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Abstract

We decompose gross cross-border bank-to-bank funding between arms-length (interbank) and related (intragroup) funding, and show that while interbank funding is withdrawn when global risk is high, intragroup funding remains stable during these periods, despite being more volatile on average. We disaggregate intragroup funding further and find advanced-economy parent banks benefit from inflows during episodes of heightened global risk. However, we do not find evidence of significantly reduced intragroup funding to foreign affiliates during these periods. Our results are in contradiction with theoretical predictions on the behaviour of cross-border banking flows, and help explain why certain banking systems lost more cross-border bank-to-bank funding than others during the global financial crisis.

Key words: Cross-border banking flows, global risk, parent banks and foreign affiliates.

JEL classification: F32, F34, G21.

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Summary

Cross-border funding between banks is an economically important source of finance. It is comprised of two distinctive forms of funding. First there is *arms-length* (interbank) funding, that takes place between unrelated banks. Second there is related (intragroup) funding that takes place between global banks and their foreign affiliates within an *internal capital market*. It has been documented how there is a risk that both forms of funding are withdrawn during periods of heightened risk in the global financial system, and economic theory predicts that the two forms should behave in the same way during a financial crisis.

Yet, the two forms of funding have key differences, which may mean they behave differently during a crisis. Within an internal capital market, a global parent bank has the power to shift liquidity from one part of its group to another. Additionally, a bank lending internally has more information about their counterparties' overall riskiness, relative to banks lending at arms-length. The differences could influence the way the two flows behave in response to fluctuations in risk in the global financial system. It is therefore possible that some countries' banking systems could be more insulated from heightened global risk than others, depending on their mix of interbank and intragroup funding and the share of intragroup funding held by global parent banks relative to foreign affiliates.

In this paper, we empirically study the behaviour of *disaggregated* cross-border bank-to-bank funding – disaggregated into interbank and intragroup funding – in relation to swings in risk in the global financial system. We do so by sequentially decomposing aggregate cross-border funding between banks, across 25 advanced and emerging market economies, using data on cross-border banking flows from the Bank for International Settlements. First, we split funding to banks in a particular country into two baskets (i) funding between *arms-length* counterparties (interbank flows) and (ii) funding between banks within the same banking group (intragroup flows). Next, to paint a more detailed picture, we further disaggregate intragroup funding between flows to parent banks and flows to foreign affiliate banks.

We find that a period of high and rising global risk aversion, such as that witnessed following the collapse of Lehman Brothers, results in markedly different behaviour in interbank and intragroup flows. Intragroup funding, which makes up around half of all cross-border funding between banks, *rises* when global risk increases and is invariant to periods of high global risk. Interbank funding displays the opposite behaviour – it is withdrawn during periods of high global risk, with emerging economies particularly vulnerable. These findings contradict the

theoretical prediction that both interbank and intragroup flows will contract during periods of heightened global risk. In fact, each country's mix of interbank and intragroup funding alone, can explain up to 45% of the change in cross-border bank-to-bank funding across countries, following the collapse of Lehman Brothers. We also reveal further information about the behaviour of cross-border banking flows. For example, the decision to withdraw interbank funding during the financial crisis is found to have been closely related to whether a country was experiencing a systemic banking crisis.

We show that higher intragroup funding during periods of heightened risk is principally driven by global banks headquartered in advanced economies, receiving funding from their foreign affiliates. We find that banking systems with a high share of global banks were relatively well insulated against funding withdrawals during the global financial crisis. But we do not find evidence of significantly reduced intragroup funding *to* foreign affiliates in either advanced or emerging economies during periods of high global risk. In fact, we find that foreign affiliates resident in emerging economies experience an *increase* in intragroup funding, when the average profitability of banks in the local economy is low. This result is found to hold even during the financial crisis, indicative of the beneficial role financial globalisation can play for emerging economies with resident foreign banks.

Overall, the results call for policy makers and academics to focus attention on the disaggregation of cross-border bank-to-bank flows, as the contrasting behaviour of interbank and intragroup funding in response to fluctuations in global risk has implications for a banking system's financial stability.

1 Introduction

Cross-border funding between banks is a volatile and economically important source of cross-border finance (Gabriele, Boratav and Parikh, 2000; Milesi-Ferretti and Tille, 2011).[1] During the global financial crisis this funding was quickly withdrawn at the *aggregate* level, leading policy makers and academics to focus their attention on cross-border banking flows, as well as the operations of global banks, which play a key role in channeling this funding around the globe (Acharya and Schnabl, 2010; Shin, 2012; Giannetti and Laeven, 2012a, 2012b; De Haas and Van Horen, 2012, 2013; Cerutti and Claessens, 2013; Ongena, Peydro and Van Horen, 2013).[2]

Investigating *disaggregated* cross-border bank-to-bank funding could, however, provide richer insights, since the aggregate flow is the sum of two distinctive forms of funding, with potentially disparate behavior. First, there is *arms-length* (interbank) funding, that takes place between unrelated banks, and second, there is related (intragroup) funding that takes place between global banks and their foreign affiliates within an *internal capital market*. Cetorelli and Goldberg (2011) have documented that both forms of funding could be equally vulnerable to withdrawal following an international funding shock, or a period of elevated global risk.

Yet, the two forms of funding have key differences. In particular, within an internal capital market, global parent banks have the power to shift liquidity from one corner of the banking group to another. Additionally, banks lending internally have more information about their counterparties' overall riskiness, relative to banks lending at arms-length. The differences could influence the way the two flows behave in response to fluctuations in global risk. It is therefore possible that some countries' banking systems could be more insulated from heightened global risk than others, depending on (i) their mix of interbank and intragroup funding and (ii) the share of intragroup funding held by global parent banks relative to foreign affiliates.

In this paper we make two broad contributions. First we build on the cross-border banking literature by empirically studying the behavior of *disaggregated* cross-border bank-to-bank funding over time and across a large panel of countries. Next, focusing on global risk allows us to test precisely the theoretical predictions made by Bruno and Shin (2014), whose recent contri-

[1] In recent years efforts have been made at policy level to both understand and regulate these flows (see Hoggarth, Mahadeva and Martin, 2010 and the Committee on International Economic Policy and Reform, 2012).

[2] Recent policy debate has centered on the 'Balkanization' of cross-border banking, including proposals to make affiliates of foreign-owned banks safer through holding more capital – potentially limiting the parent bank's ability to shift internal funding from one part of the group to another. See Goldberg and Gupta (2013) and Carney (2013) for recent discussions; see Federal Reserve Board (2014) for a description of the recently finalized rules that require large foreign affiliates operating in the US to adhere to US capital and liquidity rules.

bution has made significant strides towards building a framework for understanding cross-border bank-to-bank flows. In the empirical analysis we sequentially decompose aggregate cross-border funding between banks, across 25 advanced and emerging market economies, using the Bank for International Settlements (BIS) *International Banking Statistics* database. First, we split funding to banks in a particular country between interbank and intragroup[3] and then, to paint a more detailed picture, we further disaggregate intragroup funding between flows to parent and foreign affiliate banks.[4]

At the first level of disaggregation between interbank and intragroup funding, we find that the split has statistical, theoretical *and* economic importance. A period of high and rising global risk aversion, such as that witnessed following the collapse of Lehman Brothers, results in markedly different behavior in ensuing interbank and intragroup flows. Specifically, intragroup funding, which makes up around half of all cross-border funding between banks, *rises* when global risk increases and is invariant to periods of high global risk. Interbank funding displays the opposite behavior and is withdrawn during periods of elevated global risk, with emerging economies being particularly vulnerable.

These findings, in part, contradict the recent theoretical predictions made by Bruno and Shin (2014). Building on the Merton (1974) and Vasicek (2002) models of credit risk, the authors deduce that changes in global risk should drive *all* cross-border funding between banks.[5] When global risk is high, the model predicts that the leverage of global banks will fall, global liquidity will dissipate, and both interbank *and* intragroup funding will contract. However, our results indicate a need for policymakers to monitor *disaggregated* international funding between banks. Assuming that both forms of funding respond identically to fluctuations in global risk, could result in a misleading assessment of a country's underlying financial stability. In fact, we find that considering each country's mix of interbank and intragroup funding alone, can explain up to 45 percent of the change in cross-border bank-to-bank funding across countries during the global financial crisis.

At the second level of disaggregation, we show that increased intragroup funding during

[3]Throughout this paper the term 'intragroup funding' refers to gross cross-border bank-to-bank funding within an internal capital market of a banking group, and the term 'interbank funding' refers to gross cross-border bank-to-bank funding conducted at arms-length.

[4]While the BIS database has been used extensively by researchers in this literature, our approach to decompose aggregate cross-border bank flows is unconventional. Cetorelli and Goldberg (2011), for example, is a related paper which adopts the more common approach of examining aggregate, bilateral flows, within the BIS database.

[5]At a more general level, it is well documented that capital flows are theoretically and empirically related to fluctuations in global risk (see e.g. Adrian and Shin 2010; Bacchetta and van Wincoop, 2010; Forbes and Warnock, 2012, Fratzscher, 2012; Gourio, Siemer and Verdelhan, 2013; Milesi-Ferretti and Tille, 2011).

episodes of heightened risk is principally driven by global banks, headquartered in advanced economies, receiving funding from their foreign affiliates. In fact, we find that banking systems with a large share of global banks were relatively well insulated against funding withdrawals during the global financial crisis. The result supports the view expressed by Kohn (2008), that global banks may respond to an economic shock by using foreign affiliates as a source of liquidity, limiting liquidity pressures at home. In a related study, Cetorelli and Goldberg (2012a) analyze U.S. global banks, and find that during the global financial crisis, foreign affiliates resident in traditional funding locations were harvested for liquidity.[6] We find the result extends across advanced economies as well as periods outside the financial crisis. However, we do not find evidence of significantly reduced intragroup funding *to* foreign affiliates in either advanced or emerging economies during periods of high global risk.[7] In fact, we find that foreign affiliates resident in emerging economies experience an *increase* in intragroup funding, when the average profitability of banks in the local economy is low.

Additionally, by testing the predictions of Bruno and Shin (2014), we are also able to provide a more nuanced examination of the relationship between cross-border banking flows and other financial and economic variables, which have been deduced theoretically to drive this funding. In particular, we show that liquidity management within an internal capital market has links with both financial market prices and monetary policy. A depreciating currency for example, has been shown by Bruno and Shin (2014) to be theoretically linked to a reduction in subsequent cross-border bank-to-bank flows. We show the relationship holds across both interbank and intragroup funding. Moreover, we find evidence that global banks take advantage of higher interest rates in emerging economies, by increasing intragroup funding to foreign affiliates resident in those economies.

The remainder of the paper is organized as follows: in Section 2 we briefly review the literature on how interbank and intragroup funding could behave in response to fluctuations in global risk. In Section 3 we describe the theoretical framework which anchors our empirical analysis. In Section 4 we describe the data. We present empirical results in Section 5 and robustness analysis in Section 6. Finally, we conclude in Section 7.

[6]Cetorelli and Goldberg (2012b) demonstrate that within internal capital markets, funds are reallocated from foreign affiliates to U.S. parent banks, as a way for the parent bank to insulate itself against contractionary monetary policy in the United States.

[7]Likewise, Schnabl (2012) finds global banks maintained intragroup funding to their foreign affiliates resident in Peru in the year following the Russian financial crisis.

2 Related Literature: Interbank and Intragroup Funding

Cetorelli and Goldberg (2011) acknowledge that both interbank *and* intragroup funding could collapse in the event of bad economic news, while the model of Bruno and Shin (2014) predicts that both forms of funding will be withdrawn when global risk is high or rising. Exactly how the two flows behave in relation to different levels of global risk is, ultimately, an empirical question which we aim to shed light on in our empirical investigation. But first, we briefly review the literature on interbank and intragroup funding to describe the contrasting perspectives on how the two flows could react when global risk is high.

Interbank funding has been shown to act as a beneficial source of bank monitoring (Calomiris and Kahn, 1991; Calomiris, 1999) and to alleviate liquidity shocks caused by unexpected retail depositor withdrawals (Goodfriend and King, 1988). Given the increased 'sophistication' of interbank lenders relative to retail depositors, this funding could therefore remain stable when global risk is high, as the lending bank is unlikely to withdraw funding from healthy banks.

Yet, interbank flows may have a darker side. Indeed, Song and Thakor (2007) and Huang and Ratnovski (2011) document the high withdrawal risk of interbank funding. In fact, these authors argue that interbank funding could be *inefficiently* withdrawn when global risk is high, as a result of lending banks not having perfect information regarding the balance sheets of the banks they funded. Moreover, Brunnermeier (2009) finds banks, worried about their own capital buffers, withdrew interbank funding during the financial crisis as insurance against future balance sheet shocks, *irrespective* of the counterparty's balance sheet.

Turning to intragroup funding, De Haas and Van Lelyveld (2010) find parent banks are likely to trade-off lending across countries to support their weakest subsidiaries, while Schnabl (2012) shows foreign affiliates in Peru continued to receive intragroup funding when global risk spiked following the Russian financial crisis. On the other hand, Correa, Sapriza and Zlate (2011) find net intragroup funding of subsidiaries and branches in the U.S. *falls* when economic output in the United States is low, while Cetorelli and Goldberg (2012a, 2012b) find that U.S. parent banks smooth economic shocks at home by channeling funding *from* their foreign affiliates. De Haas and Van Lelyveld (2014) also find evidence that, unlike previous crises, parent banks were unable to support their foreign affiliates during the recent global financial crisis.

Intragroup funding has also gained attention recently, following evidence that European foreign affiliates operating in the United States, borrowed in local money-markets to fund their parent bank headquartered in Europe (BIS, 2010). This particular funding stream was severely impacted

by the global financial crisis (McGuire and von Peter, 2009), implying that intragroup funding could be significantly affected by fluctuations in global risk, with both foreign affiliates and global parent banks vulnerable to potential funding withdrawals.

