM bond yields experienced average daily increases in the 2 months after the Lehman episode, leading to a peak cumulative increase of 4 percentage points 40 days after the episode. Importantly, these daily increases in yields were heterogeneous across bonds with similar characteristics. In particular, Appendix Figure C1b shows the dispersion across daily changes in yields to maturity for bonds issued in the same country and sector, denominated in the same currency, and with a similar maturity, bid–ask spread, and credit worthiness proxied by initial yields. The dispersion of changes in yield to maturity before the Lehman episode was relatively small (below 0.5%), and tripled following the Lehman episode.

Shares of EM bond holdings by global financial intermediaries. The most novel part of our data is that for each bond in our sample, we collect data from Bloomberg on holdings by financial institutions prior to the Lehman episode. These data contain, for each individual bond (at the CUSIP level), the share held by each reporting financial institution, including banks, asset managers, holding companies, insurance companies, pension funds, and other financial institutions. We denote by θ_{ij} the share of bond i held by financial institution j as of 2008.q2.[9] Within these holders, we focus on financial institutions publicly traded on DM stock exchanges, which thus contain data on their stock prices. Sixty-four institutions meet our selection criteria. These institutions constitute our empirical measure of global banks. Appendix B lists these institutions and reports descriptive statistics for those with the largest EM bond holdings in our sample. As shown in the first column of Table 1, the global financial intermediaries included in our sample held, on average, 50% of reported bond holdings at the end of 2008.q2, prior to the Lehman episode.

[9]Data on bond holdings are available at quarterly frequency. Our baseline exercise uses the holdings of 2008.q2. For additional analysis regarding the persistence of intermediaries' bond holdings, we also collect data for the remaining quarters of 2008.

Table 1. Intermediaries' Net Worth During the 2008 Crisis: Summary Statistics

	Bank coverage per bond	Δ Stock price bank level	Δ Stock price bond level	Δ Stock price residualized
Mean	50%	-12%	-13%	0%
Median	48%	-6%	-10%	0%
Std Deviation	29%	30%	18%	7%
5th percentile	0%	-50%	-33%	-8%
95th percentile	100%	13%	3%	8%
Num. Obs.	615	64	579	531

Notes: This table shows descriptive statistics for the change in global financial intermediaries' (GFIs) market value of net worth around Lehman's bankruptcy. The first column reports summary statistics for the shares held by GFIs for the bonds included in the sample; the second column shows statistics for the change in GFIs' log stock prices with reported holdings; and the last two columns report statistics for the change in GFIs' average net worth at the bond level with and without residualizing by the bond covariates of the empirical model (17). For further details on the data, sample, and sources, see Section 3.2 and Appendix B1.

Change in global financial intermediaries' net worth per bond. We collect data on daily stock prices for each of the financial institutions and compute the change in stock prices in a window around Lehman's bankruptcy. These data were obtained from Bloomberg and Datastream. Δe_j denotes financial institution j's change in log stock price 10 days before and 3 days after September 15, 2008, the day Lehman Brothers' went bankrupt. The second column of Table 1 provides summary statistics of Δe_j, showing an average contraction in global financial intermediaries' net worth in the narrow window around the Lehman episode of 12%. Importantly, the cross-sectional standard deviation of this variable is 30%, suggesting enough variation in how global financial institutions were affected by the Lehman episode.

With data on bond holdings and stock prices, we compute a measure of the change in bond holders' average net worth around the Lehman episode, defined as $\Delta e_i = \sum_{j \in J} \theta_{ij} \Delta e_j$, where J denotes the set of global financial institutions with available data. This variable also displays significant cross-sectional variation, even after residualizing from all bond covariates used in the regressions. This is the variation we exploit in the empirical analysis.

3.3. *Identification and Empirical Model*

Our identification strategy for measuring the effect of global financial institutions' net worth on EM bond spreads is based on exploiting price differences across bonds with similar default risk, maturity, and liquidity, but held by different financial institutions. We do so by estimating the set of regressions

$$\Delta_h y_i = \alpha_{ksh} + \alpha_{ch} + \beta_h \Delta e_i + \gamma_h' X_i + \varepsilon_{hi}, \tag{17}$$

where $\Delta_h y_i$ denotes the change in the log gross yield to maturity or price of bond i issued by country k in sector s between 10 days before the Lehman episode and h days after the episode; α_{ksh} denotes country (k) by sector (s) fixed effects; α_{ch} denotes currency fixed effects; X_i is a vector of controls at the bond level, which includes the total reported share $\sum_{j\in J}\theta_{ij}$, the bond's residual maturity, its bid–ask spread, a categorical variable reflecting the bond's seniority, a dummy variable on whether the bond is subject to collective action clauses, and the average yield to maturity in the 2 months prior to the Lehman episode. The coefficient of interest, β_h, measures the elasticity of bond prices to changes in holders' net worth at horizon h. We estimate a separate regression for each horizon h to estimate the dynamic effects of global financial intermediaries' net worth on bond yields using Jorda's 2005 local projections.

Our identifying assumption is that within the EM bonds of a given country and sector and with a similar maturity, liquidity, initial yield, and other characteristics, no relevant factors that drive changes in EM bond yields are correlated with the net worth of global financial intermediaries holding that bond. The last column of Table 1 shows that our variable of interest, the change in bond holders' average net worth around the Lehman episode Δe_i, exhibits considerable cross-sectional variation once it has been residualized by the entire set of covariates used in the empirical model.

In this sense, focusing our analysis on a short window during the Lehman episode is useful for three reasons. First, during this episode, global financial intermediaries experienced differential changes in their net worth that were primarily driven by factors related to events in developed markets (see, for example, Chodorow-Reich, 2013). Second, by focusing on a narrow window, we can exploit the price differences that arise for bonds of similar characteristics, as shown in Appendix Figure C1b. Third, as we show later, global financial intermediaries' exposure to risky EM debt in this period was small, which mitigates concerns regarding reverse causality: a change in net worth due to the changes in EM bond prices. The estimated average share of EM risky assets as a function of total assets in our sample of global financial institutions is 10%—see Appendix Table C1—so the average contraction of 3% in EM bond prices during the narrow window considered should only have modest effects relative to the 12% average contraction in global financial intermediaries' net worth.[10] We also address the concern regarding reverse causality by instrumenting the change in global financial intermediaries' net worth. See the next subsection for more details.

An important element of our identification strategy is that within an EM country–sector, bonds with similar default risk, liquidity properties, and other relevant characteristics have different holders. To further clarify using an example, our identification learns from the relative price dynamics of two foreign currency bonds issued by the Mexican government with similar maturities and liquidity, which therefore have the same default risk but are held by different global financial intermediaries.

Another relevant element of our identification strategy is that, as stated above (Table 1), intermediaries exhibit differential holdings of bonds in our sample. Appendix B investigates the nature of the sorting of financial intermediaries into different types of bonds. We first document some degree of sorting of financial institutions with different changes in net worth into bonds issued by different countries and sectors. However, these are the characteristics we can precisely control for with the use of country–sector fixed effects. We then show that there is no selection of financial intermediaries into bonds with different maturities, liquidities, or default risk. A possible interpretation of why different intermediaries hold different bonds with similar default risk, liquidity properties, and other relevant characteristics is that institutions might develop some degree of specialization in certain bonds for trading purposes. Consistent with this view, Appendix B also documents that the holdings of intermediaries are "sticky," i.e., intermediaries tend to exhibit persistence in their holdings of bonds, even after controlling for country-intermediary fixed effects. We incorporate this view in our model with secondary

[10]In Appendix Tables C1 and C2, we report an average ratio of EM debt to total assets of 10% and an average leverage—adjusted to account for assets under management—of 3.8. A back-of-the envelope calculation suggests that a 3% drop in EM bond prices would result in a 1.1% drop in intermediaries' net worth.

markets, bond varieties, and trading networks, which we develop in Supplementary Material A.

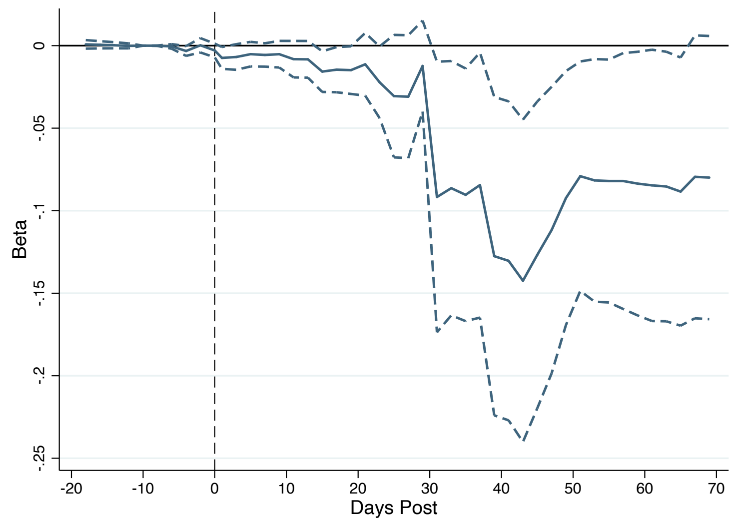
3.4. *Empirical Results*

Figure 4 presents the results from estimating (17) on the bonds' yields to maturity at different horizons, h, ranging from 20 days prior to 70 days after the Lehman episode. Panel A of Table 2 reports estimated coefficients and standard errors for the on-impact effect and the peak effect. Results indicate a negative estimated elasticity, β_h, which indicates that bonds whose lenders' net worth contracted more during the Lehman episode experienced significantly higher yields to maturities in the 2 months after the episode. The estimated elasticity ranges from -0.01 to -0.14 and averages -0.056 in the 2 months after the Lehman episode. To put this estimated coefficient into perspective, it implies that bonds whose holders suffer a contraction in net worth one standard deviation higher than the mean experienced an increase in yields that is roughly 1.5 times as large as that of the average bond during the Lehman episode.

The fact that the point estimate of β_h is zero before the Lehman episode suggests that there are no pretrends that may drive the empirical analysis. Additionally, the estimated effect of intermediaries' net worth on bond prices is temporary. The estimated elasticity begins to revert 45 days after the Lehman episode and ceases to be significantly different from zero shortly after 2 months. As we argue in Supplementary Material A, in the cross-section, temporary effects can be expected if financial intermediaries gradually arbitrage out excess returns for bonds with similar characteristics.

We perform a series of additional empirical analyses to show that the empirical results are robust to alternative specifications and to mitigate potential concerns regarding our identification strategy. Panel B of Table 2 reports a series of robustness exercises. These indicate that we estimate negative elasticities between bond yields and lenders' net worth if we do not include bond-level controls, if we restrict the sample to only sovereign bonds or bonds with similar maturity, or if we estimate a contemporaneous relationship between the bond yields and lender's net worth instead of a local projection, as in our baseline regression. In particular, this latter exercise involves estimating at each horizon h the empirical model $\Delta_h y_i = \alpha_{ksh} + \alpha_{ch} + \beta_h \Delta_h e_i + \gamma_h' X_i + \varepsilon_{hi}$, which only differs from our baseline regression (17)

FIGURE 4. The Dynamic Effect of Intermediaries' Net Worth on EM-Bond Yields



Notes: This figure shows the estimated elasticity of bonds' yields to maturity, β_h, to changes in the holder's net worth at horizon h from estimating regression (17). Solid lines represent point estimates of the regression at each horizon and dotted lines are 90% confidence intervals.

in that the changes in lenders' net worth are computed over the same horizon as our left-hand-side variable. This latter exercise is important in addressing the potential presence of autocorrelation in individual lender's net worth following the Lehman shock. Given that this elasticity is roughly half of the baseline, we use this alternative estimate to conduct robustness analysis of our quantitative model in Section 4.

Panel C of Table 2 shows estimates of our baseline regressions by splitting the bonds based on their currency of denomination. This distinction is important because, as shown in Maggiori et al. (2017), the currency of the bond is an important prediction of the marginal investor. Results show a more precise estimate for foreign currency, consistent with the view that global intermediaries are more important in the pricing of these bonds. Panel D analyzes the role of different types of intermediaries by estimating the elasticity associated with banks, banks excluding asset managers' divisions, asset managers, and other intermediaries (which includes insurance companies, among others). Although the results are imprecisely estimated, they indicate similar negative elasticities for all types of financial intermediaries. These results are consistent with our theoretical model, in which the main mechanism operates through the

Table 2. Effect of Intermediaries' Net Worth on EM-Bond Yields: Summary

		Impact	Peak	Average	Obs.
A. Baseline		-0.006	-0.142**	-0.056	531
		(0.004)	(0.059)		
B. Robustness	No Controls	-0.012***	-0.172***	-0.078	615
		(0.004)	(0.059)		
	Only Sovereign	0.0014	-0.039	-0.015	287
		(0.005)	(0.052)		
	Same Maturity	-0.009	-0.325***	-0.125	128
		(0.008)	(0.080)		
	Contemporaneous	-0.006	-0.070**	-0.022	531
		(0.004)	(0.029)		
C. By currency	Only Foreign	-0.006	-0.139**	-0.054	481
		(0.004)	(0.060)		
	Only Local	-0.022	-0.147	-0.059	50
		(0.023)	(0.115)		
D. By institution	Banks	-0.003	-0.163	-0.062	465
		(0.008)	(0.107)		
	Banks (ex. AMD)	-0.002	-0.187*	-0.072	466
		(0.008)	(0.108)		
	Asset Managers	-0.025	-0.357	-0.190	394
		(0.069)	(0.435)		
	Other	-0.012***	-0.163**	-0.063	466
		(0.004)	(0.067)		
E. IV Strategy		0.0061	-0.211***	-0.089	115
		(0.006)	(0.057)		
F. Russian Crisis		-0.059	-0.502**	-0.177	95
		(0.105)	(0.201)		

Notes: This table shows the estimated elasticity of bonds' yields to maturity, β_h, to changes in the holder's net worth at two different horizons h, from estimating the regression (17). The on-impact effect corresponds to the estimated elasticity for $h = 0$. The peak effect corresponds to the most negative estimated elasticity over all horizons before two months. Different rows show different specifications, detailed in Section 3.4. Robust standard errors are in parentheses, and *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

increasing marginal cost of external finance, which is present for both levered and unlevered institutions.

