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

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

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

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

where $\mathbf{s}' = \Gamma(\mathbf{s},\mathbf{s}'_x,\hat{A}_{\mathrm{DM}}(\mathbf{s}),\hat{D}(\mathbf{s}),\hat{b}'(b,z,\mathbf{s}))$ is the law of motion of the aggregate state $\mathbf{s}'$, and $\hat{A}_{\mathrm{DM}}(\cdot)$, $\hat{D}(\cdot)$, 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

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

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

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

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 $\{a'_{\mathrm{EM}(b,z)}(\mathbf{s}), a'_{\mathrm{DM}}(\mathbf{s}), div_{\mathrm{DM}}(\mathbf{s})\}$, 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, $\Gamma(\mathbf{s},\mathbf{s}'_x,\tilde{A}'_{\mathrm{DM}}(\mathbf{s}),\tilde{D}'(\mathbf{s}),\tilde{b}'(b,z,\mathbf{s}))$; and perceived policies, $\{\hat{\iota}(b,z,\mathbf{s}),\hat{b}'(b,z,\mathbf{s}),\hat{A}'_{\mathrm{DM}}(\mathbf{s}),\hat{D}'(\mathbf{s})\}$, 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*

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

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:

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

or equivalently,

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

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.[22] 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.

[22]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 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%	0.004	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 83% 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.[23] 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.[24] The total reported holdings of all financial institutions account for 25%, on average, of the total amount outstanding of a bond.[25]

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.

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.

[23]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.

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

[25]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	

Figure B1. Sorting of Financial Institutions into Countries

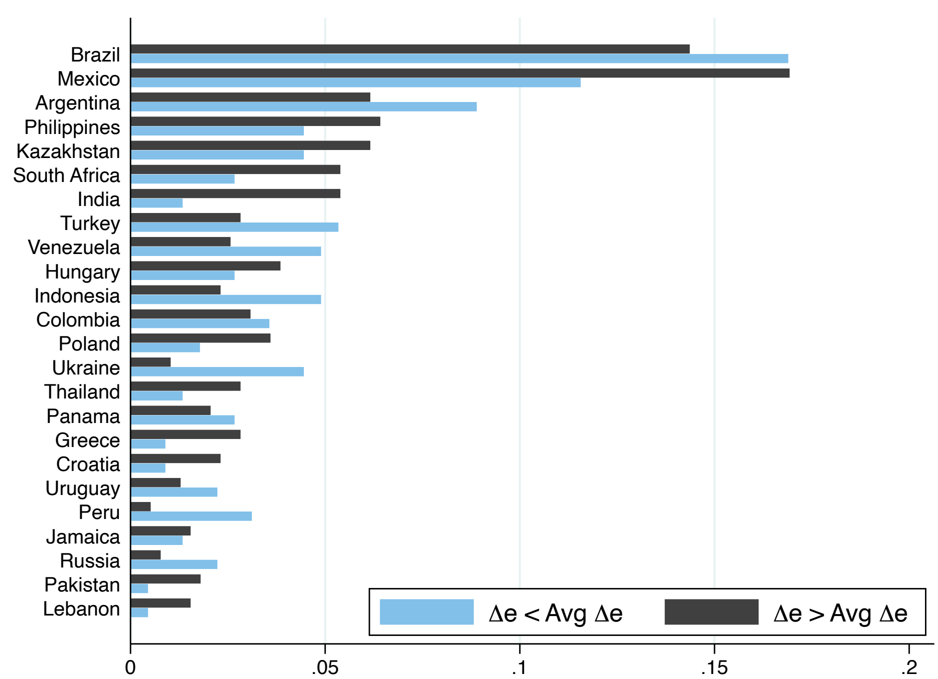


Table B5. Descriptive Statistics by Financial Institution

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%	-0.31
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%	-0.25

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. Δn_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).

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.

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).

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.

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.

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 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	158,298	158,298	158,298	158,298

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.

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
		(0.005)	(0.043)		

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.

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 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

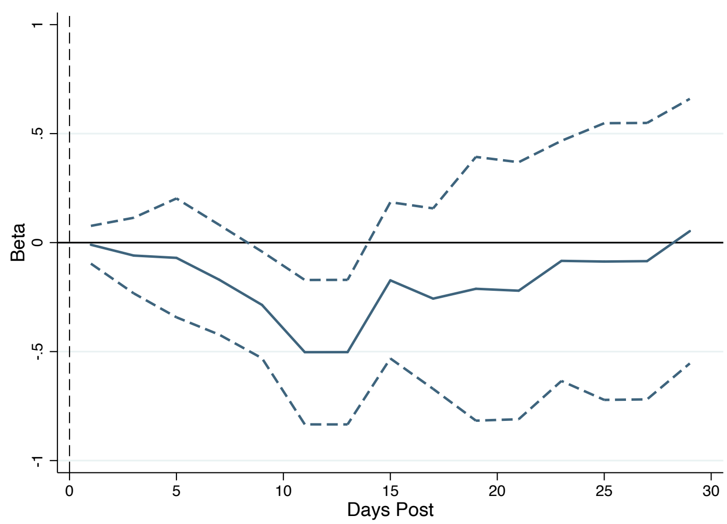
Notes: This table shows the estimates of interacting the drop in lenders' net worth of a bond with different lenders' characteristics. Column (1) shows results when interacting with its share held by global financial intermediaries; Column (2) when interacting with lenders' leverage; and Column (3) when 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



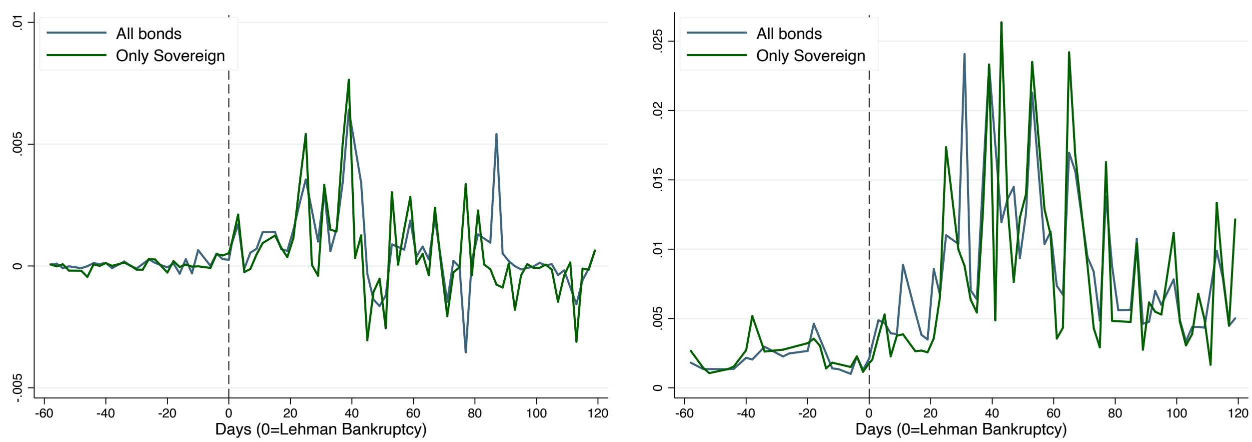
Notes: This figure shows the estimated elasticity of bonds' yields to maturity, β_h, to changes in the holder's net worth at horizon h from estimating regression (17). Solid lines represent point estimates of the regression at each horizon, and dotted lines are 90% confidence intervals.

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

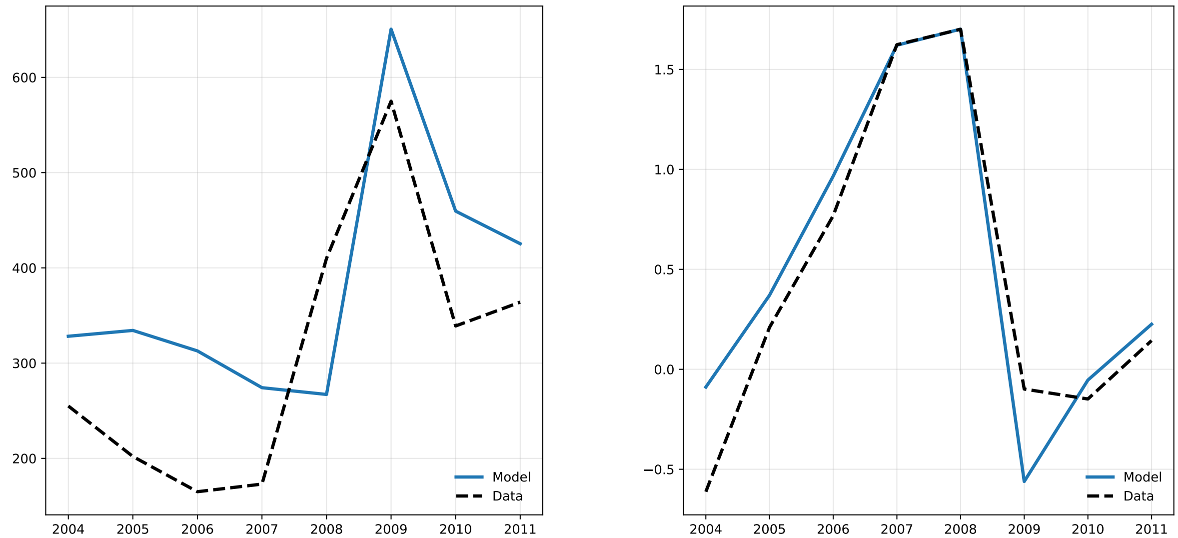
Notes: This table shows untargeted moments regarding individual EM business cycles and their model counterparts, obtained by simulating a panel of countries from the calibrated model and computing the average of individual countries' moments. C_i, Y_i, and TB_i/Y_i in the data refer, respectively, to 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	473	70.1%	−2.25	22.9%
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 8). See Supplementary Material B4 for details on the different robustness specifications.

Figure C2. Boom and Bust: Spreads and Consumption



(A) EM Spreads (B) Consumption

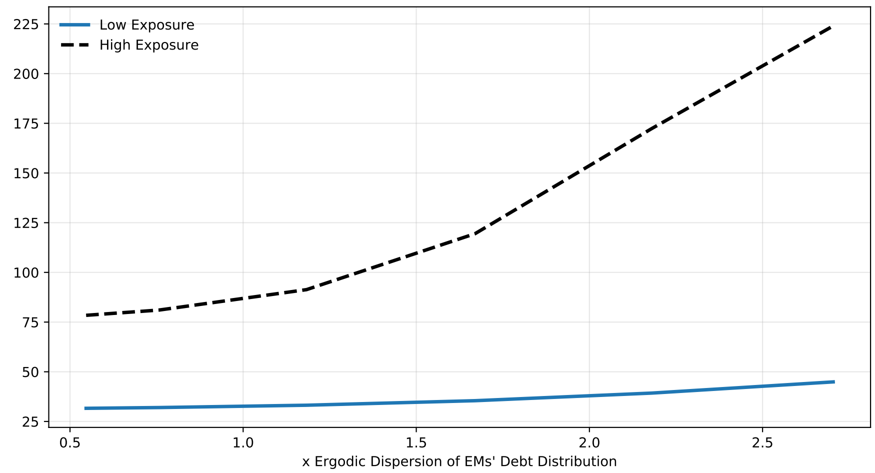
Notes: Data. Objects (dashed black lines) refer to the average of sovereign-bond spreads (in bps) and the cyclical component of consumption in a sample of EMs (see Supplementary Material B2). The cyclical component of consumption is expressed as deviations from a log-linear trend and standardized. *Model*. Objects (solid blue lines) refer to the dynamic response of these variables to a sequence of shocks $\{\epsilon_{\omega t}, \epsilon_{\mathrm{EM}t}\}$, 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.