3 Theoretical Framework

We structure our empirical analysis using the theoretical framework developed by Bruno and Shin (2014). The authors model the total cross-border bank-to-bank funding that takes place between regional and global banks and provide a strong theoretically grounded rationale for *why* a link between global risk and cross-border bank-to-bank flows exists for both interbank and intragroup funding. It also supplies us with additional theoretically-grounded control variables, which should explain changes in cross-border bank-to-bank funding. In this section we briefly outline the model's key features and predictions.

3.1 The Model

In the model of Bruno and Shin (2014), total cross-border funding of regional banks by global banks is given by

$$L = \frac{E_G + E_R.\frac{1+l}{1+b}.\delta_G.\delta_R}{1 - \frac{1+l}{1+b}.\delta_G.\delta_R}, \tag{1}$$

where E_G and E_R are the book value of global and regional bank equity, $\frac{1+l}{1+b}$ is the ratio of the lending rate regional banks require from domestic borrowers (l), to the borrowing rate paid by global banks to borrow in global money markets (b), while δ_G and δ_R are the notional debt ratios of global and regional banks, measured as the ratio of total liabilities to total assets.

A rise in the debt ratio, by definition, decreases a firm's equity, hence the debt ratios can be viewed as measures of leverage. Specifically, the debt ratios of global and regional banks are given by $\frac{(1+b)M}{(1+f)L}$ and $\frac{(1+f)L}{(1+l)C}$, where f is the funding rate charged by the global bank to the regional bank, and M and L represent the book value of global and regional bank liabilities, respectively.

We derive an approximation for the change in cross-border funding between banks, taking a first-order approximation of equation (1) with respect to changes in global bank leverage and the return on domestic bank book equity:

$$\Delta L \approx \frac{\partial L}{\partial E_R}\Delta E_R + \frac{\partial L}{\partial \delta_G}\Delta \delta_G, \tag{2}$$

$$= \gamma\left(\delta_G \Delta E_R + C\Delta\delta_G\right) \tag{3}$$

where in equation (3), γ is equal to $\frac{\frac{1+l}{1+b}\delta_R}{1-\frac{1+l}{1+b}\delta_R\delta_G}$ and C represents the total credit provided by regional banks, which is shown in the model to be equal to $\frac{E_G+E_R}{1-\frac{1+l}{1+b}.\delta_G.\delta_R}$. The equation applies equally to both interbank *and* intragroup funding.

3.2 Hypotheses

Equation (3) provides the framework for our empirical analysis. The main hypotheses that we derive from the model and investigate in our formal regression analysis are outlined below.

3.2.1 Fluctuations in Global Risk

According to equation (3), cross-border interbank and intragroup funding should be positively related to the level and change in global bank leverage δ_G. Bruno and Shin (2014) and Adrian and Shin (2010) show that the VIX index - a measure of global risk - can be substituted in place of global bank leverage because changes in global risk *drive* global bank leverage. *Hence, when global risk is high and global bank leverage is low, both interbank and intragroup funding are predicted to contract.*

The rationale for this relationship is intuitive, and reflects the marking-to-market of assets by global banks. A rise in the value of bank assets, for example, corresponds to a fall in bank leverage.[8] We should therefore observe a negative empirical relationship between asset and leverage growth. But Adrian and Shin (2010) show the opposite to be true. This finding implies that global bank's actively manage their leverage, in response to fluctuations in asset prices. Indeed, it is known from the asset pricing literature that lower volatility is associated with rising risky asset prices (Ang, Hodrick, Xing and Zhang, 2006; Menkhoff, Sarno, Schmeling and Schrimpf, 2012), and so it follows that global banks borrow more when risk aversion falls, and invest the proceeds in other financial securities – including increased cross-border funding of other banks. In fact, Adrian and Shin (2010) argue that the active management is likely driven by value-at-risk

[8] As an example, if the starting balance sheet is split: Assets ($100), Liabilities ($90), Equity ($10), then the leverage ratio is equal to $100/$10 = 10. A $10 rise in the value of assets, when marked to market, reduces the leverage ratio to $110/$20 = 5.5.

(VaR) considerations, in which a decrease in volatility reduces a bank's VaR and incentivizes an expansion of the balance sheet.

Furthermore, in their empirical analysis, Bruno and Shin (2014) confirm the main predictions of their model using data on aggregate international bank-to-bank funding, replacing global bank leverage with the VIX index. The authors argue for the suitability of the VIX index as a proxy for global bank leverage based on two findings. First, in a bivariate regression, the lagged VIX index can explain a large portion of the variation in US broker dealer leverage. Second, the residuals from the regression have no statistical significance in explaining international lending between banks. Moreover, focusing on the VIX – and global risk – is useful from a policy perspective, as a critical concern among policy makers is how capital flows react during periods of economic stress.

3.2.2 Theoretically Motivated Control Variables

Regional bank equity. *The return on domestic bank book equity E_R, is predicted to be positively related to global funding between banks.* A rise in the value of a regional bank's book equity reduces the probability of the bank defaulting (the regional bank's leverage is lower). The reduction in default probability enables the regional bank to expand its borrowing capacity and hence absorb additional funding from global banks.

Interest-rate differentials. *A rise in $\frac{1+l}{1+b}$, the ratio between individual country interest rates and global money market rates is predicted to be positively related to cross-border bank-to-bank funding.* The intuition is that an increase in a country's interest rate increases its income from lending, which in turn shifts the bank away from its default boundary, freeing up capacity to take on additional funding from global banks.

Exchange rates. Fluctuations in the foreign exchange market enter the model indirectly. Nonetheless, the model provides a key insight into the relationship between the currency market and global liquidity. *Specifically, the relationship between foreign exchange returns and cross-border lending between banks is predicted to be negative* (assuming foreign exchange rates are measured as the number of local currency units per U.S. dollar). A local currency appreciation reduces the value of U.S. dollar denominated liabilities of domestic corporations and increases the likelihood that they will be able to repay loans to regional banks. That reduces the probability of regional banks defaulting and expands their borrowing capacity.[9]

[9]The strength of this channel depends on the degree of currency mismatches on the corporate sector's balance sheet as an appreciation also reduces the value of dollar denominated assets.

4 Data

4.1 Data Sources and Variable Definitions

Banking flows data. We collect data on cross-border bank-to-bank funding for advanced and emerging market economies from the Bank for International Settlements's (BIS) *International Banking Statistics* database. In total we consider 25 banking systems that report both interbank and intragroup cross-border banking flow data, consisting of 19 advanced market economies and 6 emerging market economies as classified by the BIS. The banking systems include (emerging economies in bold): Austria, Australia, Belgium, **Brazil**, Canada, **Chile**, Cyprus, Denmark, Germany, France, **India**, Ireland, Italy, Japan, Luxembourg, Netherlands, Norway, **South Africa**, **South Korea**, Spain, Sweden, Switzerland, **Turkey**, United Kingdom, and the United States. All cross-border bank-to-bank flow data are adjusted for the effects of exchange rate movements and we exclude data on offshore banking centers.[10]

Within the *International Banking Statistics* database, we make use of Locational Statistics by Nationality (IBLN). Funding is split between the flows to (i) 'related foreign offices', which we categorize as intragroup flows, and (ii) 'other banks', which we categorize as interbank flows. We calculate the percentage change in cross-border interbank and intragroup funding for each quarter between 1998Q1 and 2011Q4 for all 25 banking systems in our study.[11] For example, for the United States, we calculate cross-border intragroup funding as the summation of all intragroup *inflows* to banks resident in the United States from related banks elsewhere in the world and divide by the previous quarter *stock* of intragroup funding held by all banks (parents and foreign affiliates) resident in the United States.

Using information on the nationality of the parent bank (as contained in IBLN), we are able to disaggregate intragroup funding further, between funding to domestically owned parent banks, and funding to foreign affiliate banks. For example, in the case of the U.S., intragroup funding can be split between (i) cross-border flows to U.S. owned banks operating in the United States, which we classify as a flow to a parent bank headquartered in the U.S. and (ii) cross-border flows to non-U.S. owned banks (foreign affiliates) operating in the United States.[12]

[10] We exclude from our sample any country which does not report both interbank and intragroup flow data. We also exclude Finland as it only reports intragroup flows from 2010Q2 onwards.

[11] While the BIS makes some international banking data publicly available, due to confidentiality, the split between interbank and intragroup funding forms part of a restricted dataset not available to the public.

[12] The BIS does not currently report locational data on a bilateral basis. The BIS's bilateral data is only available for *aggregate* (interbank *plus* intragroup) funding. So it is not known, for example, if the British or German bank located in the U.S. is borrowing from its headquarters, or from another foreign affiliate elsewhere in the world. In

As indicated, for the purposes of our empirical work we normalize quarterly interbank and intragroup flows by the previous quarter stock of interbank and intragroup funding, such that

$$\Delta L^{j}_{i,t} = \frac{\sum_{k=1}^{N} F^{j}_{i,k,t}}{\sum_{k=1}^{N} S^{j}_{i,k,t-1}} \times 100, \tag{4}$$

where ΔL is the normalized quarterly exchange rate adjusted change in either interbank or intragroup funding. F denotes the *flow* of interbank or intragroup funding, reported by the BIS, while S relates to the *stock* of interbank or intragroup funding. The subscript i denotes whether the funding is interbank or intragroup, while $j = 1, 2, .., 25$, denotes the 25 BIS reporting countries who provide the BIS with both interbank and intragroup data on their resident banks, and $k = 1, 2, ..., N$, refers to the N countries of ultimate bank origin which have banking operations in country j. That is, we sum all the cross-border funding which flows into a country j across all banks (local and foreign) resident in that country. The overall result is a panel of normalized interbank and intragroup flows between 1998Q1 and 2011Q4. Note that the countries $k = 26, 27, ..., N$, do not report banking statistics to the BIS but do have global banks with operations abroad, significant examples include China and Russia.

The split of intragroup funding between parent and foreign affiliate banks is then given by,

$$\Delta L^{P}_{j,t} = \frac{F^{j}_{t}}{S^{j}_{t-1}} \times 100, \qquad \Delta L^{FA}_{j,t} = \frac{\sum_{k=1,k\neq j}^{N} F^{j}_{k,t}}{\sum_{k=1,k\neq j}^{N} S^{j}_{t-1}} \tag{5}$$

where $\Delta L^{P}_{j,t}$ and $\Delta L^{FA}_{j,t}$ are the percentage changes in intragroup funding to parent and foreign affiliates banks, resident in country j at time t. In the case of parent banks we record the flow F, when $k = j$. That is, the bank resident in country j is also headquartered in country j. We normalize the change in funding by dividing by the previous quarter stock of intragroup funding held by parent banks headquartered in country j. In the case of foreign affiliates we sum across all banks with operations in country j that are owned by a bank outside country j.

Economic and financial data. We proxy for global risk using the VIX index from the Chicago Board Options Exchange (CBOE). The VIX index is a measure of U.S. stock market volatility,

fact, the BIS is currently expanding its dataset to include bilateral interbank and intragroup flows but at present insufficient data is available for the purposes of this study. We begin our sample in 1998, as key determinants of banking flows such as local equity growth are not available prior to this date. The data are reported on (i) an amount outstanding basis (the stock) and (ii) an exchange rate adjusted change basis (the flow).

compiled from the prices of short-dated options on the S&P 500 index, and is often considered in academic and policy circles as an empirical proxy for global risk aversion.[13] In our robustness analysis we consider alternative measures of global risk. The return on resident banks' book equity (ROE) is measured as the median return on book equity (Net Income/Total Equity) across all banks resident in a particular economy, collected from the database compiled by Beck, Demirgüç-Kunt and Levine (2000, 2009). The authors calculate the median bank book equity based on all foreign and domestic banks in an economy using data from *Bankscope*.[14]

Nominal foreign exchange rates against the U.S. dollar (USD) as well as money market rate data are collected at a quarterly frequency from the IMF's *International Financial Statistics* database. Other macroeconomic control data is collected from the IMF's *World Economic Outlook* database and includes the inflation rate, GDP growth rate and the change in the ratio of public debt to GDP. We also include annual domestic stock market volatility from the World Bank's *Global Financial Development* database. The dependent variables, $\Delta L_{i,j,t}$, $\Delta L^{P}_{j,t}$ and $\Delta L^{FA}_{j,t}$, as well as all country-specific independent variables are winsorized at 2.5 percent to limit the impact of outliers.[15]

4.2 Summary Statistics

In Table 1 we provide summary statistics for the period 1998Q1 to 2011Q4. The average quarterly percent change in interbank funding is 2.1 percent compared to 4.3 percent for intragroup funding. Intragroup funding to parents and foreign affiliates both grew at similar quarterly rates (5.2 percent and 4.0 percent, respectively). Perhaps surprising is the finding that the growth in intragroup funding is *more* volatile than interbank funding, indicating that global banks often make large shifts in internal funding with foreign affiliates. In the appendix we present correlations of macroeconomic and financial variables. We find the quarterly correlation between changes in the growth of interbank and intragroup funding is *negative* and statistically different from zero ($\approx -7\%$). All other correlations are low, mitigating concerns over multicollinearity.

In Table 2 we present statistics on the breakdown of cross-border bank-to-bank funding. In advanced economies, intragroup funding accounts, on average, for 42% of all cross-border bank

[13] Recent papers which use the VIX index as a measure of global risk include, *inter alia*, Longstaff, Pan, Pedersen and Singleton (2011), Bacchetta and van Wincoop (2013), Forbes and Warnock (2012), and Fratzscher (2012).

[14] While *Bankscope* data is comprehensive, it does not have a 100 percent coverage of banks within an economy. The return on equity data, for example, does not take into consideration the return on equity of foreign *branches* since they are not required to hold any equity.

[15] Winsorizing data involves setting all values at the extremes of the observed distribution equal to a pre-specified percentile. A 2.5 percent winsorization means all data below the 2.5^{th} percentile are set equal to the 2.5^{th} percentile and all data above the 97.5^{th} percentile are set equal to the 97.5^{th} percentile.

funding. Around half (57%) of all intragroup funding is held by parent banks. In emerging economies the split between interbank and intragroup funding is tilted more towards interbank funding. On average almost three-quarters of all cross-border borrowing by emerging economy resident banks is interbank. However for emerging economies, cross-border banking is relatively small, with total cross-border funding being on average only 7% of GDP, compared to over 100% for advanced economies.