One concern is that the empirical estimates can capture the direct effects that drops in EM bond prices around the Lehman episode can have on financial intermediaries' net worth, because these bonds are part of their asset portfolios. As argued before, this concern is alleviated because EM bonds constitute only a small fraction of global financial intermediaries' asset portfolios. To further strengthen this point, Panel E of Table 2 shows the results of conducting an instrumental variable (IV) strategy, aimed at ensuring that the results are not driven by the reverse causality of bond prices to financial intermediaries' net worth. We instrument the change in the bond holders' net worth Δe_i with the share of each bond held by AIG as of 2008.q2. AIG is a financial institution that was a relevant holder of EM bonds and was severely hit during the Lehman episode, but its downfall was driven by its activities related to subprime securities.[11] The logic of this IV strategy, then, is that by instrumenting the change in net worth held by AIG's share, we abstract from any effect that changes in bond prices may have on intermediaries' net worth. Results indicate a negative peak effect that is statistically significant and larger (in absolute value) than the baseline.

To demonstrate the external validity of our empirical exercise, we perform the same empirical analysis in a narrow window around the default of Russia in August 1998, which triggered the collapse of the Long-Term Capital Management fund (LTCM). This event is a paradigmatic case studied in the international macro literature of sovereign risk contagion through common lenders (see, for example, Calvo, 2004). We estimate equation (17), in which we compute Δe_i with data on lenders' holding of EM bonds for 1998.q2 and changes in intermediaries' net worth from 10 days before to 3 days after the Russian default on August 17,

[11]Appendix Table B5 reports descriptive statistics for AIG in the EM debt market. AIG's stock price dropped by 88% during the narrow window around the Lehman episode, and was the financial institution with the largest drop in stock price of our sample of global financial intermediaries. Its stock crash was attributed to its large volume of activity in providing insurance by issuing CDS on subprime mortgage-backed securities (see, for example, Harrington (2009)). AIG held more than 100 EM bonds, and its average share among lenders of these bonds was 9%. In the first stage of our IV strategy, $\Delta e_i = \alpha_{ksh} + \alpha_{ch} + \beta_{1S}\theta_i^{\text{AIG}} + \gamma_h' X_i + \varepsilon_{iks}$ (where θ_i^{AIG} denotes the share of bonds held by AIG in 2008.q2) and the estimated coefficient $\hat{\beta}_{1S}$ is positive and statistically significant at the 0.1% level.

1998. As in our baseline model, we measure, in the left-hand-side variables, cumulative daily changes in EM bond yields following this event. Consistent with our baseline results, Panel F shows a negative estimated elasticity of lenders' net worth on EM bond yields. Appendix Figure B2 depicts the dynamic effect, which shows that the elasticity peaks 15 days after the episode. The estimated elasticities are larger than our baseline in absolute value, consistent with the view that the Russian crisis was more concentrated in EM debt markets.

Appendix B3 presents additional robustness exercises. First, we show that our results are insensitive to choosing a wider or tighter window around the Lehman episode in computing global financial intermediaries' change in stock price Δe_i, as well as to extending the length of the window to compute Δe_i. Second, we show that the results are robust to excluding market makers when computing the change in the stock price of the holders of each bond. Third, we show that there is no selection of financial intermediaries into bonds with different maturities, liquidities, or amounts issued.

Finally, Appendix B3 examines how the effect of intermediaries' net worth on EM bond yields varies depending on the financial positions (liquidity and leverage) of intermediaries holding the bonds. For this, we collect additional data on intermediaries' balance-sheet information from Compustat. We also study how the estimated elasticity varies for bonds with different shares held by global intermediaries. Our results suggest that bonds that were held by intermediaries with higher liquidity and lower leverage and bonds that have lower shares held by global financial intermediaries exhibit lower elasticities, although the results are not precisely estimated and are not statistically significant.

To summarize the findings of this empirical section, we exploit bond-level variation to document that well-identified shocks to global financial intermediaries' net worth have an impact on EM bond prices. This evidence is of interest on its own because it supports the main mechanism highlighted in our model, through which global financial intermediaries' net worth is relevant for the pricing of EM debt. As will be seen in the next section, we use our estimated elasticity to quantitatively discipline the degree of financial frictions that financial intermediaries face in our model.

4. Quantitative Analysis

In this section, we use our model and empirical evidence to examine the relevance of global financial intermediaries to international lending. Section 4.1 discusses the model's calibration and its ability to account for observed international business-cycle patterns. Section 4.2 uses the calibrated model to quantify global banks' role in driving emerging markets' systemic debt crises and borrowing-cost fluctuations. Finally, Section 4.3 shows how financial intermediaries' portfolios and the distribution of bond positions in the world economy matter for the amplification of aggregate shocks.

4.1. *Calibration and Quantitative Performance*

4.1.1. *Parameterization*

We discuss the calibration of the model by describing functional forms, parameter values, and the quantitative performance of the model in terms of targeted and untargeted moments. In terms of solution method, our model's heterogeneity and aggregate uncertainty imply that the joint distribution of bond positions and output in the world economy—an infinite-dimensional object—is a state variable in agents' individual problems. We follow a Krusell and Smith (1998) type of approach to approximate the distribution of bond positions, combined with global methods for individual agents' problems, to solve the model's general equilibrium. We provide details on the numerical solution method in Supplementary Material B1.

In terms of functional forms, we assume that EM households' period utility function includes constant relative risk aversion $u(c) = \frac{c^{1-\gamma}}{1-\gamma}$. For the EMs' endowment processes, we assume AR(1) processes:

$$\ln y_{\text{EM}t} = \rho_{\text{EM}} \ln y_{\text{EM}t-1} + \sigma_{\text{EM}} \epsilon_{\text{EM}t}, \quad \epsilon_{\text{EM}t} \sim N(0,1),$$

$$\ln z_{it} = \rho_{\text{EM}} \ln z_{it-1} + \sigma_{\text{EM}} \epsilon_{it}, \quad \epsilon_{it} \sim N(0,1).$$

In this baseline calibration, we restrict the systemic and idiosyncratic component of output to have the same stochastic process (governed by ρ_{EM} and σ_{EM}) in order to study the differential effects of these shocks that arise due to endogenous amplification, rather than to having different stochastic processes. As further discussed below, in our robustness analysis we relax this assumption. For the capital quality shocks, we assume an i.i.d. process, $\ln \omega_t = \sigma_\omega \epsilon_{\omega t}$, with $\epsilon_{\text{DM}t} \sim N(0,1)$, that abstracts from exogenous and predictable movements in expected returns.[12] Finally, we parameterize the output net of default costs by $\mathcal{H}(y) = y(1 - d_0 y^{d_1})$, where $d_0, d_1 \geq 0$. This or similar nonlinear functional forms, which lead to higher nonlinear default costs for higher values of y, are often used in the literature to rationalize the fact that countries tend to default in bad times (e.g., Arellano, 2008; Chatterjee and Eyigungor, 2012; Aguiar et al., 2016).

We calibrate the model in two steps, by setting one subset of parameters to fixed values and another to match relevant EMs and global-bank moments. Panel (A) of Table 3 describes the set of eight parameters we fix in the calibration. One period corresponds to 1 year. For parameters on preferences and technologies, we use standard values in the business-cycle literature: a coefficient of relative risk aversion for EMs, $\gamma = 2$; a discount factor for DM households, $\beta_{\text{DM}} = 0.98$, which implies an annual risk-free interest rate of 2%; a depreciation rate $\delta = 0.15$; and the share of capital, $\alpha = 0.35$. For the probability of reentering credit markets, we set $\theta = 0.25$ so that the average exclusion period is 4 years, in line with empirical evidence (Dias and Richmond, 2008; Gelos et al., 2011). The value of $\xi = 0.8$, the decay rate of bonds, is chosen so that the duration of bonds is 5 years, which is in line with that reported in Cruces et al. (2002) for emerging economies. For EMs' endowment process, we set $\rho_{\text{EM}} = 0.68$ and $\sigma_{\text{EM}} = 0.03$ to match the average autocorrelation and volatility of GDP in the sample of countries analyzed in Section 3 with available data.

We calibrate the remaining parameters of our model (Panel (B) of Table 3) to match key EM and global-bank data moments, detailed in Table 4. The first group of moments are standard targets in the sovereign-debt literature—namely, the average EM external borrowing, the average EM default rate, and the correlation between EM-bond spreads and GDP. To compute these data moments, we use a sample of EMs with available data for the period 1994–2014. Supplementary Material B2 details the data sources. We target the observed average external-debt-to-GDP ratio of 15%, the average default frequency of 1.5%, and the average correlation between an individual country's spreads and GDP of −31%. These moments are particularly informative about EM discount factors (β_{EM}) and default costs (d_0, d_1). A second group of

[12] This parameterization also delivers an autocorrelation of DM securities close to those observed in the data for U.S. high-yield bonds (a first-order autocorrelation coefficient of 0.2 in our period of analysis).

TABLE 3. Parameter Values of the Baseline Calibration

Panel A: Fixed Parameters			Panel B: Calibrated Parameters		
Param.	Description	Value	Param.	Description	Value
γ	Risk aversion	2.00	β_{EM}	Discount rate of EMs	0.90
θ	Reentry probability	0.25	d_0	Default cost—level	0.0321
ξ	Debt duration	0.8	d_1	Default cost—curvature	14.0
ρ_{EM}	EM endowment, autocorrelation	0.68	σ	Bank survival rate	0.71
σ_{EM}	EM endowment, shock volatility	0.03	ϕ	Marginal cost of raising equity	2.50
β_{DM}	Discount rate of DM	0.98	μ_{EM}	Mass of EM economies	2.02
α	Share of capital	0.35	σ_{DM}	Volatility of DM shock	0.068
δ	Depreciation	0.15	κ	Debt to net worth ratio	3.50
			$\bar{n}$	Net worth of new entrants	0.46
			$\rho_{\text{DM,EM}}$	Correlation of exogenous shocks	0.45

Notes: This table shows the set of model parameters. Panel A describes the subset of fixed parameters; panel B shows the subset of parameters calibrated to match the targeted moments detailed in Table 4.

moments are related to the role of global banks in EM debt markets. These are the average and volatility of EM spreads, the volatility of global banks' net worth, the correlation between global banks' net worth and EMs' output, and the average leverage ratio of global banks.[13]

While each parameter can potentially affect all moments in the joint calibration, we find that the volatility of DM shocks, σ_ω, and the global banks' survival rate, σ, most affect the volatility of global banks' net worth and the volatility of EM-bond spreads. We target the observed volatility of EM-bond spreads of 173 basis points and a volatility of global banks' market value of 28%, proxied by cyclical fluctuations in the stock price of publicly traded U.S. banks that have data coverage for the period of analysis (tracked by the XLF index). We also target the observed correlation between global banks' net worth and EMs' endowment of 40%, which is mostly governed by the correlation between EM and DM shocks, $\rho_{\text{DM,EM}}$. In our model, the

[13]To compute the volatility of global banks' net worth and its correlation with EMs' output, we measure net worth at market value. In the model, both the book and market value of intermediaries' net worth are relevant variables in determining equilibrium dynamics.

average difference between the physical probability of default in EMs and their bond spreads is governed by average net worth in the system, linked to $\overline{n}$. We calibrate this parameter to target the average observed EM-bond spread of 410 basis points. Finally, the leverage ratio of global banks is mostly governed by the parameter on financial intermediaries' borrowing constraint, which we set to $\kappa = 3.5$. The data-target for this moment is 3.8 (see Table C2). As detailed in Supplementary Material B2, this moment is computed as the average of a set of levered (banks) and non-levered institutions (mostly asset managers), taking into account both assets reported in the balance sheet and off-balance-sheet assets under management. The latter is because, in our model, financial intermediaries are aimed at capturing a consolidated entity that maximizes the joint value of the owners of the firms' equity and the owners of the assets under management. With this assumption, $\kappa = 0$ corresponds to the case of asset managers. In the robustness analysis, we report our results of an alternative calibration where intermediaries are only asset managers ($\kappa = 0$), and another that targets twice the leverage of our baseline model (with $\kappa = 7.0$).

Two additional key moments are targeted by our calibration: the exposure of global banks to EMs and the elasticity of EM bond yields to global banks' net worth, estimated in our empirical analysis. The mass of EMs, μ_{EM}, particularly influences the share of EMs in global banks' portfolio of risky assets, which, as will be seen later, is an important moment that governs global banks' role in amplifying EM shocks. We measure this moment by combining data on individual financial institutions' balance sheets in the sample from our empirical section with aggregate data on debt positions, and obtain a share of EMs in global banks' risky assets of 10% (see Table C1). For details on the estimation of this moment, see Supplementary Material B2. Section 4.3 examines alternative targets for this moment.

Finally, we discipline global banks' degree of financial frictions, governed by ϕ, by targeting an elasticity of EM-bond yields to changes in global banks' net worth following a DM shock of -0.056, which is the average of our empirical estimates in Section 3.4 after the Lehman episode. In the model, to compute this elasticity, we conduct an impulse-response function on ω_t that leads to a contraction of net worth of the same magnitude as that observed around the 2008 Lehman episode during the window considered in our empirical analysis. Given that our empirical estimates were obtained in a regression that absorbs default risk (with country–sector fixed effects), in the model we compute the elasticity of the change in bond yields that is not explained by changes in default risk (i.e., the intermediation premium, as defined below) to the change in global banks' net worth. As discussed in Section 2.5, this moment depends on the degree of financial frictions faced by global banks, governed by ϕ. In the absence of financial frictions ($\phi = 0$), the elasticity of EM-bond yields to global banks' net worth would be zero. As ϕ increases, so does the elasticity in absolute value. Our calibration targets this *conditional* elasticity estimated out of cross-sectional variation. Later in this section, we also show that this calibration strategy delivers an untargeted *unconditional* correlation between aggregate net worth and EM-bond spreads close to that observed in the data (−57%).

Furthermore, in Supplementary Material A, we develop and solve an extension of the baseline model with secondary markets for risky debt. In this extension of the model, banks are heterogeneously affected by shocks and trade securities in secondary markets that feature trading frictions in the short run. These characteristics allow the model to feature the same source of variation as that used in the empirical analysis and make the net worth of the holders of each bond relevant for its pricing. We analyze a parameterization that targets the cross-sectional elasticity estimated in Section 3 when running an equivalent regression on model-simulated data. This model quantification generates quantitative results that are in line with those of the baseline model. Additionally, we show that the cross-sectional elasticity in the secondary market is tightly linked to the aggregate elasticity in the primary market. This is because the cost of raising equity, parameterized by ϕ, governs the slope of the demand for funds in the secondary and primary markets.