Table C5. Major U.S. Banks' Exposure: 1980s

	1982	1984	1986
EM Debt -to-Capital			
All Banks	186.5%	156.6%	94.8%
Top 9	287.7%	246.3%	153.9%

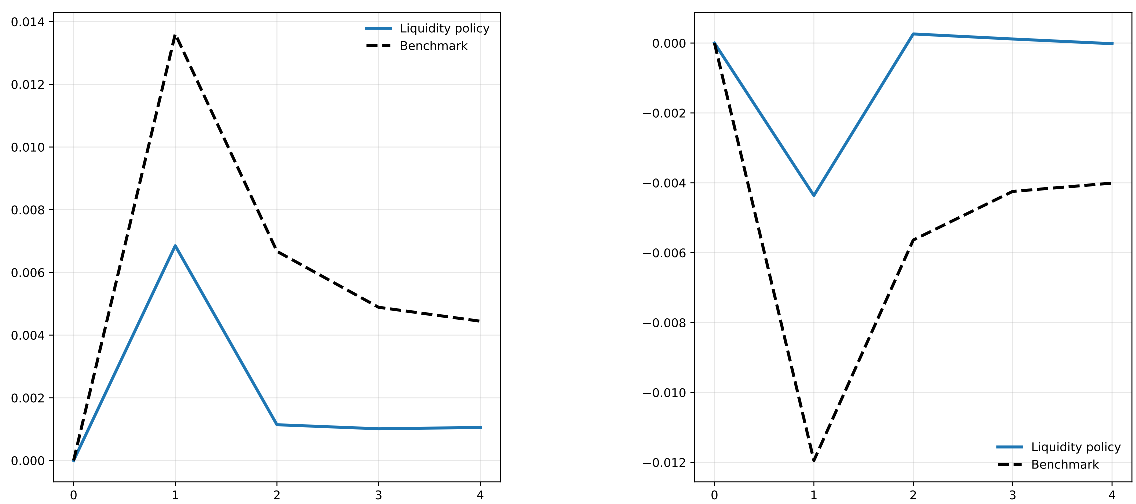
Notes: This table shows selected items from U.S. commercial banks' balance sheets from the 1980s. EM debt-to-capital refers to the ratio of banks' claims on developing countries to banks' primary capital. The top nine banks are the nine largest U.S. banks during the 1980s. Source: Sachs (1989).

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.

SUPPLEMENTARY MATERIAL TO GLOBAL BANKS AND SYSTEMIC DEBT CRISES

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A. Model with Secondary Markets

In this Appendix, we develop and solve an extension of the baseline model in which we allow for trading of securities in secondary markets. This version of the model features the same source of variation as in the empirical analysis. We show that a parameterization of the model that targets cross-sectional empirical estimates from the data delivers quantitative results similar to those in the baseline model.

A1. *Model*

Our secondary market model introduces short-run trading frictions that can account for the patterns observed in the data. We model this by introducing two additional features to the environment. First, each period contains two subperiods: a first subperiod, in which securities are traded in secondary markets, and a second subperiod, in which securities are traded in primary markets. In particular, within each period, the timing is as follows. At the beginning of each period, exogenous variables are realized. Global banks repay outstanding deposits, issue new deposits, raise equity (or pay dividends), and trade outstanding assets with each other in secondary markets. In the second subperiod, risky securities are repaid and banks repay outstanding deposits and can issue new deposits, pay dividends or raise equity, and purchase newly issued risky securities in primary markets. The second additional feature is the existence of trading networks in the secondary market. We introduce trading networks with two assumptions. First, we assume that each EM economy and DM nonfinancial firm issues different varieties of bonds, indexed by ℓ, that have the same repayment but will feature different holders in equilibrium. Second, we assume that banks specialize in a particular variety and trade securities of that variety issued by any EM economy and DM firm.

These new features allow the model to exhibit the same variation found in the empirical analysis—namely, multiple bonds issued by the same borrower with different holders—and also give rise to the possibility of bonds with similar characteristics having different prices in the secondary market. The presence of varieties of securities in which banks specialize gives rise to banks displaying different portfolios of bonds with similar default risk, liquidity properties, and other relevant characteristics, which persist over time; this is consistent with the facts documented in Section 3. Additionally, the assumption of trading networks is aimed at capturing the idea that in the short run. capital is slow moving; this may be due to the presence of search costs for trading counterparties, information frictions, or time to adjust portfolios, which potentially leads to limits to arbitrage (see, for example, Duffie, 2010; Lagos et al., 2017, and references therein).

As in the baseline model, global banks' objective is to maximize the lifetime discounted payouts transferred to DM households,

$$\max \mathbb{E}_t \sum_{s=0}^{\infty} \beta_{\text{DM}}^{s-t} \pi_{jt+s}. \tag{35}$$

A bank j that specializes in variety ℓ arrives at the period t secondary market with a portfolio of EM securities $\{a^i_{\text{EM}jt-1}(\ell)\}_{i\in\mathcal{I}_{t-1}}$, DM securities $a_{\text{DM}jt-1}(\ell)$, and deposits d_{jt-1} acquired in the primary market at $t-1$. Secondary markets are segmented by variety: Banks can only trade with others that specialize in the same variety at prices $\{q^{i0}_{\text{EM}jt}(\ell)\}_{i\in\mathcal{I}_t}$ for EM securities and $q^0_{\text{DM}jt}(\ell)$ for DM securities. This implies that the index ℓ denotes both a particular variety of EM and DM security and a particular trading network. We use the same notation as in the baseline model, and explain the new notation as it is introduced. We refer to variables in the secondary market with the 0 superscript. The value of the net worth in the secondary market is given by

$$n^0_{jt} = \int_{i\in\mathcal{I}_{t-1}} q^{i0}_{\text{EM}t}(\ell) a^i_{\text{EM}jt-1}(\ell)\,\mathrm{d}i + q^0_{\text{DM}t}(\ell) a_{\text{DM}jt-1}(\ell) - R_d d_{jt-1}. \tag{36}$$

In the secondary market, banks can purchase existing securities $(a^0_{\text{DM}jt}(\ell), \{a^{i0}_{\text{EM}jt}(\ell)\}_{i\in\mathcal{I}_{t-1}})$, issue equity div^0_{jt}, and issue new deposits d^0_{jt} to be repaid in the period t primary market. Their flow of funds constraint in the secondary market is given by

$$n^0_{jt} + d^0_{jt} = \int_{i\in\mathcal{I}_t} q^{i0}_{\text{EM}t}(\ell) a^{i0}_{\text{EM}jt}(\ell)\,\mathrm{d}i + q^0_{\text{DM}t}(\ell) a^0_{\text{DM}jt}(\ell) + div^0_{jt}. \tag{37}$$

A bank arrives at the primary market with the portfolio of securities and liabilities issued in the secondary market and a net worth given by the repayment associated with each of these securities

$$n_{jt} = \int_{i\in\mathcal{I}_{t-1}} R^{i0}_{\text{EM}t}(\ell) q^{i0}_{\text{EM}t}(\ell) a^{i0}_{\text{EM}jt}(\ell)\,\mathrm{d}i + R^0_{\text{DM}t}(\ell) q^0_{\text{DM}t}(\ell) a_{\text{DM}jt}(\ell) - R^0_d d^0_{jt}, \tag{38}$$

where $\left(\{R^{i0}_{\text{EM}t}(\ell)\}_{i\in\mathcal{I}_{t-1}}, R^0_{\text{DM}t}(\ell)\right)$ are the returns from holding EM and DM securities in period t, from the secondary market of trading network ℓ until the primary market subperiod, and R^0_d the rate on deposits from the secondary to primary markets. In the primary market, banks face a similar choice problem as in the secondary market: Each bank can purchase new securities $(a_{\text{DM}jt}(\ell), \{a^i_{\text{EM}jt}(\ell)\}_{i\in\mathcal{I}_{t-1}})$, issue equity div_{jt}, and issue new deposits d_{jt} to be repaid in the period $t+1$ secondary market. Its flow of funds constraint in the primary market is given by

$$n_{jt} + d_{jt} = \int_{i\in\mathcal{I}_t} q^i_{\text{EM}t}(\ell) a^i_{\text{EM}jt}(\ell)\,\mathrm{d}i + q_{\text{DM}t}(\ell) a_{\text{DM}jt}(\ell) + div_{jt}. \tag{39}$$

Banks face the same frictions to finance their investments in both primary and secondary markets. They face occasionally binding borrowing constraints,

$$d^0_{jt} \le \kappa n^0_{jt} \quad \text{and} \quad d_{jt} \le \kappa n_{jt}, \tag{40}$$

a cost of $\mathcal{C}(div, n) = \phi\left(\frac{-div}{n}\right)$ per unit of equity raised in the primary market, and $\mathcal{C}(div^0, n^0) = \phi\left(\frac{-div^0}{n^0}\right)$ per unit of equity raised in the secondary market. The net payouts to DM households are

$$\pi_{jt} = div^0_{jt}(1 + \mathbb{I}_{div^0_{jt}<0}\mathcal{C}(div^0_{jt}, n^0_{jt})) + div_{jt}(1 + \mathbb{I}_{div_{jt}<0}\mathcal{C}(div_{jt}, n_{jt})). \tag{41}$$

Finally, each subperiod experiences an i.i.d. exit shock that occurs with probability $1-\sigma$ in primary markets and $1-\sigma^0$ in secondary markets, with $\sigma = \sigma^0$ in the calibrated model. Banks that exit repay outstanding deposits, sell their securities in the relevant market, and transfer the net proceedings to their owners. In each subperiod, a mass of new banks equal to the exit probability enter the economy, so that the total mass of global banks is always fixed at one. The new entrants are endowed with units of the final good $\overline{n}$ and $\overline{n}^0$ in the primary market and secondary market, respectively. Aggregating banks within a trading network, we obtain an expression for net worth in the secondary market stage at the trading network level:

$$N^0_t(\ell) = \sigma\left[\int_{i\in\mathcal{I}_{t-1}} q^{i0}_{\text{EM}t}(\ell) A^i_{\text{EM}t-1}(\ell)\,\mathrm{d}i + q^0_{\text{DM}t}(\ell) A_{\text{DM}t-1}(\ell) - R_d D_{t-1}(\ell)\right] + (1-\sigma)\overline{n}_0, \tag{42}$$

where the variables in capital letters with a dependence on ℓ refer to the aggregate counterparts for the trading network ℓ.