In Figure 1, we present a breakdown of the average proportion of intragroup funding relative to total cross-border bank-to-bank funding between 1998 and 2011 for different BIS reporters. Due to data confidentiality we are unable to report specific country details on intragroup funding and hence, for the purposes of the figure, we anonymize countries. The funding models adopted across banking systems vary markedly. In a few banking systems, intragroup funding accounted, on average, for over 80 percent of all cross-border bank-to-bank funding. In contrast, others have funded themselves almost entirely using the wholesale interbank market. Of the countries in our sample, around half receive the majority of funding in the form of intragroup flows, when borrowing internationally from other banks.

In addition, we explore the structure of intragroup funding in greater detail in Figure 1 by also displaying the average share of intragroup funding held by domestically-owned parent banks between 1998 and 2011. Again, a large disparity emerges across countries. For the countries with a high share of intragroup funding, we find this could be held primarily by parents (e.g. country 3) or by foreign affiliates (e.g. country 1). Overall, the figure provides an early indication of the importance of both interbank and intragroup funding across banking system business models, and suggests a need to understand if the intragroup funding of parent and foreign affiliate banks behaves differently in the face of fluctuating global risk.

4.3 A First Look at the Data

Before commencing with our formal empirical analysis, we begin with a preliminary examination of the data on cross-border bank-to-bank funding. First, we examine the economic importance of these flows at the *aggregate* level.

The economic importance of cross-border banking. In Figure 2 we present cross-country changes in global bank-to-bank funding following the collapse of Lehman Brothers. In Figure 2a the change is shown as a percentage of the country's stock of cross-border bank funding at 2008Q3, while in Figure 2b it is shown relative to the country's size (GDP). Only a handful of countries

experienced an inflow of bank-to-bank funding in the immediate aftermath of Lehman's collapse (Japan, Australia, Italy, Canada, Spain and Norway). Most countries witnessed a large fall in their aggregate cross-border bank funding. Even if the fall was mild relative to total cross-border bank-to-bank funding, it could still generate an economy-wide shock, due to the size of a banking system relative to the underlying economy. Ireland, for example, witnessed a comparatively small drop in funding from banks abroad, relative to its stock of cross-border bank funding. But the drop translated into a much larger, 15 percent fall, relative to GDP.

The Irish case provides an illustration of the economic importance of international banking flows, which we document further in Figure 3. In 2011Q4, cross-border bank-to-bank funding accounted for over 40 percent of total resident banking system assets in the Netherlands and Ireland, and over 20 percent in the United Kingdom, Luxembourg, and Sweden (see Figure 3a).[16] As a share of GDP the numbers are even more pronounced (see Figure 3b), accounting for over 100 percent of GDP in five banking systems: Luxembourg (654 percent), Cyprus (167 percent), Ireland (150 percent), United Kingdom (128 percent) and the Netherlands (124 percent). Even in emerging market economies, where proportions were lower, contractions in funding could still impact the expansion of domestic credit due to relatively smaller banking systems, and a heavy reliance on foreign bank affiliates to expand domestic credit, as demonstrated by Schnabl (2012) in the case of Peru.

Interbank and intragroup funding. In Figure 4a we disaggregate cross-border funding between banks into two baskets - arms-length interbank flows, and related intragroup flows - and find that interbank funding fell on average across our sample of BIS reporters by almost 30 percent between September 2008 and the end of 2009. Yet, in contrast, intragroup funding *increased* in the immediate aftermath of Lehman Brothers's collapse and was stable for the remainder of the crisis period.[17] Contrasting behavior in interbank and intragroup flows is not limited, however, to the recent global financial crisis. To see this, in Figure 4b we present the distributional relationship across time between cross-border bank-to-bank funding and the VIX index. We find that on average, between 1998 and 2011, interbank funding *contracted* by two percent during quarters when the VIX index was at an elevate level (upper-25^{th} percentile), while during the same

[16]The data for total banking system assets are collected from the IMF's *Global Financial Stability Report* and are available for 15 countries in our sample.

[17]The numbers reflect the median change in interbank and intragroup funding across all 25 banking systems in our study. To calculate the change we sum over *flows* (adjusted for exchange rate fluctuations) and divide by the stock at the start of the crisis.

quarters intragroup funding *expanded* by over two percent. In the quarters when the VIX index was particularly low (lower-25^{th} percentile), both intragroup *and* interbank funding expanded by approximately four percent.

Intragroup funding to parents and foreign affiliates. In Figure 5 we plot median cumulative changes in aggregate (interbank plus intragroup) cross-border bank-to-bank funding following the collapse of Lehman Brothers, conditional on (i) the banking system's share of intragroup funding and (ii) the proportion of intragroup funding held by resident parent banks.

First we split countries into two baskets based on their share of intragroup funding at 2008Q2. We find countries with a high share of intragroup funding experienced a much smaller loss of cross-border bank financing following the collapse of Lehman Brothers. By the end of 2009, banking systems funded with a relatively high share of arms-length interbank funding had experienced, on average, a 20 percent drop in funding, while the fall in funding was less than 8 percent for banking systems with a high share of intragroup funding.

Next, we split the basket of high intragroup funded countries based on the mix of intragroup funding held by parents and foreign affiliates. Banking systems with a high share of intragroup funding held predominately by parent banks, experienced almost no loss in cross-border bank-to-bank funding during the global financial crisis – amplifying the contrasting behavior in interbank and intragroup funding in relation to fluctuations in global risk. Next, we explore these relationships in greater depth in our formal empirical investigation.

5 Results

In this section we outline the empirical methodology used in this study and present our findings. We first describe results for the disaggregation of cross-border bank-to-bank funding between interbank and intragroup flows, and explore whether our findings are mirrored across advanced *and* emerging market economies. Next, we turn our attention exclusively to intragroup flows, examining the split in funding between parent and foreign affiliate banks.

5.1 Empirical Methodology

We begin by examining the relationship between interbank and intragroup funding and fluctuations in global risk, which we proxy using the VIX index. To do so we estimate a fixed-effects panel regression, based on equation (3), which takes the form

$$\Delta L^{j}_{i,t} = \beta_{i,0} + \beta_{i,1} \cdot VIX_{t-1} + \beta_{i,2} \cdot \Delta VIX_t + \left(\sum_{l=1}^{3} \beta_{i,l+2} \cdot TCV_{j,t-1} \right) + \alpha_j + Controls + \epsilon_{i,t} \quad (6)$$

where $\Delta L^{j}_{i,t}$ is the quarterly percent change in either interbank or intragroup funding (see equation (4) for details).[18] VIX is the average level of the VIX index (in logs) during the quarter and proxies for the *level* of global risk, while ΔVIX is the quarterly change in the average level of the VIX index (in logs) and proxies for the *change* in global risk. The three theoretically motivated control variables (return on domestic bank book equity, foreign exchange returns and interest rate differentials) are denoted TCV. Control variables sampled at a quarterly frequency are lagged by one quarter, while those sampled at yearly frequency are lagged by four quarters. Control variables, both theoretically determined and other macroeconomic and financial variables, are discussed in Section 4. We include country level fixed effects α_j, in an attempt to capture any other time invariant country level effects not picked-up by our set of control variables. We calculate robust standard errors, clustered at country level.

5.2 Baseline Regression

In Table 3 we present our baseline results. In columns 1 and 2 we consider changes in interbank funding while in columns 3 and 4 we investigate intragroup funding. In the first and third columns we only include theoretically motivated control variables. The coefficients on interbank funding support the theoretical hypotheses outlined in Section 3. Interbank funding contracts when the VIX is high or rising during a quarter. In contrast, and *counter* to theoretical prediction, intragroup funding shows no relationship with the level of the VIX and *expands* in quarters when the VIX rises. We also find the return on domestic bank book equity displays, as predicted, a statistically significant and positive relationship with subsequent interbank *and* intragroup funding. Currency market movements are also shown to drive both interbank and intragroup funding. The FX return variable enters the model with the correct sign. A lower return (appreciation of the local currency) generates an inflow of funding to the local economy banking system. Finally, in this baseline regression, we find no evidence of a relationship between bank-to-bank funding and interest rate differentials.

[18] The framework for our empirical analysis is outlined fully in Section 3. We estimate a Hausman test and find the null hypothesis (the random-effects estimator is consistent) is strongly rejected, indicating the need to estimate a fixed-effects rather than random-effects model.

The results from the full specification, including all control variables, are shown in the second and fourth columns. Two of the controls variables, domestic GDP growth and the change in public debt (as a proportion of GDP), are found to be statistically significant drivers of arms-length interbank funding. However, we find none of the control variables are significant in determining intragroup funding, suggesting that interbank flows are more responsive to local economic and financial factors. One potential reason why intragroup funding is less affected by the control variables is offered by Cetorelli and Goldberg (2012a). Examining internal capital markets, the authors find that the funding of foreign affiliates by U.S. parent banks is, in part, determined by factors detached from short-term macroeconomic fluctuations. For example, the location of the affiliate bank as a source of funding or destination for foreign investment, and its distance from the headquarters of the parent bank, could both be more important determinants of funding than local economic or financial conditions.

5.2.1 Economic Significance

In this subsection we examine the relative economic significance of the estimated coefficients in our baseline regression. We do so by studying a stylized scenario analysis that reflects events following the collapse of Lehman Brothers. We consider three hypothetical banking systems (A, B, and C). The banking systems have different business models in terms of their mix of arms-length and related funding. Banking System A is financed 20 percent with intragroup funding and 80 percent in the interbank market (the Netherlands has similar proportions). Banking System B is equally funded with intragroup and interbank funding (similar to the German banking system), while Banking system C obtains 80 percent of overseas bank-to-bank funding in internal capital markets (similar to the United States). We consider a scenario in which the VIX index rises from an average of 25 during the first quarter to an average of 45 in the subsequent quarter. The VIX then remains at an average of 45 for two quarters.[19]

First, the statistically significant coefficients on the VIX and ΔVIX, estimated in the baseline regression (Table 3), are used to estimate the change in cross-border bank-to-bank funding when the VIX rises by 20 points.[20] Banking System A, with the lowest share of intragroup funding, experiences a 17 percent drop in funding. Funding to Banking System B falls by 10 percent, while Banking System C maintains a roughly stable level of funding. The stability of funding to Banking System C is a consequence of intragroup inflows offsetting interbank outflows. Since intragroup

[19]The average level of the VIX in 2008Q3 was 25 and increased to an average of 45 between 2008Q4 and 2009Q2.

[20]The coefficients are: VIX (interbank: -5.20) and ΔVIX (interbank: -4.04; intragroup: 4.09). We provide details of these calculations in the Appendix.

flows remain stable during periods of high global risk, flows over the following two quarters – when the VIX remains at 45 – are *only* due to outflows in interbank funding. Accounting for these flows results in Banking System A losing almost 40 percent of cross-border bank funding over the entire three quarter period. However, Banking System C, with the largest share of intragroup funding, experiences a relatively modest 8 percent drop in funding. Banking System B, as expected, falls in between, with a 23 percent drop in funding.

Comparing the scenario with the actual outcomes for the countries listed above (Netherlands, Germany and the United States) results in a similarly large and economically important difference across countries. The Dutch banking system experienced over a *30 percent* drop in cross-border bank-to-bank funding following the collapse of Lehman Brothers. The German banking system faced a smaller drop in funding, of approximately 10 percent, while the United States, at the epicenter of the financial crisis but holding the largest relative share of intragroup funding, experienced only a 5 percent withdrawal of total cross-border bank-to-bank funding.

5.2.2 Advanced and Emerging Market Economies

We augment the baseline regression to include an emerging-market dummy variable, which is equal to **1** when the funding is to an emerging economy (as classified by the BIS, see Section 4 for sample information), and zero otherwise. The dummy variable is interacted with the VIX and the other theoretically motivated control variables. In Table 4 we report parameter estimates for interbank funding in column 1 and for intragroup funding in column 2. Once again, we find the coefficient on the VIX is negative and statistically significant for interbank funding. However, the effect is almost *three times larger* for banks resident in emerging market economies.

In row 3 we run an *F-test* to investigate if the sum of coefficients on the VIX index is statistically significant, with the *p-value* reported below. The equivalent *F-test* is also run and reported for ΔVIX and all other theoretically motivated control variables. The *F-test* for both the VIX and ΔVIX yields a negative and statistically significant coefficient, indicating that banks resident in emerging economies observe an outflow of interbank funding when the VIX index is high or rising during a quarter. The coefficient on the ΔVIX alone, is not, however, statistically different from zero. This finding provides evidence that an increase over one quarter in global risk does indeed impact interbank funding but *only* to those banks resident in emerging economies.

The split between advanced and emerging economies also impacts intragroup funding. The ΔVIX coefficient is positive and highly significant, in keeping with the earlier baseline regression. However, the *F-test* for ΔVIX implies *only* advanced economy resident banks experience an inflow

of intragroup funding when global risk rises. Moreover, we find contrasting implications for the return on equity. Mirroring our earlier result and prediction from theory, the ROE coefficient is positive across both interbank and intragroup funding – better domestic conditions increase the capacity to borrow. Yet, the *F-test* on ROE for intragroup funding, yields a negative and statistically significant value. This finding implies that emerging market banking systems *receive* funding when their average profitability is low. We find a similar asymmetric result on the FX return variable. Currency market activity is particularly relevant for emerging economies, which lose both interbank *and* intragroup funding following a depreciation of the local currency.

5.2.3 Funding During the Financial Crisis

We examine the extent to which information on a country's mix of interbank and intragroup funding could explain cross-border bank-to-bank flows following the collapse of Lehman Brothers. To do so we estimate a cross-sectional regression which takes the form

$$\Delta L_j = \beta_0 + \beta_1 \cdot IntraShare_j + \epsilon_j, \tag{7}$$

where $IntraShare_j$ is the amount of intragroup funding held by country j as a percentage of its total (interbank *plus* intragroup) cross-border funding from banks, measured at 2008Q3. ΔL is the percent change in total funding (interbank plus intragroup) between 2008Q4 and 2009Q2, relative to the stock at 2008Q3.