In addition to this baseline calibration, we study the robustness of our results to four alternative calibrations, all of which are detailed in Supplementary Material B4. First, we calibrate the model to target a more conservative elasticity of EM-bond yields to changes in global banks' net worth of −0.022, which we estimate in a contemporaneous regression in Section 3. Second, we conduct a calibration in which we estimate different autoregressive and volatility parameters for the systemic and idiosyncratic processes of EM endowment and obtain results similar to those presented in this section. Third, we report the results for an alternative calibration of the model with $\kappa = 0$, which would correspond to asset managers

Table 4. Targeted Moments

Target	Description	Data	Model
$\mathbb{E}[D_i/Y_i]$	Average EM debt	15.0%	14.4%
$\mathbb{P}[DF_i]$	EM default frequency	1.5%	1.7%
$\mathbb{E}[SP_i]$	Average EM-bond spreads	410bp	416bp
$\sigma(SP_i)$	Volatility EM-bond spreads	173bp	152bp
$\text{corr}(SP_i, \log Y_i)$	Correlation EM-bond spreads & endowment	−31%	−84%
$\sigma(\log V(N))$	Volatility global banks' net worth (NW)	0.28	0.24
$\text{corr}(\log V(N), \log Y_{\text{EM}})$	Correlation banks' NW & systemic EM endowment	40%	44%
$\mathbb{E}[A_{\text{EM}}/(A_{\text{EM}} + A_{\text{DM}})]$	Global banks' exposure to EMs	10%	10%
$\eta_{\text{EM,N}}$	Elasticity EM spreads to banks' NW	0.056	0.059
$\mathbb{E}[(A_{\text{EM}} + A_{\text{DM}})/NW]$	Total assets to equity ratio	3.8	3.7

Notes: This table shows the set of data moments targeted in our calibration and their model counterparts, obtained by simulating a panel of countries from the calibrated model and computing the average of individual countries' moments. Supplementary Material B2 provides details on the data measurements of EM debt, default frequency and bond spreads, and global banks' net worth. See Sections 3 and 4 for details on the data measurement of global banks' exposure to EMs and assets to equity ratio, as well as on the data and model counterparts of the elasticity of EM-bond spreads to global banks' net worth.

(unlevered institutions) being the only type of global financial intermediaries in the model. Finally, we extend the model to allow for a time-varying marginal cost of raising external finance and capture the idea that it may be less costly for intermediaries to raise external funding during tranquil times.

4.1.2. *Targeted and Untargeted Moments*

Table 4 shows that our model closely approximates most targeted moments. An exception is the countercyclicality of bond spreads, which our model overestimates relative to the data.[14]

[14]Our calibration does not perfectly match the targeted moments because our model is nonlinear. Matching more closely the countercyclicality of bond spreads can only be done at the expense of worsening model performance in other important dimensions, such as the average debt position and default rate.

TABLE 5. International Comovements: Data and Model

	Correlation of SP_{EM} with		Correlation of logV(N) with		Factor Models	
	$SP_{\text{EM},i}$	SP_{DM}	SP_{EM}	SP_{DM}	R^2	RMSE
Data	0.69	0.51	-0.57	-0.79	96.9%	3.19%
Model	0.74	0.69	-0.65	-0.80	97.4%	0.72%
Model λ_f					83.2%	3.05%

Notes: This table shows untargeted moments regarding international asset prices. SP_{EM} refers to the average EM-bond spread; $SP_{\text{EM},i}$ to the bond spread of an individual EM economy i; SP_{DM} to high-yield U.S. corporate bond spreads; and $V(N)$ to the market value of global banks' net worth. Supplementary Material B2 provides details on the data measurements of these variables. The last two columns show the R^2 and root mean squared error of the cross-sectional regressions of expected sovereign bond returns using a factor model structure. See Supplementary Material B6 for details on the analysis of factor models.

Most of the parameter values of our baseline calibration, detailed in Table 3, are broadly aligned with those of the related literature.

Our calibrated model is also consistent with key untargeted moments regarding the international synchronization of EM debt prices. First, our model is consistent with the large comovement within EM-bond spreads and between them and DM spreads documented in Section 3 and Longstaff et al. (2011). The first two columns of Table 5 show that our model predicts an average correlation between an individual EM-bond spread and the average EM-bond spread close to that observed in the data, and a high correlation between EM and DM spreads, although larger than that observed in the data for U.S. high-yield corporate bonds. Importantly, columns (3) and (4) of Table 5 show that the model also predicts comovements between debt spreads and global banks' net worth that are quantitatively aligned with those observed in the data. This result means that if we were to follow an alternative calibration strategy, targeting the *unconditional* correlation between global banks' net worth and EM-bond prices instead of our estimated elasticity in Section 3.4, we would obtain results similar to those in our current baseline calibration, which uses our empirical estimates.

We also assess the model's ability to price the cross-section of EM sovereign bond returns. To do so, we follow standard practice in the empirical finance literature (see Borri and Verdelhan, 2011; Lettau et al., 2014, for two examples related to international asset prices), by estimating a factor version of our model and assessing its ability to explain cross-sectional expected returns in the data and the model. In our model, the stochastic discount factor that prices EM sovereign debt is a nonlinear function of the model's state variables. In this exercise we consider an approximated stochastic discount factor given by a linear function of global banks' market value of net worth. The benefit of considering such an approximation is that this factor is also measurable in the data, thereby allowing us to perform the same exercises in the model and the data.

We consider the data bond portfolios analyzed by Borri and Verdelhan (2011) that vary in the degree of default risk and comovement with market returns, and construct similar portfolios in model-simulated data. We then carry out an estimation in two stages. In the first stage, we regress excess returns on the global banks' net worth to obtain portfolio loadings. In the second stage, we regress time-series average returns for each portfolio on their factor loadings. We perform three sets of estimation exercises. The first uses observed data to compute portfolios' returns and the market factor; the second uses model-simulated data; and in the third we assess the explanatory power of estimating cross-sectional expected returns in the data with the model-estimated market price of risk. Supplementary Material B6 provides details on the construction of bond portfolios and estimation procedures. We report multiple statistics related to the goodness of fit of these estimations in columns (5) and (6) of Table 5. In both the data and the model, the net worth of global banks can account for an important component of the cross-sectional variation in expected returns (with R^2 of 97% for both model and data estimations). Additionally, the R^2 of predicted expected returns in the data with the model-estimated price of risk is 83%, suggesting that the calibrated model also prices well the observed cross-sectional sovereign risk.

Finally, our model is also consistent with important individual business-cycle patterns in emerging markets (see, for example, Neumeyer and Perri, 2005; Aguiar and Gopinath, 2007). In particular, Appendix Table C3 shows that our model is able to reproduce the high volatility of consumption relative to output and the high correlation between consumption and output.

Additionally, consistent with the data, the model delivers a countercyclical trade balance, which in the model is due to the fact that interest rates endogenously increase in downturns due to the higher likelihood of default.

4.2. *Global Banks' Relevance*

We now use our calibrated model to quantitatively assess global banks' role in the international transmission and amplification of shocks.

4.2.1. *Systemic Debt Crises*

We begin by focusing on the recent global financial crisis as an example of a systemic debt crisis that affected borrowing economies in a synchronized fashion. Appendix Figure B2 shows that during the 2007–2009 global financial crisis, the net worth of U.S. banks contracted by more than 3 standard deviations, and EMs' GDP contracted by more than 2 standard deviations. We study episodes of this nature in the model by analyzing the response to aggregate DM and EM shocks (ω_t and $y_{\text{EM}t}$) that lead to a contraction in global banks' net worth and EMs' endowment of the magnitude observed in these data during 2007–2011. In particular, we consider the decrease in $y_{\text{EM}t}$ observed during 2007–2009 and a decrease in ω_t that generates a drop in global banks' net worth that is of the same magnitude as that observed in the data.

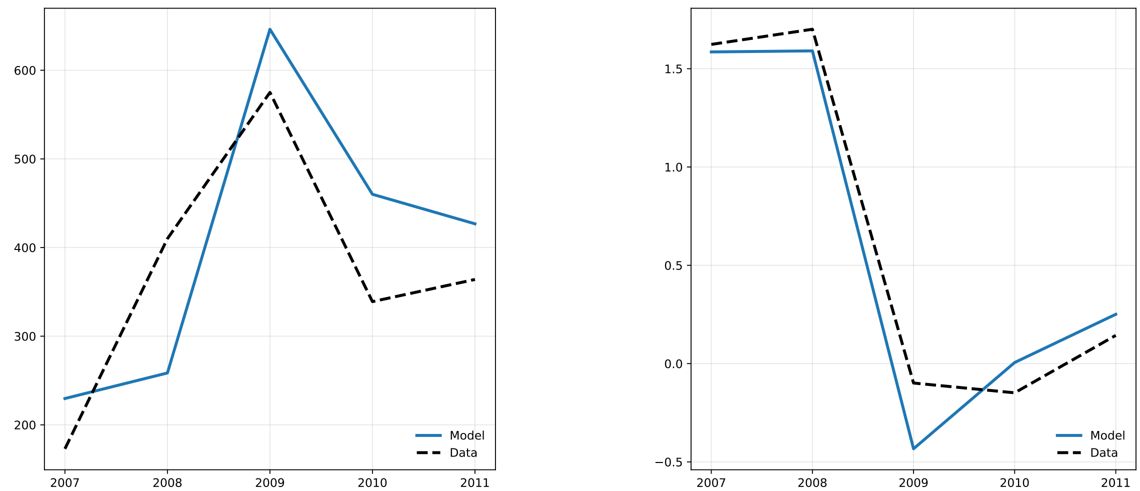
Figure 5 compares the dynamics of EM-bond spreads and consumption predicted in the model with those observed in the data during 2007–2011. In the data, during the 2007–2009 contraction, EM-bond spreads increased by 400 basis points (more than 2 standard deviations) and consumption adjusted by 1.5 standard deviations. The model predicts that in the face of a contraction of global banks' net worth and EMs' systemic endowment of the magnitude observed in the data during 2007–2009, EM-bond spreads increased and consumption-experience adjustments aligned with those observed in the data.[15] In the model, spreads and consumption adjustment are the result of two forces. First, the lower realizations of returns on DM

[15]The model predicts an increase in bond spreads of 500 basis points and an adjustment of consumption of 2 standard deviations, both of which are larger than those observed in the data. A reason for the overprediction of adjustment in consumption in the model relative to the data might lie in the set of unconventional macroeconomic policies introduced worldwide during the global financial crisis (see, for example, Catão et al., 2009).

Figure 5. EM-Bond Spreads and Consumption Dynamics During the Global Financial Crisis: Data and Model

(a) EM-Bond Spreads

(b) EMs' Consumption Dynamics



Notes: Data. Objects in the figure (dashed black lines) refer to the average of sovereign-bond spreads and the cyclical component of consumption in a sample of EMs (detailed in Supplementary Material B2). EM-bond spreads are expressed in basis points. The cyclical component of consumption is expressed as deviations from a log-linear trend and standardized. *Model.* Objects in the figure (solid blue lines) refer to the dynamic response of the model counterparts of these variables under the Lehman exercise. For details on the Lehman exercise, see Section 4.

risky assets have a negative impact on global banks' aggregate net worth. With a lower net worth, global banks must reduce their lending and thereby reduce their supply of funds to EMs. Given an aggregate EM demand for funds, this reduces bond prices and increases spreads. Higher costs of borrowing induce households to adjust consumption. Second, a drop in EM output increases spreads due to a combination of an increase in default risk and an amplification effect through global banks' net worth.

We then use the model to disentangle the relevance of each mechanism in the dynamics of spreads and consumption adjustment during the global financial crisis. For this, we analyze spread and consumption dynamics predicted by the model in response to only a drop in ω of the magnitude analyzed in the 2007–2009 episode. Appendix Table C4 shows that two-thirds of the increase in borrowing costs and 20% of the consumption adjustment during the crisis can be explained by DM shocks, transmitted through global banks. Thus, global banks play an important role during systemic debt crises, which operates by transmitting DM shocks rather than amplifying EM-origin shocks. Appendix Table C4 also shows that the main quantitative insights from the decomposition are still present in all of the alternative calibrations we consider.

We also assess whether our model is able to account for the dynamics of spreads and consumption before the global financial crisis. To study the predictions of our model for the full boom-bust episode, we feed DM and EM shocks to recreate the observed dynamics of global banks' net worth and EM output during the period 2004-11. Appendix Figure C2 shows that the dynamics of spreads and consumption in the model are similar to those observed in the data. It is worth mentioning that our model abstracts from the buildup of risk through time-varying leverage, which was a relevant element at the onset of the crisis.[16]

4.2.2. *Decomposing Borrowing Costs*

The recent global financial crisis was characterized by a sharp decline in global banks' net worth. How relevant are global banks for regular business-cycle fluctuations? Table 6 conducts an unconditional decomposition of borrowing costs in EMs into their default- and intermediation-premium components. We define the default premium component of spreads as the bond spreads that would be observed, given EMs' equilibrium sequence repayment and borrowing policies, if debt were priced by a risk-neutral lender. Similarly, we define the intermediation premium component of spreads as the bond spreads that would be observed if

[16]See, for example, Adrian and Shin (2010); Schularick and Taylor (2012); Bruno and Shin (2015a); Coimbra and Rey (2017); and Krishnamurthy and Muir (2017) for a related literature that studies the buildup of risk prior to financial crises.

debt were risk-free.[17] These two components need not account for the level of spreads, since bond payoffs covary with the stochastic discount factor. We define this remainder component as the pure risk component.

The first three columns of Table 6 show the decomposition of average spreads. Consistent with our calibration, which targets physical default probabilities and average spreads, the default premium accounts for slightly more than half of total spreads. The remainder of average spreads are mostly accounted for by the intermediation premium, with the pure risk component playing a modest role. The last three columns show that the intermediation premium also accounts for roughly half the standard deviation of spreads. Panel (C) of the table shows that these results are robust to alternative model specifications. The role the intermediation premium played in EMs' spreads fluctuations is in line with the conditional decomposition of risky asset prices reported in the impulse-response functions in Bocola (2016). Our findings are also aligned with independent empirical estimates of the role of global factors for EM-bond spreads from the international-finance literature (e.g., Longstaff et al., 2011), and suggest that global banks play a central role in driving these global factors. Moreover, global banks' role, which drives half of the fluctuations in EMs' spreads, suggests that the proposed model can provide a microfoundation for exogenous fluctuations in external borrowing costs, which have been identified as critical drivers of EM consumption, output, and exchange-rate dynamics (e.g., Neumeyer and Perri, 2005; García-Cicco et al., 2010). In Supplemental Material B5, we show how the unconditional decomposition of spreads changes for different values of ϕ, highlighting the fact that financial frictions drive the role of global banks in the determination of sovereign spreads.

