Global Banks and Systemic Debt Crises*

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Abstract. This paper studies the role of financial intermediaries in the global market of risky external debt. In the data, most of emerging economies' external debt is held by financial intermediaries, who have a sizable portfolio exposure to these securities. Guided by this fact, we construct a model of international lending in which a set of heterogeneous emerging economies, facing systemic and idiosyncratic shocks, borrow from developed economies through global banks. We show that the nature the role played by global banks in systemic debt crises is governed by their exposure to emerging market debt. When banks are highly exposed, they play a major role in amplifying systemic shocks originated in emerging economies, whereas when their exposure to these securities is low, they play a major role transmitting shocks from other risky assets to the emerging debt market. Our model with global banks sheds light on the history of systemic debt crises in emerging economies, and on the changing nature of these crises over the last decades. In addition, global banks can help explain key patterns of debt prices, including the large co-movement observed within emerging economies and with other risky securities, and the differential sensitivity of bond prices to systemic and idiosyncratic income shocks.

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

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1. Introduction

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

This paper is aimed at understanding the role of global banks in systemic debt crises. We begin by documenting that global banks hold significant amount of emerging market debt, and that these securities represent a sizable share of banks' portfolio of risky assets. Motivated by these facts, we construct a model of global banks' lending to emerging economies, and use the model to study under what conditions these intermediaries can play a major role in systemic debt crises. We find that the exposure of these banks to emerging economies is the key to determine their role propagating shocks, and that the evolution of banks' exposure over the last decades can explain the changing nature of systemic debt crises in emerging economies. In addition, we show that global banks help explain key patterns of debt prices, including the large comovement observed within emerging economies and with other risky securities, and the sensitivity of bond prices to systemic income shocks.

The paper begins by documenting that banks are important lenders in the debt market for emerging economies. We combine various sources of aggregated and disaggregated data to show that global banks, understood in a broad sense, hold a significant fraction of EM external debt. These intermediaries include depository institutions, mutual funds, hedge funds, and asset management firms. We then show that the exposure of global banks to EM risky debt is sizable. On average, banks hold approximately 8% of their assets invested in EM risky debt. This exposure is half of what it was in the 1980s, when a few banks held most of EM debt. We later argue that this shift in the exposure of global banks had an impact on the changing nature of debt crises over the last decades.

We then construct a model of global banks' lending to emerging economies, and use the model to analyze their role in systemic debt crises. We model the world economy as composed by a set of heterogeneous emerging economies facing systemic and idiosyncratic income shocks, which borrow from developed economies using risky debt. Global banks intermediate in this international lending process, but face financing frictions linking investments in risky securities to their net worth. The key new mechanism of this global economy is that the net worth of global banks propagates aggregate shocks, through a feedback effect between the supply of funds and default rates in emerging economies. For instance, a systemic negative income shock to emerging economies increases their default rates, which contracts global bank's net worth and their aggregate supply of funds, leading to higher borrowing rates faced by emerging economies, further increasing their default rates.

The nature played by global banks in systemic debt crises is governed by their exposure to emerging market debt. On the one hand, if financial lenders who participate in the market only invest in emerging economies, then these intermediaries play a major role propagating systemic shocks originated in emerging economies. For instance, under full exposure, systemic income shocks in emerging economic have an effect on borrowing spreads three times larger than idiosyncratic income shocks, as the later do not affect banks' net worth. On the other hand, in a calibrated version of our model in which financial lenders have a low exposure to emerging economies (e.g., 10 percent of their portfolio of risky assets, as observed in the seven largest global banks), these intermediaries play a very small role propagating income shock originated emerging economies, which have a small balance-sheet effect, but a large role driving contagion from shocks originated in the returns of the other securities of their portfolio. For instance, if global banks are heavily exposed to corporate bonds in developed economies, negative shocks to these returns have an effect in emerging economies through the contraction in the aggregate supply of funds that result from the contraction of global bank's net worth.

Global banks can help explain key patterns of debt prices in emerging economies. First, they can explain why, in the data, bond spreads are highly correlated within emerging economies, and also highly correlated with the returns of other risky securities in developed economies, such as U.S. corporate bonds. In our model, an important part of the fluctuations in debt prices are driven by changes in banks net worth and the aggregate supply of funds, leading to large comovements similar to those observed in the data. Second, global banks can help explain why, in the data, bond spreads are more sensitive to changes in the systemic component of income of emerging economies than they are to changes in their idiosyncratic component. As mentioned before, systemic income shocks are associated with changes in the global supply of funds through their effect of global banks' net worth, leading to a larger effect on debt prices.

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

Related literature

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

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

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

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

The rest of the paper is organized as follows. Section 2 documents stylized facts about the market of emerging economies risky debt and the role that global banks play in this market. Section 3 lays out the model. Section 4 discusses the channels through which global banks amplify and transmit shocks in the risky debt market. Section 5 presents the calibration. We perform the main quantitative exercises in section 6, and conclude in section 7.

2. Global Banks and External Debt: Stylized Facts

This section documents three main facts regarding the global market of EM debt. First, we show that banks hold an important fraction of EM external debt and document their exposure to this type of debt. Second, we assess how synchronized debt prices are within emerging economies and with prices of other risky assets. Finally, we document a differential sensitivity of debt prices to fundamental shocks depending on the nature of the shock.

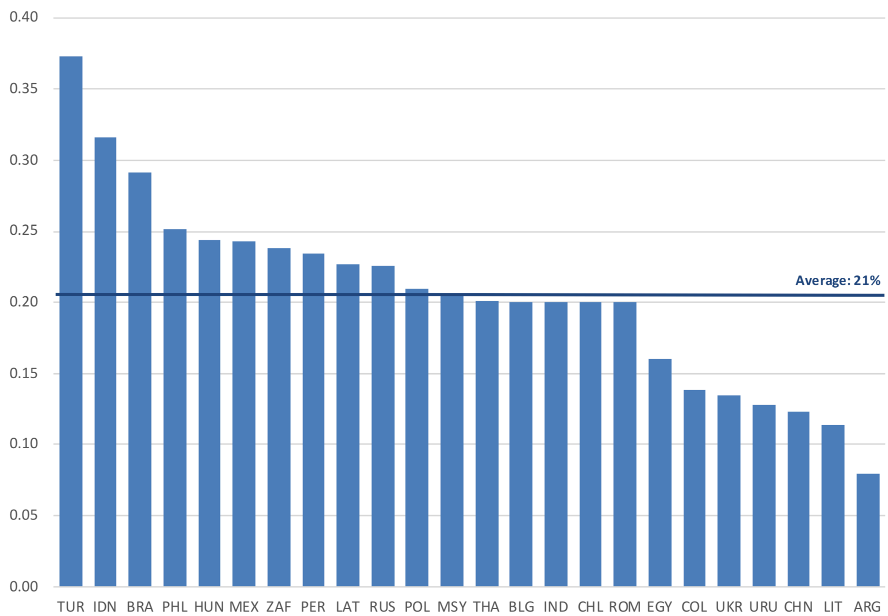
2.1. *Global Banks and Emerging Market Debt*

Our goal is to assess the role of global banks, understood in a broad sense, as lenders of emerging market economies. This is a challenging task since there is no unique source of data that tracks the holders of emerging market debt by disaggregated types of investors. Given this, we analyze various sources of aggregated and micro data to infer the role of global banks.

The first dataset we analyze is obtained from Arslanalp and Tsuda (2014). This dataset includes the stock of sovereign debt of various emerging economies broken down by type of lenders. The advantage of this dataset is that it covers the entire stock of debt for various emerging economies. The disadvantage is that it separates investors into only three groups. The type of lenders are foreign officials, foreign banks and foreign non-banks. In this dataset, foreign banks constitute depository institutions that report to the BIS. This constitutes a narrow definition of banks that does not include other financial institutions like mutual funds, hedge funds. We describe this dataset in more detail in Appendix B.

Figure 1 shows the share of total external debt that is held by foreign banks, for each country included in the dataset. On average, foreign banks hold 21% of total external debt securities of a given country. This figure varies by countries with the share being around 30% for certain countries.

FIGURE 1. External Debt Held by Global Banks



Notes: This figure shows the fraction of external debt of each country held by banks reporting to the BIS. The definition of banks corresponds to depository institutions and excludes other financial institutions like mutual funds, hedge funds and asset management firms.

We argue that most of the remaining 80% is likely to be held by other asset management firms. We reach this conclusion by analyzing two types of data. We first argue that foreign households hold a negligible part of this debt. In particular, data from the SCF shows that US households hold directly \$216bn dollars distributed between foreign corporate/sovereign bonds of emerging/advanced economies. This figure is negligible given that the size of the EM sovereign debt market is estimated at \$1.6tn dollars. Consistent with this fact, Morelli (2018) shows that direct bond holdings represent less than 5% of households portfolio six major European economies.