In Table 5, we present the results from the bivariate regression. In column 1, we show the result for all banking systems in our sample. The fit across the 25 countries can explain around 12% of the total variation in funding loss during the crisis. The coefficient on intragroup funding is positive and statistically significant. We then investigate if the share of intragroup funding was particularly important for countries having suffered from a systemic banking crisis following the collapse of Lehman Brothers. To do so, we classify countries as having suffered a systemic banking crisis or not, using the database compiled by Laeven and Valencia (2013).[21] None of the emerging economies in our sample were classified as having experienced a systemic banking crisis during 2008-09, while ten advanced economies banking systems were found to have experienced such a crisis.

[21]Leaven and Valencia (2013) define a borderline set of countries, not found to have experienced a systemic banking crisis, but whose banking systems were affected by the crisis. These countries include Sweden, Italy, France and Switzerland. We choose to classify these countries as not having experienced a systemic banking crisis.

When we limit the regression to the ten banking systems having experienced a systemic banking crisis (column 2), the simple bivariate regression explains 45% of the variation in funding loss across countries. The coefficient on intragroup funding is now larger than in the first specification and remains highly significant. A country which experienced a systemic banking crisis and held no intragroup funding could expect to witness a loss of funding exceeding 30%. However, if the banking system relied fully on intragroup funding when borrowing from banks overseas, the country would be expected to see a small inflow of funding. To contrast with this finding we run a third specification (column 3) including advanced economy countries which did not experience a systemic crisis. This time we do not find any clear relationship between the use of intragroup funding and the amount of funding withdrawn. In addition, the constant in the regression becomes insignificantly different from zero, indicating that these countries did not, on average, lose any cross-border bank-to-bank funding during the crisis.

The results from the bivariate regression point to a selective withdrawal of bank-to-bank funding. Banking systems not directly connected with the 2008-09 global financial crisis, including Norway, Australia, Japan, Italy and Canada experienced limited cross-border bank-to-bank outflows. Furthermore, as suggested by the scenario analysis, countries with high shares of intragroup funding – even if having suffered a systemic banking crisis – were less likely to experience a large outflow of funding, while emerging market economies (with relatively low shares of intragroup funding) faced some of the largest outflows, despite not having experienced systemic banking crises.

As a follow-up exercise we investigate how much of the loss in total (interbank plus intragroup) funding could have been predicted from our prior regression on advanced and emerging economies. Specifically, we focus on advanced economies, split between those which experienced a systemic banking crisis and those which did not, and use the regression coefficients estimated on the VIX and ΔVIX *only*. In Figure 6 we plot the actual and predicted loss in total funding based on each country's mix of interbank and intragroup funding between 2008Q3 and 2009Q2 (as a percentage of the 2008Q3 stock), combined with the coefficients on the VIX and ΔVIX reported in Table 4. We find that over 20% of the total fall in funding could be explained for banking systems which experienced a systemic banking crisis. To put the result in context, had the split between interbank and intragroup funding not been made, then none of the cross-sectional spread could have been explained.[22]

[22]Using aggregate information, in which interbank and intragroup flows are predicted to behave symmetrically results in a predicted loss of around 15 percent in funding for *every* banking system (see Figure 6). The results

5.3 Parent and Foreign Affiliate Banks

The second part of our sequential disaggregation of cross-border banking flows involves splitting intragroup funding between parent and foreign affiliate banks. In doing so, we tease out more detail on the behavior of intragroup funding than could be achieved at the first level of disaggregation.

We run the augmented baseline regression including an emerging market dummy variable, in which the left-hand-side variables are the quarterly percentage change in intragroup flows to parent and foreign affiliate banks (see equation (5) for details). Results are reported in Table 6. In columns 1 and 2 we present results for domestically headquartered parent banks, and do the same for foreign affiliates in columns 3 and 4. Parent banks resident in advanced economies are found to have a robust positive relationship with the VIX and ΔVIX, while foreign affiliates do not. The finding indicates that advanced economy parent banks receive funding from their foreign affiliates during periods of heightened global risk. The result supports a recent finding by Hoggarth, Hooley and Korniyenko (2013), who show that gross intragroup lending by foreign affiliates resident in the U.K. increased strongly following the run on the British bank, Northern Rock.[23]

Parent banks in emerging economies are more exposed to global shocks, echoing our earlier finding. Possibly due to limited banking presence overseas, these parent banks observe a large fall in intragroup funding when global risk rises. The evidence is mixed, however, on their ability to withstand periods when the VIX is elevated, with the *F-test* showing a negative, albeit insignificant, point estimate. We find a similar result for foreign affiliates resident in emerging economies, although overall we find no robust evidence that foreign affiliates, in either advanced or emerging economies, lose funding when global risk is high.

Earlier we noted that intragroup funding appears to increase to emerging economies when the average return on equity in those banking systems is low. Comparing columns 2 and 4, we see that the result was driven by increased funding to foreign affiliate banks rather than to parent banks. The finding provides support to the view that negative local economic shocks in emerging economies, give rise to an increase in parent funding to their foreign affiliates resident in those economies. In an additional test we find that including a three-way interaction between the return on equity, the emerging market dummy variable and a time dummy variable for the post-Lehman

from the regression on aggregate flows are provided in the Appendix.

[23]Notably, the result is driven by the intragroup lending of foreign *branches*. The gross lending by foreign subsidiaries remained unchanged.

episode, yields a negative and statistically significant coefficient, indicating that parent banks increased support to their weakest subsidiaries in emerging economies *even* during the financial crisis.

Furthermore, we find that higher interest rates in emerging economies lead to an increase in intragroup funding, as parent banks fund foreign affiliates resident in those economies. But this finding also implies that emerging economies can expect resident foreign banks to *lose* intragroup funding whenever expansionary monetary policy is implemented.

6 Robustness

In this section we examine the robustness of our results under alternative specifications. First, we investigate if any one country materially drives our results. Next, we use alternative measures of global risk in place of the VIX index, and finally we test if our results are robust to the exclusion of the global financial crisis and the European sovereign-debt crisis.

6.1 Excluding Individual Countries

We examine the impact individual countries have on our results, by augmenting our baseline model with a country-specific dummy variable C,

$$\begin{aligned}\Delta L^{j}_{i,t} = \beta_{i,0} + \beta_{i,1} \cdot VIX_{t-1} + \beta_{i,2} \cdot (VIX_{t-1} \cdot C_j) \\ + \beta_{i,3} \cdot \Delta VIX_t + \left(\sum_{l=1}^{3} \beta_{i,l+3} \cdot TCV_{j,t-1} \right) + \alpha_j + Controls + \epsilon_{i,t}. \end{aligned} \tag{8}$$

In Panel A of Table 7 we report the range of coefficient estimates for $\beta_{i,1}$, which we estimate by sequentially adding and removing each country from the analysis by setting $C_j = 1$, $\forall\ j = 1, 2, ...25$. The interbank coefficient on the VIX is always statistically different from zero at the one percent level. The coefficient is never greater than -4.75 and reaches a low of -5.48. Consistent with our earlier baseline results, the intragroup coefficient on the VIX is always positive, ranging between 0.61 and 1.52.

In Panel B we report individual country estimates of the $\beta_{i,2}$ coefficient – the interaction term between the VIX and country dummy variable. We also run an *F-test* to determine if the sum of coefficients $\beta_{i,1} + \beta_{i,2}$, is statistically different from zero. We find the sum on interbank flows is negative and statistically significant for 17 of the 25 countries in our study. In fact, all emerging economy banking systems in our sample witness an outflow of interbank funding when global

risk is high. The finding confirms our earlier result that emerging market banking systems are particularly vulnerable to fluctuations in global risk. In Brazil and India the loss of interbank funding is particularly pronounced, and highly significant at the one percent level. Only two countries (Cyprus and Denmark) experience an increase in interbank inflows when global risk is high. The sum of coefficients on intragroup flows is either statistically insignificant (consistent with our earlier result) or *positive*, for 21 out of 25 countries.

6.2 Alternative Measures of Global Risk

We replace the VIX as our measure of global risk with five alternative measures: (i) the VXO provided by the CBOE, the predecessor to the VIX index and an alternative measure of global risk used in a related study by Forbes and Warnock (2012), (ii) the Credit Suisse Global Risk Appetite Index, a measure of risk calculated using asset price data from advanced and emerging markets,[24] (iii) the spread between AAA and BAA rated securities, a measure of corporate bond credit quality provided by Moody's Corporation, (iv) the global risk factor from Della Corte, Riddiough and Sarno (2014) which reflects a measure of global risk extracted from fluctuations in the foreign exchange market and (v) the TED spread, a measure of funding liquidity equal to the difference between the rates on a 3-month U.S. euro deposit contract and the 3-month T-bill.

We run our full baseline specification, accounting for heterogeneity across advanced and emerging market economies, replacing the VIX index with each of our alternative risk metrics:

$$\Delta L^{j}_{i,t} = \beta_{i,0} + \beta_{i,1} \cdot RISK_{t-1} + \beta_{i,2} \cdot (RISK_{t-1} \cdot EME) + \beta_{i,3} \cdot \Delta RISK_t + \beta_{i,4} \cdot (\Delta RISK_t \cdot EME) + \left(\sum_{l=1}^{3} \beta_{i,l+4} \cdot TCV_{j,t-1} \right) + \alpha_j + Controls + \epsilon_{i,t}. \quad (9)$$

The results are reported in Table 8. In columns 1 to 5 we report results for interbank funding and do the same for intragroup funding in columns 6 to 10.[25] The alternative measures of global risk lead to noticeably similar results. Interbank funding has a negative and statistically significant relationship with each alternative measure of global risk except for the TED spread. An increase in the TED spread leads, however, to a fall in interbank funding. In fact, a reduction in funding to emerging economies when global risk is high, is evident across all alternative measure of risk.

[24] The index is calculated as the coefficient on a cross-sectional linear regression of excess returns on risk (past price volatility). It is based on 64 indexes of bonds and equities in advanced and emerging markets and is updated daily. Advanced market indexes are denominated in local currency while U.S. dollar indexes are used for emerging economies. A large coefficient (slope) reflects increased investor risk and therefore we multiply the index by minus one to make the coefficients comparable with our other risk measures.

[25] In the appendix we provide summary statistics and correlations across our alternative measure of risk.

Intragroup funding is not found to have a clear relationship with any measure of global risk (echoing our earlier baseline estimation) except for the Credit Suisse risk appetite index, whereby the relationship is, in fact, *positive*. Intragroup funding also shows a positive relationship with the change in global risk across all alternative measures except for the global currency risk factor, although the point estimate on the factor is positive. Furthermore, the ROE and FX Return variables are shown to have robust links with global risk, which align correctly with the hypotheses stated in Section 3. In fact, the coefficient estimates for both variables are statistically significant across *all* alternative measures of global risk for both interbank and intragroup funding.

6.3 Global Financial Crisis

We test if our earlier parameter estimates remain robust to the exclusion of the global financial and European sovereign-debt crises. To do so, we estimate the augmented baseline regression with an emerging market dummy variable, but exclude crisis periods. First, we exclude the period 2008Q4-2009Q2 and re-estimate the model to account for the immediate aftermath of Lehman Brothers collapse. The results are reported in columns 1 and 2 of Table 9. Once again, interbank funding is shown to have a strong negative relationship with global risk, with the effect amplified for emerging market economies.

The main difference is that the ΔVIX coefficient shows a less robust relationship with interbank funding. The large spike in the VIX during 2008Q4 is responsible for the negative relationship we documented earlier for emerging economies. Nonetheless, we still find a robust positive relationship for intragroup funding with the ΔVIX coefficient. Moreover, the increase in intragroup funding to emerging economies, when their host banking system is experiencing low profitability, continues to be observed.

In the third and fourth columns we exclude the entire period following 2008Q3 and, in doing so, exclude both the global financial crisis and European sovereign debt crisis. The results across global risk remain almost unchanged and qualitatively identical. The main addition is that before the crisis, emerging economies did receive inflows of intragroup funding when global risk increased. The finding provides evidence for the European sovereign debt crisis, similar to the results of De Haas and Van Lelyveld (2014) for the global financial crisis, that European global banks, affected by the crisis, were unable to maintain lending to their foreign affiliates abroad and hence, when assessing the international transmission of funding shocks, one needs to first ascertain the extent to which the underlying global bank is affected.

7 Conclusions

The collapse of Lehman Brothers in September 2008 and the subsequent reduction in cross-border lending between banks, focussed policy-maker and academic attention on the behavior and determinants of this economically important form of cross-border finance. In fact, the Committee on International Economic Policy Reform (2012) concluded that "effective regulation of cross-border banking is essential for domestic and global financial stability."

In this paper we ask the question: do interbank and intragroup flows react differently to fluctuations in global risk and, if so, is the disaggregation of cross-border bank-to-bank funding of economic importance to academic and policy makers working in the area of international capital flows? To answer the question we disaggregate cross-border bank-to-bank funding at two levels: first between arms-length *interbank* funding and related *intragroup* funding and then, by splitting intragroup funding between flows to parent and foreign affiliate banks.

The paper, to our knowledge, is the first to provide systematic cross-country evidence on the behavior of interbank and intragroup funding in relation to fluctuations in global risk. In the empirical analysis, we adopt the framework of Bruno and Shin (2014) and find the disaggregation of funding has statistical, theoretical *and* economic implications. A period of high and rising global risk results in markedly different behavior in subsequent interbank and intragroup funding, offering evidence contrary to the theoretical predictions made by Bruno and Shin (2014) that both forms of funding should react symmetrically to movements in global risk. Intragroup funding is shown to remain stable during periods of heightened risk and *increase* when global risk rises. In contrast, interbank funding is withdrawn from all economies – but especially emerging markets – when global risk is high. We also reveal additional granularity in the results. For example, the decision to withdraw interbank funding during the financial crisis is found to have been closely related to whether a country was experiencing a systemic banking crisis.