The problem of global bank j specializing in variety ℓ is to choose state-contingent plans $\{((a^{i0}_{\text{EM}jt}(\ell), a^i_{\text{EM}jt+1}(\ell))_{i\in[0,\mu_{\text{EM}}]}, a^0_{\text{DM}jt}(\ell),\ a_{\text{DM}jt}(\ell), div^0_{jt}, div_{jt}, d^0_{jt}, d_{jt})\}^\infty_{t=0}$ to maximize (7) subject to flow of funds and financial constraints (36)–(41). The bank's problem is characterized by asset-pricing conditions for the secondary and primary market:

$$R^{i0}_{\mathrm{EM}t}(\ell) = R^{0}_{\mathrm{DM}t}(\ell), \tag{43}$$

$$\mathbb{E}\left[\nu^0_{t+1}(\ell)\frac{q^{i0}_{\mathrm{EM}t+1}(\ell)}{q^{i}_{\mathrm{EM}t}(\ell)}\right] = \mathbb{E}\left[\nu^0_{t+1}(\ell)\frac{q^{0}_{\mathrm{DM}t+1}(\ell)}{q_{\mathrm{DM}t}(\ell)}\right] \equiv R^e_t(\ell), \tag{44}$$

for all ℓ and securities i with positive investments, where $\nu^0_{t+1}(\ell)$ is the marginal value of net worth of a bank specializing in variety ℓ in secondary markets of period $t+1$.[26] The first equation states that required returns from holding any security of a given variety from secondary to primary markets are the same.[27] Similarly, the second equation states that required returns from holding any security of a given variety from primary markets of period t to secondary markets of period $t+1$ are the same. The optimal choices of debt financing are characterized by the following complementary slackness conditions:

$$\left(R^e_t(\ell) - \mathbb{E}\left[\nu^0_{t+1}(\ell)\right]R_d\right)(\kappa n_{jt} - d_{jt}) = 0 \quad \text{and} \quad \left(R^0_{\mathrm{DM}t}(\ell) - R^0_d\right)\left(\kappa n^0_{jt} - d^0_{jt}\right) = 0. \tag{45}$$

These equations state that the borrowing constraint will bind whenever the expected risk-adjusted returns on assets exceed those from deposits. The optimal equity choices are given by[28]

$$-2\phi\left(\frac{div_{jt}}{n_{jt}}\right) = \beta_{\mathrm{DM}}R^e_t(\ell) - 1 \quad \text{and} \quad -2\phi\left(\frac{div^0_{jt}}{n^0_{jt}}\right) = \nu_t R^0_{\mathrm{DM}t}(\ell) - 1. \tag{46}$$

[26]The marginal value of net worth in the secondary market, $\nu^0_{t+1}(\ell)$, and in the primary market, ν_{t+1}, satisfy two difference equations:

$$\nu^0_t(\ell) = (1-\sigma^0) + \sigma^0 \max\left\{\frac{1}{4\phi}\left(\nu_t R^0_d - 1\right)^2 + \nu_t R^0_d; \frac{1}{4\phi}(\nu_t R^0_{\mathrm{DM}t}(\ell) - 1)^2 + \nu_t\left[R^0_{\mathrm{DM}t}(\ell)(1+\kappa) - \kappa R^0_d\right]\right\},$$

$$\begin{aligned}\nu_t =& (1-\sigma) + \sigma \max\left\{\frac{1}{4\phi}\left(\mathbb{E}\left[\nu^0_{t+1}(\ell)\right] - 1\right)^2 + \mathbb{E}\left[\nu^0_{t+1}(\ell)\right];\right.\\ &\left.\frac{1}{4\phi}\left(\beta_{\mathrm{DM}}\mathbb{E}\left[\nu^0_{t+1}(\ell)\frac{q^0_{\mathrm{DM}t+1}(\ell)}{q_{\mathrm{DM}t}(\mathbf{s})}\right] - 1\right)^2 + \beta_{\mathrm{DM}}\left(\mathbb{E}\left[\nu^0_{t+1}(\ell)\frac{q^0_{\mathrm{DM}t+1}(\ell)}{q_{\mathrm{DM}t}(\ell)}\right](1+\kappa) - \mathbb{E}\left[\nu^0_{t+1}(\ell)\right]R_d\kappa\right)\right\}.\end{aligned}$$

These equations are obtained by solving the banks' recursive problems, which we omit for brevity. They are available upon request.

[27]In this case, since there is no uncertainty between secondary and primary markets, required returns are equal to realized returns.

[28]These choices are in those states in which the return of injecting one additional unit of equity in the banks and investing it in risky assets is larger than the inverse of the DM discount factor, i.e., the right-hand sides of (46) are positive. Note that in the optimal equity choice in the secondary market, the relevant DM discount factor is one. We focus on parameterizations in which this condition always holds.

In both primary and secondary markets, higher required returns lead to larger equity issuance.

The DM households' problem is similar to that in the baseline model, with the addition that households can also choose intraperiod deposits (from secondary to primary markets of period t). Given that DM households are risk neutral and do not discount time between secondary and primary markets, the equilibrium interest rate for intraperiod deposits is $R_d^0 = 1$.

The EM economy faces a problem that is similar to that in the baseline economy, with the only difference being that it can choose to issue debt of different varieties $b_{\text{EM}it+1}(\ell)$ for $\ell \in [0,1]$. EM households only make choices in the primary-market subperiod. We assume that the repayment/default decision applies to all outstanding varieties.[29] The EM budget constraint under repayment is given by

$$c_{it} = y_{\text{EM}t} + z_{it} + \int \left[q^i_{\text{EM}t}(\ell)\left(b_{it+1}(\ell) - \xi b_{it}(\ell)\right) - b_{it}(\ell)\right] \mathrm{d}\ell. \tag{47}$$

It follows that for EMs to issue positive bonds of any two varieties, their prices should be equal,

$$q^i_{\text{EM}t}(\ell) = q^i_{\text{EM}t}(\ell'), \tag{48}$$

for all $\ell, \ell' \in [0,1]$. Using this condition, the EM households' problem can be collapsed to the same as in the baseline model in which the EM households choose total borrowing $b_{it+1} = \int b_{it+1}(\ell)\,\mathrm{d}\ell$. The split of total debt between varieties is determined by the demand for securities, since each EM household is indifferent between issuing any of them.

Nonfinancial DM firms face the same problem as in the baseline model, but with the difference that they can issue securities of different varieties and they only make decisions in the primary-market subperiod. Similar to EM economies, in equilibrium, prices of the DM securities for different varieties in the primary market will be the same. Additionally, if we assume that the aggregate amount of DM securities is equal to the capital stock, $A_{\text{DM}t} = k_{t+1}$, then the prices of the securities will be equal to one, $q^i_{\text{DM}t}(\ell) = 1$, for all ℓ.

Finally, we define returns and EM bond prices in equilibrium. Returns from holding securities from secondary markets until primary markets are given by $R^{i0}_{\text{EM}t+1}(\ell) = \frac{\iota_{it+1}(1+\xi q^i_{\text{EM}t+1}(\ell))}{q^{i0}_{\text{EM}t}(\ell)}$

[29] This assumption is motivated by the fact that cross-default clauses in bonds prevent discriminatory defaults on different securities, especially when issued in the same market.

and $R^0_{\mathrm{DM}t+1}(\ell) = \frac{\omega_{t+1}[\alpha A^{\alpha-1}_{\mathrm{DM}t}+1-\delta]}{q^0_{\mathrm{DM}t}(\ell)}$. The price of EM bonds in primary markets is given by $q^i_{\mathrm{EM}t}(\ell) = \frac{\mathbb{E}[\nu^0_{t+1}(\ell)q^{i0}_{EMt+1}(\ell)]}{R^e_{t+1}(\ell)}$.

Definition 2. *Given global banks' initial portfolios* $(((a^i_{\mathrm{EM}j0}(\ell))_{i\in[0,\mu_{\mathrm{EM}}]}, a_{\mathrm{DM}j0}(\ell), d_{j,0})_{j\in[0,1]})_{\ell\in[0,1]}$, *EM households' initial debt positions* $(b_{i0})_{i\in[0,\mu_{\mathrm{EM}}]}$, *and state-contingent processes* $\{\omega_t, y_{\mathrm{EM}t}, (z_{it}, \psi_{it})_{i\in[0,\mu_{\mathrm{EM}}]}\}$, *a competitive equilibrium in the global economy is a sequence of prices* $\{(w_t, (q^{i0}_{\mathrm{EM}t}(\ell), q^i_{\mathrm{EM}t})_{i\in[0,\mu_{\mathrm{EM}}]}, q^0_{\mathrm{DM}t}(\ell), q_{\mathrm{DM}t})^\infty_{\ell=0}\}^\infty_{t=0}$ *and allocations for DM households* $\{c_{\mathrm{DM}t}, d^0_{t+1}, d_{t+1}\}^\infty_{t=0}$, *EM households* $\{((c_{it}, b_{it+1}(\ell), \iota_{it})_{\ell\in[0,1]})_{i\in[0,\mu_{\mathrm{EM}}]}\}^\infty_{t=0}$, *nonfinancial firms* $\{h_t, k_{t+1}\}^\infty_{t=0}$, *and global banks* $\{(((a^{i0}_{\mathrm{EM}jt+1}(\ell), a^i_{\mathrm{EM}jt+1}(\ell))_{i\in[0,\mu_{\mathrm{EM}}]}, a^0_{\mathrm{DM}jt+1}(\ell), a_{\mathrm{DM}jt+1}(\ell), d^0_{jt+1}, d_{jt+1}, div^0_{jt}, div_{jt})_{j\in[0,1]})\}^\infty_{\ell=0}\}^\infty_{t=0}$ *such that*

i. Allocations solve agents' problems at the equilibrium prices,

ii. Assets and labor markets clear.

It is worth analyzing how each asset market clears. Denote as $\mathcal{J}(\ell)$ the set of banks that specialize in variety ℓ. Market clearing in the primary market implies

$$\int_{j\in\mathcal{J}(\ell)} q^i_{\mathrm{EM}t} a^i_{\mathrm{EM}jt}(\ell)\,\mathrm{d}j = q^i_{\mathrm{EM}t} b_{it+1}(\ell), \tag{49}$$

$$\int_{\ell\in[0,1]}\int_{j\in\mathcal{J}(\ell)} q_{\mathrm{DM}t}(\ell) a_{\mathrm{DM}jt}(\ell)\,\mathrm{d}j\,\mathrm{d}\ell = k_{t+1}. \tag{50}$$

Equation (49) refers to the market clearing of variety ℓ issued by EM economy i. In this case, since EMs are indifferent in how they split their total issuance into different varieties, equilibrium quantities are determined by their demand and prices are the same for all varieties of a given economy i. Equation (50) refers to market clearing of the DM risky security. Market clearing in the secondary market of trading network ℓ implies

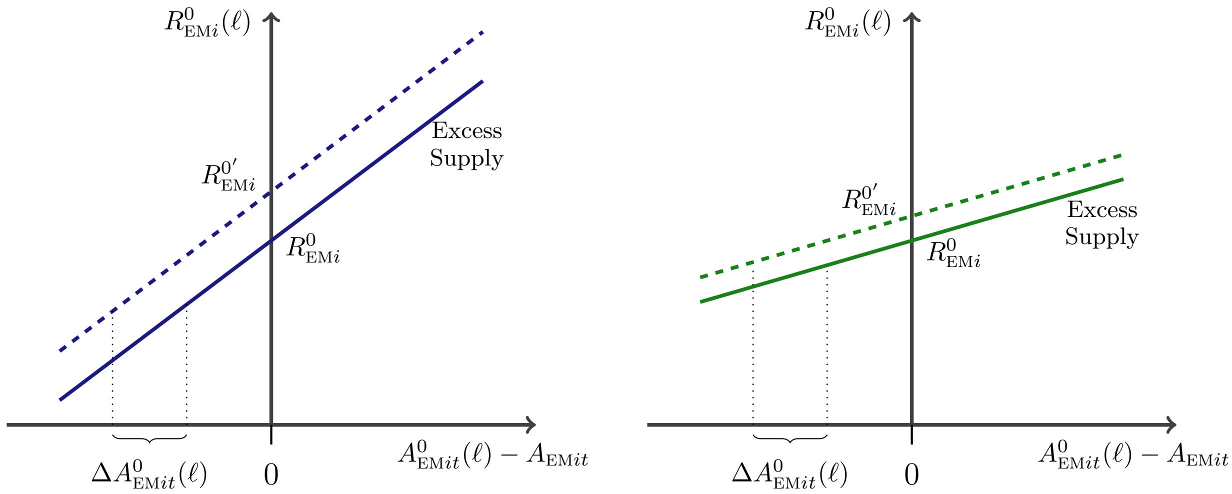
$$\int_{j\in\mathcal{J}(\ell)} q^{i0}_{\mathrm{EM}t} a^{i0}_{\mathrm{EM}jt}(\ell)\,\mathrm{d}j = \int_{j\in\mathcal{J}(\ell)} q^{i0}_{\mathrm{EM}t} a^i_{\mathrm{EM}jt-1}(\ell)\,\mathrm{d}j, \tag{51}$$

$$\int_{j\in\mathcal{J}(\ell)} q^0_{\mathrm{DM}t}(\ell) a^0_{\mathrm{DM}jt}\,\mathrm{d}j = \int_{j\in\mathcal{J}(\ell)} q^0_{\mathrm{DM}t}(\ell) a_{\mathrm{DM}jt-1}\,\mathrm{d}j. \tag{52}$$

In each secondary market, the stock of outstanding securities is given by the amount of securities of that type purchased by banks in the same trading network in the previous primary market. Hence, expost heterogeneity across trading networks can give rise to the price dispersion of securities of different varieties. Importantly, these prices can only arise in secondary

FIGURE A1. Equilibrium in the Secondary Market

(A) High Costs of Equity Issuance, ϕ (B) Low Costs of Equity Issuance, ϕ



markets. In primary markets, the fact that each EM household and DM firm can issue any variety prevents these price differences' persistence.