Second, we collected data on bond holdings reported to Bloomberg by financial institutions. For each country in our sample we observe the reported holdings of all issued bonds registered in Bloomberg. Institutions voluntarily report their holdings. The coverage of reported holdings is on average 20% of the total value outstanding of all bonds. Our preliminary findings suggest that more than 80% of total reported holdings of sovereign bonds are in 'investment advisors' firms, a classification made by Bloomberg which includes asset management firms and mutual funds.

Finally, we analyze the exposure of global banks to EM risky debt. We show that this exposure is sizable, yet lower than what it was in 1980s. First, we focus on six major banks that operate in international asset markets and document their current exposure to EM risky debt. We collect data from the balance-sheets of Citibank, HSBC, JPMorgan, Bank of America, Wells Fargo and Banco Santander. Table A1 reports summary statistics on the leverage and the exposure of these banks to EM risky debt. On average, 8% of total assets of global banks correspond to EM risky debt. Second, we analyze the exposure of banks to EM risky debt in early 1980s, before the Latin American debt crisis. Table A2 shows that the average exposure of the major banks to EM risky debt was 15% of their total assets.

2.2. *Emerging Market Debt Prices*

In this section we shift attention to EM debt prices. We focus our analysis on a comprehensive sample of emerging economies that are integrated to world capital markets. Our sample includes the following 28 economies: Argentina, Brazil, Bulgaria, Chile, China, Colombia, Croatia, Ecuador, El Salvador, Hungary, Indonesia, Jamaica, Latvia, Lithuania, Malaysia, Mexico, Morocco, Pakistan, Panama, Peru, Philippines, Poland, Russia, South Africa, Thailand, Turkey, Ukraine and Venezuela. The sample period ranges from 1994 to 2014. We collect data at a quarterly frequency on sovereign spreads and output for all countries in our sample. Further details about the description of the data can be found in Appendix B.

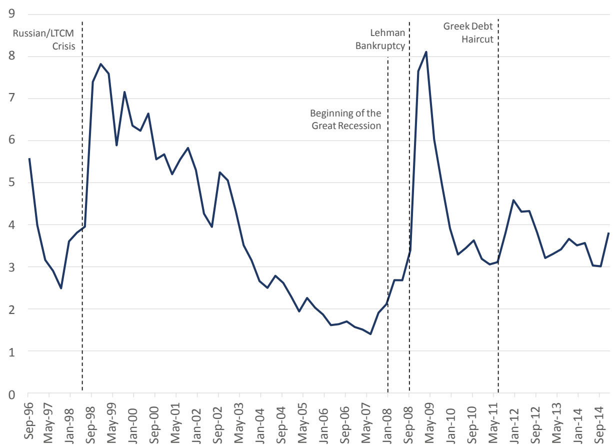
2.2.1. *Co-Movement of EM Debt Prices*

We first document a high synchronization of debt prices within emerging economies. For this we compute the average spread across countries over time. Figure 2a shows the average spread for the sample period. EMs exhibit a positive spread of 395 basis points on average. The average spread displays substantial movements with spikes following the Russian/LTCM crisis, the Great Recession -particularly immediately following Lehman Brother's bankruptcy-, and the recent Greek debt crisis.

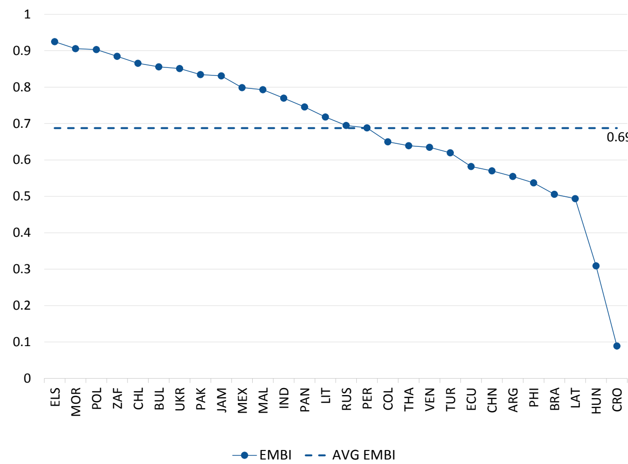
We then assess how correlated are country spreads with the average EM spread. To avoid capturing a spurious component in the correlations we compute for each country the correlation

Figure 2. Bond Spreads Synchronization in Emerging Economies

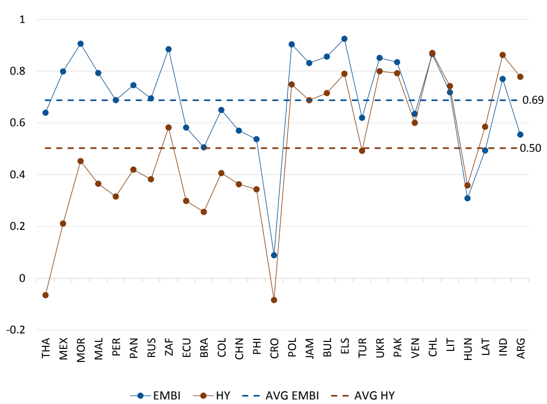
(A) Average Bond Spread



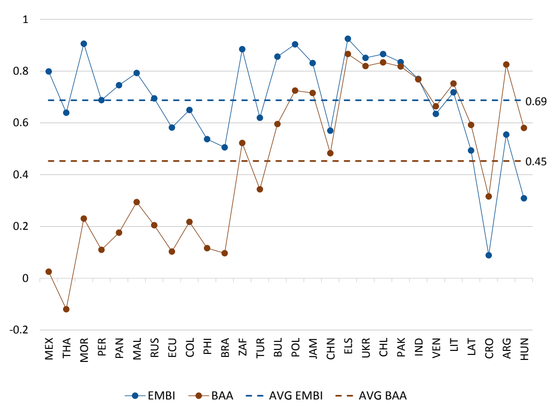
(B) Bond Spread Synchronization



(C) Synchronization with US High Yield



(D) Synchronization with US BAA



Notes: Panel (A) shows he average EM spread, which is computed as the simple average of sovereign spreads of all countries in our sample. Panel (B) shows the correlation of sovereign spreads of each country with the average EM spread. Panel (C) and (D) show the correlation of sovereign spreads of each country with the spreads of the US High Yield corporate bonds and the US BAA corporate bonds, respectively.

of their own spread with the average EM spread excluding that particular country. Results, shown in Figure 2b, document a high synchronization of spreads for almost all countries in our sample. The average correlation is 69%, and in 26 of the 28 countries, the correlation is 50% or above. The high synchronization of spreads in emerging economies is also documented in Longstaff et al. (2011) and Aguiar et al. (2016).

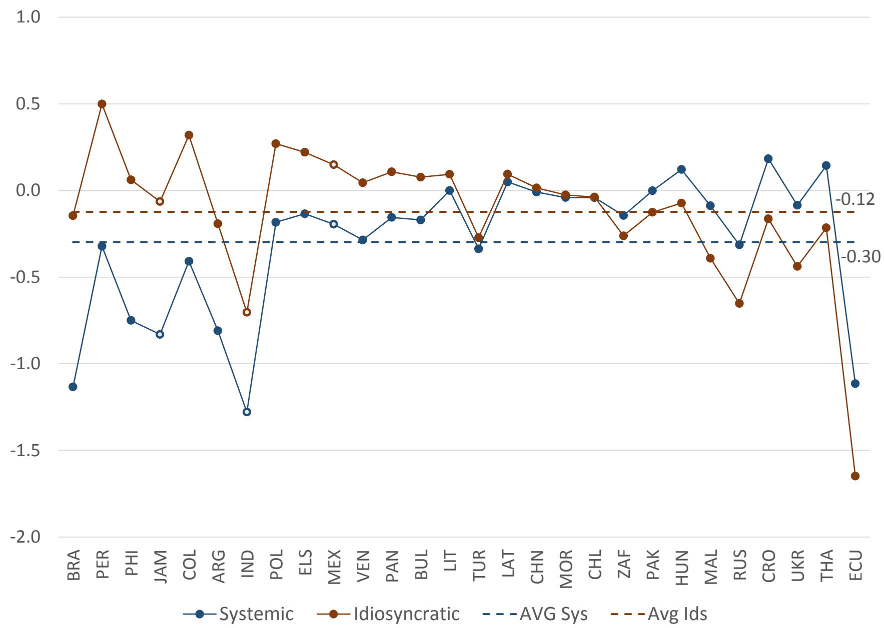
We document that country spreads are also synchronized with other types of risky assets. We compute the correlation of the spreads of each country in our sample with the spreads of high yield US corporate debt and BAA rated corporate debt. Results are shown in Figures 2c and 2d, respectively. The correlations are positive for almost all countries in our sample, both with the High Yield bonds and the BAA bonds. Additionally, these correlations are smaller in magnitude than the correlations with the average EM spread. In particular, in approximately three fourths of the countries in our sample, the country spreads are more correlated with the average EM spread than they are with the High Yield or BAA spreads. We also computed the correlations with the returns of the US stock market and find similar results (see Figure A.1).