Further disaggregation reveals that parent banks in advanced economies receive funding from their foreign affiliates to smooth liquidity shocks at home. This behavior explains the *increase* in intragroup funding when global risk rises. However, we do not find evidence of significantly reduced intragroup funding *to* foreign affiliates during these periods. In fact, we find that foreign affiliates resident in emerging economies experience an increase in intragroup funding, when the average profitability of banks in the local economy is low. This result is found to hold even during the financial crisis, and is indicative of the beneficial role financial globalization can play for emerging economies with resident foreign banks.

Overall, the results call for policy makers and academics to focus attention on the disaggregation of cross-border bank-to-bank flows, as the contrasting behavior of interbank and intragroup funding in response to fluctuations in global risk has implications for a banking system's underlying financial stability.

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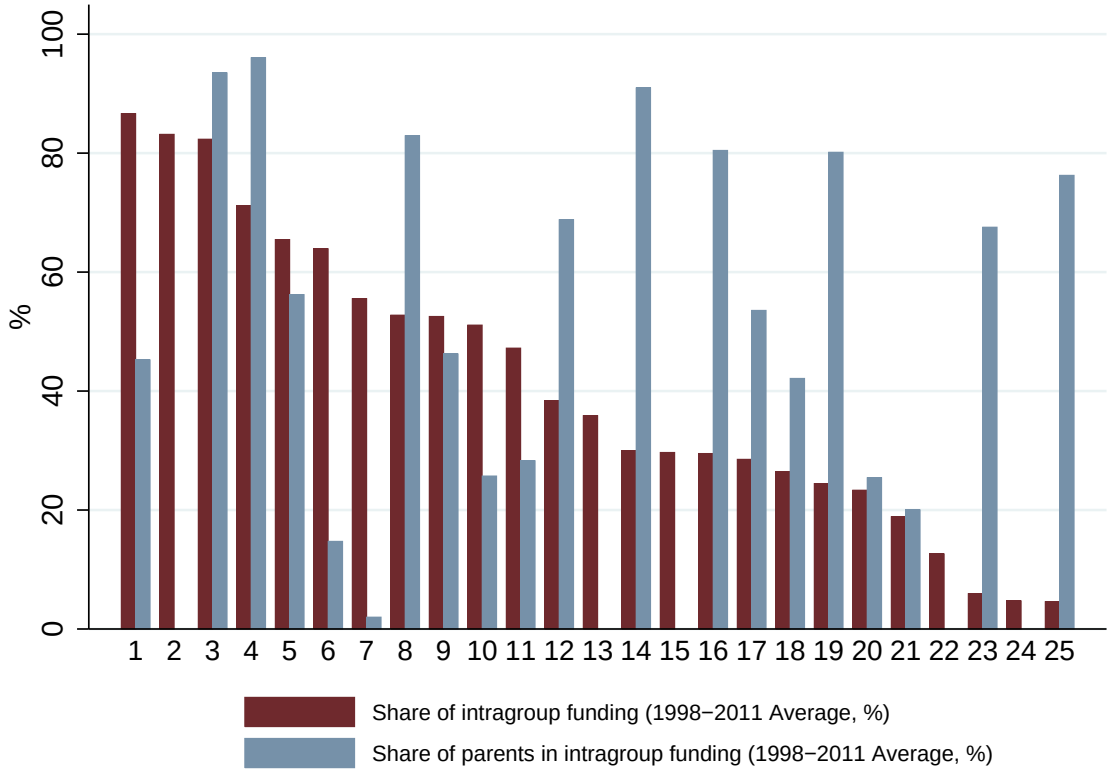
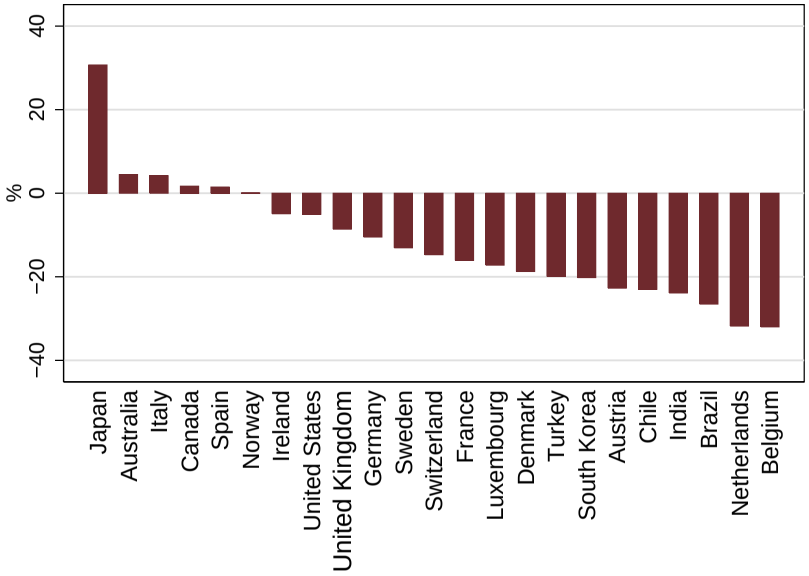
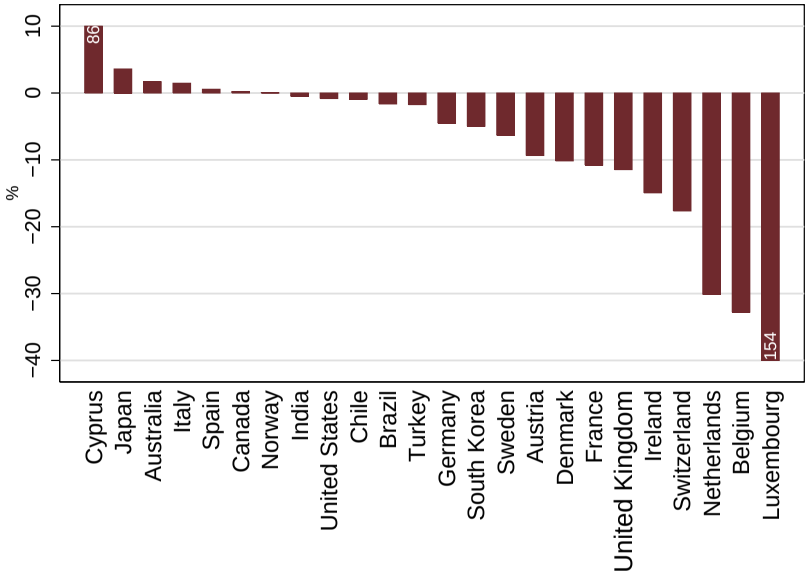


Figure 1: ***Intragroup Funding Across Countries.*** *The figure shows the average share of intragroup funding as a percentage of total cross-border bank-to-bank funding, between 1998 and 2011, for the 25 banking systems within our sample. The figure also shows the average share of intragroup funding held by domestically-owned parent banks, between 1998 and 2011. Country specific data are confidential and hence anonymized. Data on banking flows are collected from the Bank for International Settlement's International Banking Statistics database. The sample period is from 1998Q1 to 2011Q4.*

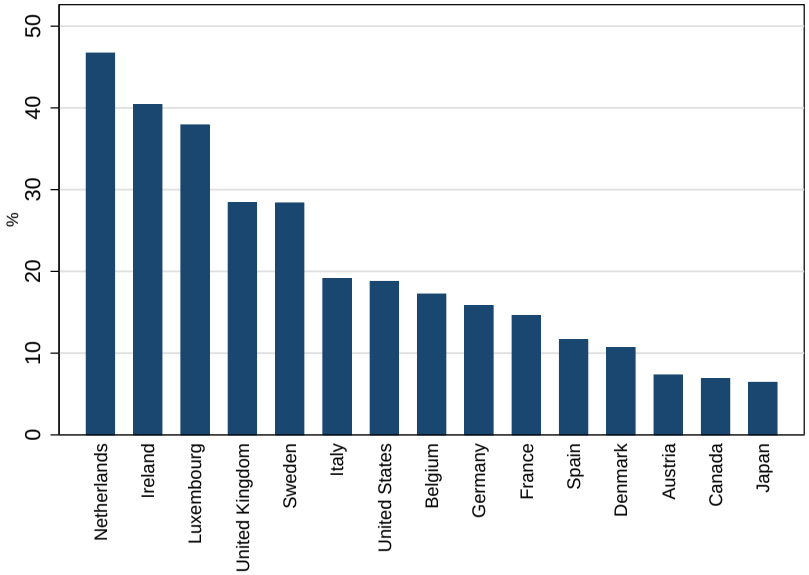


(a) Cumulative Change in Funding 2008Q4 to 2009Q2 (% Aggregate Cross-Border Bank-to-Bank Funding)

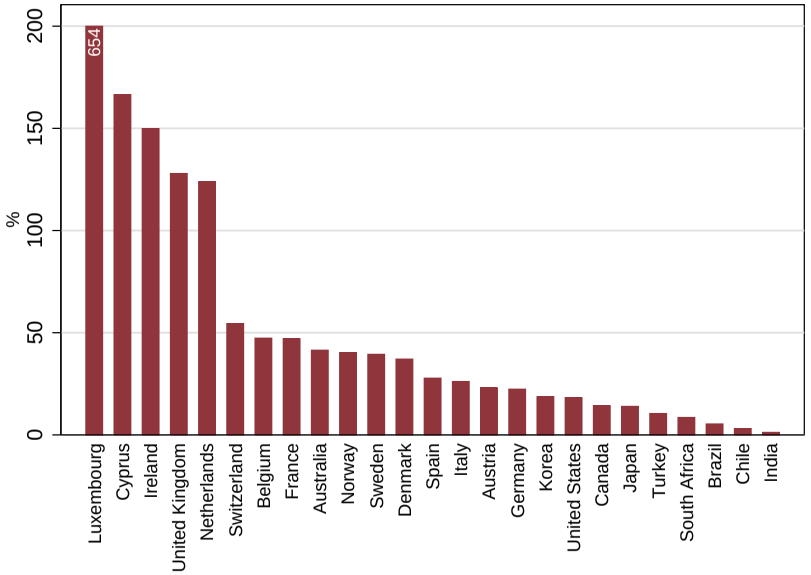


(b) Cumulative Change in Funding 2008Q4 to 2009Q2 (% GDP)

Figure 2: ***Cross-Border Bank-to-Bank Flows Following the Collapse of Lehman Brothers.*** *Figure (a) shows the cumulative change in cross-border interbank and intragroup funding following the collapse of Lehman Brothers in 2008Q3. The change is measured as the sum of exchange-rate-adjusted flows between 2008Q4 and 2009Q2 relative to the stock of cross-border funding in 2008Q3. In Figure (b) the change is measured relative to GDP at 2008Q3. Data on banking flows are collected from the Bank for International Settlement's International Banking Statistics database. The sample period is from 1998Q1 to 2011Q4.*

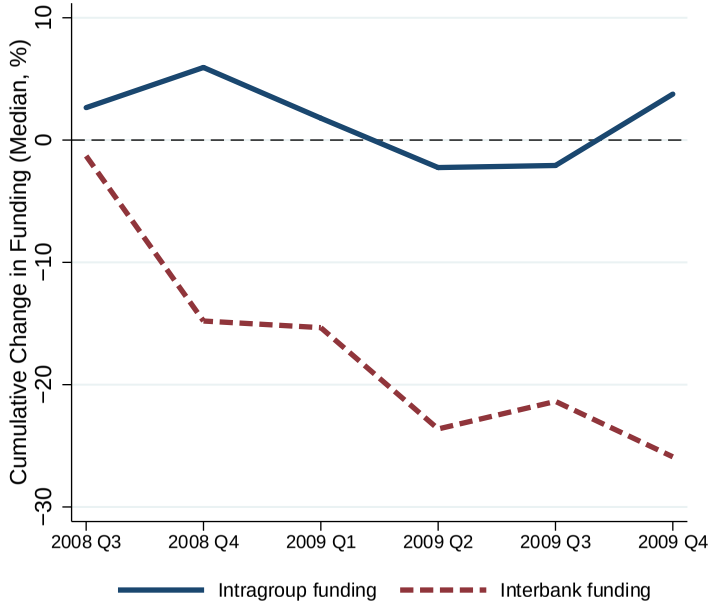


(a) Ratio of Cross-Border Funding to Total Resident Bank Assets (%)

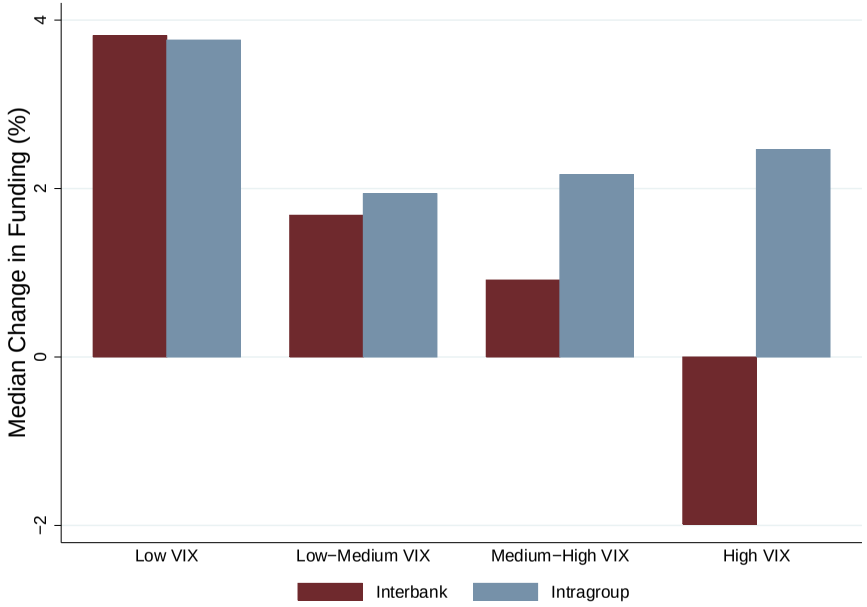


(b) Ratio of Cross-Border Funding to GDP (%)