A2. *Financial Frictions and Secondary-market Elasticity*

This section illustrates how the secondary-market elasticity of bond yields to banks' net worth is informative of the degree of financial frictions faced by banks. In the secondary market, the outstanding stock of securities is fixed from previous issuance and the equilibrium rate of return should be such that the excess supply of funds, or demand for additional securities, is zero. The excess supply is increasing in required returns in the secondary market, since, as noted in (46), optimal equity issuance is increasing in returns. If returns are higher, banks are willing to increase their equity issuance to lend more funds to EMs by purchasing additional securities. Equilibrium in the secondary market is depicted in Supplementary Material Figure A1.

Consider now a trading network composed of more distressed banks that have lower net worth due to a lower share of retained earnings $\sigma^0(\ell)$. This implies that banks have less resources available to purchase securities in the secondary market, which reduces the excess supply of funds for a given required return, as depicted by the dotted line in Supplementary

Material Figure A1a, and increases the equilibrium required return. The net worth of banks in this trading network also falls, since all of their assets are now worth less.

How much secondary market prices respond to shocks to $\sigma^0(\ell)$ depends on the banks' marginal cost of issuing equity, ϕ. Consider an economy with high costs of equity issuance (high ϕ). In this economy, the excess supply of funds is steep, since banks require a significant increase in returns to issue equity to finance purchases of additional risky securities. As shown in Supplementary Material Figure A1a, a shock to $\sigma^0(\ell)$ will be associated with a large drop in price, and a large increase in required returns, to induce equity issuance to purchase the outstanding stock of securities. Consider now an economy with low ϕ. In this economy, it is less costly for banks to issue equity; therefore, prices and returns need to respond less to the same magnitude shock to $\sigma^0(\ell)$ to induce equity issuance and restore equilibrium. This can be seen in Supplementary Material Figure A1b. This analysis suggests that, as in the baseline model, the degree of price drops in response to shocks to banks' net worth is informative of the degree of financial frictions banks face. The difference is that in this model, this differential response is also manifested at the cross-section of bond varieties in secondary markets.

A3. *Mapping the Secondary-markets Model to the Data*

We recreate the episode of analysis from the empirical section in the secondary-markets model. We do this by focusing on an aggregate negative shock to ω, combined with an unexpected idiosyncratic shock to the fraction of earnings that are retained at each trading network. This shock is introduced with a mean-preserving spread to the parameter $\sigma^0(\ell)$, and can capture differential initial levels of capitalization due to bank-specific runs or exogenous recapitalizations. This combination of shocks introduces expost heterogeneity across trading networks and allows us to study the differential effect on securities from the same borrower held by different investors.

Table A1. Model with Secondary Markets: Model and Data Moments

Target	Description	Data	Model
$\mathbb{E}[D/Y]$	Average debt	15.0%	13.2%
$\mathbb{P}[DF]$	Default frequency	1.5%	1.3%
$\mathbb{E}[SP]$	Average EM spread	410bp	497bp
$\sigma(SP)$	Volatility EM spread	173bp	138bp
$\text{corr}(SP_i, Y_i)$	Correlation EM spread & endowment	−31%	−85%
$\sigma(\ln(V(N)))$	Volatility banks' net worth (NW)	0.28	0.21
$\text{corr}(\ln(V(N), Y_{\text{EM}})$	Correlation banks' NW & systemic EM endowment	40%	39%
Weight DM	Banks' exposure to EMs	90%	90%
η_{XS}	SM cross-sectional elasticity	0.056	0.057
A/NW	Total assets to equity ratio	3.6	4.3
R^0	Return secondary to primary markets	1.0	1.01
$\eta_{\text{EM,N}}$	Aggregate elasticity EM spreads to banks' NW	0.056	0.031

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. The data moments regarding EM debt, default frequency, and bond spreads were computed using a sample of EMs with available data for the period 1994–2014. Supplementary Material B2 details the sample and data sources. Data moments on global banks' net worth were computed using the cyclical component in the stock price of publicly traded U.S. banks that have data coverage for the period of analysis (tracked by the XLF index). The share of global banks' exposure to EMs was measured by combining data on individual banks' balance sheets in the sample of banks from our empirical section (detailed in Appendix Table C1) with aggregate data on debt position. The elasticity of EM-bond spreads to global banks' net worth corresponds to the average of the empirical estimates in Section 3.4. See Section 4.1.1 and Supplementary Material A for a detailed discussion of the model counterpart of this data object.

We then use this model to quantitatively reproduce the empirical analysis from Section 3 in model-simulated data. The objective is to show that a parameterization that targets the cross-sectional elasticity estimated from the data generates quantitative results that are in line with those of the baseline model. We parameterize this model by calibrating the same set of moments as in the baseline model, with the main difference being that instead of targeting the aggregate elasticity, we now target the cross-sectional elasticity from the secondary markets.[30] The targeted moments are reported in Supplementary Material Table A1.

To compute the cross-sectional elasticity, we feed into the model a shock to ω such that banks' aggregate net worth falls by the same amount as it did in the window around the Lehman episode (see Table 1), together with unexpected idiosyncratic shocks to the capitalization of banks in different trading networks. In order to generate dispersion across trading networks, we simulate various $\sigma^0(\ell)$ from a lognormal distribution with mean 0.71 (which is the calibrated value σ^0 in the model) and standard deviation 0.13. We calibrate the standard deviation so that the cross-sectional standard deviation of the fall in net worth across trading networks is the same as the cross-sectional standard deviation of the residualized fall in net worth per bond in the empirical section, 7%. We then compute yields to maturity (obtained from secondary-market prices) of 50 varieties of bonds from 60 countries in the model, maintaining the share of average bonds per country found in the data. We also compute the log-change in the market value of net worth in each of the 50 trading networks that trade different varieties. Supplementary Material Figure A2a shows the raw simulated data, with the demeaned change in net worth at the variety/trading-network level on the horizontal axis and the demeaned change in yields on the vertical axis. The negative slope of the line of best fit indicates a negative relationship between the change in bond yield and the change in bond holders' net worth. This relationship does not fully explain the simulated data, as there is dispersion in changes in yields of a given variety due to heterogeneity in the default risk that comes from different borrowers. Once this borrower heterogeneity is filtered out with fixed effects, the change in net worth accounts for most of the residual change in yields (see Supplementary Material Figure A2b).

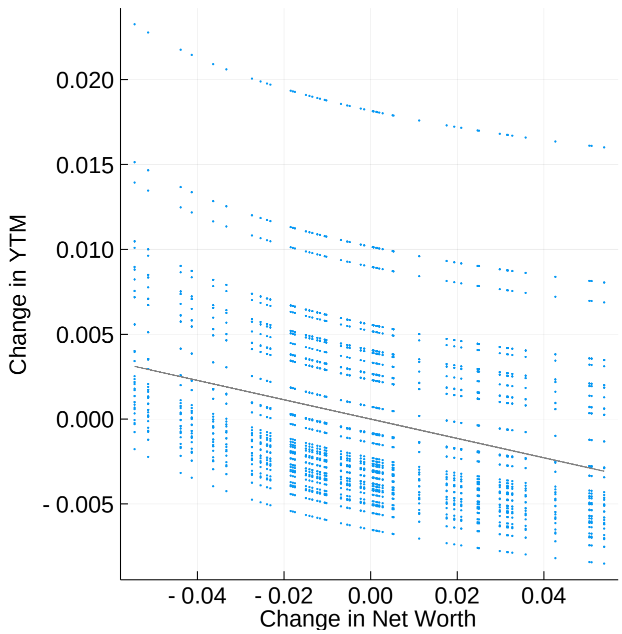
We then estimate the regression on model-simulated data:

$$\Delta ytm^0_{i\ell} = \alpha_i + \eta_{xs} \Delta \log V^0(N^0_\ell) + \epsilon_{i\ell}, \tag{53}$$

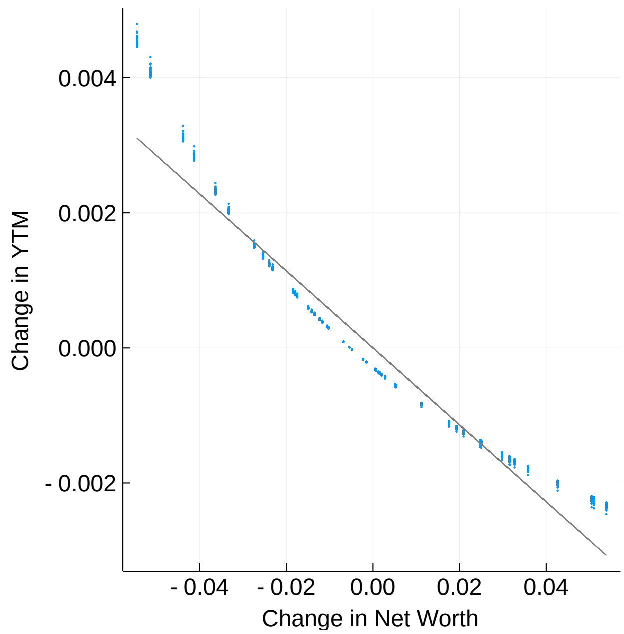
[30]This model also features one parameter, $\overline{n}^0$, that is not in the baseline model. We calibrate it so that the within-period average return from holding risky debt from the secondary market to the primary market is one. This moment is introduced to capture the high-frequency notion of the secondary market subperiod in which there is no time discounting and zero net returns.

FIGURE A2. Change in Yield to Maturity and Holders' Net Worth: Model-simulated Data

(A) Without Country Fixed Effects



(B) With Country Fixed Effects



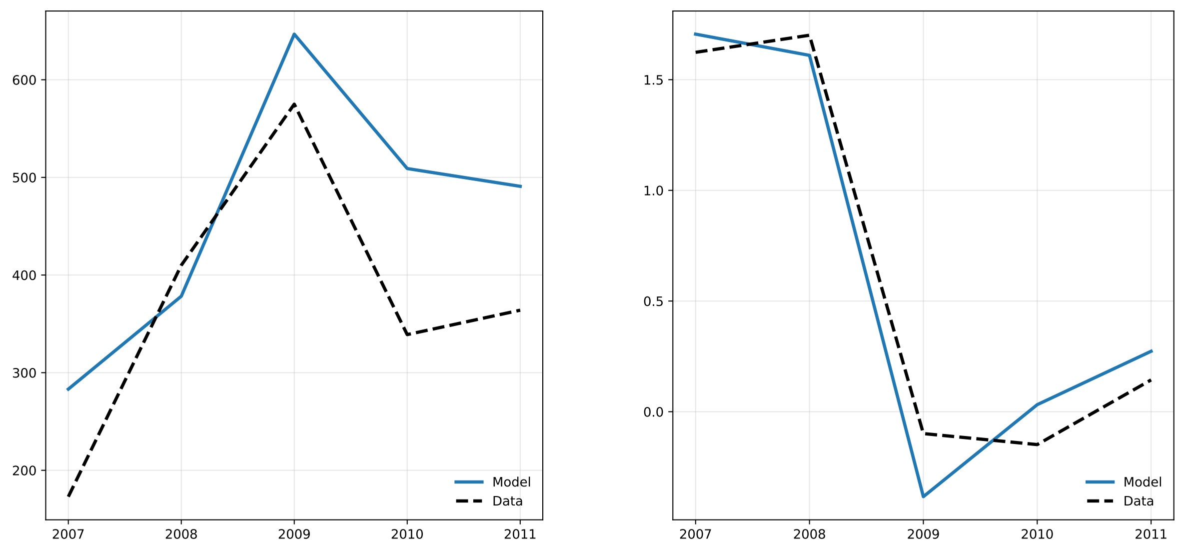
Notes: Panel (A) shows the model-simulated data on changes in bond-yield and in the log market value of net worth. The horizontal axis includes the demeaned change in net worth for each variety (and trading network). The vertical axis shows the demeaned change in bond yields of different countries and varieties. Panel (B) shows the same graph as in Panel (A), but now the change in yields is reduced to a residual from the country-average change in yields.

where $\Delta ytm^0_{i\ell}$ is the within-period change in the yield to maturity of a bond of variety ℓ, issued by economy i, where the period corresponds to the joint shock to ω and $\sigma^0(\ell)$; α_i is a borrower fixed effect; $\Delta \log V^0(N^0_\ell)$ is the change in the aggregate log market value of net worth of banks that trade variety ℓ. This regression is equivalent to the empirical regression (17) without controls, as these are not featured in the model. The estimated cross-sectional elasticity is $\eta_{xs} = -0.057$, which is close to the empirical target.