2.3. *EM Debt Prices and Fundamentals*

Next we examine the co-movement of country spreads and output. We are interested in studying how systemic and idiosyncratic output co-move with debt prices. To this end, we compute the compute the systemic component of EM output as the average output across countries in our sample, and the idiosyncratic component of output as the difference of each country's output with the systemic component of output. The systemic component of output, shown in Figure A.2, captures the generalized recessions following the Russian/LTCM crisis in 1998, as well as the global financial crisis of 2008-09. We then estimate a regression for each country in which we regress the country's spread on the idiosyncratic and systemic component of output.

Figure 3 shows the point estimates of the coefficient associated to the systemic and idiosyncratic component of output for all countries. The first observation is that the average point estimates associated to both components of output are negative. That is, a drop in either the systemic or the idiosyncratic component of output has associated an increase in spreads in the average economy. The second observation is that the average sensitivity of spreads to the systemic component of output is stronger (i.e. more negative) than the average sensitivity of spreads to the idiosyncratic component of output. In approximately two thirds of the countries of our sample, spreads react more to the systemic than to the idiosyncratic component of output.

Figure 3. Bond Spreads Sensitivity to Fundamentals



Notes: This figure shows the estimated coefficients of regressing country sovereign spreads on the systemic and idiosyncratic component of output of each country. The systemic component is defined as the average output of all countries in our sample, and the idiosyncratic component is computed as the residual.

We argue that this relationship is robust to controlling for global factors that previous literature has argued can capture variations in the stochastic discount factor of global investors. In particular, for each country in our sample we perform two additional sets of regressions of spreads on both components of output. One in which we include US output as an additional control, and one in which we include the Fama-French-Cahart risk factors[1] as additional controls. Table 1 shows the median regression coefficients associated to the systemic and idiosyncratic component of output. The first row corresponds to the baseline estimation, the second row corresponds to the regressions with US output as control, and the last row corresponds to the regressions with the risk factors. In all specifications the median sensitivity of spreads to the systemic component of output is stronger than to the idiosyncratic component. This exercise suggest that the results are not capturing a potential relationship between the systemic component of EM output and global factors that can affect global stochastic discount factors.

[1]These factors include the excess return of the market portfolio, the small-minus-big portfolio, the high-minus-low book-to-market portfolio, and momentum. These factors have been typically used in empirical asset pricing literature to price securities.

Table 1. Differential Sensitivity of Spreads to Output Components

	Median β	
	β_{sys}	β_{ids}
Baseline	-0.19	-0.15
+ US Cycle	-0.13	-0.08
+ Factors	-0.16	-0.05

Notes: The first row reports the median of the estimated coefficients of regressing country sovereign spreads on the systemic and idiosyncratic component of output of each country. The systemic component is defined as the average output of all countries in our sample, and the idiosyncratic component is computed as the residual. The second row reports the same coefficients when we include US output as an additional control. The last row reports the same coefficients when we include the Fama-French-Cahart risk factors as additional controls.

To sum up, in this section we argue that global banks, understood in a broad sense, play an important role as lenders of emerging markets. We also show that debt prices: (i.) are highly synchronized within emerging markets and are also correlated with other risky assets, (ii.) have a stronger sensitivity to the systemic component of EM output than to its idiosyncratic component. The model we develop in the next section will address these facts.

3. A Model of the Global Economy

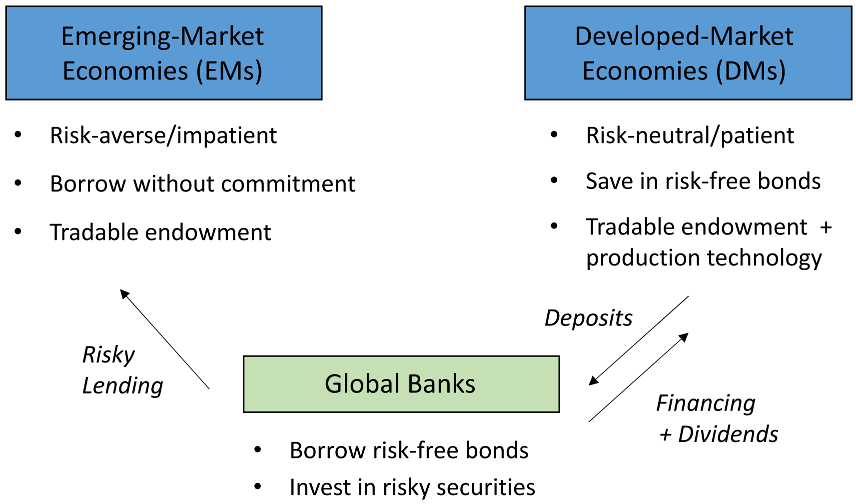
3.1. *Environment*

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

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

Households in EMs receive each period a stochastic endowment of tradable goods, which has a systemic component (common across all EMs) and an idiosyncratic component (whose realizations differ across EMs). EMs households lack commitment to repay their debt. We interpret household borrowing in a broad sense, capturing direct international borrowing, sovereign borrowing, or borrowing through other agents (e.g., local banks). Figure 4 provides a graphical representation of the global economy.

FIGURE 4. The Global Economy



Time is discrete and infinite. Within each period, the timing is as follows. At the beginning of each period exogenous variables are realized. EM households choose repayment. Global banks choose their portfolio, DM households their savings, and EMs household their borrowing. For technical convenience, we denote the aggregate state at repayment stage by $\mathbf{s}_-$ and at the saving and borrowing stage by $\mathbf{s}_+$. Appendix C provides details of these state vectors and the recursive representation of the model.

3.2. *Developed Economies*

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

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_{DM}^t c_{DMt} \tag{1}$$

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

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

$$c_{DMt} = y_{DM} + w_t \overline{h} + R_{dt} d_t - d_{t+1} + \pi_t \tag{2}$$

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

The DM household's problem is to choose state-contingent plans $\{c_{DMt}, d_{t+1}\}_{t=0}^{\infty}$ to maximize (11) subject to (2), taking as given prices $\{R_{dt}, w_t\}_{t=0}^{\infty}$ and transfers $\{\pi_t\}_{t=0}^{\infty}$. Household's optimization delivers a constant equilibrium interest rate for deposits, $R_{dt} = \beta_{DM}^{-1}$.

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

$$F_t(k_t, h_t) = z_{DMt} k_t^{\alpha} h_t^{(1-\alpha)}, \tag{3}$$

$$k_{t+1} = (1-\delta)\, k_t + i_t, \tag{4}$$

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

3.3. *Global Banks*

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

$$\max \mathbb{E}_t \sum_{s=0}^{\infty} \beta_{DM}^{s-t} div_{jt+s}, \tag{5}$$

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

$$n_{jt} = \int_{i\in\mathcal{I}_{t-1}} R^i_{EMt} a_{EMjt-1} \mathrm{d}i + R_{DM} a_{DM,jt-1} - R_d d_{jt-1} \tag{6}$$

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

$$n_{jt} + d_{jt} = \int_{i \in \mathcal{I}_t} a^i_{EMjt} \mathrm{d}i + a_{DMjt} + div_{jt}. \tag{7}$$

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

$$\kappa \left(\int_{i \in \mathcal{I}_t} a_{iEMt} \mathrm{d}i + a_{DMt} \right) \leq n_t, \tag{8}$$

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

The global bank's problem is to choose state-contingent plans $\{\{a_{EMjt}\}, a_{DMjt}, d_{jt}, div_{jt} \geq 0\}$ to maximize (5) subject to (6) and (8). Appendix C shows the bank's recursive problem. Our formulation gives rise to a problem that is linear in net worth, and whose solution is characterized by constraints (8) and $div_{jt} \geq 0$ holding with equality and

$$R^e_{EMit} = R^e_{DMt} \tag{9}$$

$$R^e_{DMt} = R^e_{dt} + \mu_t \kappa \tag{10}$$

for any solution with $a_{iEM} > 0, a_{jEM} > 0$, where $R^e_{EMit} \equiv \mathbb{E}_t[v_{t+1} R_{EMit+1}]$, $R^e_{DMt} \equiv \mathbb{E}_t[v_{t+1} R_{DMt+1}]$, $R^e_{dt} \equiv R_d \mathbb{E}_t[v_{t+1}]$, v_t is the marginal value of net worth for global banks, and $\mu_t \geq 0$ the Lagrange mutiplier associated with the borrowing constraint (8). Equation (9) implies that the global bank equates expected returns across asset classes, while equation (10) implies that the borrowing constraint prevents global banks from equalizing expected returns between risky and risk-free assets.