[17] In the model, the equilibrium prices of EM debt are given by $q^i_{\mathrm{EM}t} = \mathbb{E}_t\left[m_{t+1}\iota_{it+1}\left(1+\xi q^i_{\mathrm{EM}t+1}\right)\right]$, where $m_{t+1} = v_{t+1}/R^e_{\mathrm{DM}t}$ is the global banks' stochastic discount factor. To compute the default premium component of spreads, we compute a sequence of risk-neutral prices, $\tilde{q}^i_{\mathrm{EM}t} = \mathbb{E}_t\left[\beta_{\mathrm{DM}}\iota_{it+1}\left(1+\xi\tilde{q}^i_{\mathrm{EM}t+1}\right)\right]$, where $\{\iota_{it}\}_{t=0}^{\infty}$ denotes the sequence of state-contingent repayment policies from our baseline economy. We then compute EM yields to maturity based on risk-neutral prices $\{\tilde{q}^i_{\mathrm{EM}t}\}_{t=0}^{\infty}$. Similarly, to compute the intermediation premium, we price a synthetic EM risk-free bond, $\hat{q}^i_{\mathrm{EM}t} = \mathbb{E}_t\left[m_{t+1}\left(1+\xi\hat{q}^i_{\mathrm{EM}t+1}\right)\right]$, where $\{m_t\}_{t=0}^{\infty}$ denotes the stochastic process of the stochastic discount factor from our baseline economy. We then compute EM yields to maturity based on this risk-free bond $\{\hat{q}^i_{\mathrm{EM}t}\}_{t=0}^{\infty}$.

Table 6. Unconditional Decomposition of EM-Bond Spreads

	Average			Standard Deviation		
	Total	% Default Premium	% Interm. Premium	Total	% Default Premium	% Interm. Premium
Data	410			173		
Baseline Model	416	57%	39%	152	76%	39%
Robustness						
i. Alternative Elasticity	314	82%	16%	128	92%	16%
ii. Measured Income Process	521	53%	47%	192	84%	40%
iii. Asset Managers	470	46%	52%	163	68%	62%
iv. High Leverge	378	63%	30%	141	80%	28%
v. Time-varying ϕ	442	52%	50%	141	73%	46%

Notes: This table shows a decomposition of EM-bond spreads predicted by the model into the contribution to total spreads of their default-premium and intermediation-premium components. For definitions of default and intermediation premiums, see Section 4. The Total columns are expressed in basis points, and the remaining columns are expressed in share of the Total. The first row corresponds to observed data and the remaining rows to different model specifications. For details on each model specification, see Supplementary Material B4.

4.3. *The Role of Financial Intermediaries' Portfolios and the Distribution of Bond Holdings*

So far our quantitative model has focused on a calibration in which, as currently observed in the data, global banks' exposure to EMs in their portfolio of risky securities is relatively low (10%). However, as the literature on the history of debt crises suggests, low exposure is not always the rule. For instance, in the Latin American debt crisis of the 1980s, U.S. banks' exposure to these economies debt was roughly three times their current exposure to EMs (see, for example, Sachs, 1989). We now study the predictions of the model for a calibration of the model in which global banks' exposure to EM debt is 35%, closer to that observed in the 1980s. We refer to this calibration as a *high-exposure* economy and to our baseline calibration as a *low-exposure* economy.

Supplementary Material Figure B3c shows that in a high-exposure economy, EMs' borrowing costs respond significantly more to EM systemic endowment shocks than to idiosyncratic endowment shocks.[18] This is because negative systemic shocks lead to EM default, which contracts global banks' net worth, contracting the global supply of funds and further increasing the returns to EMs. Supplementary Material Figure B3a shows that in our baseline calibration, this effect is relatively small, since low exposure attenuates the effect of lower EM debt prices on global banks' net worth.

This exercise analyzes the effects of changes in the share of intermediaries' portfolios that is invested in EM debt. Even if this share is held constant, the amplification of EM-originated shocks can change if the degree of leverage or the term structure of banks' assets change. As emphasized by previous literature, when banks are more levered or when they hold debt with longer maturities, an increase in sovereign risk can be amplified through a larger impact on intermediaries' net worth (see, for example, Bocola, 2016). The time-varying nature of intermediaries' exposure to EMs, leverage, and other factors highlights the importance of having a micro-founded model of risky lending to assess systemic risks in emerging markets.

We further argue that the degree of amplification is also influenced by the distribution of debt positions in the economy. To illustrate this, we replicate the same impulse-response analysis starting from an initial distribution of debt positions with a cross-sectional standard deviation that is twice as large as the average standard deviation from the ergodic distribution.[19] Supplementary Material Figure B3d shows the differential reaction of spreads to an idiosyncratic and systemic output shock. In this case, the amplification is roughly 50% larger than starting from the ergodic dispersion. The reason is that when debt positions are more dispersed, a systemic output drop increases default risk for those heavily indebted economies, which constitute a larger fraction and hence create a larger drop in global banks' net worth.

[18] In particular, we analyze the impulse-response of equal-magnitude negative shocks to the systemic and idiosyncratic components of output. To compute the responses to a shock to the systemic (idiosyncratic) component of output, we analyze the economy starting from the average aggregate states from its ergodic distribution and feed in a negative shock of the same magnitude to each component of output, then trace the dynamics of the variables of interest.

[19] A standard deviation that is twice as large is empirically plausible. Both in the data and in model simulations, the standard deviation fluctuates to reach levels that are twice as large as the average.

Finally, Appendix Figure C3 shows that this differential amplification holds globally for multiple parameterizations of the debt-distribution dispersion. It also shows that banks must be more heavily exposed to EM debt to generate this differential amplification. This last exercise demonstrates that two key variables, banks' exposure to EM debt and the dispersion in the debt distribution, are relevant in determining the transmission and amplification of aggregate shocks in the world economy.

4.4. *Global Policies*

The recurrent occurrence of systemic debt crises also stresses the value of implementing global stabilization policies during these episodes. Historically, we have observed different examples of such policies, which include coordinated expansionary monetary policies, global liquidity provision by multilateral institutions and central banks, and demand–stimulating fiscal policies.

We use our model of the world economy to study the effects of policies that provide liquidity to financial intermediaries. We introduce this policy by allowing the funding rate of financial intermediaries to be contingent on the aggregate shock.[20] In particular, we parameterize the risk–free rate as $R_d^{-1}(\omega) = \beta(\omega) = \beta_1 \omega^{\beta_2}$, where $\{\beta_1, \beta_2\}$ govern the average rate and its elasticity to the ω shock. Note that the timing assumption is that a DM shock in period t affects the risk-free rate at which banks can borrow from period t to $t+1$, and not the repayments on outstanding deposits. We keep the same parameterization as in the baseline model and calibrate $\beta_1 = 0.98$ and $\beta_2 = -0.2$ to match the data moments of an average risk-free rate of 2% and a covariance of the risk-free rate and the log of the market value of intermediaries' net worth of 0.18. The negative value of $\beta_2 = -0.2$ implies that the funding rate intermediaries face is reduced during DM–recessions. We label this model parameterization as the economy with liquidity provision.

We then analyze the effects of a negative 2–s.d. DM shock to the economy with liquidity provision and compare it with the baseline economy. As shown in Appendix Figure C4, the effect of the ω shock on EM bond yields and EM aggregate consumption is attenuated by approximately one-half in the economy with liquidity provision. In this economy, funding

[20]This type of policy could be implemented by imposing a tax/subsidy on the risk-free funding of global financial intermediaries that is financed via lump-sum transfers/taxes to DM households.

rates decrease in response to the shock, which allows intermediaries to access funding at cheaper rates and mitigate the impact on their demand for risky assets.

This exercise suggests that global policies aimed at mitigating the impact of debt crises on global financial intermediaries can also benefit emerging economies through their effects on borrowing rates.

5. Conclusions

In this paper, we examined the long-held view in policy circles that global financial intermediaries are central actors who shape systemic debt crises. We did so by combining new empirical evidence and a quantitative model of the world economy with heterogeneous borrowers and financial intermediaries. The empirical evidence shows that emerging-market bond prices are affected by changes in the net worth of the global financial intermediaries holding these bonds. Our model shows that this evidence can be interpreted as being driven by the financial frictions faced by intermediaries investing in emerging-market debt, and the quantitative analysis of our model suggests a key role for financial intermediaries in driving fluctuations in borrowing costs and consumption in emerging-market economies, during both debt crises and in regular business cycles.

Our findings stress the lender side of systemic debt crises and episodes of large external borrowing and consumption adjustments (or *sudden stops*). From the perspective of individual borrowing economies, lenders' dynamics manifest themselves as fluctuations in external borrowing costs, which have a long tradition in international macroeconomics. However, for policymakers operating in the world economy, a detailed framework such as the one constructed in this paper can help understand the nature of these fluctuations. In this sense, the paper's findings highlight the importance of measuring global financial intermediaries' portfolios and the distribution of debt positions in the global economy in detail in order to assess potential global risks. We leave a more detailed policy analysis based on this framework for future research.

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APPENDIX TO GLOBAL BANKS AND SYSTEMIC DEBT CRISES

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A. Theoretical Framework: Further Details and Extensions

A1. *Recursive Model Representation*

This section provides a recursive representation of the model global economy developed in Section 2, and presents some results on the characterization of equilibrium allocations. The timing is as follows.

i. At the beginning of each period, the exogenous idiosyncratic and aggregate shocks $(z_i, y_{\text{EM}}, \omega)$ are realized. An individual bank enters the period with book value of net worth n and market value $v(\mathbf{s}, n)$. The aggregate state is given by $\mathbf{s} \equiv \{\mathbf{s}_x, \Delta\}$, where $\mathbf{s}_x \equiv \{y_{\text{EM}}, \omega\}$, $\Delta \equiv \{A_{\text{DM}}, D, g(b, z)\}$, and $g(b, z)$ is the joint distribution of debt and idiosyncratic output of EMs that borrowed in the previous period.
ii. Exit shocks are realized. Assets are repaid and banks can issue new deposits.
iii. Banks can issue new equity and purchase new EM and DM assets in primary markets.

Global Banks' Recursive Problem. The market value of a global bank is given by

$$v(\mathbf{s}, n) = \max_{\substack{\{a'_{\text{EM},(b,z)} \geq 0\},\\ a'_{\text{DM}} \geq 0, d', div}} (1-\sigma)n + \sigma\left(div(1 + \mathbb{I}_{div<0}\mathcal{C}(div, n)) + \beta_{\text{DM}}\mathbb{E}\left[v(\mathbf{s}', n')\right]\right), \tag{18}$$

subject to

$$\int\int_{(b,z):g_+(b,z)>0} q_{\text{EM},(b,z)}(\mathbf{s}) a'_{\text{EM},(b,z)}\, \mathrm{d}b\, \mathrm{d}z + q_{\text{DM}}(\mathbf{s}) a'_{\text{DM}} = n + d' - div,$$

$$d' \leq \kappa n,$$

$$n' = \int\int_{(b,z):g_+(b,z)>0} \iota_{\text{EM},(b,z)}(\mathbf{s}') \left(1 + \xi q_{\text{EM},(b,z)}(\mathbf{s}')\right) a'_{\text{EM},(b,z)}\, \mathrm{d}b\, \mathrm{d}z$$
$$+ \omega' \left(\alpha A_{\text{DM}}^{\alpha-1} + 1 - \delta\right) a'_{\text{DM}} - R_d d'.$$

where d' denotes the choice of deposits; div denotes dividend payments from banks that did not exit; $a'_{\text{EM},(b,z)}$ the mass of securities from economies with borrowing b and idiosyncratic income z; a'_{DM} the mass of nonfinancial DM securities purchased; $q_{\text{EM},(b,z)}(\mathbf{s})$ and $q_{\text{DM}}(\mathbf{s})$ their respective prices; R_d is the deposit rate; and $\iota_{\text{EM},(b,z)}(\mathbf{s})$ denotes EMs' repayment policies. Note that banks are subject to an occasionally binding borrowing constraint, which we account for in the quantitative solution of the model.

EMs' Recursive Problem. The borrower's repayment decision is characterized by the following problem $V(b,z,\mathbf{s}) = \max_\iota \iota V^{\mathrm{r}}(b,z,\mathbf{s}) + (1-\iota)V^{\mathrm{d}}(z,\mathbf{s})$, where $V^{\mathrm{r}}(b,z,\mathbf{s})$ and $V^{\mathrm{d}}(z,\mathbf{s})$ denote, respectively, the values of repayment and default, described below. The borrower's debt-repayment decision is characterized by the problem

$$V^{\mathrm{r}}(b,z,\mathbf{s}) = \max_{b'} u(c) + \beta\mathbb{E}\left[V(b',z',\mathbf{s}')\right], \tag{19}$$

$$\text{s.t. } c = y_{\text{EM}} + z + q(b',z,\mathbf{s})(b' - \xi b) - b, \tag{20}$$

$$\mathbf{s}' = \Gamma(\mathbf{s}, \mathbf{s}'_x, \hat{A}_{\text{DM}}(\mathbf{s}), \hat{D}(\mathbf{s}), \hat{b}'(b,z,\mathbf{s})),$$

where $\mathbf{s}' = \Gamma(\mathbf{s}, \mathbf{s}'_x, \hat{A}_{\text{DM}}(\mathbf{s}), \hat{D}(\mathbf{s}), \hat{b}'(b,z,\mathbf{s}))$ is the law of motion of the aggregate state $\mathbf{s}'$, and $\hat{A}_{\text{DM}}(\cdot)$, $\hat{D}(\cdot)$, and $\hat{b}'(\cdot)$ denote perceived policies at the borrowing stage that describe, respectively, aggregate DM assets, bank deposits, and EM borrowing. The law of motion and perceived policies are equilibrium objects in the model, taken as given by global banks and EM borrowers. Finally, the value of default is given by

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

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

$$\mathbf{s}' = \Gamma\left(\mathbf{s}, \mathbf{s}'_x, \hat{A}_{\text{DM}}(\mathbf{s}), \hat{D}(\mathbf{s}), \hat{b}'(b,z,\mathbf{s})\right).$$

Recursive Equilibrium. We define a recursive equilibrium as follows:

Definition **1.** *A recursive competitive equilibrium consists of global banks' policies in the primary market stage* $\{a'_{\text{EM}(b,z)}(\mathbf{s}), a'_{\text{DM}}(\mathbf{s}), div_{\text{DM}}(\mathbf{s})\}$*, and value function* $v(\mathbf{s},n)$*; borrowers' policies,* $\{\iota(b,z,\mathbf{s}), b'(b,z,\mathbf{s})\}$*, and value functions,* $\{V(b,z,\mathbf{s}), V^{\mathrm{r}}(b,z,\mathbf{s}), V^{\mathrm{d}}(z,\mathbf{s})\}$*; primary market price schedules,* $q(b',z,\mathbf{s})$*; law of motion of the aggregate state,* $\Gamma(\mathbf{s}, \mathbf{s}'_x, \tilde{A}'_{\text{DM}}(\mathbf{s}), \tilde{D}'(\mathbf{s}), \tilde{b}'(b,z,\mathbf{s}))$*; and perceived policies,* $\{\hat{\iota}(b,z,\mathbf{s}), \hat{b}'(b,z,\mathbf{s}), \hat{A}'_{\text{DM}}(\mathbf{s}), \hat{D}'(\mathbf{s})\}$*, such that (1) Given prices, laws of motion, and perceived policies, global banks' policies and value functions solve their recursive problem. (2) Given prices, laws of motion, and perceived policies, borrowers' policies and value functions solve their recursive problem. (3) Asset markets clear. (4) The laws of motion of the aggregate state are consistent with individual policies. (5) Perceived policies coincide with optimal policies.*

The following proposition characterizes global banks' optimal choices.