We then compute the elasticity at the aggregate level as a non-targeted moment, computed as in our baseline model. The untargeted aggregate elasticity is -0.031 (see last row of Supplementary Material Table A1), which is negative but slightly smaller in absolute value than the cross-sectional elasticity. The quantitative differences between the cross-sectional and aggregate elasticity are due to differences in the supply of bonds in primary and secondary markets. In secondary markets, the supply of outstanding bonds is fixed from the previous period. In primary markets, the supply of bonds (or equivalently, the demand of funds) comes from solving the EM households' problem and is decreasing in the required returns. The presence of this downward-sloping demand of funds attenuates the aggregate elasticity relative to the cross-sectional one, which is computed purely from the price dynamics in the secondary markets.

A4. *Aggregate Quantitative Results*

FIGURE A3. Response in the Secondary-markets Model during the Lehman Episode



(A) EM Spreads (B) Consumption

Notes: Data (dashed black lines) refers to the average of sovereign-bond spreads (in bps) and the cyclical component of consumption (standarized) in a sample of EMs (see Supplementary Material B2). *Model* (solid blue lines) refers to the response of the variables to a sequence of shocks $\{\epsilon_{\omega t}, \epsilon_{\text{EM}t}\}$ that targets the dynamics of global banks' net worth and EMs' systemic endowment during 2007–2011 (see Figure B2).

This section summarizes the main quantitative aggregate results in the model with secondary markets. We first recompute the exercise that analyzes the dynamics of spreads and consumption during the global financial crisis in this version of the model. Supplementary Material Figure A3 shows that the dynamics of these variables are similar to those observed in the data. In addition, the conditional decomposition of shocks in this model still suggests a major role of DM shocks in explaining the dynamics of spreads. Finally, we also perform the unconditional decomposition of spreads in this model and find that the intermediation premium accounts for roughly one-third of the fluctuations in spreads. These results suggest that the calibrated model with secondary markets delivers quantitative results that are similar to those observed in the baseline model. Results are available upon request.

B. Quantitative Analysis

B1. *Solution Method*

As discussed in Appendix A1, our model's agent heterogeneity and aggregate uncertainty imply that the distribution of assets in the world economy, Δ, an infinite-dimensional object, is a state variable in agents' individual problems. To solve for the equilibrium of the model numerically, we follow a common practice in existing algorithms and use as state variables a set of statistics that summarize the information from this distribution (see Algan et al., 2014, for a review of algorithms to solve models with heterogeneous agents and aggregate uncertainty).

The detailed choices in our solution method are guided by three features of our model. First, an individual EM's problems involve a default choice without commitment, which requires the use of global methods in the solution of these problems. Second, with default risk, the degree of aggregate uncertainty in the economy significantly affects the debt–price schedules EMs face as well as their policy functions. Therefore, we choose a method that uses summary statistics as part of the state variables in the agents' individual problems.[31] The curse of dimensionality in the solution of these problems then naturally limits the dimension of the vector of states summarizing the distribution of assets. Finally, in our economy, the debt–price schedules individual EMs face depend on the perceived policy for banks' DM-firm-invested assets, $\hat{A}_{\text{DM}}(\mathbf{s})$, which governs DM firms' marginal product of capital. In equilibrium, perceived policies must coincide with actual policies. To avoid inaccuracies originating from this perceived policy

[31]The relevance of the degree of aggregate uncertainty in our model causes us to depart from algorithms that involve perturbation methods around a solution of the model with no aggregate uncertainty (e.g., Reiter, 2009), which have typical computational speed and allow for a large set of state variables.

function, we allow for an auxiliary aggregate variable $\hat{A}_{\text{DM}}$—which describes aggregate investment in DM firms at the end of the period—as a state variable in agents' individual problems. Using $\hat{A}_{\text{DM}}$ as a state also has the advantage that the approximate solution is always consistent with market clearing.

From these considerations, our approximate solution considers the following problems for individual agents. We express global banks' recursive problem as

$$\nu(s_x) = (1-\sigma) + \sigma \max \left\{ \frac{1}{4\phi} \left(\mathbb{E}\left[\nu\left(s_x'\right)\right] - 1\right)^2 + \mathbb{E}\left[\nu\left(s_x'\right)\right]; \right. \tag{54}$$

$$\left. \frac{1}{4\phi} \left(\beta_{\text{DM}} \mathbb{E}\left[\nu(s_x') R_{\text{DM}}(s_x', s_x)\right] - 1\right)^2 + \beta_{\text{DM}} \left(\mathbb{E}\left[\nu(s_x') R_{\text{DM}}(s_x', s_x)\right](1+\kappa) - \mathbb{E}\left[\nu(s_x')\right] R_d \kappa\right) \right\}$$

$$\hat{A}_{\text{DM}}' = \mathcal{F}_A(s_x, \hat{A}_{\text{DM}}), \tag{55}$$

where $\mathcal{F}_A(\cdot)$ denotes the forecasting rule assumed to be used by agents under the approximate solution and s_x is the exogenous aggregate state.

Individual EMs' repayment decision under our approximate solution is characterized by

$$V(b, z, s_x, \hat{A}_{\text{DM}}) = \max_{\iota} \iota V^{\text{r}}(b, z, s_x, \hat{A}_{\text{DM}}) + (1-\iota) V^{\text{d}}(z, s_x, \hat{A}_{\text{DM}}), \tag{56}$$

where $V^{\text{r}}(b, z, s_x, \hat{A}_{\text{DM}})$ denotes the value of repayment described by

$$V^{\text{r}}(b, z, s_x, \hat{A}_{\text{DM}}) = \max_{b'} u(c) + \beta \mathbb{E}\left[V(b', z', s_x', \hat{A}_{\text{DM}}')\right], \tag{57}$$

$$\text{s.t. } c = y_{\text{EM}} + z - b + q(b', z, s_x, \hat{A}_{\text{DM}})(b' - \xi b), (55),$$

$$q(b', z, s_x, \hat{A}_{\text{DM}}) = \frac{\mathbb{E}[v(s_x', \hat{A}_{\text{DM}}') \tilde{\iota}(b', z', s_x', \hat{A}_{\text{DM}}')(1 + \xi q(b'', z', s_x', \hat{A}_{\text{DM}}'))]}{\mathbb{E}[v(s_x', \hat{A}_{\text{DM}}') R_{\text{DM}}(s_x', \hat{A}_{\text{DM}}')]},$$

and $V^{\text{d}}(z, s_x, \hat{A}_{\text{DM}})$, the value of default, is given by

$$V^{\text{d}}(z, s_x, \hat{A}_{\text{DM}}) = u(c) + \beta \mathbb{E}\Big[\phi V^{\text{r}}(0, z' s_x', \hat{A}_{\text{DM}}') + (1-\phi) V^{\text{d}}(z', s_x', \hat{A}_{\text{DM}}')\Big], \tag{58}$$

$$\text{s.t. } c = \mathcal{H}(y_{\text{EM}} + z), (55).$$

For the forecasting rule, $\mathcal{F}_A(\cdot)$, our benchmark algorithm follows Krusell and Smith (1998) in parameterizing an assumed functional form for the rule and using an iterative procedure with model-simulated data to estimate the parameters of the functional form. To render the procedure parsimonious, we assume a log-linear forecasting rule in $\{\omega, \hat{A}_{\text{DM}}\}$ and reduce the aggregate state space to $(s_x, \hat{A}_{\text{DM}})$.[32] Our algorithm then proceeds as follows.

(1) Specify the initial forecasting rule, denoted $\mathcal{F}_A^j(\cdot)$ for $j = 0$.

(2) Solve individual agents' problems, given the forecasting rule $\mathcal{F}_A^j(\cdot)$ for $j = 0$, using value function iteration.

(3) Simulate data from the model using the policy functions obtained in (2) for a given sequence of exogenous variables, $\tilde{s}_x \equiv \{s_{x,t}\}_{t=1}^T$, where T is the time length of the panel of model-simulated data. Estimate the parameters of the forecasting rule with model-simulated data and denote the new forecasting rule $\mathcal{F}_A^{j+1}(\cdot)$. Defining $\mathcal{F}^j(\tilde{s}_x)$ as the sequence of forecasts under the rule $\mathcal{F}_A^j(\cdot)$ for the sequence $\tilde{s}_x$, compute the distance $\delta_{j+1} \equiv ||\tilde{\mathcal{F}}^{j+1}(\tilde{s}_x) - \tilde{\mathcal{F}}^j(\tilde{s}_x)||$.

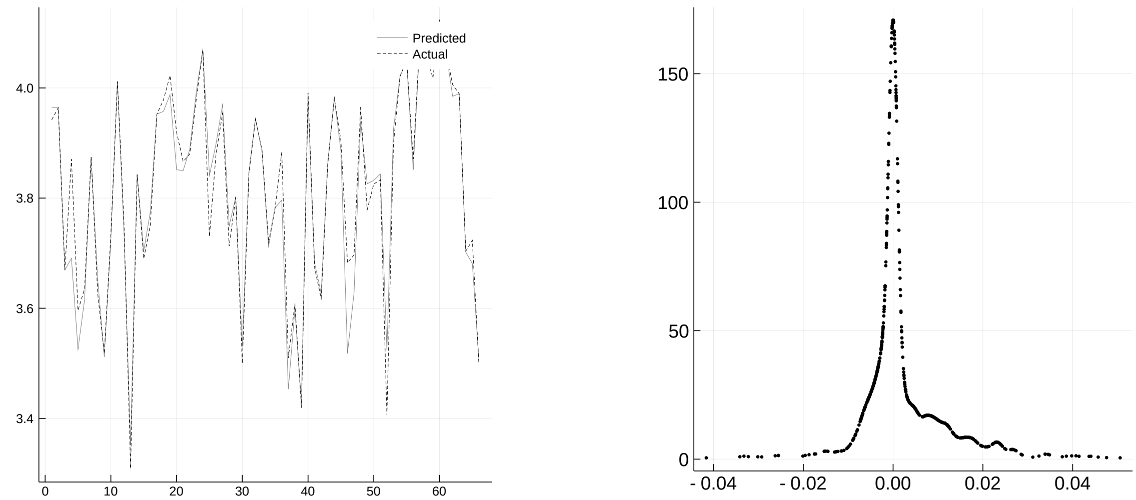
(4) Update the forecasting rule and iterate in steps (2) and (3) for $j = 1, 2, 3, \ldots,$ until δ_{j+1} is sufficiently small.