3.4. *Emerging Economies*

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

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t_{EM} u(c_{it}) \tag{11}$$

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

where $u(\cdot)$ is increasing and concave, c_{it} denotes consumption of the representative household of emerging economy i in period t and $\beta_{EM} \in (0, \beta_{DM})$ the subjective discount factor of EM households. Each period households in EMs receive a stochastic endowment of tradable goods, with a systemic component $y_{EM,t}$, common across all EMs, and an idiosyncratic component z_{it}. After observing the realization of their endowment households choose to repay debt they inherited from previous period ($\iota_{it} = 0$) or to default ($\iota_{it} = 1$). Households that default loose access to external credit markets and re-enter when the random variable $\zeta_{it} \sim Bernouli(\theta)$ equals one. This implies that households remain in financial autarky for a stochastic number of periods. Households that repay their previous promises can issue one-period bonds, whose promised payments are not state contingent, facing a bond price schedule $q_{it}(b_{it+1})$ that depends on the EM characteristics and borrowing choices. Their sequential budget constraint is given by

$$c_{it} = y_{EMt} + z_{it} + q_{it}(b_{it+1})b_{it+1} - b_{it} \tag{12}$$

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

$$c_{it} = \mathcal{H}(y_{EMt} + z_{it}) \tag{13}$$

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

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

3.5. *Equilibrium*

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

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

i. Allocations solve agents problems at the equilibrium prices,

ii. Assets and labor markets clear.

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

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

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

4. Global Supply and Demand for EM Debt

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

4.1. *Equilibrium in the Risky Debt Market*

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

$$A_{EMt} = \mathcal{A}^s_t(R^e_{EMt}, N_t) \equiv \frac{1}{\kappa}N_t - \left\{\left[R^e_{DMt} - (1-\delta)\right](\alpha z_{DMt})^{-1}\right\}^{\frac{1}{\alpha-1}} \tag{14}$$

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

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

$$A_{EMt} = \mathcal{A}^d_t(R^e_{EMt}) = \int_{i\in\mathcal{I}_t} \frac{1}{R^e_t}\iota_{it+1}b_{it+1}\,\mathrm{d}i. \tag{15}$$

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

Figure 5 depicts the equilibrium aggregate borrowing and required returns as the intersection between aggregate demand and supply of funds, for given levels of global bank's net worth. Net worth, however, is also endogenous in this system, as required returns affect borrowers' repayments and realized returns. To obtain this relationship, we integrate the evolution of net worth (6) across banks to obtain:

$$N_t = \int_{i\in\mathcal{I}_{t-1}} \iota_{it}A_{EMit-1}\mathrm{d}i + R_{DMt}A_{DMt-1} - R_d D_{t-1}. \tag{16}$$

Given previous period investments $\{(A_{EMit-1})_{i\in[0,1]}, A_{DMt-1}, D_{t-1}\}$, the slope of net worth with respect to required returns is given by $\frac{\partial N_t}{\partial R_{EMt}^e} = \int_{i\in\mathcal{I}_{t-1}} \frac{\partial \iota_{it}}{\partial R_{EMt}^e} A_{EMit-1}\mathrm{d}i$. We focus in the case in which this slope is negative, as will be in our quantitative model, reflecting that higher required returns decrease the value of repayment and leads to more default in EMs. This relationship is depicted in the right panel of Figure 5. Together, aggregate supply, aggregate demand, and evolution of net worth constitute a system of three equations determining aggregate EM borrowing A_{EMt}, required returns R_{EMt}^e, and global bank's aggregate net worth N_t.

4.2. *Aggregate shocks*

We now use our equilibrium scheme to analyze the role of global banks propagating aggregate shocks. First, consider the effect of an unexpected negative shock to the return of the DM security. This shock affects global banks' net worth and, through this channel, the aggregate supply of funds (see equations (14) and (16)). This initial effect of this shock is represented in Figure 6 as a shift of the net worth and aggregate supply curves, indicating less net worth and supply of funds for any given level of EM required returns, leading to an increase of EM required returns. In addition to this initial effect of the shock, there is an amplification effect that operates through global banks' net worth: Higher required returns in EM lead to more EM economies to default, further contracting bank's net worth and the aggregate supply of funds and further increasing EM required returns.

FIGURE 5. The Global Debt Market Equilibrium

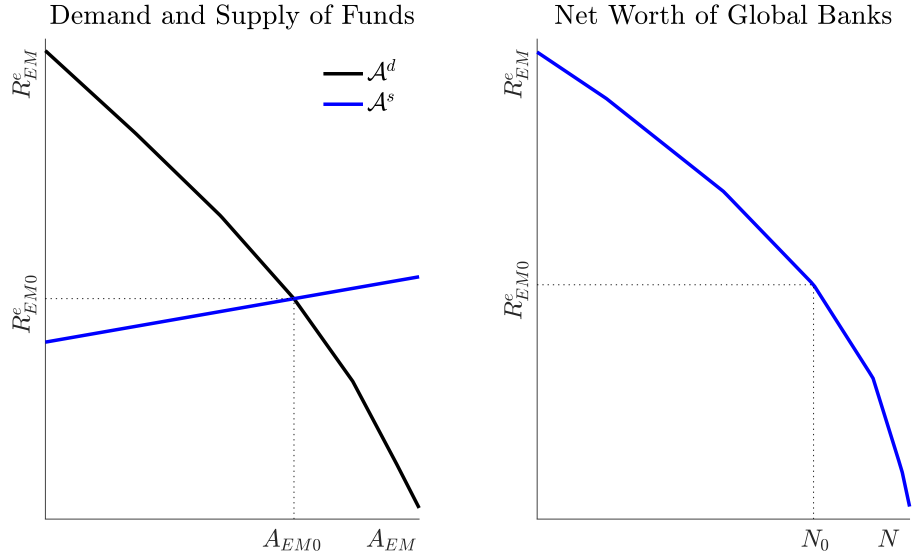
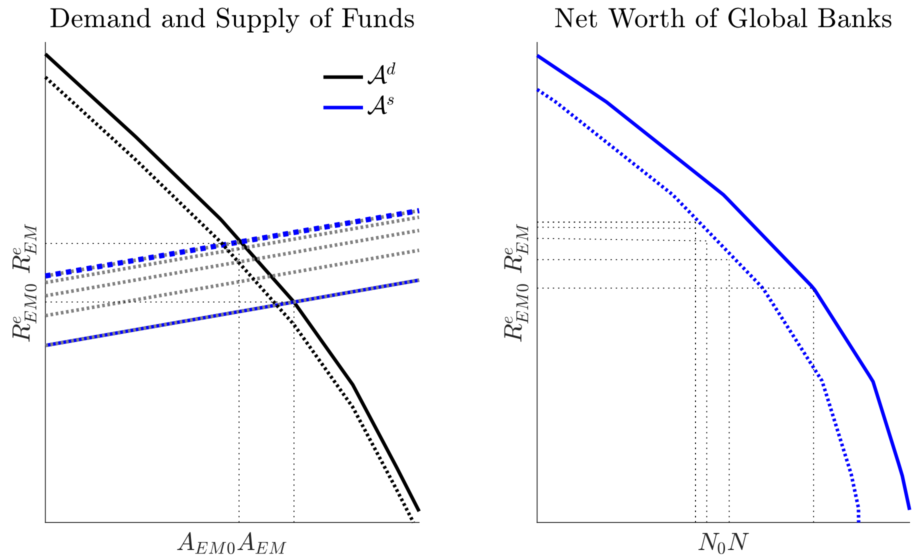


FIGURE 6. Aggregate Shocks and Global Debt Market Equilibrium



Through a similar mechanism, global banks also amplify systemic shocks originated in EMs. For this, consider now the effect of an unexpected negative shock to systemic EM income. The negative income shock leads to more EM economies to default, affecting banks' net worth and the supply of funds in a similar fashion than analyzed above for the shock to the realized return of DM securities. The negative income shock also affects the demand of funds. In Figure 6, this is represented as a downward shift in the aggregate demand of funds, as typically occurs in models of risky external borrowing. If the increase in required returns driven by the contraction in aggregate supply is not fully offset by a weaker demand, global banks trigger the amplification trough net worth explained below.

The amplification through global banks is a key difference between systemic and idiosyncratic EM income shocks. When income shocks are idiosyncratic, they do not affect global bank's net worth and have a smaller effect in debt prices. This result is important because it implies that our model can provide a theoretical explanation of the fact that EM spreads are more sensitive to systemic than to idiosyncratic changes income, documented in Section 2. In the next section we show that this explanation of our model is also quantitatively consistent with the data.

5. Quantitative Analysis

In this section we calibrate the model to match the salient features of the market of EM risky debt. We then re-visit the stylized facts documented in section 2 and evaluate them in the light of our quantitative model. We then use our quantified model to assess the relevance of global banks as lenders of emerging economies.

5.1. *Calibration*

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

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

The endowment processes of EM households follow

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

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

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

Finally, the output net of default costs is parametrized by

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

where $d_0, d_1 \geq 0$. This functional form is also used in is consistent with non-linear costs of default that are higher for higher values of y.

We analyze two calibrations of the model. The first one, which we denote 'Low Exposure' calibration, refers to a calibration in which global banks invest both in DM and EM risky assets and their exposure to the latter is low, as the one observed in main US banks. The second calibration, which we denote 'High Exposure', refers to an economy in which global banks are exclusively exposed to EM debt. These two economies allow us to estimate bounds on the role of amplification of systemic shocks to output through the lenders balance sheets. In the first economy a low return on EM debt due to a mass of economies defaulting will have a mild impact on global banks balance-sheets, whereas in the second the effect will be stronger.