Figure 3: ***The Economic Importance of Cross-Border Bank-to-Bank Funding.*** *Panel (a) shows the ratio of cross-border bank-to-bank funding to the total assets of resident commercial banks (including foreign subsidiaries) in 2011Q4. Data on total resident bank assets are taken from the IMF's Global Financial Stability Report. Panel (b) shows the ratio of cross-border bank-to-bank funding relative to GDP in 2011Q4. Data on banking flows are collected from the Bank for International Settlement's International Banking Statistics database. The sample period is from 1998Q1 to 2011Q4.*



(a) Cross-border flows after the collapse of Lehman Brothers



(b) The relationship between cross-border flows and the VIX index

Figure 4: ***A First Look at Interbank and Intragroup Funding.*** *Figure (a) shows the cumulative median change in aggregate cross-border interbank and intragroup funding, across 25 advanced and emerging market banking systems, following the collapse of Lehman Brothers in September 2008. The change is measured relative to the stock of cross-border funding in 2008Q2. In Figure (b) quarterly funding is split into four groups, conditional on the average level of the VIX index in each quarter between 1998 and 2011. Each bar represents the median quarterly percentage change in interbank or intragroup funding if the VIX index is low (below the* 20^{th} *percentile), at a medium level (between the* 20^{th} *and* 50^{th} *percentiles), at an elevated level (between the* 50^{th} *and* 80^{th} *percentiles) or at a high level (above the* 80^{th} *percentile). Data on banking flows are collected from the Bank for International Settlement's International Banking Statistics database. The sample period is from 1998Q1 to 2011Q4.*

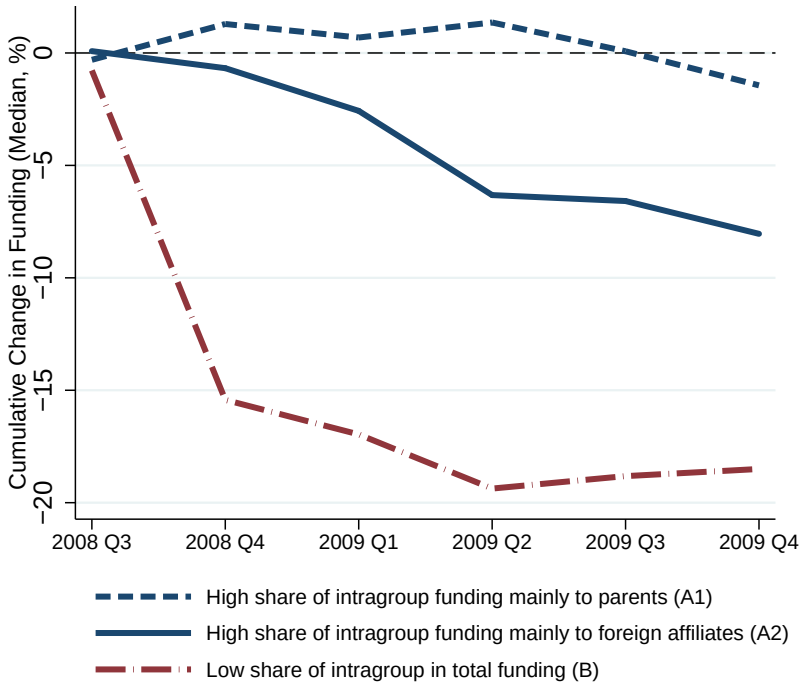


Figure 5: ***Intragroup Funding and Parent Banks.*** *The figure shows the cross-country median, exchange rate adjusted change of total (interbank plus intragroup) cross-border bank funding between 2008Q3 and 2009Q4. The values are scaled by the stock of funding at 2008Q2. Countries are classified as having a high share of intragroup funding if their 2008Q2 share of intragroup funding, as a proportion of total cross-border bank-to-bank funding, exceeds the cross-country median. Within the group of countries with a high share of intragroup funding, we further classify them as having intragroup funding 'mainly held by parents', if the share of intragroup funding held by parents, as a proportion of total intragroup funding, exceeds the cross-country median. Data on banking flows are collected from the Bank for International Settlement's International Banking Statistics database. The sample period is from 1998Q1 to 2011Q4.*

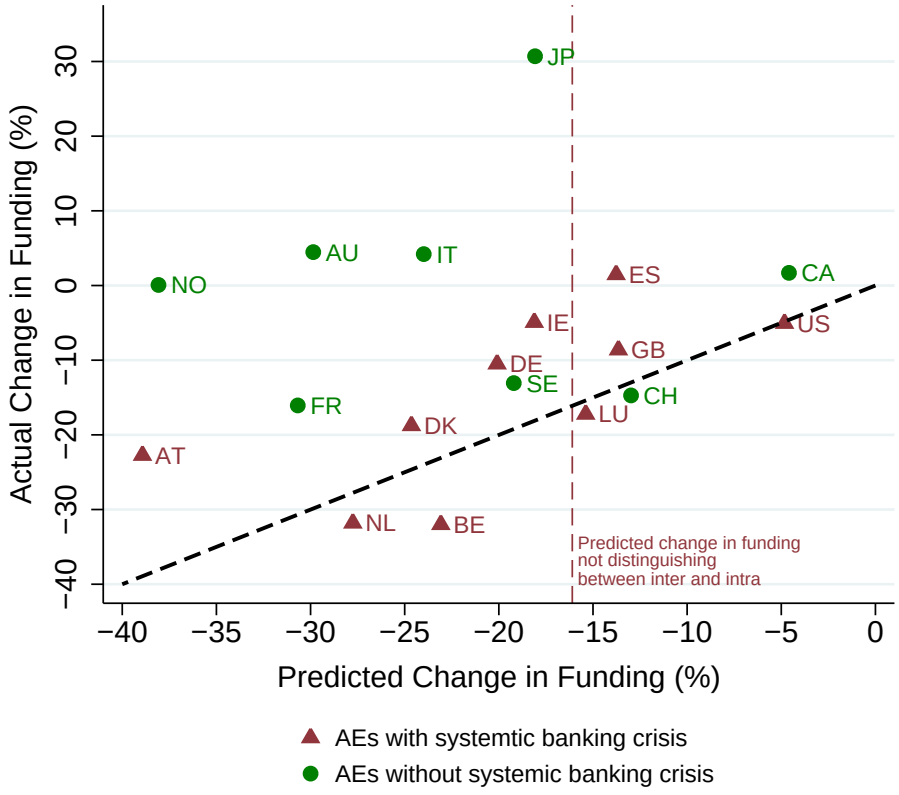


Figure 6: ***Funding Loss During the Global Financial Crisis.*** *This figure shows the predicted loss or gain in total cross-border bank-to-bank funding between 2008Q4 and 2009Q2 using the actual data on the VIX between 2008Q4 and 2009Q2, in combination with the statistically significant coefficients estimated for the VIX and ΔVIX, reported in Table 4. We also split the advanced market economies between those which experienced a systemic banking crisis during the global financial crisis and those which did not. The classification as to whether a country experienced a systemic banking crisis or not is based on the database of Laeven and Valencia (2013). Following the BIS country classification system: AT=Austria, AU=Australia, BE=Belgium, BR=Brazil, CA=Canada, CH=Switzerland, CL=Chile, DE=Germany, DK=Denmark, ES=Spain, FR=France, GB=United Kingdom, IE=Ireland, IN=India, IT=Italy, JP=Japan, KR=South Korea, LU=Luxembourg, NL=Netherlands, NO=Norway, SE=Sweden, TR=Turkey, US=United States. Data on banking flows are collected from the Bank for International Settlement's International Banking Statistics database. The sample period is from 1998Q1 to 2011Q4.*

Variable	Description	Source	Mean	Std.dev.	Min	Max	Obs.
Cross-Border Bank-to-Bank Flows							
Interbank Funding	Estimated exchange rate adjusted flow in cross-border interbank funding scaled by the stock of interbank funding (%).	BIS International Banking Statistics by Nationality (IBLN).	2.06	11.37	-23.03	33.35	1,178
Intragroup Funding	Estimated exchange rate adjusted flow in cross-border intragroup funding scaled by the stock of intragroup funding (%).	BIS International Banking Statistics by Nationality (IBLN).	4.20	16.88	-30.95	58.27	1,178
Intragroup Funding: Parent banks	Estimated exchange rate adjusted flow in parent cross-border intragroup funding scaled by the stock of parent intragroup funding (%).	BIS International Banking Statistics by Nationality (IBLN).	5.18	23.59	-40.73	100.0	964
Intragroup Funding: Foreign Affiliates	Estimated exchange rate adjusted flow in affiliate cross-border intragroup funding scaled by the stock of affiliate intragroup funding (%).	BIS International Banking Statistics by Nationality (IBLN).	4.00	19.43	-41.67	72.50	975
Global Risk Appetite							
VIX	Implied one-month volatility on the S&P 500 index. Monthly average of the log index value.	Bloomberg, authors' own calculations.	3.06	0.34	2.40	4.07	1,400
ΔVIX	Change in the average log index value.	Bloomberg, authors' own calculations.	0.00	0.22	-0.33	0.85	1,400
Theoretically Motivated Controls							
ROE	Average Return on Equity (Net Income/Total Equity).	Beck, Demirgüç-Kunt and Levine (2000)	9.45	11.62	-35.01	27.55	1,392
FX Return	% Change in log end-of-period nominal exchange rate. US dollar numéraire.	International Financial Statistics Database (IMF)	0.00	0.06	-0.21	0.62	1,400
ΔIR Spread	Change in the difference between domestic and the average of US and UK money market rates.	International Financial Statistics Database (IMF)	0.00	0.68	-2.35	1.78	1,346
Other Macroeconomic and Financial Controls							
Inflation	Annual inflation rate (%).	World Economic Outlook (IMF)	2.93	2.67	-0.33	13.24	1,400
GDP Growth	Quarterly GDP growth (%).	World Economic Outlook (IMF)	2.63	5.46	-11.74	19.45	1,398
ΔPublic Debt	Ratio to GDP (Annual, %).	World Economic Outlook (IMF)	0.09	1.17	-1.74	3.58	1,323
Stock Volatility	360-day standard deviation of returns on the national stock market index (Annual).	Global Financial Development Database (World Bank)	26.24	11.36	12.39	59.62	1,332

Table 1: ***Data Sources and Summary Statistics.***

Variable	Mean	Std.dev.	Min	Max	Obs.
Full sample					
Total external bank funding/total bank assets (%)	22.6	11.8	5.2	73.5	555
Total external bank funding/GDP (%)	89.2	192.6	1.1	1,132.8	1,186
Intragroup funding/total funding (%)	42.2	25.2	0.1	97.4	1,186
Intragroup funding of parents/intragroup funding (%)	56.8	30.2	0.0	100.0	1,004
Advanced Economies					
Total external bank funding/total bank assets (%)	22.6	11.8	5.2	73.5	555
Total external bank funding/GDP (%)	104.7	206.3	6.5	1,132.8	998
Intragroup funding/total funding (%)	45.6	25.2	0.1	97.4	998
Intragroup funding of parents/intragroup funding (%)	57.4	30.4	0.0	100.0	861
Emerging Market Economies					
Total external bank funding/GDP (%)	7.0	5.7	1.1	24.6	188
Intragroup funding/total funding (%)	24.3	16.9	0.1	66.0	188
Intragroup funding of parents/intragroup funding (%)	52.9	28.6	0.0	93.8	143

Table 2: ***Summary Data on the Breakdown of Interbank and Intragroup Funding.***

	(1)	(2)	(3)	(4)
	Interbank		Intragroup	
VIX	-5.22***	-5.20***	0.32	0.97
	(1.18)	(1.09)	(1.29)	(1.47)
ΔVIX	-3.94*	-4.04*	5.32**	4.09*
	(1.97)	(2.03)	(2.21)	(2.39)
ROE	0.13***	0.08**	0.18***	0.14**
	(0.03)	(0.03)	(0.04)	(0.05)
FX Return	-12.15**	-12.98***	-24.02**	-24.70**
	(5.16)	(3.98)	(8.71)	(9.37)
ΔIR Spread	1.09	0.93	-0.26	-0.98
	(0.66)	(0.70)	(1.18)	(1.25)
Inflation		-0.10		-0.74
		(0.32)		(0.58)
GDP Growth		0.15***		-0.08
		(0.05)		(0.09)
ΔPublic Debt		-0.73**		-0.13
		(0.32)		(0.51)
Stock Volatility		0.02		-0.08
		(0.04)		(0.08)
Constant	16.53***	15.86***	1.84	4.25
	(3.72)	(3.65)	(4.03)	(4.64)
Observations	1,142	1,088	1,142	1,088
R-squared	0.07	0.08	0.04	0.05
Countries	25	25	25	25

Table 3: ***Baseline Results.*** *In this Table we report the estimated parameter values from fixed-effects panel regressions. The dependent variable is the quarterly percentage change in either interbank or intragroup funding. In columns (1) and (2) we report results for interbank funding, while in columns (3) and (4) we do the same for intragroup funding. VIX is the quarterly average of the log VIX index, while* Δ *VIX is the quarterly change in the average level of the log VIX index. All control variables are discussed in Section 4.1 with summary statistics provided in Table 1. Standard errors, clustered at country level, are reported in brackets. *** is significant at the 1% level, ** at the 5% level and * at the 10% level. Data on banking flows are collected from the Bank for International Settlement's International Financial Statistics database. The sample period is from 1998Q1 to 2011Q4.*