In each period t of the simulation, we need to evaluate whether the borrowing constraint binds. We start by guessing that the constraint does not bind. This requires finding the policy $\bar{A}_{\text{DM}}$ such that $R^e_{DM}(\mathbf{s}) = \mathbb{E}[\nu(\mathbf{s}')]R_d$, evaluating borrowers' policies, computing lenders' dividends from the optimality condition and deposits from the flow of funds constraint, and checking whether $\frac{d'}{R_d} < \kappa N$. If this is the case, we find that period's solution and move on to the next period. If not, we find A^*_{DM} such that markets clear when the borrowing constraint is binding.

[32]Borrowers only need $(s_x, \hat{A}_{\text{DM}})$ to infer current required returns. Adding moments related to the joint distribution of assets could potentially improve forecastability, but we find that first moments of debt and deposits do not make significant improvements and would be subject to the curse of dimensionality. Considering richer forecasting rules leads to convergence problems in the iterative procedure.

Figure B1. Fundamental Accuracy Plot

(A) Actual versus Predicted (B) Density of Log Residuals



Notes: The left panel shows a subset of the time series of the actual and forecasted versions of the bond price for a simulated individual economy. The right panel shows the estimated density of the log residuals for the entire sample. On the x-axis, we have the value for the log residual and on the y-axis the density value.

We analyze the goodness of fit of the assumed forecasting rule following Den Haan (2010), who suggests testing the accuracy of the forecast rule by performing a multiperiod forecasting without updating the endogenous state variable. This method does not adjust for deviations from the true endogenous state, and thus provides some sense of divergence in the model. Since the relevant variable for the borrower is the bond price, we simulate a series of bond prices under the true policy $\hat{A}_{\text{DM}}$ and compare it with a series of bond prices under the multiperiod forecast of the policy $\hat{A}^f_{\text{DM}}$. The steps are as follows.

(1) Draw a sample for the exogenous processes s_x.
(2) Solve for the equilibrium prices and allocations in each period. In particular, obtain a realization for $\{\hat{A}_{\text{DM},t}\}_{t=1}^T$.
(3) Let $\hat{A}^f_{\text{DM},0} = \hat{A}_{\text{DM},0}$ and construct $\hat{A}^f_{\text{DM},t} = \mathcal{F}_A(\omega_t, \hat{A}^f_{\text{DM},t-1})$.
(4) Draw a series for idiosyncratic endowments, z, to simulate an individual borrower. Compute a series of bond prices $\{q_t\}_{t=1}^T$ using the actual realization of $\{\hat{A}_{\text{DM},t}\}_{t=1}^T$ and a series of bond prices $\{q^f_t\}_{t=1}^T$ using $\{\hat{A}^f_{\text{DM},t}\}_{t=1}^T$.
(5) Construct a series for log residuals $\{\log(q_t) - \log(q^f_t)\}_{t=1}^T$ and its R^2.

The R^2 of the series is 97%. Supplementary Material Figure B1 shows a subset of the time series for the log residuals, as well as the estimated density for the entire time series excluding default episodes. These results show that forecasts do not exhibit the accumulation of errors over time. The predicted series closely follows the actual series for bond prices, which suggests that the main driver for the DM policy is the ω shock. In addition, the residuals are centered around zero most of the time, although mildly skewed; 65% of the absolute values of the log residuals are less than 0.5%; 81% are less than 1%; and 96% are less than 2.5%.

B2. *Data Used in Quantitative Analysis*

B.2.1. *EM country data*

Our sample of countries consists of emerging economies with sufficient data available to conduct the empirical analysis of Section 3, using bond-level data, and our quantitative analysis in Section 4, using aggregate data. In particular, we consider those countries that (i) are part of JPMorgan's EMBI, (ii) have outstanding bonds issued before 2008 and maturing after 2010 with daily data, and (iii) have at least 10 years of available data on aggregate debt prices and output. Twenty-five countries met the sample criteria: Argentina, Brazil, Bulgaria, Chile, China, Colombia, Croatia, El Salvador, Indonesia, Jamaica, Lithuania, Latvia, Mexico, Malaysia, Panama, Peru, Philippines, Pakistan, Poland, Russia, South Africa, Thailand, Turkey, Ukraine, and Venezuela. For all countries in the sample, we collect daily data on sovereign spreads and quarterly data on real GDP, real consumption, and trade balance over GDP. Sovereign spreads are a summary measure computed by JP Morgan on a synthetic basket of bonds for each country. It measures the implicit interest-rate premium required by investors to be willing to invest in a defaultable bond of that particular country. Spread data were obtained from Datastream. Data on real GDP, real consumption, and trade balance ratio were obtained from national sources and the IMF. The sample period is from 1994 to 2014, but data on particular countries may have different starting and ending points, depending on availability.

B.2.2. *Global Banks' Net Worth*

The data moments on global banks' net worth were computed using the cyclical component 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 obtain institution-level data to compute two key moments of the calibration: the leverage of financial intermediaries and their estimated exposure to EM debt. We obtain the data used in these estimates from the intermediaries' annual reports (from AnnualReports.com), which include balance-sheet information and off-balance-sheet information on assets under management.

We compute two measures of leverage. The first measure corresponds to the "book value" of leverage, which is defined as the ratio of total assets to total equity. The second measure, which we label "AUM adjusted leverage," incorporates assets under management in the measurement of leverage. In particular, it is defined as the ratio of the sum of total assets in the institution's balance-sheet and assets under management to the sum of total equity in the balance-sheet and assets under management. We compute this measure because, in our model, financial intermediaries are aimed at capturing a consolidated entity that maximizes the joint value of the owners' equity in the firm and the owners of the assets under management. Table C2 reports the two measures of leverage for 28 financial intermediaries in our sample for the year 2006. On average, the book value of leverage is 19 and the adjusted leverage is 3.8.

To estimate the exposure of total assets to EM debt, we proceed in two steps. In the first step, we identify government and private-sector securities reported in the institution's assets side of the balance-sheet that are disaggregated by country. For example, HSBC reports the holdings of government bonds issued by the US, UK, Hong Kong, and other governments. The second step consists of estimating how much of the share of the other governments' debt holdings can be attributed to emerging markets and how much to advanced economies that are not the US, UK or Hong Kong. We estimate this by using WEO data; in particular, we distribute the holdings of other governments' debt according to the ratio of emerging-market government debt to the sum of emerging-market government debt and that from advanced economies that are not the US, UK or Hong Kong.

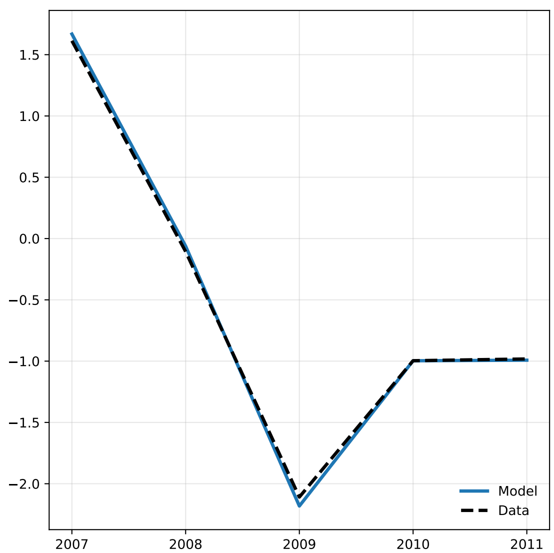
Formally, denote N_{EM} and N_{DM} the set of emerging and advanced economies. Denote $N_j \subseteq N_{\text{DM}}$ the set of advanced economies for which bank j reports disaggregated data; $\{(d_{ji})_{i\in N_j}\}$ the amount of holdings by institution j of bonds issued by government i; and D_j the total government debt holdings by institution j. We can compute the holdings of other non-reported governments as $d_{j,other} \equiv D_j - \sum_{i\in N_j} d_{ji}$. Finally, let d_i^{WEO} denote the outstanding debt of government i in the WEO dataset. We then estimate the share of EM holdings by institution j as $s_{j\text{EM}} = \frac{d_{j,other}}{D_j} \frac{\sum_{i\in N_{\text{EM}}} d_i^{WEO}}{\sum_{i\notin N_j} d_i^{WEO}}$.

Finally, we follow a similar procedure for estimating intermediaries' exposure to private EM securities. Table C1 reports the estimated exposure of 25 financial intermediaries in our sample for the year 2006, with an average of 10%.

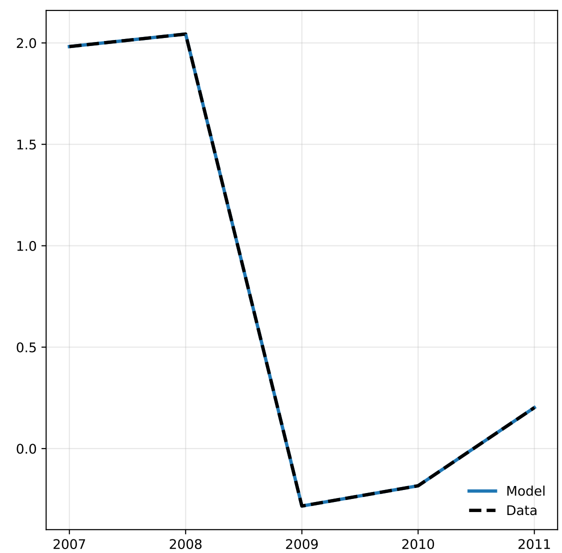
B3. *Additional Quantitative Results from the Baseline Model*

FIGURE B2. Global Financial Crises: Aggregate Drivers

(A) Global Banks' Net Worth

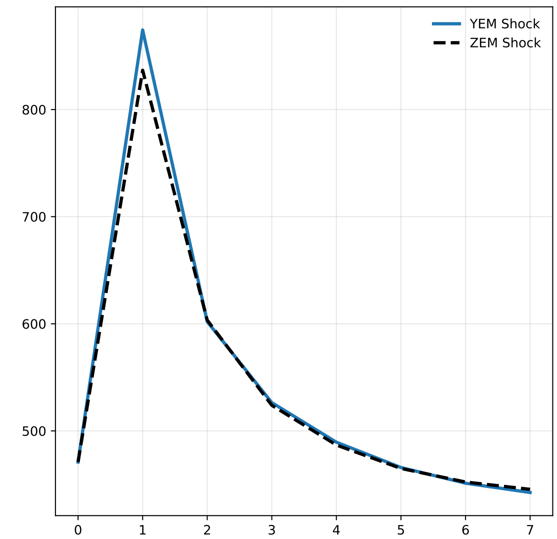


(B) EMs' Systemic Endowment

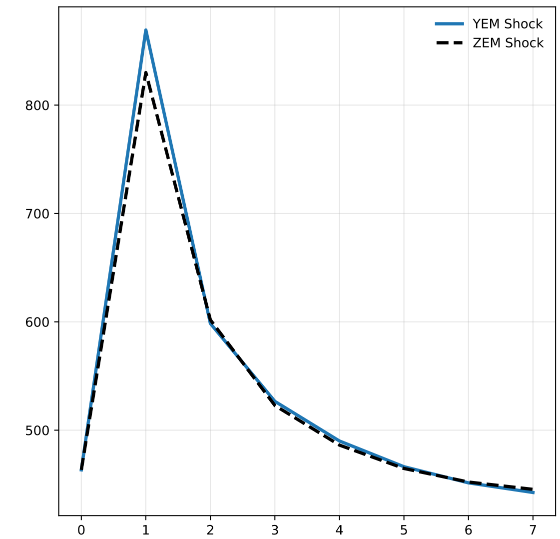


Notes: Global banks' net worth and EMs' systemic endowment were proxied, respectively, by the stock price of publicly traded U.S. banks (XLF index) and by the average GDP in a sample of EMs (detailed in Supplementary Material B2). *Data*. Objects in the figure (dashed black lines) refer to the cyclical components of these variables, expressed as deviations from a log-linear trend and standardized. *Model*. Objects in the figure (solid blue lines) refer to the dynamic response of global banks' net worth and EMs' systemic endowment to a sequence of shocks $\{\epsilon_{\omega t}, \epsilon_{\text{EM}t}\}$ that target the data objects during 2007–2011. Responses in the model were computed starting from the ergodic aggregate states. Variables in the model are expressed in log deviations from their ergodic means and standardized. Calibration of the model is detailed in Section 4.1.