We first describe the 'Low Exposure' calibration. The model features a set of parameters which we set exogenously and another set which we calibrate to match certain moments, reported in the first column of Table 2. We follow the literature on quantitative macroeconomic models to set values for the exogenous parameters. The coefficient of risk aversion of EM households is set to $\gamma = 2$. The probability of re-entering credit markets is set to $\theta = 0.25$, so that the average exclusion period is of 4 years, in line with empirical evidence (and). The parameters of the endowment process of EM households are estimated using data on output for the sample of countries analyzed in section 2. We restrict the systemic and idiosyncratic component of output to have the same stochastic process, i.e. $\rho_{y_{EM}} = \rho_{z_{EM}}$ and $\sigma_{y_{EM}} = \sigma_{z_{EM}}$. We make this parametric restriction to study the differential effects of these shocks that arise due to endogenous amplification, rather than due to having different stochastic processes. The estimated values of the autocorrelation and standard deviation are $\rho_{y_{EM}} = \rho_{z_{EM}} = 0.66$ and $\sigma_{y_{EM}} = \sigma_{z_{EM}} = 0.048$. The discount factor of DM households is $\beta_{DM} = 0.98$ which implies an annual risk-free interest rate of 2%. The share of capital in the production function of DM firms is $\alpha = 0.35$ and the depreciation rate is $\delta = 0.08$. Finally, the parameter on the borrowing constraint of global banks is set to $\kappa = 0.1$, so that the leverage (defined as the ratio of net worth to assets) is set to 10%, as observed in the data.

The remaining parameters are calibrated to match specific data moments. A subset of these parameters are related EM households (β_{EM}, d_0, d_1), others to global banks $(\sigma, \overline{n})$, and others to DM firms $(\mu_{z_{DM}}, d_0, d_1)$. We target a set of moments related to EM debt and default and another set of moments related to global banks and other risky assets. Related to EM debt we target the average level of external debt, the annual rate of default, the average spread, the average correlation of spreads and output, and the average volatility of spreads. Related to global banks and other risky assets we target the average exposure of global banks to DM risky assets, and the volatility and autocorrelation of spread of the DM risky asset.[3] The calibrated

[3]The average level of debt in the data is computed as the average level of external debt of the countries in our sample for the period Sep-96 to Dec-14. The annual rate of default is computed as the average share of EM defaults that occurred in our sample period. The average level and volatility of spreads is computed as the country-time average of sovereign spreads. Its correlation with output is computed as the average correlation

Table 2. Model Calibration

Parameter	Description	Low Exposure	High Exposure
Exogenous Parameters			
γ	risk aversion	2.00	2.00
θ	re-entry probability	0.25	0.25
$\rho_{y_{EM}}$	systemic endowment autocorrelation	0.66	0.66
$\sigma_{y_{EM}}$	systemic endowment shock volatility	0.048	0.055
$\rho_{z_{EM}}$	idiosyncratic endowment autocorrelation	0.656	0.656
$\sigma_{z_{EM}}$	idiosyncratic endowment shock volatility	0.048	0.055
β_{DM}	discount rate of DM	0.98	0.96
α	share of capital	0.35	n.a.
δ	depreciation	0.08	n.a.
κ	leverage ratio	0.10	0.10
Calibrated Parameters			
β_{EM}	discount rate of EMs	0.85	0.87
d_0	default cost - level	0.05	0.06
d_1	default cost - curvature	1.50	1.50
σ	bank survival rate	0.42	0.83
$\bar{n}$	level of net worth	0.100	0.001
$\mathbb{E}z_{DM}$	unconditional mean of DM shock	0.37	n.a.
$\sigma_{z_{DM}}$	volatility of DM shock	0.15	n.a.
$\rho_{z_{DM}}$	autocorrelation of DM shock	0.07	n.a.

values are shown in Table 2. While in the joint calibration all moments can be affected by all parameters, we find that the parameters related to EM households mostly affect the EM spread and debt moments, the parameters related to global banks affect average spreads (both of EM and DM risky debt) and exposures to the two types of assets, and the parameters related to DM firms affect the moments related to DM risky assets. It is worth noting that, in order to

of sovereign spreads and the cyclical component of output for each country in our sample. We compute the average exposure of global banks to DM risky assets as the exposure to all risky assets that are not EM debt as a fraction of total assets. We use the spreads on the US High Yield corporate bonds to compute the volatility and autocorrelation of the DM risky asset. See Appendix B for data sources and further details in the computation of moments.

match the levels of debt, we obtain a low calibrated value of $\beta_{EM} = 0.85$ which is in line with previous literature on quantitative models of sovereign default.

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

Table 3. Model Calibration

Target	Data	Low Exposure	High Exposure
Average debt	15.0%	13.6%	13.4%
Yearly default rate	1.6%	0.1%	0.0%
Correlation of spread and GDP	-31.0%	-30.0%	-37.7%
Average spread	395bp	330bp	314bp
Spreads volatility	170bp	305bp	177bp
Portfolio weight on DM	90.0%	92.4%	n.a.
Volatility of DM Spread	255bp	246bp	n.a.
Autocorrelation of DM Spread	0.16	0.19	n.a.

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

We now describe the 'High Exposure' calibration, reported in the last column of Table 2. This economy features a smaller set of relevant parameters. This is because the parameters associated to the DM firm are not relevant for the dynamics of EM households variables since global banks do not invest in DM firms. Other than this, we maintain both calibrations as close to each other as possible. The exogenous parameters are the same as in the 'Low Exposure' calibration. The only difference is that in this economy the parameters of the DM firm are not relevant since global banks cannot invest in them. Hence, we do not take stance in their values. The calibrated parameters in this economy are β_{EM}, d_0, d_1 related to EM households and $\sigma, \overline{n}$. We set them to match the average level of external debt, the annual rate of default, the average spread, the average correlation of spreads and output, and the average volatility of spreads. The model moments corresponding to this calibration are reported in the last column of Table 3.

6. Systemic Debt Crises and the Role of Global Banks

In this section we use the calibrated model to assess quantitatively the role of global banks in the transmission and amplification of shocks in the market of EM risky debt. We first analyze the role that global banks play in the propagation of shocks originated in EMs and then study the contagion of shocks that originate in the market of other risky assets. We conclude that when banks are highly exposed to EM debt they play a major role in amplifying EM-originated systemic shocks, whereas when bank's exposure to EM debt is low they play a major role transmitting shocks from other risky assets to the EM debt market.

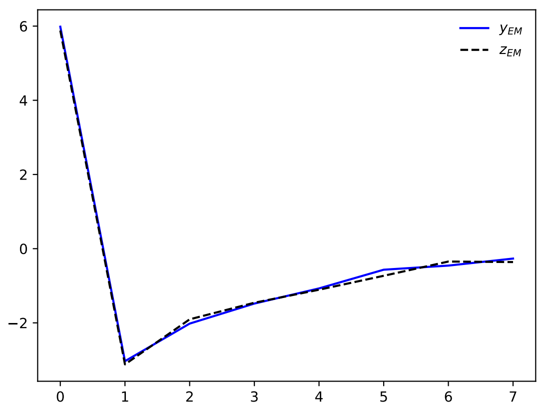
6.1. *Amplification of EM-Originated Shocks*

We analyze the effects of output shocks in EM households on debt prices under the two calibrations. In particular, we analyze the impulse-response of a negative shock to the systemic and idiosyncratic component of output of equal magnitude.[4] Results are shown in Figure 7. The top panels show the responses of output and spreads to a negative shock to both components of output in the 'Low Exposure' economy. Both negative shocks have the same negative effect on output since they follow the same stochastic process. Both shocks also trigger an increase in spreads. This is because a lower output increases the value of default relative to the value of repaying and thus, increases the probability of default. Interestingly, the increase in spreads in response to the both shocks is similar in magnitudes. This suggests the absence of any amplification of systemic shocks through global banks in the 'Low Exposure' calibration.