	(1)	(2)
	Interbank	Intragroup
VIX	-4.14***	1.18
	(1.22)	(1.31)
VIX*EME	-7.40**	-1.31
	(2.77)	(5.97)
*VIX+VIX*EME*	*-11.54****	*-0.14*
p-value	*0.0001*	*0.9823*
ΔVIX	-3.37	5.23***
	(2.26)	(1.78)
ΔVIX*EME	-4.66	-9.06
	(4.22)	(8.87)
*ΔVIX+ΔVIX*EME*	*-8.03***	*-3.83*
p-value	*0.0346*	*0.6648*
ROE	0.10***	0.18***
	(0.03)	(0.04)
ROE*EME	-0.16	-0.90***
	(0.15)	(0.31)
*ROE+ROE*EME*	*-0.06*	*-0.72***
p-value	*0.6975*	*0.0275*
FX Return	-8.62**	-13.17
	(3.85)	(8.32)
FX Return*EME	-11.74	-63.19**
	(10.25)	(24.16)
*FX Return+FX Return*EME*	*-20.36***	*-76.36****
p-value	*0.0389*	*0.0020*
ΔIR Spread	1.96**	-2.40*
	(0.91)	(1.16)
ΔIR Spread*EME	-1.50	3.27*
	(1.16)	(1.70)
*ΔIR Spread+ΔIR Spread*EME*	*0.46*	*0.87*
p-value	*0.5631*	*0.5040*
Controls	Y	Y
Observations	1,088	1,088
R-squared	0.09	0.07
Countries	25	25

Table 4: ***Advanced and Emerging Economy Banking Systems.*** *In this Table we report the estimated parameter values from fixed-effects panel regressions. The dependent variable is the quarterly percentage change in either interbank or intragroup funding. In column (1) we report results for interbank funding, while in column (2) we do the same for intragroup funding. EME is a dummy variable which equals* **1** *if the banking system is in an emerging market economy and zero otherwise. VIX is the quarterly average of the log VIX index, while ΔVIX is the quarterly change in the average level of the log VIX index. Our control variables are discussed in Section 4.1 with summary statistics provided in Table 1. Standard errors, clustered at country level, are reported in brackets. *** is significant at the 1% level, ** at the 5% level and * at the 10% level. We include F-tests to determine if the effect of a variable on emerging economies is significant. Data on banking flows are collected from the Bank for International Settlement's International Financial Statistics database. The sample period is from 1998Q1 to 2011Q4.*

	(1)	(2)	(3)
	All countries	AEs with systemic banking crisis	AEs without systemic banking crisis
Share of intragroup funding	0.21**	0.34**	0.04
	(0.09)	(0.12)	(0.14)
Constant	-20.10***	-31.61***	-2.00
	(4.64)	(6.99)	(6.23)
Observations	23	10	8
R-squared	0.12	0.45	0.00

Table 5: ***Explaining Funding During the Global Financial Crisis.*** *In this Table we report the estimated parameter values from cross-sectional regressions. The dependent variable is the change in total (interbank plus intragroup) cross-border bank-to-bank funding to countries between 2008Q4 and 2009Q2. The right-hand-side variable is the share of intragroup funding as a percentage of total (interbank plus intragroup) cross-border bank-to-bank funding, measured at 2008Q3. In column (1) all 25 countries are included in the regression. In column (2) only the ten advanced economies having experienced a systemic banking crisis during 2008-09 as classified by Laeven and Valencia (2013) are included. Finally, in column (3) we only include advanced economies not classified as having experienced a systemic banking crisis during 2008-09. *** is significant at the 1% level, ** at the 5% level and * at the 10% level. Data on banking flows are collected from the Bank for International Settlement's International Financial Statistics database.*

	(1)	(2)	(3)	(4)
	Parents		Foreign Affiliates	
VIX	3.90*	4.69**	-1.81	-0.76
	(2.25)	(2.20)	(1.36)	(1.48)
VIX*EME		-8.86*		-6.84
		(4.99)		(5.47)
*VIX+VIX*EME*		*-4.17*		*-7.60*
p-value		*0.3808*		*0.1545*
ΔVIX	4.66	7.97*	2.52	1.92
	(4.17)	(4.05)	(2.83)	(3.08)
ΔVIX*EME		-27.12***		1.18
		(8.12)		(3.79)
*ΔVIX+ΔVIX*EME*		*-19.15****		*3.10*
p-value		*0.0092*		*0.2346*
ROE	0.23***	0.26***	0.09	0.12
	(0.06)	(0.06)	(0.10)	(0.10)
ROE*EME		-0.15		-1.06***
		(0.49)		(0.31)
*ROE+ROE*EME*		*0.11*		*-0.94****
p-value		*0.8265*		*0.0065*
FX Return	-35.09**	-38.36**	-8.44	-2.46
	(15.58)	(16.21)	(13.97)	(6.50)
FX Return*EME		24.96		-32.41
		(50.45)		(67.72)
*FX Return+FX Return*EME*		*-13.40*		*-34.87*
p-value		*0.7848*		*0.6067*
ΔIR Spread	-1.40	0.23	0.84	-2.34
	(1.89)	(1.50)	(1.21)	(1.83)
ΔIR Spread*EME		-2.22		5.67**
		(3.36)		(1.99)
*ΔIR Spread+ΔIR Spread*EME*		*-1.99*		*3.33****
p-value		*0.5255*		*0.0000*
Controls	Y	Y	Y	Y
Observations	919	919	922	922
R-squared	0.05	0.05	0.04	0.06
Countries	20	20	20	20

Table 6: ***Intragroup Funding: Flows to Parent and Foreign Affiliate Banks.*** *In this Table we report the estimated parameter values from fixed-effects panel regressions. The dependent variable is the quarterly percentage change in intragroup funding of either parent or foreign affiliate banks. In columns (1) and (2) we report results for parents banks, while in columns (3) and (4) we do the same for foreign affiliates. EME is a dummy variable which equals* **1** *if the banking system is in an emerging market economy and zero otherwise. VIX is the quarterly average of the log VIX index, while ΔVIX is the quarterly change in the average level of the log VIX index. Our control variables are discussed in Section 4.1 with summary statistics presented in Table 1. Standard errors, clustered at country level, are reported in brackets. *** is significant at the 1% level, ** at the 5% level and * at the 10% level. We include F-tests to determine if the effect of a variable on emerging economies is significant. Data on banking flows are collected from the Bank for International Settlement's International Financial Statistics database. The sample period is from 1998Q1 to 2011Q4.*

Panel A: Range of coefficients $\beta_{i,j,1}$				
VIX	Interbank:	-5.48***/ -4.75***	Intragroup:	0.61/ 1.52

Panel B: Individual country interaction coefficients ($\beta_{i,j,2}$)

	Interbank		Intragroup			Interbank		Intragroup	
		$\beta_{i,j,1}+\beta_{i,j,2}=0$		$\beta_{i,j,1}+\beta_{i,j,2}=0$			$\beta_{i,j,1}+\beta_{i,j,2}=0$		$\beta_{i,j,1}+\beta_{i,j,2}=0$
VIX*Austria	2.21*	-3.08***	-12.77***	-11.25***	VIX*Switzerland	-2.95***	-8.00***	-3.32***	-2.18*
	(1.12)		(1.14)			(0.94)		(1.09)	
VIX*Belgium	0.48	-4.74***	-2.08*	-1.01	VIX*UK	0.37	-4.85***	-1.60	-0.56
	(0.92)		(1.17)			(0.91)		(1.11)	
VIX*Cyprus	10.78***	5.39***	15.58***	16.27***	VIX*Australia	4.60***	-0.74	4.54***	5.37***
	(1.75)		(2.48)			(0.94)		(1.40)	
VIX*France	-4.75***	-9.69***	3.70***	4.46***	VIX*Canada	-1.24	-6.37***	-1.65	-0.59
	(0.86)		(1.01)			(0.96)		(1.07)	
VIX*Germany	3.46***	-1.91***	2.07*	2.94**	VIX*Japan	2.30*	-3.01***	7.18***	7.79***
	(0.90)		(1.02)			(1.14)		(1.43)	
VIX*Ireland	5.19***	-0.15	-0.63	0.36	VIX*US	-7.67***	-12.42***	-2.12*	-1.03
	(1.12)		(2.06)			(0.77)		(1.15)	
VIX*Italy	2.78***	-2.55***	-4.24***	-3.07**	VIX*Brazil	-7.79***	-12.71***	0.66	1.61
	(0.93)		(1.10)			(1.08)		(2.03)	
VIX*Luxemburg	-2.40**	-7.49***	-2.07*	-1.00	VIX*Chile	-3.04	-8.18***	20.51***	21.1***
	(0.92)		(1.16)			(2.02)		(2.53)	
VIX*Netherlands	4.85***	-0.56	3.58**	4.39***	VIX*India	-12.36***	-17.24***	-5.03***	-3.93***
	(1.01)		(1.41)			(0.95)		(1.39)	
VIX*Spain	4.69***	-0.76	-2.58**	-1.47	VIX*Turkey	-3.24**	-8.29***	4.04**	4.83***
	(0.84)		(1.08)			(1.23)		(1.80)	
VIX*Denmark	9.15***	3.67***	3.77**	4.62***	VIX*South Africa	-1.69	-6.89***	18.82***	19.78***
	(0.94)		(1.50)			(2.17)		(3.32)	
VIX*Norway	-1.83	-6.96***	-1.35	-0.33	VIX*Korea	-3.30***	-8.39***	-3.92***	-2.83
	(1.21)		(1.51)			(1.09)		(1.32)	
VIX*Sweden	0.76	-4.47***	-3.03**	-1.93					
	(1.10)		(1.35)						
Constant	Y		Y			Y		Y	
Controls	Y		Y			Y		Y	
Observations	1088		1088			1088		1088	
Countries	25		25			25		25	

Table 7: ***Excluding Individual Countries.*** *In this Table we report the estimated parameter values from fixed-effects panel regressions. The dependent variable is the quarterly percentage change in either interbank or intragroup funding. In columns (1) and (2) we report results for interbank funding, while in columns (3) and (4) we do the same for intragroup funding. VIX is the quarterly average of the log VIX index. In Panel A we report the range of coefficient estimates on $\beta_{i,1}$ from equation (8). In Panel B we report individual country estimates of the coefficient $\beta_{i,2}$ from equation (8). Our control variables are discussed in Section 4.1 with summary statistics presented in Table 1. Standard errors, clustered at country level, are reported in brackets. *** is significant at the 1% level, ** at the 5% level and * at the 10% level. We include F-tests to determine if the effect of the VIX is significant for a country. Data on banking flows are collected from the Bank for International Settlement's International Financial Statistics database. The sample period is from 1998Q1 to 2011Q4.*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Interbank					Intragroup				
	VXO	CS	Moody's	Glob. Imb.	TED	VXO	CS	Moody's	Glob. Imb.	TED
Risk	-3.50***	-0.45***	-2.61**	-0.77**	-0.40	0.85	0.35*	-0.76	0.95	0.15
	(1.14)	(0.15)	(1.15)	(0.35)	(0.36)	(1.23)	(0.17)	(1.66)	(0.56)	(0.55)
Risk*EME	-7.05***	-0.66*	-9.35***	-2.08**	-2.70**	0.94	0.53	3.11	-0.98	2.54
	(1.96)	(0.32)	(1.62)	(0.96)	(0.97)	(4.44)	(0.65)	(7.32)	(1.38)	(3.57)
*Risk+Risk*EME*	*-10.55****	*-1.11****	*-11.95****	*-2.85****	*-3.10****	*1.78*	*0.88*	*2.35*	*-0.04*	*2.70*
p-value	*0.0000*	*0.0023*	*0.0000*	*0.0051*	*0.0029*	*0.6865*	*0.1871*	*0.7364*	*0.9794*	*0.4731*
ΔRisk	-2.70	-0.26	-5.42*	-0.12	-3.34**	5.45***	0.38*	6.11**	0.57	4.58**
	(2.23)	(0.19)	(2.78)	(0.38)	(1.30)	(1.77)	(0.21)	(2.64)	(0.53)	(1.83)
ΔRisk*EME	-4.12	-0.02	-5.06	-0.98	4.13	-6.41	0.47	-6.01	0.58	-10.18*
	(3.39)	(0.41)	(3.83)	(0.67)	(2.85)	(8.28)	(0.83)	(14.87)	(1.44)	(5.14)
*ΔRisk+ΔRisk*EME*	*-6.83***	*-0.28*	*-10.48****	*-1.09**	*0.79*	*-0.96*	*0.85*	*0.10*	*1.15*	*1.21*
p-value	*0.0232*	*0.4499*	*0.0077*	*0.0656*	*0.7848*	*0.9092*	*0.3253*	*0.9948*	*0.4166*	*0.2823*
ROE	0.09***	0.10***	0.09***	0.12***	0.12***	0.15**	0.15***	0.13**	0.14***	0.13**
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
FX Return	-11.72***	-13.44***	-9.34*	-13.58***	-13.63***	-25.12**	-27.03**	-28.09***	-21.22**	-26.72***
	(3.91)	(4.25)	(4.86)	(4.58)	(4.46)	(9.63)	(11.24)	(9.53)	(9.19)	(8.90)
ΔIR Spread	1.09	1.30*	1.05	0.96	0.30	-0.95	-1.60	-0.85	-0.74	-0.51
	(0.67)	(0.73)	(0.70)	(0.76)	(0.65)	(1.30)	(1.26)	(1.39)	(1.29)	(1.25)
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	1,088	1,088	1,088	1,088	1,088	1,088	1,088	1,088	1,088	1,088
R-squared	0.09	0.08	0.08	0.08	0.08	0.05	0.05	0.05	0.05	0.06
Countries	25	25	25	25	25	25	25	25	25	25

Table 8: ***Alternative Measures of Global Risk.*** *In this Table we report the estimated parameter values from fixed-effects panel regressions. The dependent variable is the quarterly percentage change in either interbank or intragroup funding. In columns (1) to (5) we report results for interbank funding, while in columns (6) to (10) we do the same for intragroup funding. EME is a dummy variable which equals* **1** *if the banking system is in an emerging market economy and zero otherwise. We describe the alternative risk measures in Section 7.2. Our control variables are discussed in Section 4.1 with summary statistics provided in Table 1. Standard errors, clustered at country level, are reported in brackets. *** is significant at the 1% level, ** at the 5% level and * at the 10% level. We include F-tests to determine if the effect of a variable on emerging economies is significant. Data on banking flows are collected from the Bank for International Settlement's International Financial Statistics database. The sample period is from 1998Q1 to 2011Q4.*