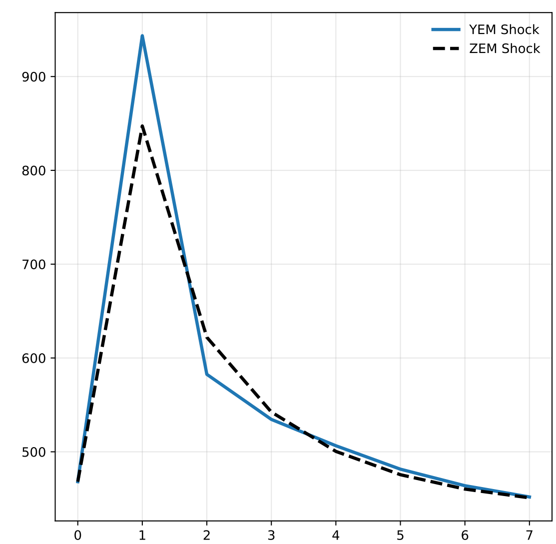
Figure B3. Amplification Sorted by Intermediaries' Exposure to EMs and the Dispersion of EM Debt



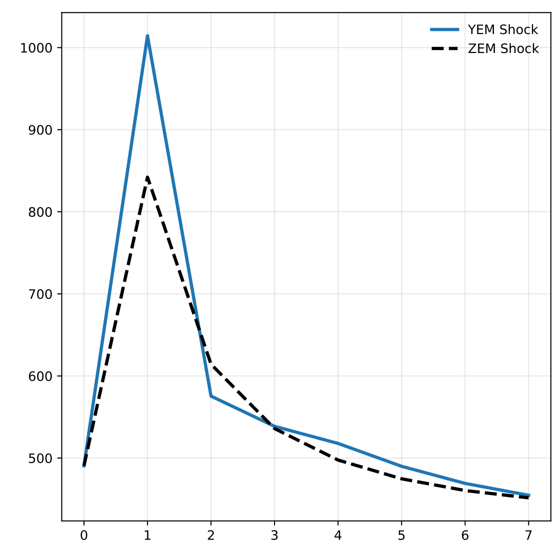
(a) Low Exposure, Ergodic Dispersion



(b) Low Exposure, High Dispersion



(c) High Exposure, Ergodic Dispersion



(d) High Exposure, High Dispersion

Notes: These figures show the dynamics of spreads (in bps) following a 2–s.d. shock to the systemic (solid blue line) and idiosyncratic (dashed black line) endowment. In the first row, global banks' exposure to EMs is 10%; in the second row, banks' exposure is 35%. In the first column, the initial distribution of EM debt is the ergodic one; in the second column, the initial distribution has twice the dispersion.

B4. *Alternative Calibration Strategies*

This section describes alternative calibration strategies and extensions of the baseline model. We consider five model extensions: one that targets a lower elasticity (*Alternative Elasticity*); one that allows for different stochastic processes for idiosyncratic and aggregate EM endowments (*Measured Income Process*); one that calibrates financial intermediaries to only asset managers (*Asset Managers*); one with a state-contingent cost of external finance (*Cost of External Finance*); and one that introduces global liquidity policies with a state-contingent funding rate for banks (*Liquidity Policies*).

B.4.1. *Alternative Elasticity*

This extension consists of an alternative calibration strategy that targets an elasticity $\eta_{\text{EM,N}} = -0.022$ while keeping all other targets unchanged. This alternative elasticity is estimated with contemporaneous regressions (see Panel B of Table 2). Row (i) of Supplementary Material Table B1 shows the new set of calibrated parameters. The remaining parameters are set to the same value as in the baseline calibration. Row (i) of Supplementary Material Table B2 reports the targeted parameters. Appendix Table C4 shows that it is still the case that global banks play an important role during systemic debt crises by transmitting DM shocks rather than amplifying EM-origin shocks. In addition, Table 6 shows that the contribution of the intermediation premium to total spreads is lower under this alternative calibration, but still quantitatively important.

Table B1. Robustness: Fixed Parameters

	Constant									State-Contingent	
	β_{EM}	d_0	d_1	σ	μ_{EM}	σ_{DM}	κ	$\bar{n}$	$\rho_{DM,EM}$	ϕ	β_{DM}
Baseline Model	0.90	0.03	14.0	0.71	2.02	0.07	3.50	0.46	0.45	2.50	0.98
Robustness											
i. Alternative Elasticity	0.90	0.03	14.0	0.71	2.06	0.07	4.00	0.70	0.45	0.70	0.98
ii. Measured Income Process*	0.92	0.06	14.0	0.71	1.95	0.07	3.40	0.35	0.45	3.50	0.98
iii. Asset Managers	0.90	0.03	14.0	0.80	1.99	0.21	0.00	0.80	0.47	0.750	0.98
iv. High Leverage	0.90	0.03	14.0	0.7	2.06	0.04	7.00	0.29	0.50	3.00	0.98
v. Time-varying ϕ	0.90	0.03	14.0	0.71	2.14	0.06	3.50	0.37	0.50	$\phi_1 = 3.00$	0.98
										$\phi_2 = 0.50$	
vi. Time-varying β_{DM}	0.90	0.03	14.0	0.71	2.05	0.07	3.50	0.46	0.45	2.50	$\beta_1 = 0.98$
											$\beta_2 = -0.20$

* Parameters for measured EM income process are $\rho_z = 0.82$, $\sigma_z = 0.025$, $\rho_{EM} = 0.70$, $\sigma_{EM} = 0.016$

Notes: This table describes the values parameters take in each robustness exercise. Parameters are categorized between those that are always constant vs those that are state-contingent in some exercises. Alternative elasticity refers to the case in which we target $\eta_{EM,N} = 0.022$; Measured Income Process is the case in which the systemic and idiosyncratic components of endowment are calibrated as in the data; Asset Managers refers to the case with $\kappa = 0$; High Leverage refers to the case with $\kappa = 7$; Cost of External Finance is for a state-contingent $\phi(\omega)$; Liquidity Policies is the scenario with state-contingent risk-free rate $r_f(\omega)$.

TABLE B2. Robustness: Targeted Moments

Panel A: Benchmark Moments									
	$\mathbb{E}[D_i/Y_i]$	$\mathbb{P}[DF_i]$	$\mathbb{E}[SP_i]$	$\sigma(SP_i)$	$\text{corr}(SP_i, Y_i)$	$\sigma(\log V(N))$	$\text{corr}(\log V(N), \log Y_{\text{EM}})$	$\eta_{\text{EM,N}}$	$\mathbb{E}\left[\frac{(A_{\text{EM}}+A_{\text{DM}}}{NW}\right]$
Data	15.0%	1.5%	410bp	173bp	-31%	0.28	40%	0.056	3.8
Baseline Model	14.4%	1.7%	416bp	152bp	-84%	0.24	44%	0.059	3.7
Robustness									
i. Alternative Elasticity	15.6%	1.7%	314bp	128bp	-86%	0.33	43%	0.026	3.4
ii. Measured Income Process	13.8%	1.3%	521bp	192bp	-75%	0.23	38%	0.071	3.6
iii. Asset Managers	14.4%	1.6%	435bp	160bp	-82%	0.27	41%	0.060	N.A.
iv. High Leverage	14.7%	1.5%	378bp	141bp	-85%	0.23	46%	0.056	6.4
v. Time-varying ϕ	13.1%	1.5%	442bp	141bp	-84%	0.23	46%	0.064	3.7
vi. Time-varying β_{DM}	14.2%	1.5%	426bp	196bp	-72%	0.25	41%	0.05	3.4

Panel B: Extended Model Moments			
	skew(SP)	$\mathbb{E}[RF]$	cov(ln(V(N)), RF)
Data	0.64	2.0%	0.18
iv. Time-varying ϕ	0.74		
v. Time-varying β_{DM}		2.0%	0.2

Notes: This table shows the set of targeted moments under each robustness exercise. Panel A shows the set of moments shared with the baseline model and panel B shows an extended set of moments associated with state-contingent parameters. Alternative elasticity refers to the case in which we target $\eta_{\text{EM,N}} = 0.022$; Measured Income Process is the case in which the systemic and idiosyncratic components of endowment are calibrated as in the data; Asset Managers refers to the case with $\kappa = 0$; High Leverage refers to the case with $\kappa = 7$; Cost of External Finance is for a state-contingent $\phi(\omega)$; Liquidity Policies is the scenario with state-contingent risk-free rate $r_f(\omega)$.

B.4.2. *Measured Income Process*

This model extension allows for different stochastic processes for idiosyncratic and aggregate EM endowments.[33] We measure the systemic EM endowment as the cross-sectional average of the HP cycle of GDP for each of the countries in the sample. For each country, we measure its idiosyncratic component as the residual between the country's observed HP cycle of output and the constructed systemic component. We assume that both are first-order autoregressive. The calibrated parameters and targeted moments are reported in Row ii of Supplementary Material Tables B1 and B2, respectively. In Table 6 and Appendix Table C4, we show that the key quantitative insights of the paper regarding the role of global banks still hold.

B.4.3. *Asset Managers and High Leverage*

We consider two alternative calibrations involving changes in the κ parameter. The first exercise is aimed at capturing the case in which asset managers (non-levered institutions) are the only type of global financial intermediaries in the economy. To this end, we recalibrate the model for the case when $\kappa = 0$. It is worth highlighting the fact that in this case, recursive problem (18) corresponds to a consolidated problem that maximizes the joint value of the owners' equity in the asset-management firm and the owners of the assets under management (i.e., its customers, who are assumed to be members of the DM household). In this case, the cost of raising external funds refers to either the cost of raising new external equity or the cost of expanding the customer base. This formulation abstracts from frictions between managers and customers, which are beyond the scope of the paper.

The calibrated parameters and targeted moments are reported in Row (iii) of Supplementary Material Tables B1 and B2, respectively. In Table 6 and Appendix Table C4, we show that these non-levered institutions play a role similar to that of global banks in our baseline model. This is the case because the main mechanism by which negative shocks to intermediaries' net worth increase required returns in risky assets is still in play, since intermediaries face a higher marginal cost of raising external finance.

The second exercise is to set $\kappa = 7$ (twice that of the baseline calibration), aim at obtaining a higher level of average leverage. In this case, the recursive problem of the bank is the same as in the baseline model. The calibrated parameters and targeted moments are reported in

[33] In the baseline calibration, we restricted these to follow the same stochastic process.

Row (iv) of Supplementary Material Tables B1 and B2, respectively. In Table 6 and Appendix Table C4, we show that the key quantitative insights of the paper regarding the role of global banks still hold.

B.4.4. *Cost of External Finance*

This model extension allows for a time-varying marginal cost of raising external finance (ϕ_t). It is intended to capture the notion that it can be less costly for intermediaries to raise external funding during tranquil times. We parameterize the marginal cost of raising equity as $\phi(\omega) = \phi_1\omega^{-\phi_2}$, with $\phi_1 > 0, \phi_2 > 0$.[34] The calibrated parameters and targeted moments are reported in Row (v) of Supplementary Material Tables B1 and B2, respectively. We set $\phi_1 = 3$ and $\phi_2 = 0.5$ to match the EM elasticity $\eta_{\text{EM,N}} = -0.056$ and the skewness of EM spreads of 0.64, as observed in the data. Appendix Table C4 shows that it is still the case that the majority of the rise in spreads during the Lehman episode, as well as a significant fraction of the variation in consumption, can be explained by the transmission of DM shocks through global banks.