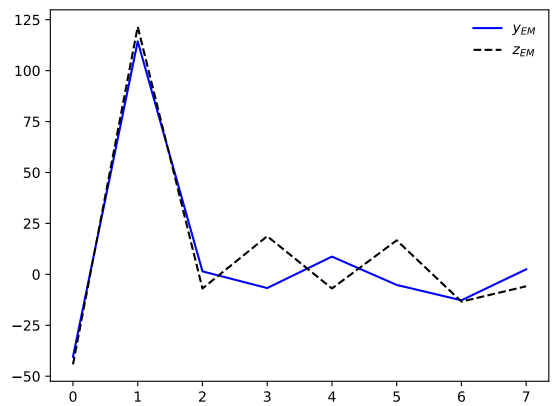
[4]To compute the responses of a shock to the systemic (idiosyncratic) component of output we simulate the calibrated economies for 1,000,000 periods and identify period in which the systemic (idiosyncratic) component falls by one standard deviation and then trace the dynamics of the variables of interest.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

Figure 7. Impulse-Response Analysis of Shocks to EM Output

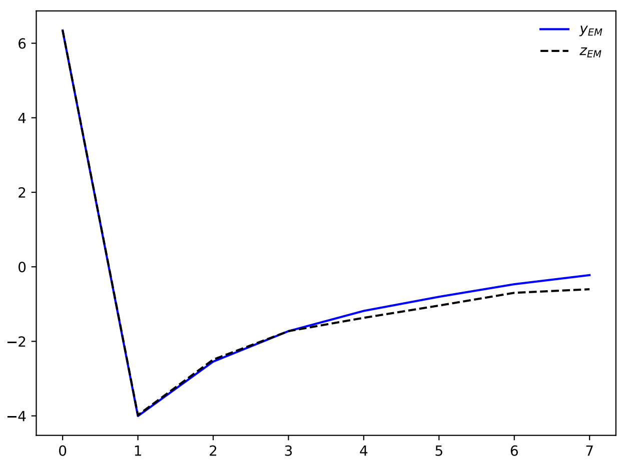
(a) ‘Low Exposure’: Output



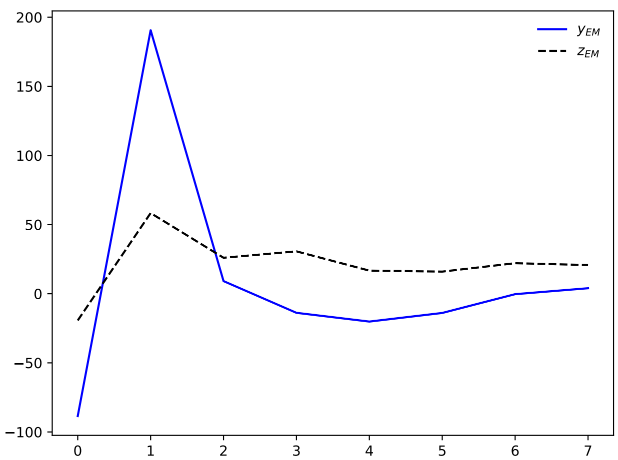
(b) ‘Low Exposure’: Spread



(c) ‘High Exposure’: Output



(d) ‘High Exposure’: Spread



Notes: impulse-responses were computed from simulated data for 50,000 periods. Windows were constructed for 8 years, where the variable (i.e. y_{EM} or z_{EM}) fell at least one standard deviation at $t = 1$, starting from an expansion period at $t = 0$. We get, on average, 1200 of such episodes. We also compute the observed spread on each window. The displayed path is the simple average across windows.

The bottom panels show the responses of output and spreads to the same shocks in the ‘High Exposure’ economy. In this economy a negative shock to output can have a differential effect on spreads depending on the nature of the shock. A negative shock to the idiosyncratic component of output of one standard deviation triggers an increase in the spreads of that country of approximately 60bps. On the other hand, a negative shock of the same magnitude to the systemic component of output triggers an increase in spreads that is three times as large as the response to the idiosyncratic shock. We argue next that this differential response is due to the amplification effect that systemic shocks create by affecting the balance-sheets of global banks.

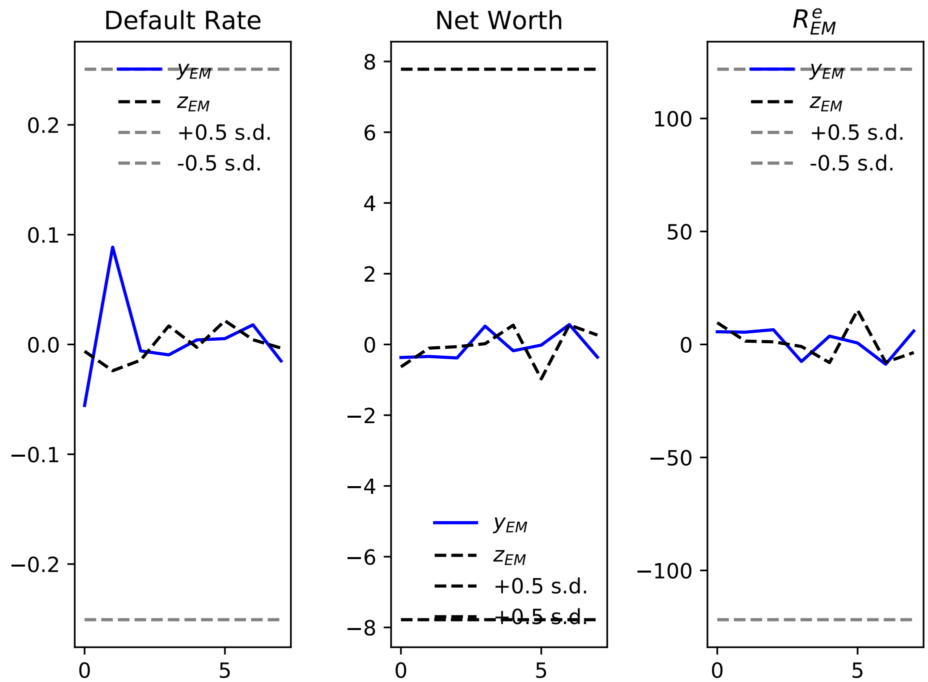
To investigate the amplification mechanism we analyze the response of aggregate variables related to lenders in response to the negative shock to the systemic component of EM output. Figure 8a shows the response of the aggregate default rate, the net worth of global banks and the expected return on EM debt in the 'Low Exposure' economy. A negative shock to the systemic component of output increases the share of countries that default. This implies that the realized return of investing in EM risky debt is low. However, given the low exposure of global banks to this type of assets, the effect of a lower realized return on banks' net worth is small. This in turn does not significantly affect the ability of global banks to supply funds to EMs, and hence the expected return is roughly unaffected.

A different response is observed in the 'High Exposure' economy, reported in Figure 8b. As in the 'Low Exposure' economy, a negative shock to the systemic component of output increases the share of countries that default. This implies that the realized return of investing in EM risky debt is low. However, in contrast to the 'Low Exposure' economy, this lower return has a strong negative effect on the net worth of global banks since these are uniquely exposed to this type of debt. When global banks are less capitalized it is more costly for them to raise funds from DM households, which in turn implies that global banks have less funds available to lend to EM households. In face of a lower aggregate supply of funds, the equilibrium required rate of return from EM borrowing increases, as shown in the bottom right panel. This increase in the premium for lending to EMs is what explains the stronger reaction of spreads to systemic shocks in the 'High Exposure' economy.

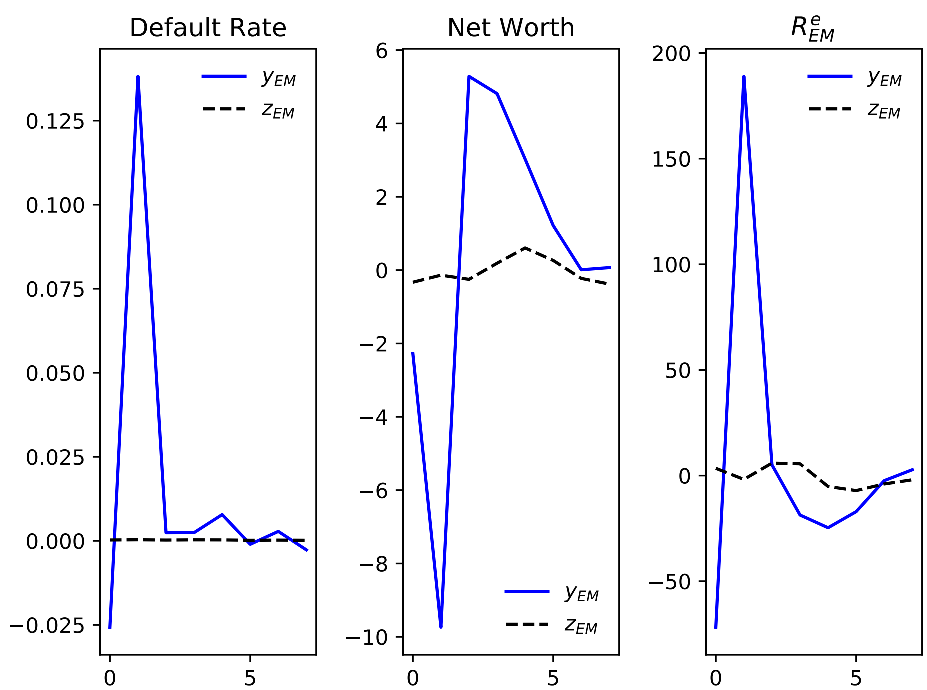
We then evaluate the model's ability to reproduce the data facts documented in section 2. In particular, we ask to what extent is the model able to generate the high synchronization of debt prices within EM economies and whether the model is able to reproduce the differential sensitivity of debt prices to the systemic and idiosyncratic component of ouptut. These exercises serve two purposes. First, they provide a source of validation of the model since matching these data facts was not part of the calibration target. Second, they help shed light into the role that global banks play in explaining the facts regarding debt prices. We compute all exercises for the two calibrations and for another version of the model without global banks. This version of the model corresponds to an economy in which global banks do not face financial

Figure 8. Aggregate Response of Shocks to EM Output

(a) 'Low Exposure' Economy



(b) 'High Exposure' Economy



Notes: impulse-responses were computed from simulated data for 50,000 periods. Windows were constructed for 8 years, where the variable (i.e. y_{EM} or z_{EM}) fell at least one standard deviation at $t = 1$, starting from an expansion period at $t = 0$. We get, on average, 1200 of such episodes. We also compute the observed default rate, net worth and the required EM Return R^e_{EM}. The default rate is the fraction of countries that default at each period. The displayed path is the simple average across windows.

frictions (i.e. $\kappa = \infty$ in the borrrowing constraint) or equivalently, to an economy in which there is no financial intermediation and DM households directly lend to EM households. To parametrize this economy we set the same values for the exogenous parameters and re-calibrate the remaining parameters to match the same moments as in the 'High Exposure' economy.