	(1)	(2)	(3)	(4)
	Exclude Crisis		Exclude Crisis and Aftermath	
	Interbank	Intragroup	Interbank	Intragroup
VIX	-4.38***	1.65	-4.90***	0.53
	(1.52)	(1.38)	(1.51)	(1.19)
VIX*EME	-4.31	3.21	-1.67	-0.01
	(2.79)	(8.37)	(2.55)	(10.62)
*VIX+VIX*EME*	*-8.69****	*4.86*	*-6.57****	*0.53*
p-value	*0.0006*	*0.5770*	*0.0028*	*0.9609*
ΔVIX	0.36	6.43***	-1.12	4.92**
	(2.40)	(1.82)	(2.94)	(2.34)
ΔVIX*EME	0.58	-4.75	-4.15	12.97
	(5.96)	(5.26)	(9.06)	(9.65)
*ΔVIX+ΔVIX*EME*	*0.94*	*1.68*	*-5.27*	*17.89**
p-value	*0.8654*	*0.7346*	*0.5514*	*0.0653*
ROE	0.06*	0.14***	0.02	0.11
	(0.04)	(0.05)	(0.04)	(0.07)
ROE*EME	-0.13	-0.73**	-0.08	-0.70**
	(0.14)	(0.33)	(0.18)	(0.28)
*ROE+ROE*EME*	*-0.06*	*-0.59**	*-0.05*	*-0.59***
p-value	*0.6519*	*0.0757*	*0.7638*	*0.0369*
FX Return	-3.77	-11.49	-8.32	-23.09*
	(5.35)	(9.34)	(6.06)	(12.00)
FX Return*EME	-8.43	-63.85**	-21.71	-52.72**
	(19.04)	(25.07)	(16.89)	(22.80)
*FX Return+FX Return*EME*	*-12.19*	*-75.34****	*-30.03**	*-75.80****
p-value	*0.5048*	*0.0033*	*0.0616*	*0.0011*
ΔIR Spread	1.00	-2.80*	0.91	-2.68*
	(0.84)	(1.46)	(0.86)	(1.39)
ΔIR Spread*EME	-0.22	3.88**	-0.89	4.38**
	(1.29)	(1.71)	(1.58)	(1.63)
*ΔIR Spread+ΔIR Spread*EME*	*0.78*	*1.08*	*0.02*	*1.70*
p-value	*0.4363*	*0.3163*	*0.9870*	*0.1307*
Controls	Y	Y	Y	Y
Observations	1,017	1,017	784	784
R-squared	0.07	0.07	0.07	0.06
Countries	25	25	23	23

Table 9: ***The Global Financial and European Sovereign-Debt Crises.*** *In this Table we report the estimated parameter values from fixed-effects panel regressions. The dependent variable is the quarterly percentage change in either interbank or intragroup funding. In columns (1) and (2) we exclude the period 2008Q4-2009Q2 from the sample, while in columns (3) and (4) we exclude the entire post-2008Q3 period. EME is a dummy variable which equals* **1** *if the banking system is in an emerging market economy and zero otherwise. VIX is the quarterly average of the log VIX index, while ΔVIX is the quarterly change in the average level of the log VIX index. Our control variables are discussed in Section 4.1 with summary statistics presented in Table 1. Standard errors, clustered at country level, are reported in brackets. *** is significant at the 1% level, ** at the 5% level and * at the 10% level. We include F-tests to determine if the effect of a variable on emerging economies is significant. Data on banking flows are collected from the Bank for International Settlement's International Financial Statistics database. The sample period is from 1998Q1 to 2011Q4.*

Appendix

Table A1. Aggregate Cross-Border Bank-to-Bank Funding
We run our baseline specifications as originally presented in Table 3. The left-hand-side variable is the aggregate cross-border bank flow (summation of quarterly interbank and intragroup flows) as a proportion of the previous quarter stock of total cross-border bank-to-bank funding. The results confirm the main findings of Bruno and Shin (2014). One discrepancy is the ΔVIX coefficient, which we find to be consistently insignificant for aggregate flows. This finding is likely due to sample differences, as we are confined to investigating 25 banking systems which report both interbank and intragroup flows to the BIS. The additional banking systems analyzed by Bruno and Shin (2014) are primarily emerging market economies and, as we demonstrate in our main results, emerging economy banking systems have a higher propensity to lose funding given an increase in the VIX index.

Table A2. Interbank Funding: Parents and Foreign Affiliate Banks
The table replicates the disaggregated results of Table 6 but for interbank funding.

Table A3. Correlations
We present correlations between the main dependent and independent variables.

Table A4. Summary Statistics for the Alternative Measures of Global Risk
We report summary statistics for the five alternative measures of global risk: the VXO index, Credit Suisse Global Risk Appetite Index, the corporate bond spread between AAA and BAA rated securities provided by Moody's, the TED spread, and the Global Imbalance Risk Factor from Della Corte, Riddiough and Sarno (2014).

Table A5. Correlations Between the Alternative Measures of Global Risk
We report correlations between our five alternative measures of global risk: the VXO index, Credit Suisse Global Risk Appetite Index, the corporate bond spread between AAA and BAA rated securities provided by Moody's, the TED spread, and the Global Imbalance Risk Factor from Della Corte, Riddiough and Sarno (2014).

Table A6. Example Calculation
We present an example calculation for the scenario analysis described in section 5.2.

	(1)	(2)	(3)
	Interbank and Intragroup		
VIX	-2.62***	-2.39***	-1.50*
	(0.77)	(0.85)	(0.83)
VIX*EME			-6.37***
			(1.89)
*VIX+VIX*EME*			*-7.87****
p-value			*0.0001*
ΔVIX	-0.25	-0.53	0.24
	(1.40)	(1.43)	(1.59)
ΔVIX*EME			-5.68**
			(2.60)
*ΔVIX+ΔVIX*EME*			*-5.44***
p-value			*0.0139*
ROE	0.15***	0.11***	0.13***
	(0.02)	(0.03)	(0.03)
ROE*EME			-0.33*
			(0.16)
*ROE+ROE*EME*			*-0.19*
p-value			*0.2357*
FX Return	-12.32***	-11.94***	-6.89*
	(4.32)	(3.73)	(3.57)
FX Return*EME			-18.73*
			(9.81)
*FX Return+FX Return*EME*			*-25.62****
p-value			*0.0069*
ΔIR Spread	0.51	0.24	0.70
	(0.40)	(0.42)	(0.50)
ΔIR Spread*EME			-0.43
			(0.59)
*ΔIR Spread+ΔIR Spread*EME*			*0.27*
p-value			*0.4424*
Controls	N	Y	Y
Observations	1,142	1,088	1,088
R-squared	0.09	0.10	0.12
Countries	25	25	25

Table A1: Aggregate Cross-Border Bank-to-Bank Funding. *In this Table we report the estimated parameter values from fixed-effects panel regressions. The dependent variable is the quarterly percentage change in aggregate cross-border bank-to-bank funding. EME is a dummy variable which equals* **1** *if the banking system is in an emerging market economy and zero otherwise. VIX is the quarterly average of the log VIX index, while* VIX Change *is the quarterly change in the average of the log VIX index. Our control variables are discussed in Section 4.1 with summary statistics provided in Table 1. Standard errors, clustered at country level, are reported in brackets. *** is significant at the 1% level, ** at the 5% level and * at the 10% level. We include F-tests to determine if the effect of a variable on emerging economies is significant. Data on banking flows are collected from the Bank for International Settlement's International Financial Statistics database. The sample period is from 1998Q1 to 2011Q4.*

	(1)	(2)	(3)	(4)
	Parents		Foreign Affiliates	
VIX	-3.96***	-3.24**	-7.32***	-6.45***
	(1.33)	(1.34)	(1.75)	(1.73)
VIX*EME		-5.20		-9.96
		(3.68)		(6.36)
*VIX+VIX*EME*		*-8.44***		*-16.40***
p-value		*0.0243*		*0.0190*
ΔVIX	-5.08*	-5.03*	-1.56	-0.04
	(2.44)	(2.73)	(3.14)	(3.30)
ΔVIX*EME		-0.88		-13.85
		(3.64)		(9.95)
*ΔVIX+ΔVIX*EME*		*-5.91***		*-13.89*
p-value		*0.0298*		*0.1530*
ROE	0.12***	0.14***	0.02	0.06
	(0.03)	(0.03)	(0.05)	(0.04)
ROE*EME		-0.15		-0.26
		(0.18)		(0.33)
*ROE+ROE*EME*		*-0.01*		*-0.20*
p-value		*0.9559*		*0.5483*
FX Return	-13.55**	-8.25	-1.86	3.60
	(5.35)	(5.27)	(7.54)	(8.61)
FX Return*EME		-22.20*		-15.03
		(11.78)		(13.87)
*FX Return+FX Return*EME*		*-30.45****		*-11.43*
p-value		*0.0067*		*0.2737*
ΔIR Spread	0.78	1.26	-0.55	3.42**
	(0.85)	(1.49)	(1.34)	(1.47)
ΔIR Spread*EME		-0.50		-6.01***
		(1.75)		(1.56)
*ΔIR Spread+ΔIR Spread*EME*		*0.76*		*-2.59****
p-value		*0.4191*		*0.0006*
Controls	Y	Y	Y	Y
Observations	919	919	922	922
R-squared	0.07	0.08	0.06	0.07
Countries	20	20	20	20

Table A2: Interbank Funding: Parents and Foreign Affiliate Banks. *In this Table we report the estimated parameter values from fixed-effects panel regressions. The dependent variable is the quarterly percentage change in interbank funding to either parent or foreign affiliate banks. In columns (1) and (2) we report results for parents banks, while in columns (3) and (4) we do the same for foreign affiliates. EME is a dummy variable which equals* **1** *if the banking system is in an emerging market economy and zero otherwise. VIX is the quarterly average of the log VIX index, while ΔVIX is the quarterly change in the average level of the log VIX index. Our control variables are discussed in Section 4.1 with summary statistics presented in Table 1. Standard errors, clustered at country level, are reported in brackets. *** is significant at the 1% level, ** at the 5% level and * at the 10% level. We include F-tests to determine if the effect of a variable on emerging economies is significant. Data on banking flows are collected from the Bank for International Settlement's International Financial Statistics database. The sample period is from 1998Q1 to 2011Q4.*

Variables	*Inter* Fund	*Intra* Fund.	VIX	VIX Change	ROE	ER Dep.	ΔIR Spread	Inflation	Growth	Public Debt	Stock Vol.
Interbank Funding	1.000										
Intragroup Funding	-0.071	1.000									
	(0.015)										
VIX	-0.172	-0.059	1.000								
ΔVIX	-0.020	0.044	-0.320	1.000							
Return on Equity	0.166	0.135	-0.313	-0.037	1.000						
FX Return	-0.090	-0.084	0.143	0.068	-0.098	1.000					
ΔIR Spread	-0.001	-0.032	0.122	0.022	-0.065	0.060	1.000				
Inflation	0.010	0.020	0.109	-0.053	0.027	0.100	-0.235	1.000			
GDP Growth	0.162	0.009	-0.243	0.029	0.175	-0.078	-0.067	0.072	1.000		
ΔPublic Debt	-0.096	-0.056	0.138	-0.137	-0.272	0.007	-0.039	-0.202	-0.125	1.000	
Stock Volatility	-0.049	-0.028	0.265	-0.112	-0.164	0.091	-0.179	0.359	0.044	0.349	1.000

Table A3: Correlations.

Variable	Mean	Std.dev.	Min	Max	Obs.
VXO	3.09	0.37	2.36	4.12	1,400
CS Global Risk Appetite Index	-0.33	2.70	-6.31	4.69	1,400
Moody's Spread	-0.01	0.34	-0.53	1.11	1,400
Global Imbalance Risk Factor	-0.26	1.32	-3.06	3.84	1,400
TED Spread	3.74	0.71	2.52	5.57	1,400

Table A4: Summary Statistics for the Alternative Measures of Global Risk. *Moody's Spread refers to the spread between AAA and BAA rated securities. The Global Imbalance Risk factor is taken from Della Corte, Riddiough and Sarno (2014). Data on the TED Spread is collected from Bloomberg. See section 6.2 for further details.*

Variable	VIX	VXO	CS	Moody's	GI Risk	TED
VIX	1.000					
VXO	0.989	1.000				
CS Global Risk Appetite Index	0.692	0.701	1.000			
Moody's Spread	0.562	0.522	0.376	1.000		
Global Imbalance Risk Factor	0.264	0.239	0.083	0.115	1.000	
TED Spread	0.292	0.258	0.171	0.201	0.267	1.000

Table A5: Correlations Between the Alternative Measures of Global Risk. *Moody's Spread refers to the spread between AAA and BAA rated securities. The Global Imbalance Risk factor is taken from Della Corte, Riddiough and Sarno (2014). Data on the TED Spread is collected from Bloomberg. See section 6.2 for further details.*

	Banking System A			Banking System C		
Quarter	Interbank	Intragroup	Total	Interbank	Intragroup	Total
2008 Q3	80	20	100	20	80	100
2008 Q4	62.3	20.5	82.7	15.6	81.9	97.5
2009 Q1	49.9	20.5	70.4	12.5	81.9	94.4
2009 Q2	40.1	20.5	60.5	10	81.9	91.9

Table A6: Example Calculation (Section 5.2). *The VIX rises from 25 to 45 and remains there for two quarters. Based on the significant coefficients in Table 4 the change in total bank-to-bank funding in 2008Q4 for an advanced economy that has a pre-crisis stock of interbank funding of 80 is calculated as:* $80 \times [1 + (-0.0520 \times log(45) + -0.0404 \times log(45/25)] + 20 \times [1 + (0.0409 \times log(45/25))] = 82.7$. Then for 2009Q1: $62.3 \times [1 + (-0.0520 \times log(45))] + 20.5 = 70.4$.