Proposition **2.** *Any equilibrium with equity issuance by global banks and positive aggregate holdings of all risky assets must have* $\mathbb{E}\left[\nu(\mathbf{s}')R_{\text{EM},(b,z)}(\mathbf{s}',\mathbf{s})\right] = \mathbb{E}\left[\nu(\mathbf{s}')R_{\text{DM}}(\mathbf{s}',\mathbf{s})\right]$, *where returns on EMs,* $R_{\text{EM},(b,z)}(\mathbf{s}',\mathbf{s})$, *and DM economies,* $R_{\text{DM}}(\mathbf{s}',\mathbf{s})$, *are defined as*

$$R_{\text{DM}}(\mathbf{s}',\mathbf{s}) = \omega'\left(\alpha A_{\text{DM}}^{\alpha-1} + 1 - \delta\right) \text{ and } \qquad R_{\text{EM},(b,z)}(\mathbf{s}',\mathbf{s}) = \frac{\iota_{\text{EM},(b,z)}(\mathbf{s}')\left(1+\xi q_{\text{EM},(b,z)}(\mathbf{s}')\right)}{q_{\text{EM},(b,z)}(\mathbf{s})}.$$

Additionally, global banks' value function is linear in their book value of net worth: $v(\mathbf{s},n) = \nu(\mathbf{s})n$, *where the marginal value of net worth solves the recursive equation*

$$\nu(\mathbf{s}) = (1-\sigma) + \sigma \max\left\{\frac{1}{4\phi}\left(\mathbb{E}\left[\nu\left(s'\right)\right]-1\right)^2 + \mathbb{E}\left[\nu\left(s'\right)\right];\right. \tag{22}$$
$$\left.\frac{1}{4\phi}\left(\beta_{\text{DM}}\mathbb{E}\left[\nu(\mathbf{s}')R_{\text{DM}}(\mathbf{s}',\mathbf{s})\right]-1\right)^2 + \beta_{\text{DM}}\left(\mathbb{E}\left[\nu(\mathbf{s}')R_{\text{DM}}(\mathbf{s}',\mathbf{s})\right](1+\kappa) - \mathbb{E}\left[\nu(\mathbf{s}')\right]R_d\kappa\right)\right\}$$

Proof. We proceed by guessing linearity of the value function and verifying the conjecture. Start by conjecturing linearity of the banks' problem: $v(\mathbf{s},n) = \nu(\mathbf{s})n$. Then

$$v(\mathbf{s},n) = \max_{\substack{\{a'_{\text{EM},(b,z)}\geq 0\} \\ a'_{\text{DM}}\geq 0, d'\leq R_d\kappa n, div}} (1-\sigma)n + \sigma div(1+\mathbb{I}_{div<0}\mathcal{C}(div,n))$$
$$+\sigma\beta_{\text{DM}}\mathbb{E}\left[\nu(\mathbf{s}')\left(\iint_{(b,z):g_+(b,z)>0} R_{\text{EM},(b,z)}(\mathbf{s}',\mathbf{s})q_{\text{EM},(b,z)}(\mathbf{s})a'_{\text{EM},(b,z)}\,\mathrm{d}b\,\mathrm{d}z + R_{\text{DM}}(\mathbf{s}',\mathbf{s})q_{\text{DM}}(\mathbf{s})a'_{\text{DM}} - R_d d'\right)\right]$$

$$\text{subject to} \int\int_{(b,z):g_+(b,z)>0} q_{\text{EM},(b,z)}(\mathbf{s})a'_{\text{EM},(b,z)}\,\mathrm{d}b\,\mathrm{d}z + q_{\text{DM}}(\mathbf{s})a'_{\text{DM}} = n - div + d'.$$

In any asset b, z with positive investments,

$$\mathbb{E}\left[\sigma\beta_{\text{DM}}\nu(\mathbf{s}')R_{\text{EM},(b,z)}(\mathbf{s}',\mathbf{s})\right] = \mathbb{E}\left[\sigma\beta_{\text{DM}}\nu(\mathbf{s}')R_{\text{DM}}(\mathbf{s}',\mathbf{s})\right] \equiv R^e_{\text{DM}}(\mathbf{s}). \tag{23}$$

Otherwise banks will not have positive holdings of the asset with the lower risk-adjusted return. Substituting this condition and the flow of funds constraint into the objective function,

$$v(\mathbf{s},n) = (1-\sigma)n + \sigma div(1+\mathbb{I}_{div<0}\mathcal{C}(div,n))$$
$$+(R^e_{\text{DM}}(\mathbf{s}) - R^e_d(\mathbf{s}))\left(\int\int_{(b,z):g_+(b,z)>0} q_{\text{EM},(b,z)}(\mathbf{s})a'_{\text{EM},(b,z)}\,\mathrm{d}b\,\mathrm{d}z + q_{\text{DM}}(\mathbf{s})a'_{\text{DM}}\right) - \sigma\mathbb{E}\left[\nu(\mathbf{s}')\right](div-n),$$

where $R^e_d(\mathbf{s}) \equiv \beta_{\text{DM}}\sigma\mathbb{E}\left[\nu(\mathbf{s}')\right]R_d$. Combining the flow of funds equation and the borrowing constraint:

$$\int\int_{(b,z):g_+(b,z)>0} q_{\text{EM},(b,z)}(\mathbf{s})a'_{\text{EM},(b,z)}\,\mathrm{d}b\,\mathrm{d}z + q_{\text{DM}}(\mathbf{s})a'_{\text{DM}} + div - n \leq \kappa n. \tag{24}$$

Let $\zeta(\mathbf{s})$ be the multiplier for the combined constraint. Taking the first order condition with respect to $div < 0$,

$$\sigma\left[1+\mathcal{C}\left(div,n\right)+div\mathcal{C}_{div}\left(div,n\right)-\mathbb{E}\left[\nu\left(\mathbf{s}'\right)\right]\right]=\zeta(\mathbf{s}). \tag{25}$$

Under the assumed $\mathcal{C}(div,n)=\phi\left(\frac{-div}{n}\right)$, we get

$$\sigma\left[1+2\phi\left(\frac{-div}{n}\right)-\mathbb{E}\left[\nu\left(\mathbf{s}'\right)\right]\right]=\zeta(\mathbf{s}). \tag{26}$$

Re-arranging this last equation, and noting that $\sigma\mathbb{E}\left[\nu\left(\mathbf{s}'\right)\right]=R^e_d(\mathbf{s})$ yields (13). The first order conditions for $a'_{\text{EM},(b,z)}$ and a'_{DM} are, respectively,

$$\sigma\beta_{DM}\left(\mathbb{E}\left[\nu(\mathbf{s}')R_{\text{EM},(b,z)}(\mathbf{s}',\mathbf{s})\right]-\mathbb{E}\left[\nu(\mathbf{s}')\right]R_d\right)=\zeta(\mathbf{s}) \tag{27}$$

$$\sigma\beta_{DM}\left(\mathbb{E}\left[\nu(\mathbf{s}')R_{\text{DM},(b,z)}(\mathbf{s}',\mathbf{s})\right]-\mathbb{E}\left[\nu(\mathbf{s}')\right]R_d\right)=\zeta(\mathbf{s}). \tag{28}$$

Combining these two equations yields (12) and (14). Additionally, note that, given (28), we can express the complementary slackness condition as

$$\left(R^e_{\text{DM}}(\mathbf{s})-R^e_d(\mathbf{s})\right)\left((\kappa+1)n-\int\int_{(b,z):g_+(b,z)>0}q_{\text{EM},(b,z)}(\mathbf{s})a'_{\text{EM},(b,z)}\,\mathrm{d}b\,\mathrm{d}z-q_{\text{DM}}(\mathbf{s})a'_{\text{DM}}-div\right)=0. \tag{29}$$

We can use (29) to express the value function as:

$$\begin{aligned} v(\mathbf{s},n)&=(1-\sigma)n+\sigma div\left(1+\phi\left(\frac{-div}{n}\right)\right) \\ &\quad+\max\left\{\sigma\mathbb{E}[\nu(\mathbf{s}')](n-div);\left[R^e_{\text{DM}}(\mathbf{s})-R^e_d(\mathbf{s})\right](n-div+\kappa n)+\sigma\mathbb{E}[\nu(\mathbf{s}')](n-div)\right\}, \end{aligned} \tag{30}$$

or equivalently,

$$\begin{aligned} v(\mathbf{s},n)=(1-\sigma)n+\sigma\max\Bigg\{&\left(n\mathbb{E}[\nu(\mathbf{s}')]+div\left[1+\phi\left(\frac{-div}{n}\right)-\mathbb{E}[\nu(\mathbf{s}')]\right]\right); \\ &\left(n\mathbb{E}[\nu(\mathbf{s}')]+div\left[1+\phi\left(\frac{-div}{n}\right)-\mathbb{E}[\nu(\mathbf{s}')]\right]\right)+\left[R^e_{\text{DM}}(\mathbf{s})-R^e_d(\mathbf{s})\right]((\kappa+1)n-div)\Bigg\}. \end{aligned} \tag{31}$$

In the first argument of the *max* operator, the constraint is not binding and $R^e_{\text{DM}}(\mathbf{s})=R^e_d(\mathbf{s})$. In the second argument, the constraint is binding and $R^e_{\text{DM}}(\mathbf{s})>R^e_d(\mathbf{s})$.

Additionally, combining optimality conditions for div and $a'_{\text{EM},(b,z)}$, we get

$$div=\frac{n}{2\phi}\left[1-\frac{R^e_{DM}(\mathbf{s})}{\sigma}\right]. \tag{32}$$

Substituting the expression for optimal equity issuance (32) into the objective function, we arrive at

$$v(\mathbf{s},n) = (1-\sigma)n + \sigma n \max\left\{ \frac{1}{4\phi}\left(\mathbb{E}\left[\nu\left(s'\right)\right]-1\right)^2 + \mathbb{E}\left[\nu\left(s'\right)\right]; \right. \tag{33}$$
$$\left. \frac{1}{4\phi}\left(\beta_{\text{DM}}\mathbb{E}\left[\nu(\mathbf{s}')R_{\text{DM}}(\mathbf{s}',\mathbf{s})\right]-1\right)^2 + \beta_{\text{DM}}\left(\mathbb{E}\left[\nu(\mathbf{s}')R_{\text{DM}}(\mathbf{s}',\mathbf{s})\right](1+\kappa) - \mathbb{E}\left[\nu(\mathbf{s}')\right]R_d\kappa\right)\right\},$$

which confirms linearity of net worth with $v(\mathbf{s},n) = \nu(\mathbf{s})n$.

□

B. Empirical Analysis

B1. *Data Description and Analysis*

B.1.1. *Macro data*

For the background empirical analysis using aggregate data in Section 3.1, we use data on EM sovereign and corporate spreads for countries included in JP Morgan's Emerging Markets Bond Index (EMBI) and Corporate Emerging Markets Bond Index (CEMBI; for corporate spreads) obtained from Bloomberg and Datastream. We also use data on U.S. high-yield spread and global banks' net worth, the latter defined as the difference between the real value of assets and liabilities reported by U.S. chartered depository institutions obtained from the Federal Reserve Board, Flow of Funds.

B.1.2. *Micro data*

Our sample of countries includes those countries that, at some point, were part of the EMBI and had a credit rating (from Standard & Poor's) below A in 2008.q2. The set of 30 countries included in our sample are Argentina, Brazil, Colombia, Costa Rica, Croatia, Ecuador, Greece, India, Indonesia, Jamaica, Kazakhstan, Latvia, Lebanon, Mexico, Morocco, Pakistan, Panama, Peru, Philippines, Poland, Romania, Russia, El Salvador, South Africa, Thailand, Tunisia, Turkey, Ukraine, Uruguay, and Venezuela. For each country in the sample, we collect information on all bonds issued in foreign markets before 2008. The average country issued 23 bonds. For each bond, we observe a borrower identifier, the country and sector of the borrower, the coupon structure and maturity, seniority, and whether the bond is subject to collective action clauses. We complement this data with daily bond-price data and bid-ask spreads provided by Bloomberg based on information gathered from trading desks.

Appendix Table B1 reports descriptive statistics of our sample of bonds for those countries with the largest number of bonds. On average, the bonds of these countries have a pre-Lehman yield-to-maturity of 8%, a maturity of 9.5 years, and a bid-ask spread of 0.5%. These variables exhibit heterogeneity across countries.

Panel (A) of Appendix Table B2 reports similar statistics for bonds by sector. Approximately half of the bonds in our sample are sovereign bonds and half are corporate bonds. Corporate bonds issued by financial firms account for half of the sample. Across sectors, there is some yield-to-maturity, maturity, and bid–ask-spread heterogeneity. Panels (B) and (C) of Appendix Table B2 report the same statistics for bonds that differ in the presence of collective action clauses and in their seniority.

Appendix Table B3 shows the average yield to maturity and its cross-sectional standard deviation 2 months before and after Lehman's bankruptcy episode. Average yields increased by 2 percentage points on average, and its cross-sectional standard deviation also increased by 2 percentage points. Similar patterns hold if we focus exclusively on sovereign bonds.