We first analyze the differential sensitivity of debt prices to shocks to the systemic and idiosyncratic component of output in the model and in the data. For this we simulate a panel of 500 economies for 50,000 years. We then estimate the same regressions as in the data of spreads on both components of output, and report the median coefficient of country regressions both in the model and in the data. Results are reported in Table 4. Consistent with the IRF analysis, the 'Low Exposure' model economy fails to reproduce the differential sensitivity of spreads to both components of output. In contrast, the sensitivties of spreads to both components of output in the simulated data from the 'High Exposure' model economy are in line with those estimated in the data. In particular, a one percent increase in the systemic component of output has associated a decrease of 16 basis points in spreads in the data and 17 basis points in the 'High Exposure' model economy. On the other hand, the sensitivities of spreads to the idiosyncratic component of output are negative and close to zero in both the data and the 'High Exposure' model economy. Finally, in the version of the model without global banks there is no differential sensitivity of debt prices to the differnt components of output. This is due to the fact that the absence of financial frictions in global banks implies that their level of capitalization is no longer relevant to determine asset prices.

Second, we use the simulated data from the different versions of the model to assess synchronized are debt prices within EM economies. As shown in Table 4, the average correlation of each country's spread with the average EM spread is 69%. In the 'Low Exposure' model economy this correlation is 77%, while in the 'High Exposure' model economy this moment is 85%, since the relevance of the systemic component of output is likely to be overestimated. In the model without global banks the correlation is lower than the one observed in the data since there is zero amplification of the systemic component of outupt.

6.2. *Transmission of Shocks from Other Risky Assets*

In this subsection we analyze the role of global banks in transmitting shocks originated in the markets for other risky debt. In the case of the 'High Exposure' model economy these markets are not connected to each other and thus there is no transmission. This is due to the fact that in this economy global banks are only exposed to EM debt and therefore not exposed to shocks in the market of DM risky debt. Similarly, in the economy without global banks there

Table 4. Model Calibration

	Spreads Sensitivity		Correlation
	Systemic	Idiosyncratic	
Data	-0.16	-0.05	0.69
Model			
Low Exposure	-0.10	-0.11	0.77
High Exposure	-0.11	-0.07	0.85
No Global Banks	-0.28	-0.28	0.60

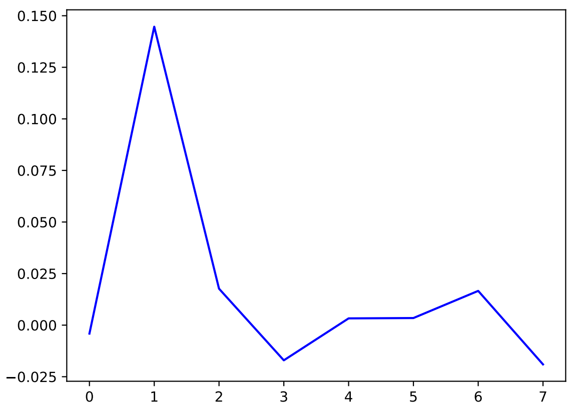
Notes: Spreads sensitivity is the regression coefficients of spreads onto systemic output and idiosyncratic output. The data counterpart includes US growth and Fama-French-Cahart risk factors as additional controls, for the period Sep-96 to Dec-14 for our sample of countries. The model coefficients were computed by simulation. The correlation variable refers to the correlation of each country's spread with the mean across countries, excluding the treated country. The *Low Exposure* and *High Exposure* versions of the model refer to banks having respectively low and high expusures to EMs on their balance-sheets. The *No Global Banks* version excludes financial frictions on global banks, thus there is no differential sensitivity of debt prices to the differnt components of output.

is no transmission either. In this case, banks are exposed to both assets and yet they do not transmit shocks since they do not face financial frictions and asset prices are unresponsive to the financial health of global banks.

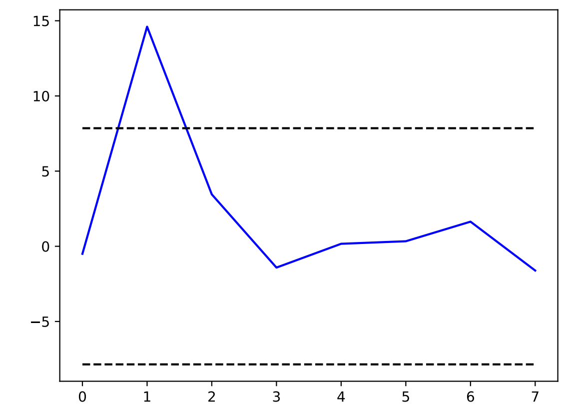
We then analyze the transmission of shocks in the DM risky debt market in the 'Low Exposure' model economy. In particular, we study the effects of an increase in the productivity of DM firms. We compute the impulse-response analysis following a similar approach as in the previous subsection. Results are shown in Figure 9. Since global banks own claims on DM firms profits this positive shock increases the realized return that banks earn on their investments on DM firms, and their net worth (see Figures 9a and 9b). Better capitalized banks are able to raise more funds from DM households and thereby increase their investments both in DM and EM risky debt. This increase in the supply of funds lowers required returns in the markets of risky debt (see Figure 9c). As a corollary, the spreads in EM economies fall (see Figure 9c).

Figure 9. Impulse-Response Analysis of Shocks to DM Productivity

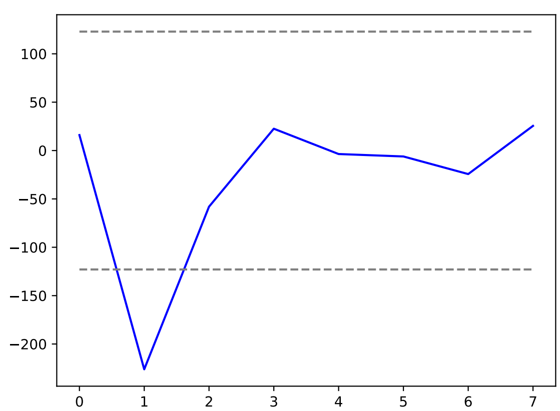
(a) DM Firms' Productivity



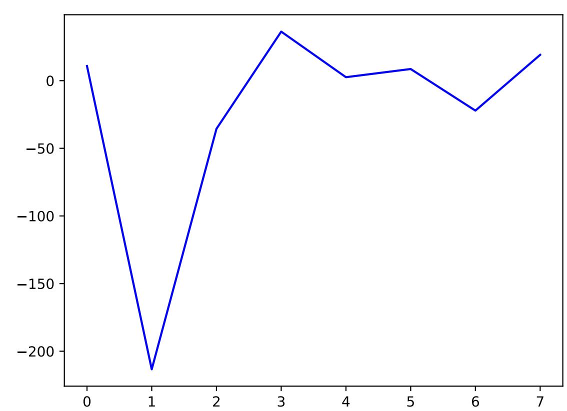
(b) Global Banks' Net Worth



(c) Required EM Return



(d) EM Spreads



Notes: impulse-responses were computed from simulated data for 50,000 periods. Windows were constructed for 8 years, where the z_{DM} variable increased, on average, one standard deviation at $t = 1$, starting from its mean value at $t = 0$. We also compute the observed net worth, required EM Return R^e_{EM} and EM spread on each window. The displayed path is the simple average across windows.

7. Conclusion

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

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

References

Aguiar, M., S. Chatterjee, H. Cole, and Z. Stangebye (2016): "Quantitative models of sovereign debt crises," in *Handbook of Macroeconomics*, Elsevier, vol. 2, 1697–1755.

Aguiar, M. and G. Gopinath (2006): "Defaultable Debt, Interest Rates and the Current Account," *Journal of International Economics*, 69, 64–83.

Arellano, C. (2008): "Default Risk and Income Fluctuations in Emerging Economies," *The American Economic Review*, 98, 690–712.

Arellano, C., Y. Bai, and S. Lizarazo (2017): "Sovereign risk contagion," Tech. rep., National Bureau of Economic Research.

Arslanalp, S. and T. Tsuda (2014): "Tracking Global Demand for Emerging Market Sovereign Debt," IMF Working Paper 14/39.