B.4.5. *Liquidity Policies*

The last model extension is to introduce global liquidity policies that cause the risk-free funding rate for banks to vary with the state. We introduce these policies by allowing the discount factor of DM households, which in equilibrium determines the deposit rate, to vary with the aggregate DM exogenous state. We parameterize the risk-free rate as $R_d^{-1}(\omega) = \beta_{\text{DM}}(\omega) = \beta_1\omega^{\beta_2}$.[35] The calibrated parameters and targeted moments are reported in Row (vi) of Supplementary Material Tables B1 and B2, respectively. We keep the baseline parameters and choose $\beta_1 = 0.98$ 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. In Appendix Figure C4, we show that in the model with liquidity provision, the effect of the ω shock on EM bond yields and EM aggregate consumption is attenuated by roughly one-half when compared with the baseline economy. This is because funding rates

[34] For numerical stability, we restrict ϕ to take values within the interval $[0.4, 5.0]$.

[35] For numerical stability, we restrict r_f to take values within the interval $[1.005, 1.04]$.

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

B5. *The Role of Global Banks' Equity Issuance Cost, ϕ*

Supplementary Material Table B3 shows the impact of the marginal cost of equity issuance, ϕ, on the composition of the EM-spread risk premium—defined as the sum of intermediation premium and pure risk components of EM spreads. In particular, the exercise is to set ϕ to values below and above the baseline calibration, without recalibrating, and document the variation in the decomposition of risk. The case $\phi = 0$ resembles an economy without global banks, in line with such canonical models as Eaton and Gersovitz (1981) and Arellano (2008). The first panel shows the average spreads of decomposition and the second panel its volatility. The main takeaway is that financial frictions drive global banks' role in determining sovereign spreads, with higher costs of equity issuance being associated with a greater contribution of risk or intermediation premium to total spreads, for both the average and the standard deviation.

B6. *Cross-sectional Asset Pricing*

This appendix provides details on the empirical exercises that assess the market value of net worth of financial intermediaries as a risk factor in pricing the cross-sectional returns on EMs in the model. We start by describing the theoretical setup and then discuss our implementation of the exercises in the observed and model-simulated data.

In the model, the stochastic discount factor (SDF) that prices EM debt is a nonlinear function of the model's state variables. In this exercise, we consider a linearized factor version of the SDF that takes the form of

$$m_{t+1} = 1 - b\left(f_{t+1} - \mu\right), \tag{59}$$

where f_t is the factor vector (which can be multidimensional), μ is its mean, and b is the factor loading. In most of the exercises, we consider a single factor given by the market value of global banks' net worth. As we will see, this factor conveys the relevant information on price securities. The linear-factor model implies that the excess expected returns of any portfolio j

Table B3. Equity Issuance Costs and Unconditional Decomposition of EM-Bond Spreads

	Baseline	Equity Cost			
		$\phi = 0.0$	$\phi = 0.9$	$\phi = 4.0$	$\phi = 8.0$
(A) Average					
Total Spread	416bp	285bp	396bp	417bp	422bp
Default Premium	239bp	285bp	258bp	230bp	229bp
Risk Premium	177bp	0bp	139bp	186bp	193bp
Contribution Risk Premium	42.5%	0.0%	35.0%	44.7%	45.8%
(B) Standard Deviation					
Total Spread	152bp	139bp	137bp	151bp	152bp
Default Premium	116bp	139bp	123bp	112bp	111bp
Risk Premium	70bp	0bp	21bp	75bp	79bp
Contribution Risk Premium	46.1%	0.0%	15.3%	49.7%	52.0%

Notes: This table shows a decomposition of the model's predicted EM-bond spreads into their default- and risk-premium components for different values of global banks' costs of raising equity, ϕ. The model's other parameters are those detailed in Section 4.1. 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. To compute the default-premium component of spreads, we compute a sequence of risk-neutral prices, $\tilde{q}^i_{\text{EM}t} = \mathbb{E}_t\left[\beta_{\text{DM}}\iota_{it+1}\left(1+\xi\tilde{q}^i_{\text{EM}t+1}\right)\right]$, 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 $\{\tilde{q}^i_{\text{EM}t}\}_{t=0}^{\infty}$. We define the risk premium as the difference between the spreads predicted by the model and the default-premium component. Panel (A) shows the unconditional average of each variable and Panel (B) the unconditional volatility.

are given by

$$E\left[\widetilde{r^{ej}}\right] = \lambda_f'\beta_{jf}, \tag{60}$$

where $\widetilde{r^{ej}}$ is the log excess return, $\lambda_f = \Sigma_{ff} b$, with Σ_{ff} being the variance-covariance matrix of the factors, and β_{jf} is the exposure of each portfolio j to the risk factor f.

The objective of our exercise is to assess how well approximated are excess expected returns under (60). We use a two-stage cross-sectional regression approach (see Cochrane (2005), Chapter 12) to estimate portfolios' exposure to the risk factor, the price of risk, and the cross-sectional predicted returns. In the first stage, we use the time series of the factor and the portfolio returns to obtain estimates of the exposures $\beta_{j,f}$ by estimating

$$r^e_{jt} = c_j + \beta_{jf} f_t + \epsilon_{jt}. \tag{61}$$

In the second stage, we estimate the price of risk λ_f from the cross-sectional regression

$$\bar{r}^e_j = \beta'_{jf} \lambda_f + u_j, \tag{62}$$

where $\bar{r}^e_j$ is the average return (across time) of portfolio j. We then use the estimated price of risk to predict cross-sectional returns and compare them with the actual values.

Implementation with observed data. We first compute this estimation exercise on the observed data. We consider the six sovereign bond portfolios analyzed by Borri and Verdelhan (2011), which vary in the degree of default risk and comovement with market returns. Panels (A) and (B) of Supplementary Material Table B4 report summary statistics of the realized returns of these bond portfolios at monthly and annual frequencies, respectively. We measure the factor as the monthly variation in the stock price of publicly traded U.S. banks, tracked by the XLF index. Panel (A) of Supplementary Material Figure B4 shows that the linear-factor model correctly predicts the cross-section of observed expected returns for the six bond portfolios.

Table B4. Bond Portfolios: Summary Statistics

β_j	Low			High		
Default Prob.	Low	Medium	High	Low	Medium	High
Portfolios	1	2	3	4	5	6
	Panel A. Data (Monthly Frequency)					
Mean	2.5%	4.6%	7.4%	7.4%	10.7%	14.7%
Std. Dev.	32.0%	37.0%	55.0%	31.8%	39.8%	66.0%
Sharpe	0.08	0.12	0.13	0.23	0.27	0.22
	Panel B. Data (Annual Frequency)					
Mean	2.0%	3.8%	5.7%	6.6%	9.6%	12.1%
Std. Dev.	5.9%	8.4%	18.3%	8.1%	11.7%	27.5%
Sharpe	0.34	0.45	0.31	0.82	0.81	0.44
	Panel C. Model (Annual Frequency)					
Mean	2.9%	4.0%	5.6%	3.1%	4.3%	6.0%
Std. Dev.	3.8%	4.4%	5.5%	4.0%	4.6%	5.8%
Sharpe	0.75	0.89	1.01	0.77	0.93	1.03

Notes: This table shows summary statistics for EM portfolio returns, in both the model and the data. In the data, portfolio returns are obtained from Borri and Verdelhan (2011) at monthly frequency. In the model, we construct portfolios and returns as explained in Supplementary Material B6.

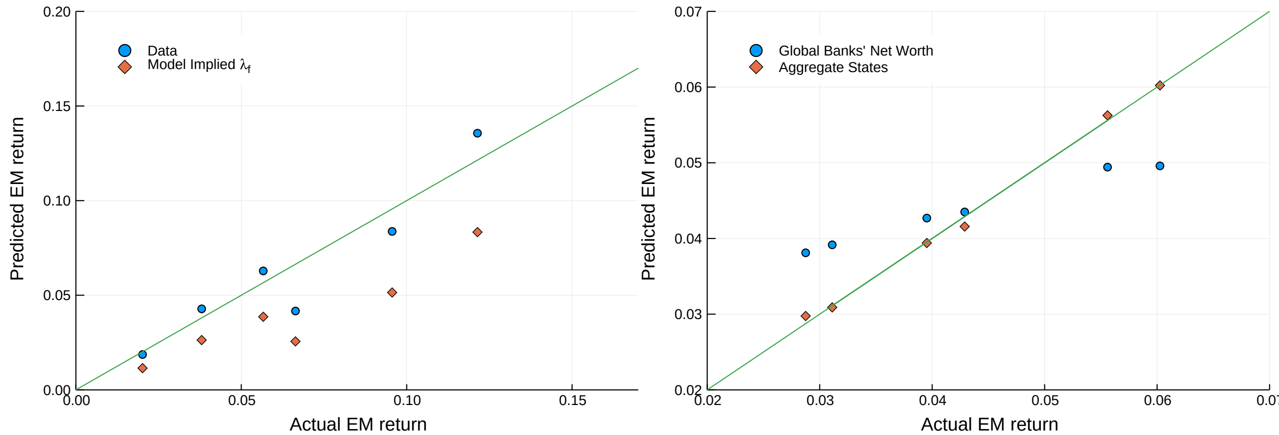
Implementation with model-simulated data. To implement this approach in our model, we first construct six EM portfolios similar to those in Borri and Verdelhan (2011). Portfolios are based on (i) the covariance of EM returns with the log-change in the market value of net worth and (ii) the default probability as measured by EM spreads. Data are simulated data for $T = 1,000$ periods and $N = 1,000$ borrowing countries. The covariance is measured by computing a 5-year rolling window estimation of

$$r^{EM}_{i,t} = \alpha_i + \beta^{EM}_{i,t} f_t + \epsilon_{i,t}, \quad (63)$$

where $r^{EM}_{i,t}$ are the returns on country i during the 5-year window ending in period t, f_t is the risk factor during this window, and $\beta_{i,t}$ is the measured covariance for that country and window. Assuming a rebalancing period of 5 years, we sort countries by having low vs high $\beta^{EM}_{i,t}$. For each of these two groups, we further differentiate countries by having low, medium, or high spreads. Panel (C) of Supplementary Material Table B4 reports summary statistics of the simulated returns of these bond portfolios. We measure the factor as the log variation in the market value of global banks' net worth in the model. Panel (B) of Supplementary Material Figure B4 shows that the linear-factor model correctly predicts the cross-section of model-simulated expected returns for the six bond portfolios, which suggests that the market value of global banks' net worth conveys the information relevant to price EM bonds in the model. For comparison purposes, the figure also shows the goodness of fit of a linear-factor model in which the factors are the model's aggregate state variables. As expected, this alternative model provides almost a full accounting of the cross-sectional variation in returns.

Implementation with observed returns and the model-implied market price of risk. We consider a third exercise in which we use the model-estimated market price of risk, λ_f, together with data–estimated loadings of bond portfolios, to estimate the observed cross-sectional excess expected returns. The goodness of fit of this exercise, reported in Panel (A) of Supplementary Material Figure B4, suggests that the calibrated model also prices well the observed cross-sectional sovereign risk.

Figure B4. Cross-sectional Asset Pricing: Actual vs Fitted



(A) Data (B) Model

Notes: These figures contrast the cross-sectional returns on six EM–bond portfolio holdings (y-axis) against the realized returns (x-axis), for both model-simulated and actual data. In the data, portfolios are obtained from Borri and Verdelhan (2011) for the period 1995 to 2011. In the model, portfolios are constructed based on (i) the covariance of EM returns with the log-change in $V(N)$ and (ii) the default probability as measured by EM bond spreads. We consider the log-change in global banks' market value of net worth as a unique risk factor ($V(N)$ in the model and XLF in the data), and use a standard cross-sectional regression approach to compute the price of risk and the predicted returns. Panel (A) shows results in the data and compares them with the case in which we instead use the model-implied value of the price of risk, while keeping the first-stage estimated factor loadings fixed. Panel (B) shows the results of the model and compares them with the case in which we instead use aggregate states $\{Y_{EM}, \omega, A'_{DM}\}$ to price EM portfolios.