We then assess the extent to which bonds' yields to maturity can be explained by bond and borrower characteristics. To do this, we estimate the following empirical model:

$$y_{it} = \alpha_{kst} + \alpha_{ct} + \gamma_t' Z_{it} + \varepsilon_{it}, \tag{34}$$

where y_{it} denotes the log gross yield to maturity of bond i in period t; α_{kst} denotes the country of issuance (k) by sector (s) by time fixed effect; α_{ct} denotes a currency fixed effect; and Z_{it} is a vector of bond-level controls that includes residual maturity, bid–ask spread, a categorical variable reflecting the bond's seniority, a dummy variable on whether the bond is subject to collective action clauses, and initial yield.[21] The last four rows of Appendix Table B3 show the average R^2 of running daily regressions on different sets of controls. The sole inclusion of country–sector and currency fixed effects already accounts for around 62% of the observed yield variation. If we include the full set of controls, the empirical model can account for 99% of the variation from the pre-Lehman period.

[21]Initial yield corresponds to the yield 60 days before the Lehman episode for those regressions with pre-Lehman data, and to the yield at the Lehman episode for those regressions with post-Lehman data.

Table B1. Descriptive Statistics by Country

Country	N Bonds	YTM	Residual Maturity	Bid-Ask Spread
Argentina	44	15.0%	10.6	0.65%
Brazil	94	8.0%	11.4	0.38%
Colombia	20	6.9%	8.55	0.36%
Costa Rica	5	5.9%	5.52	0.44%
Greece	13	6.3%	6.28	0.18%
Croatia	11	6.1%	4.76	0.33%
Hungary	21	5.4%	6.40	0.29%
Indonesia	20	7.0%	13.3	0.29%
India	24	6.4%	8.51	0.45%
Jamaica	9	8.3%	10.9	0.66%
Kazakhstan	34	11.9%	6.17	0.52%
Lebanon	7	8.0%	5.71	0.42%
Mexico	92	7.5%	8.55	0.32%
Panama	14	6.5%	13.2	0.45%
Peru	9	7.1%	11.6	0.39%
Philippines	35	6.7%	10.1	0.36%
Pakistan	8	13.3%	7.16	0.56%
Poland	18	4.5%	5.60	0.21%
Russia	8	6.8%	8.15	0.17%
El Salvador	5	6.4%	18.7	0.44%
Thailand	14	10.1%	17.6	0.45%
Turkey	23	6.4%	9.33	0.32%
Ukraine	14	9.2%	4.81	0.27%
Uruguay	10	6.3%	14.9	0.55%
Venezuela	21	11.4%	11.9	0.44%
South Africa	27	8.4%	8.01	0.36%
Average	23	7.9%	9.54	0.49%

Notes: This table shows descriptive statistics by country of the EM bonds included in the empirical analysis of Section 3, for those countries with five or more bonds. *N* Bonds refers to the number of bonds available per country. YTM refers to the bond's average yield to maturity in percent. Maturity refers to the average residual maturity in years. Bid–ask spread is expressed in percent. All averages are computed using their values before the Lehman episode (10 days before September 15, 2008).

Table B2. Descriptive Statistics by Sector and Other Characteristics

		Share	YTM	Residual Maturity	Bid-Ask Spread
A. Sector	Government	49.4%	7.2%	9.75	0.40%
	Industrial	4.6%	11.4%	6.15	0.73%
	Financial	21.5%	9.5%	9.74	0.50%
	Utilities	4.2%	8.6%	6.91	0.32%
	Communications	7.0%	9.0%	7.57	0.44%
	Energy	5.4%	8.0%	9.60	0.46%
	Other	8.0%	9.0%	11.5	0.62%
	Average	14.3%	9.0%	9.25	0.49%
B. CAC	Yes	39.8%	7.9%	11.7	0.46%
	No	48.5%	8.6%	8.09	0.45%
	NA	11.7%	7.8%	7.35	0.35%
	Average	33.3%	8.1%	9.05	0.42%
C. Seniority	1st Lien	2.4%	9.4%	8.94	0.13%
	2nd Lien	0.5%	9.0%	5.70	0.66%
	Secured	3.6%	8.6%	3.97	0.49%
	Senior Unsecured	76.4%	8.4%	9.34	0.46%
	Unsecured	10.1%	7.0%	3.65	0.32%
	Senior Subordinated	0.5%	8.8%	34.4	0.46%
	Subordinated	3.9%	7.9%	7.59	0.40%
	Junior Subordinated	2.6%	8.2%	42.0	0.60%
	Average	12.5%	8.4%	14.4	0.44%

Notes: This table reports descriptive statistics of bonds by sectors included in the empirical analysis of Section 3. The first column shows the average share of bonds. Other groups include consumer (68%), basic materials (35%), diversified (7%), and technology (0.5%). YTM refers to the average yield to maturity in percent. Maturity refers to the average residual maturity in years. Bid–ask spread is expressed in percent. All average variables are computed using their values before the Lehman episode (10 days before September 15 2008). Source of data and sector definitions: Bloomberg.

Table B3. Bond Yields to Maturity Before and After the Lehman Episode

	All Bonds			Only Sovereign		
	Pre-Lehman	Post-Lehman	Diff.	Pre-Lehman	Post-Lehman	Diff.
Average	7.01%	9.01%	0.000	6.73%	8.65%	0.000
Cross-Sec. Std. Deviation	13.64%	15.49%	0.000	8.41%	10.23%	0.000
R^2 from Yield Regressions						
(1): Country-Sector FE	55.6%	61.6%	0.000	48.0%	56.8%	0.000
(2): (1) + Currency FE	62.0%	64.8%	0.002	52.5%	58.6%	0.000
(3): (2) + Add. Controls	65.5%	68.2%	0.000	56.0%	62.1%	0.000
(4): (3) + Initial Yield	99.1%	85.9%	0.000	98.2%	87.0%	0.000

Notes: This table reports summary statistics for the pre-Lehman and post-Lehman periods (2 months before and after Lehman's bankruptcy episode, respectively). The first three columns use data from all bonds, and the last three columns use data from sovereign bonds. The columns *Diff* report the *p*-value of the test of equality of pre- and post-Lehman statistics. The first two rows show the average and cross-sectional standard deviations. The remaining rows report the average R^2 of running daily regressions from specification (34) for the pre- and post-Lehman periods. Different rows expand the set of controls used. The first row uses country–sector fixed effects; the second also includes currency fixed effects; the third also includes maturity, bid–ask spreads, and amount outstanding as additional controls; and the last row also includes initial yields.

Appendix Table B3 also shows that the explanatory power of the empirical model is significantly undermined post-Lehman relative to pre-Lehman. The largest R^2 is 99% pre-Lehman compared with 86% post-Lehman, which are statistically different from each other. Similar patterns hold if we focus exclusively on sovereign bonds. This fact suggests a significant increase in yield dispersion after Lehman that cannot be explained by bonds' observable characteristics. This motivates us to focus on this episode, which displays considerable bond price deviations that may be related to other factors. We analyze how this unexplained variation is related to bond holders' differential performance during this episode.

The most novel part of our data concerns the data on holdings by financial institutions for each bond in the sample. These data are provided by Bloomberg, a leading data source for shareholder and debt holder ownership information.[22] We obtained data on holdings by financial institution for all quarters of 2008. Holdings are self-reported by major financial institutions, which include global and national banks, asset-management firms (mutual funds, hedge funds, and financial advisors), pension funds, insurance companies, holding companies, and other financial institutions.[23] The total reported holdings of all financial institutions account for 25%, on average, of the total amount outstanding of a bond.[24]

Of the reporting financial institutions, we focus on the 64 publicly traded institutions for whom we are able to measure the change in their stock price around the Lehman episode (Appendix Table B4). These institutions constitute our sample of financial institutions. Major global banks (e.g., JPMorgan, Deutsche Bank, Goldman Sachs, BNP Paribas, Citigroup) and major asset managers and insurance companies (e.g., AIG, BlackRock, Allianz) are included in the sample. The institutions in our sample hold 50%, on average, of total reported bond holdings in our sample (see Table 1). Appendix Table B5 reports descriptive statistics for the top 20 financial institutions in terms of numbers of EM bonds held. These institutions hold more than 200 bonds on average from a wide set of countries. Importantly, these financial institutions experienced differential capital shocks in the narrow window around Lehman's bankruptcy (see the last column of Appendix Table B5). To give an illustrative example, although JPMorgan did not experience a stock price drop, AIG experienced a drop in its stock price of 88% (−2.12 in log terms). This heterogeneity, which was due to the differential impact of their business activities in developed markets, is the focus of our empirical analysis.

[22]Bloomberg's Ownership Data Fact Sheet describes these data in further detail. Regarding its coverage, Bloomberg states that it "contains transactions and positions data from over 70,000 unique fund portfolios, 93,000 institutional investors and 444,000 insiders from 179 countries," thus providing ownership details for 527,000 fixed income securities.

[23]In certain situations, institutional investors have a fiduciary duty to report their holdings.

[24]This is consistent with the fact that a sizable fraction of external debt is held by central banks and other official institutions (see Arslanalp and Tsuda, 2014).

Table B4. Financial Institutions Included in the Empirical Analysis

Aegon NV	GE Capital	Prudential Financial
Allianz SE	Genworth Financial	Raiffeisen Bank International AG
Allstate	Goldman Sachs	Regions
American International Group	HSBC	Royal Bank of Canada
Ameriprise Financial	Hartford	Royal Bank of Scotland
BNP Paribas	Intesa Sanpaolo	SEI Investments Co
BNYM	Invesco	Schroders
Banca Mediolanum	JPMorgan	Societe Generale
Banco Bilbao Vizcaya Argentaria	Janus Henderson Group	Standard Life Aberdeen
Banco Santander	KBC Group NV	State Street
Bank of America	Legg Mason	Sumitomo Mitsui Financial Group.
Bank of Nova Scotia	Loomis Sayles	Sun Life Financial
Barclays Bank	MetLife	T Rowe Price Group
BlackRock	Mitsubishi UFJ	U.S. Bancorp
CIBC	Morgan Stanley	UBS
Citigroup	NN Group NV	UniCredit
Commonwealth Bank of Australia	Natixis	Virtus Investment Partners
Credit Suisse	Nikko Asset Management Co	Wells Fargo
Daiwa Securities Group	Nomura Holdings	
Deutsche Bank	Nordea Bank Abp	
Fidelity National Financial	Northern Trust	
Franklin Resources	PNC	
GAM Holding AG	Principal Financial Group	

Table B5. Descriptive Statistics by Financial Institution

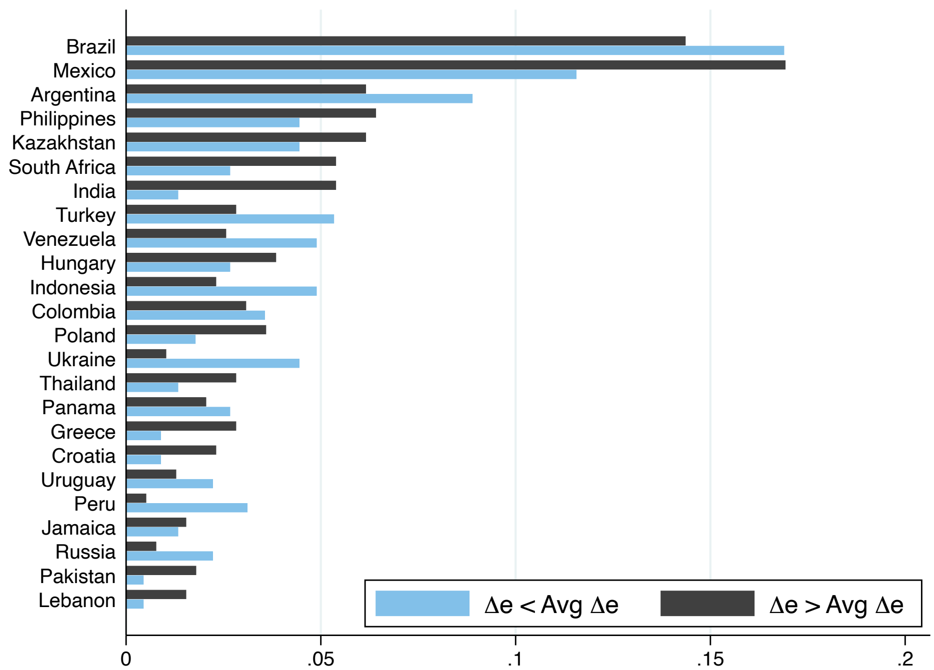
Financial Institution	N Bonds	N Countries	Avg Share	Δe_i
Allianz SE	420	35	43.5%	-0.12
Aegon NV	380	26	16.9%	-0.23
Hartford	331	29	13.4%	-0.08
UBS	316	33	38.6%	-0.33
BNP Paribas	282	35	18.4%	-0.03
Deutsche Bank	278	34	24.5%	-0.07
BNYM	244	31	14.8%	-0.14
Raiffeisen Bank International AG	239	35	16.3%	-0.23
SEI Investments Co	216	29	14.5%	-0.17
NN Group NV	200	30	38.1%	-0.03
HSBC	188	32	12.8%	-0.02
JPMorgan	184	26	15.4%	0.02
GAM Holding AG	167	32	33.2%	-0.03
Mitsubishi UFJ	154	23	25.9%	0.05
Credit Suisse	149	25	39.8%	-0.03
American International Group	145	25	18.4%	-2.12
Goldman Sachs	143	27	14.9%	-0.41
KBC Group NV	125	26	21.7%	-0.06
Morgan Stanley	112	26	24.6%	-0.61
Royal Bank of Canada	104	23	33.9%	-0.01
Average	219	29	24.0%	-0.23

Notes: This table shows descriptive statistics of the 20 financial institutions included in the empirical analysis in Section 3 that hold the largest number of EM bonds. N bonds refers to the number of bonds in our sample held by each of these financial institutions and N countries to the number of different countries issuing these bonds. The column *Avg Share* reports the average share of a bond held by a given institution before the Lehman episode (2008.q2). To compute this statistic, for each institution i and bond j we compute the ratio of the holdings of institution i of bond j to the total holdings by all financial intermediaries of bond j. We then report the average across all bonds with positive holdings for each institution i. Δe_i denotes the change in the log stock price of each financial institution in the narrow window around the Lehman episode (10 days before September 15 2008 to 3 days after).

B2. *Sorting of Financial Institutions into Different Bonds*

This section presents additional empirical work that supports the validity of our identification strategy by analyzing the nature of the sorting of financial institutions into different bonds.

FIGURE B1. Sorting of Financial Institutions into Countries



Notes: This figure shows the share of bonds by country among the set of bonds whose holders' net worth changed by less than average ($\Delta e < \text{Avg}\Delta e$), and among the set of bonds whose holders' net worth changed by more than average ($\Delta e > \text{Avg}\Delta e$).