Avdjiev, S., B. Hardy, S. Kalemli-Ozcan, and L. Serven (2018): "Gross capital flows by banks, corporates, and sovereigns," The World Bank.

Bai, Y., P. J. Kehoe, and F. Perri (2018): "World Financial Cycles," Manuscript.

Baskaya, Y. S., J. di Giovanni, S. Kalemli-Ozcan, and M. F. Ulu (2017): "International spillovers and local credit cycles," NBER Working Paper No. w23149.

Bianchi, J. (2011): "Overborrowing and systemic externalities in the business cycle," *The American Economic Review*, 101, 3400–3426.

Bocola, L. (2016): "The pass-through of sovereign risk," *Journal of Political Economy*, 124, 879–926.

Borri, N. and A. Verdelhan (2011): "Sovereign risk premia," .

Calvo, G. A. and E. G. Mendoza (1996): "Mexico's balance-of-payments crisis: a chronicle of a death foretold," *Journal of International Economics*, 41, 235–264.

Gabaix, X. and M. Maggiori (2015): "International liquidity and exchange rate dynamics," *The Quarterly Journal of Economics*, 130, 1369–1420.

Gennaioli, N., A. Martín, and S. Rossi (2014): "Sovereign Default, Domestic Banks, and Financial Institutions," *The Journal of Finance*, 69, 819–866.

Gertler, M. and P. Karadi (2011): "A Model of Unconventional Monetary Policy," *Journal of Monetary Economics*, 58, 17–34.

Gertler, M. and N. Kiyotaki (2010): "Financial Intermediation and Credit Policy in Business Cycle Analysis," *Handbook of Monetary Economics*, 3, 547–599.

Gourinchas, P.-O. and H. Rey (2007): "International financial adjustment," *Journal of Political Economy*, 115, 665–703.

Kaminsky, G. L. and C. M. Reinhart (1999): "The twin crises: the causes of banking and balance-of-payments problems," *American economic review*, 89, 473–500.

Longstaff, F. A., J. Pan, L. H. Pedersen, and K. J. Singleton (2011): "How sovereign is sovereign credit risk?" *American Economic Journal: Macroeconomics*, 3, 75–103.

Mendoza, E. G. (2002): "Credit, prices, and crashes: Business cycles with a sudden stop," in *Preventing currency crises in Emerging markets*, University of Chicago Press, 335–392.

——— (2010): "Sudden stops, financial crises, and leverage," *American Economic Review*, 100, 1941–66.

Morelli, J. M. (2018): "Households Financial Development and Economic Crises," Working paper.

Perez, D. (2018): "Sovereign debt, domestic banks and the provision of public liquidity," Manuscript.

Reinhart, C. M. and K. Rogoff (2009): *This Time Is Different: Eight Centuries of Financial Folly*, Princeton University Press.

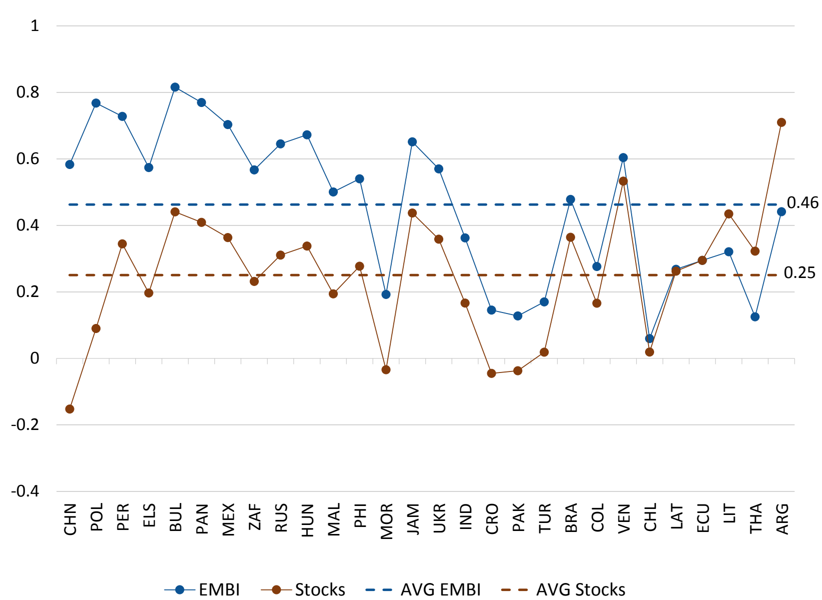
Rey, H. (2015): "Dilemma not trilemma: the global financial cycle and monetary policy independence," NBER Working Paper No. w21162.

Sachs, J. (1989): *New approaches to the Latin American debt crisis*, 174, Princeton Univ Intl Economics.

Tourre, F. (2017): "A Macro-Finance Approach to Sovereign Debt Spreads and Returns," Manuscript.

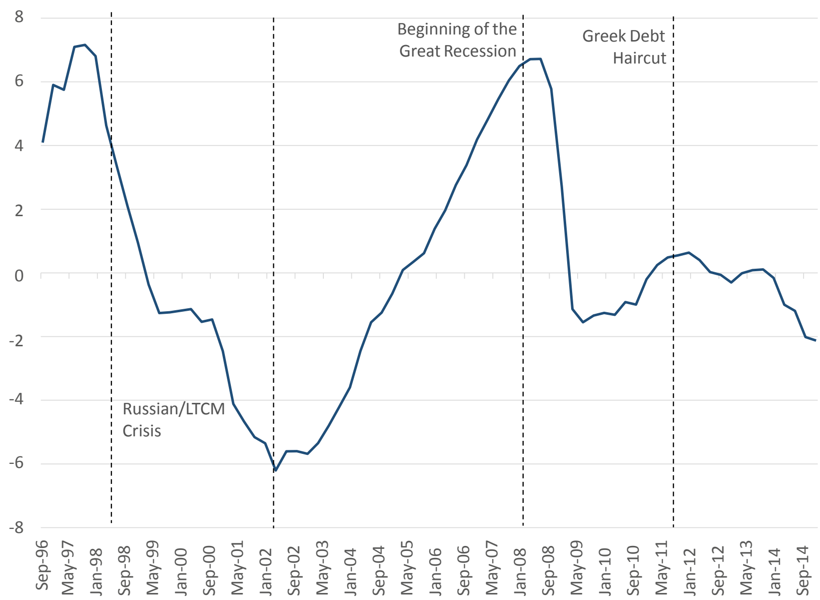
Appendix A. Additional Figures and Tables

Figure A.1. Returns Co-movements within EMs and with US Stocks



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

FIGURE A.2. Systemic Component of Output in Emerging Markets



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

Appendix B. Data Description

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

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

For all countries in the sample we collect data on debt prices of sovereign debt, as well as data on output. Debt price data consists on data on sovereign spreads of a synthetic basket of

Table A1. Balance-Sheets of Major Global Banks: 2017

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

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

Table A2. Balance-Sheets of Major Global Banks: 1982

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

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

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

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

Appendix C. Model Recursive Representation

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

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

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

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

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

$$v(n, \mathbf{s}_+) = \max_{\{a_{EM,(b,z)}\geq 0\}, a_{DM}\geq 0, d} div + \beta_{DM}\mathbb{E}[v(n', \mathbf{s}'_+)] \tag{17}$$

subject to

$$n + d = \int\int_{(b,z):\mathrm{d}G_+(b,z)>0} a_{EM,(b,z)}\mathrm{d}b\mathrm{d}z + a_{DM} + div$$

$$\kappa\left(\int\int_{(b,z):\mathrm{d}G_+(b,z)>0} a_{EM,(b,z)}\mathrm{d}b\mathrm{d}z + a_{DM}\right) \leq n,$$

$$n' = \int\int_{(b,z):\mathrm{d}G_+(b,z)>0} R_{EM,(b,z)}(\mathbf{s}_+, \mathbf{s}'_-)a_{EM,(b,z)}\mathrm{d}b\mathrm{d}z + R_{DM}(\mathbf{s}'_-)a_{DM} - \beta_{DM}^{-1}d,$$

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

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

$$V(b,z,\mathbf{s}_-) = \max_{\iota} \iota V^r(b,z,\mathbf{s}_+) + (1-\iota)V^d(z,\mathbf{s}_+) \tag{18}$$

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

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

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

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

Finally, the value of default is given by

$$V^d(z,\mathbf{s}_+) = \max_{b'} u(c) + \beta\mathbb{E}\left[\phi V^r(0,z',\mathbf{s}'_+) + (1-\phi)V^d(z',\mathbf{s}'_+)\right] \tag{20}$$

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

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

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

(1) Given prices, laws of motion, and perceived policies, global banks policies and value function solve their recursive problem (17)*.*

(2) Given prices, laws of motion, and perceived policies, borrowers' policies and value functions solve their recursive problem (18) - (20)*.*

(3) Asset markets clear.

(4) Law of motion of aggregate state are consistent with individual policies.

(5) Perceived policies coincide with optimal policies.