We first document the presence of the sorting of financial institutions across countries and sectors. We separate bonds into those whose holders' net worth decreased by more and less than the average, and analyze the distribution of those bonds across countries and sectors. Appendix Figure B1 shows that financial institutions sort themselves into different countries. Financial institutions that were more severely hit during the Lehman episode held more bonds from Brazil and Argentina, while those institutions that were less hit had more bonds from Mexico and India. We also perform a similar analysis by sector. Panel (A) of Appendix Table B6 shows that there is some degree of sorting of financial institutions into different sectors. Financial institutions more severely hit during the Lehman episode held more sovereign bonds than those institutions that were less hit. Panels (B) and (C) show the distribution based on the seniority and presence of collective action clauses of bonds. Sorting is observed across bonds with and without collective action clauses, but to a lesser extent across seniority. The presence of sorting along these observable dimensions does not confound our empirical estimates, since we can absorb the effects of these characteristics with the introduction of country–sector–time fixed effects and a dummy for the presence of collective action clauses.

We then analyze selection into other bond observable characteristics; these include maturity, default risk, and liquidity. We do not observe sorting of financial institutions into bonds with different observable characteristics within each country–sector. Appendix Table B7 reports average observable bond characteristics for those bonds whose holders' net worth fell by more and less than average. The first two columns report the unconditional averages for these two groups, and the last two columns report the averages after reducing variables to residuals from country–sector means. The average residual maturity, bid–ask spread, and pre-Lehman yield to maturity of those bonds held by more and less distressed financial institutions are not statistically different from each other. These differences become smaller once we filter out country–sector differences.

We further investigate the finding of no sorting among these covariates by estimating a regression for each bond covariate on the change in holders' net worth. We then analyze the statistical significance of the coefficient associated with the change in the bond holders' net worth—the independent variable—which is a more formal way to identify a monotonic relationship between these variables. Appendix Table B8 shows the estimated coefficients of separately regressing residual maturity, bid–ask spread, and initial yields on the change in bond holders' net worth, with and without country–sector fixed effects. No estimated coefficients are statistically different from zero, which confirms the absence of sorting along these dimensions.

Table B6. Sorting of Financial Institutions into Sectors

		All bonds	$\Delta e_i < \Delta\bar{e}_i$	$\Delta e_i > \Delta\bar{e}_i$
A. Sector	Government	49.4%	65.3%	40.3%
	Industrial	4.6%	4.0%	4.9%
	Financial	21.5%	14.7%	25.4%
	Utilities	4.2%	3.1%	4.9%
	Communications	7.0%	4.9%	8.2%
	Energy	5.4%	3.1%	6.7%
	Other	8.0%	4.9%	9.7%
B. CAC	Yes	39.8%	52.4%	32.6%
	No	48.5%	40.4%	53.1%
	NA	11.7%	7.1%	14.4%
C. Seniority	1st Lien	2.4%	2.2%	2.6%
	2nd Lien	0.5%	0.9%	0.3%
	Secured	3.6%	1.3%	4.9%
	Senior Unsecured	76.4%	87.1%	70.3%
	Unsecured	10.1%	7.1%	11.8%
	Senior Subordinated	0.5%	0.0%	0.8%
	Subordinated	3.9%	0.9%	5.6%
	Junior Subordinated	2.6%	0.4%	3.8%

Notes: This table reports the share of bonds by different characteristics (sectors in Panel A, the presence of collective action clauses in Panel B, and bond seniority in Panel C). The first column shows the share of all bonds included in the analysis. The second (third) column shows the share of those bonds whose holders' net worth changed by less (more) than average ($\Delta e_i < \Delta\bar{e}_i$ and $\Delta e_i > \Delta\bar{e}_i$, respectively).

Table B7. EM Bonds' Characteristics by Holders' Change in Net Worth

	No Fixed Effects		Country by Sector FE	
	$\Delta e_i < \Delta \bar{e}_i$	$\Delta e_i > \Delta \bar{e}_i$	$\Delta e_i < \Delta \bar{e}_i$	$\Delta e_i > \Delta \bar{e}_i$
Residual maturity	3420	3469	-262.3	151.3
	[193]	[260]	[178.4]	[219.5]
Bid-ask spread	0.46%	0.44%	-0.01%	0.00%
	[0.02%]	[0.02%]	[0.02%]	[0.01%]
Yield (pre-Lehman)	8.6%	7.9%	0.18%	-0.10%
	[0.34%]	[0.20%]	[0.23%]	[0.13%]

Notes: The first two columns of this table show the mean residual maturity, bid–ask spread, and yield to maturity of bonds whose holders' change in net worth was less than the mean ($\Delta e_i < \Delta \bar{e}_i$) and more than the mean ($\Delta e_i > \Delta \bar{e}_i$). The last two columns show the averages for the same variables after subtracting country–sector means. Residual maturity is expressed in years, bid–ask spreads in percent, and yields in annual terms. Standard errors are in brackets.

Table B8. Regressions of Bond Covariates on Change in Holders' Net Worth

	With FE	Without FE
Residual maturity	0.028	-0.35
	[0.909]	[0.962]
BA Spread	-0.00	-0.00
	[0.002]	[0.004]
YTM	-0.01	-0.05
	[0.019]	[0.046]

Notes: This table shows the estimated coefficients of separately regressing residual maturity, bid–ask spread, and initial yields on the change in bond holders' net worth, with and without country–sector fixed effects. No estimated coefficients are statistically different from zero.

Table B9. Stickiness of Lender's Share of Holdings

	(1)	(2)	(3)	(4)
Previous Share	0.8449***	0.8253***	0.8362***	0.7796***
	(0.005)	(0.005)	(0.005)	(0.006)
Lender FE	No	Yes	No	No
Country FE	No	No	Yes	No
Country-lender FE	No	No	No	Yes
R-squared	0.6988	0.7035	0.7006	0.7159
Observations	158298	158298	158298	158298

Notes: This table presents the quarterly autocorrelation of the share of a particular bond held by a particular institution. Each column differs in the inclusion of fixed effects. See text for details.

Finally, we analyze the persistence of bond holdings in the portfolios of financial intermediaries. Appendix Table B9 shows estimates of the autocorrelation at quarterly frequency of the holdings of a particular bond by a particular institution. Different columns show estimates that include different levels of fixed effects. In all specifications, holdings are persistent over time, with estimates of autocorrelation ranging from 0.78 to 0.85.

In summary, our analysis shows no evidence of sorting among financial institutions into bonds with different maturity, liquidity, or default risk—three dimensions that could potentially affect bond-price dynamics during the Lehman episode. In contrast, the data points financial institutions persistently sorting into bonds from different countries and sectors.

A possible interpretation of this behavior is that financial institutions acquire specialized knowledge about certain bonds for trading purposes. This could rationalize why institutions are heterogeneous in their exposure to bonds with similar maturities, liquidity, and default risk. We incorporate this view in our model with secondary markets, bond varieties, and trading networks developed in Supplementary Material A.

B3. *Empirical Results: Robustness and Further Analysis*

This section presents a robustness analysis of our baseline empirical results and additional empirical exercises. First, Panel (B) of Appendix Table B10 shows estimates for our baseline specification (17), in which we vary the length of the window over which we compute the change in bond holders' stock price. We consider a tighter window of 5 days around Lehman's bankruptcy and a wider window of 30 days, compared with the baseline window of 13 days. Results remain roughly unchanged, with similar point estimates for the on-impact and peak effects. Additionally, we compute the same regression and extend the end date of the window to 10, 30, and 45 days after the Lehman bankruptcy. Results based on extending the window are important, because a wider window incorporates subsequent price movements that might be linked to the initial Lehman episode. Results indicate a negative elasticity, although smaller. Supplementary Material B4 studies the robustness of our quantitative analysis to targeting these alternative estimates.

Panel (C) of Appendix Table B10 shows an estimate of the baseline specification in which we exclude market makers when computing the change in the stock price of bond holders. This robustness analysis is aimed at isolating a potentially confounding mechanism that may operate through the undermined ability of market makers to provide liquidity during Lehman's bankruptcy episode. During this episode, the market-making activity of some institutions could have been impaired by shocks to the value of their firm. The results based on this alternative sample of financial institutions feature point estimates similar to those in the baseline specification.

Finally, we study the heterogeneous effects of global financial intermediaries' net worth on EM bond yields. Column (1) of Appendix Table B11 shows the estimates of interacting the drop in lenders' net worth of a bond with its share held by global financial intermediaries, which suggests the absence of economically significant interactions. This result is consistent with the view that other intermediaries that hold external bonds have degrees of financial frictions similar to those faced by global financial intermediaries. This reduces concern about the simplifying assumption in our model, whereby external debt is only held by global financial intermediaries. Columns (2) and (3) report the results of models that examine the role of heteregeneity by intermediaries' financial positions. We do so by collecting data on intermediaries' balance sheets from Compustat in 2008.q2. For each institution, we measure leverage as the ratio of total assets to net worth and liquidity as the ratio of cash holdings to total assets. We standardize these variables across bonds. We find larger elasticities (in absolute value) for bonds held by institutions with higher leverage and lower liquidity. These results are more precisely estimated for the case of the interaction with liquidity and are economically significant, which suggests that bonds held by intermediaries with one standard deviation less liquidity than the mean have an elasticity that is twice as large (in absolute value) as the average.

Table B10. Effect of Intermediaries' Net Worth on EM-Bond Yields: Robustness

		Impact	Peak	Average	Obs.
A. Baseline		-0.006	-0.142**	-0.056	531
		(0.004)	(0.059)		
B. Alternative Windows	Tighter	-0.004	-0.241**	-0.091	531
		(0.007)	(0.100)		
	Wider	-0.003	-0.201***	-0.075	531
		(0.011)	(0.072)		
	10d Post	-0.015**	-0.157**	-0.068	531
		(0.007)	(0.069)		
	30d Post	-0.058*	-0.098**	-0.059	531
		(0.033)	(0.044)		
	45d Post	-0.044*	-0.044*	-0.032	530
		(0.024)	(0.024)		
C. Excluding Market Makers		-0.014***	-0.164**	-0.064	512
		(0.004)	(0.064)		

Notes: This table shows the estimated elasticity of bonds' yields to maturity, β_h, to changes in the holder's net worth at two different horizons h. The on-impact effect corresponds to the estimated elasticity for $h = 0$. The peak effect corresponds to the most negative estimated elasticity over all horizons before 2 months. Different rows show different specifications; see text for details. Robust standard errors are in parentheses, and *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

Table B11. Interactive Effects with Intermediaries' Change in Net Worth

	(1)	(2)	(3)
Share held by GFIs Interaction	0.0072	-	-
	(0.037)		
Leverage Interaction	-	-0.040	-
		(0.048)	
Liquidity Interaction	-	-	0.0898**
			(0.035)
Peak Day	19	53	35
N Observations	531	511	507

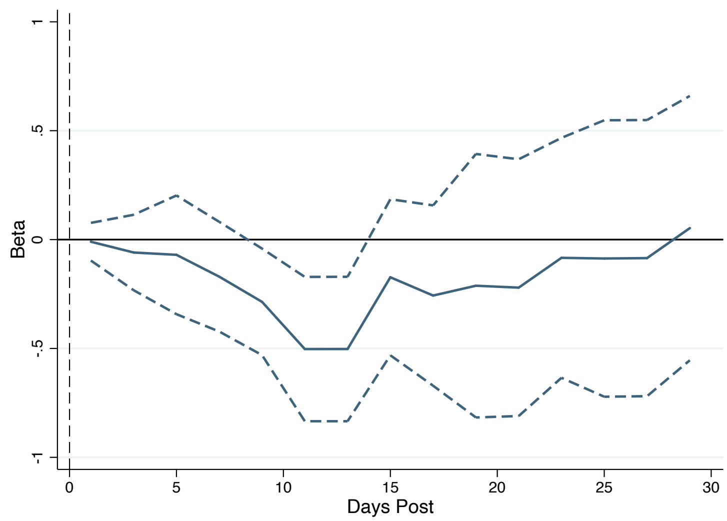
Notes: This table shows the estimates of interacting the drop in lenders' net worth of a bond with different lenders' characteristics. Column (1) shows results when interacting with its share held by global financial intermediaries; Column (2) when interacting with lenders' leverage; and Column (3) when interacted with lenders' liquidity. Peak day corresponds to the strongest effect on the interaction. See text for details on data and specifications. Robust standard errors are in parentheses, and ** represents statistical significance at the 5% level.

B4. *Evidence from the Russian Crisis*

Our baseline empirical analysis focuses on the Lehman episode. This section provides external validity for our exercise by reporting evidence from the Russian crisis. This episode unfolds with the default of the Russian government on its debt on August 17, 1998, and was exacerbated by the collapse of the Long-Term Capital Management fund (LTCM) in late 1998—a US-based hedge fund with sizable investments and large exposures in the EM debt market. This episode was widely studied in the emerging markets literature as an example of contagion across EMs through financial intermediaries (Calvo, 2004).

We study the Russian episode with an empirical model similar to that of our baseline (17). In this case, we measure the contraction in intermediaries' net worth at the bond level, Δe_i, using stock price data 10 days before to 3 days after the Russian default and the share of each bond held by financial intermediaries in 1998.q2. As in our baseline strategy, we focus on the response in yields of outstanding EM bonds, controlling for the same observable characteristics.

FIGURE B2. The Effect of Intermediaries' Net Worth on EM-Bond Yields: Russian Crisis 1998



Notes: This figure shows the estimated elasticity of bonds' yields to maturity, β_h, to changes in the holder's net worth at horizon h from estimating regression (17). Solid lines represent point estimates of the regression at each horizon, and dotted lines are 90% confidence intervals.

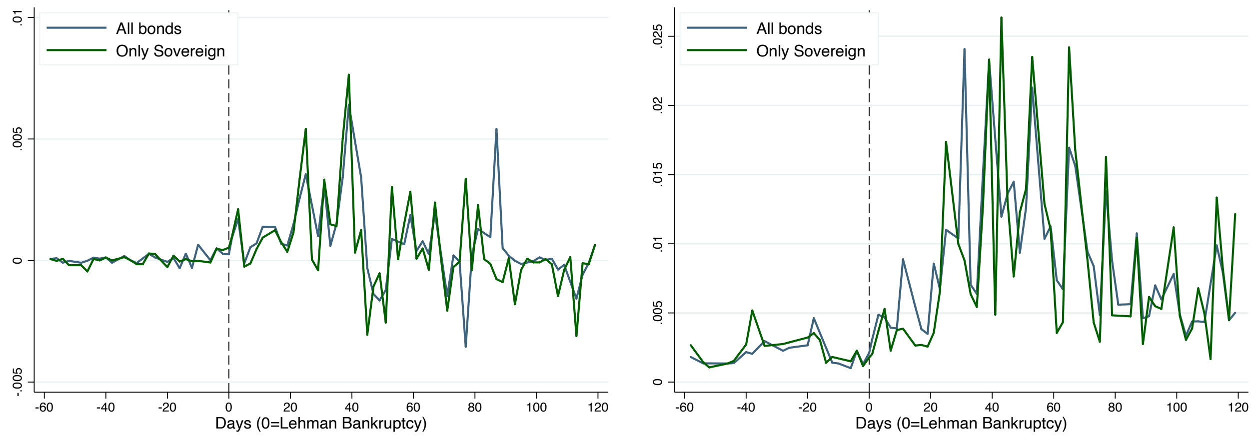
Results are shown in Table 2 and Appendix Figure B2. Table 2 shows that the estimated elasticity is negative, with a larger peak and average effect than our baseline estimates from the Lehman episode. Appendix Figure B2 shows that the dynamic effects exhibit a pattern similar to that of our baseline estimates, although more short-lived, which vanishes after 1 month.

C. Additional Figures and Tables

Figure C1. EM-Bond Yields Following the Lehman Episode

(A) Average yield to maturities

(B) Standard dev. of residual yield to maturities



Notes: Panel (A) shows the average daily change in yield to maturities for the EM bonds in our sample around the Lehman bankruptcy episode (September 15, 2008, $t = 0$). Panel (B) shows the standard deviation of the residuals from the empirical model $\Delta y_{it} = \alpha_{kst} + \alpha_{ct} + \gamma_t' Z_{it} + \varepsilon_{it}$, where Δy_{it} denotes the daily change in the log gross yield to maturity of bond i in period t; α_{kst} denotes a country of issuance by sector and time fixed effect; α_{ct} is a currency–time fixed effect; and Z_{it} is a vector of controls at the bond level, including the bond's residual maturity, bid–ask spread, and outstanding amount. In Appendix B, we show that this empirical model can account for up to 98% of the variation in yields before the Lehman episode and 80% of the variation after the Lehman episode. For details on the data, see Section 3.

Table C1. Estimated Exposure to Emerging Markets

Lender	Estimated Exp.	Lender	Estimated Exp.
AIG	13.1%	HSBC	21.8%
Aegon NV	1.0%	Hartford	4.5%
Allianz SE	19.0%	Intesa Sanpaolo	29.3%
Ameriprise	8.0%	JP Morgan Chase	10.4%
BNP Paribas	22.3%	Merrill Lynch	14.6%
Banco Santander	23.2%	MetLife Inc	1.3%
Bank of America	2.8%	Mitsubishi UFJ	3.6%
Barclays Bank	8.8%	Morgan Stanley	10.8%
CIBC	3.4%	Principal Financial	2.0%
Citigroup	17.2%	U.S. Bancorp	5.1%
Credit Suisse	28.8%	UBS	26.4%
Deutsche Bank	4.0%	Wells Fargo Co	0.6%
Goldman Sachs	8.0%		
Average			
Positive exposure	11.6%		
All lenders	10.0%		

Notes: This table shows the estimated exposure of international lenders to emerging markets. See text for details.

Table C2. Book and AUM Adjusted Leverage

Lender	Leverage		Lender	Leverage	
	Book Value	AUM Adjusted		Book Value	AUM Adjusted
AIG	9.6	5.6	Goldman Sachs	23.4	2.1
Aegon NV	13.6	13.0	HSBC	16.2	3.2
Allianz SE	18.5	2.2	Hartford	31.5	1.6
Ameriprise	13.1	1.3	Intesa Sanpaolo	16.1	4.6
BNP Paribas	26.3	4.8	JP Morgan Chase	11.7	2.1
BNYM	8.9	7.5	Merrill Lynch	21.6	2.3
Banco Santander	17.7	4.7	Mitsubishi UFJ	19.3	2.2
Bank of America	10.8	3.0	Morgan Stanley	31.7	2.5
Barclays Bank	36.4	2.0	PNC	9.4	1.6
BlackRock Inc	1.9	1.0	Principal Financial	18.3	1.5
CIBC	24.7	4.3	T Rowe Price	1.1	1.0
Citigroup	15.7	12.1	U.S. Bancorp	10.3	2.8
Credit Suisse	28.8	1.8	UBS	48.2	2.6
Deutsche Bank	34.3	8.1	Wells Fargo Co	10.5	3.7
Average					
All lenders	18.9	3.8			
Banks	21.1	3.9			
Other	13.5	3.4			

Notes: This table shows two measures of leverage of the main global financial institutions included in the empirical analysis in Section 3 (listed in Appendix Table B4), with available balance-sheet data. The first measure is "book value" of leverage, defined as the ratio of total assets to total equity. The second measure is "AUM adjusted leverage," defined as the ratio of the sum of total assets in the institution's balance-sheet and assets under management to the the sum of total equity in the balance-sheet and assets under management. The last three rows represent the average for all GFIs, banks only, and nonbanks. For most financial institutions included in this sample, balance-sheet data are publicly available at AnnualReports.com.

Table C3. Individual EM Business Cycles: Data and Model

Target	Description	Data	Model
$\sigma(\log C_i)/\sigma(\log Y_i)$	Excess Volatility of Consumption	1.14	1.03
$\text{corr}(\log C_i, \log Y_i)$	Cyclicality of Consumption	0.90	0.97
$\sigma(TB_i/Y_i)$	Volatility of the Trade-balance-to-output Ratio	0.04	0.01
$\text{corr}(TB_i/Y_i, \log Y_i)$	Cyclicality of the Trade-balance-to-output Ratio	-0.31	-0.1

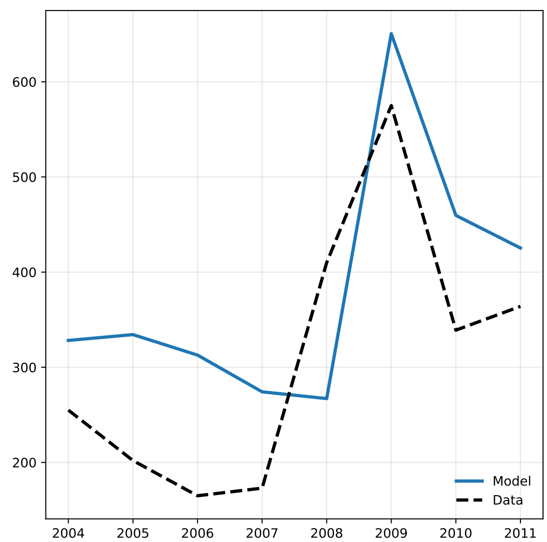
Notes: This table shows untargeted moments regarding individual EM business cycles and their model counterparts, obtained by simulating a panel of countries from the calibrated model and computing the average of individual countries' moments. C_i, Y_i, and TB_i/Y_i in the data refer, respectively, to consumption, GDP, and the trade-balance-to-output ratio of a given country i. Moments were computed using a sample of EMs with available data for the period 1994–2014. Supplementary Material B2 details the sample and data sources.

Table C4. Decomposing EM-Bond Spreads and Consumption Dynamics During the Global Financial Crisis

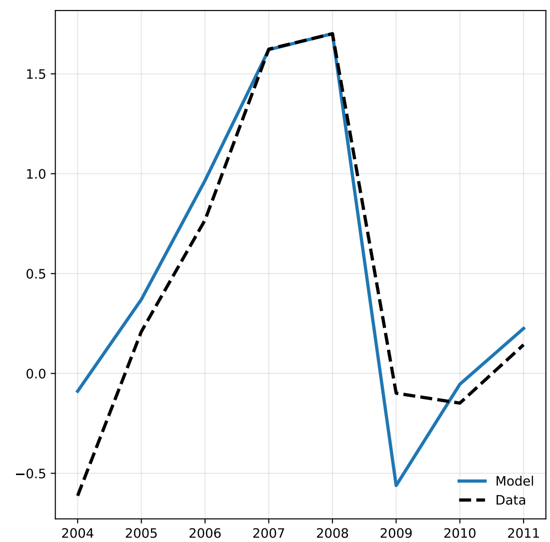
	Δ Spread		Δ Consumption	
	Joint Shocks	DM Contribution	Joint Shocks	DM Contribution
Data	402		−1.72	
Baseline Model	417	64.2%	−2.02	21.0%
Robustness				
i. Alternative Elasticity	275	48.5%	−1.99	13.8%
ii. Measured Income Process	394	72.0%	−3.09	44.5%
iii. Asset Managers	476	73.0%	−2.29	25.0%
iv. High Leverge	457	67.1%	−2.28	22.4%
v. Risk Buildup	376	57.8%	−2.18	18.0%
vi. Time-varying ϕ	428	66.5%	−2.35	26.1%

Notes: Data figures (first line) correspond to the dynamics of variables of interest observed during the 2007–2009 period. ΔSpread refers to the change in the average EM bond spread in a sample of EMs (detailed in Supplementary Material B2) between 2009 and 2007, in basis points. Δ Consumption refers to the change in the average cyclical component of consumption for the same sample of EM countries. The cyclical component was computed with respect to a log-linear trend and standardized. *Baseline Model* figures (second line) correspond to experiments in the calibrated model (detailed in Section 4.1) aimed at decomposing the dynamics of EM-bond spreads and consumption during an episode targeted to match the aggregate drivers of the 2007–2009 global financial crisis. All variables in the model are expressed in the same units as in the data. *Joint Shocks* (columns 2 and 4) correspond to the dynamic response in the model to a sequence of shocks $\{\epsilon_{\omega t}, \epsilon_{\text{EM}t}\}$ that target the dynamics of global banks' net worth and EMs' systemic endowment during 2007–2011 (see Appendix Figure B2). Responses in the model were computed starting from the ergodic aggregate states. *DM Contribution* (columns 3 and 5) shows the contribution to overall dynamics of the response predicted by the model to only the sequence of $\epsilon_{\omega t}$ shocks from the previous exercise. The table also shows the results of performing exercises identical to the ones previously described for a set of model robustness and extensions (lines 4 to 9). See Supplementary Material B4 for details on the different robustness specifications.

FIGURE C2. Boom and Bust: Spreads and Consumption



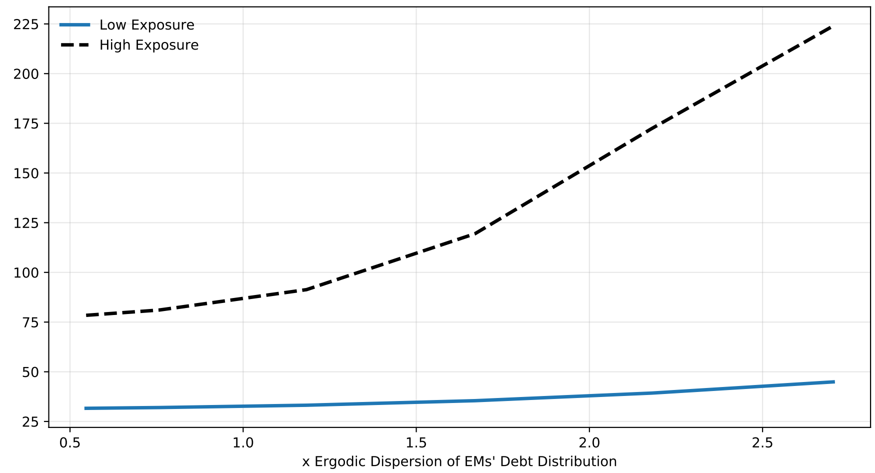
(A) EM Spreads



(B) Consumption

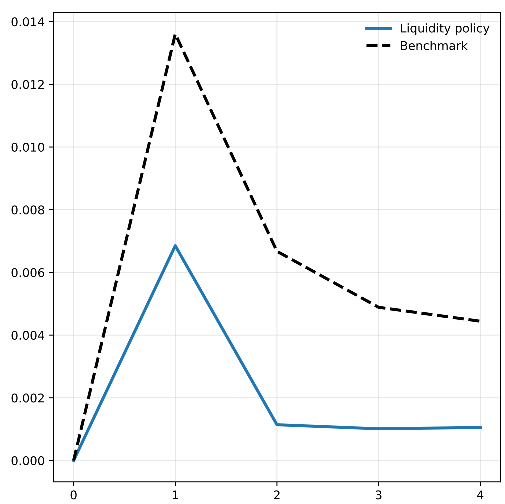
Notes: Data. Objects (dashed black lines) refer to the average of sovereign-bond spreads (in bps) and the cyclical component of consumption in a sample of EMs (see Supplementary Material B2). The cyclical component of consumption is expressed as deviations from a log-linear trend and standardized. *Model.* Objects (solid blue lines) refer to the dynamic response of these variables to a sequence of shocks $\{\epsilon_{\omega t}, \epsilon_{\text{EM}t}\}$, which targets the dynamics of global banks' net worth and EMs' systemic endowment during 2004–2011. Responses in the model were computed starting from the ergodic aggregate states. Consumption in the model is expressed in log deviations from its ergodic mean and standardized.

Figure C3. Global Banks' Portfolios and the Distribution of EM Debt

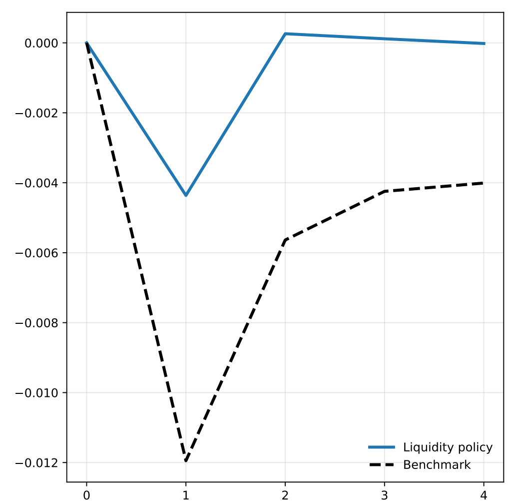


Notes: This figure shows the difference between the response of EM bond spreads to a 2–s.d. systemic and a 2–s.d. idiosyncratic endowment shocks, for different initial distributions. The solid blue line is for global banks having low exposure (10%) and the dashed black line is for high exposure (35%).

Figure C4. Liquidity Provision Policy and Responses to a Negative DM Shock



(A) Effect on EM Bond Yields



(B) Effect on EM Consumption

Notes: This figure contrasts the response of EM bond yields and EM aggregate consumption (in log–changes) to a negative 2–s.d. DM shock in the baseline economy against one with liquidity provision.