Capital Flows, Cross-Border Banking and Global Liquidity*

Valentina Bruno
bruno@american.edu

Hyun Song Shin
hsshin@princeton.edu

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Abstract

This paper develops a model of global liquidity with international banks as the carriers of liquidity conditions across borders. Global banks raise wholesale funding from financial centers which is deployed globally through centralized portfolio allocation decisions from headquarters. As the shadow value of bank funding is equalized across regions, permissive credit conditions in financial centers are transmitted across borders. We derive closed-form solutions for banking sector capital flows and domestic private credit in the recipient economies and find empirical support for the key predictions.

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1 Introduction

The renewed surge in capital flows to emerging economies in the aftermath of the global financial crisis has ignited a lively debate on the nature of "global liquidity" and its transmission across borders. Low interest rates and permissive monetary policy pursued by advanced economy central banks are often cited in the press and popular commentary[1] as a key factor in driving the capital flows. One of the tasks in our paper is to shed light on the validity of this claim.

Our paper develops a theory of global liquidity centered on the fluctuating leverage of cross-border banks as the channel through which permissive financial conditions are transmitted globally. We then subject the key predictions to an empirical investigation.

Our theory draws on two themes. The first is the role of financial intermediaries in driving fluctuations in risk premiums and financial conditions, especially in connection with the growing use of wholesale (or market-based) bank funding. When credit is growing rapidly, the core funding such as household deposits available to the banking sector is likely to be insufficient to finance the rapid growth in new lending. Other sources of wholesale (or "non-core") funding is then tapped to finance bank lending. Global banks intermediate such funding, and the composition of their liabilities can be expected to reflect the state of the financial cycle and risk premiums ruling in the financial system. Although banking sector flows are just one component of overall capital flows, it is a procyclical component that plays a prominent role in transmitting financial conditions. Figure 1 is a chart from a recent issue of the IMF's Global Financial Stability Report showing capital flows to 41 open emerging and advanced economies disaggregated into the four main categories of capital flows. We see that aggregate FDI flows are steady and portfolio equity flows are small in net terms. However, banking sector flows display the signature procyclical pattern of surging during the boom, only to change sign abruptly and surge out with the deleveraging of the banking sector. The downward pointing bar in 2008Q4 is particularly striking.

The second element of our theory is the role of interlocking claims and obligations in trans-

[1] See, for instance, the full page feature in the *Financial Times* entitled "Carried Away", April 30th, 2010.

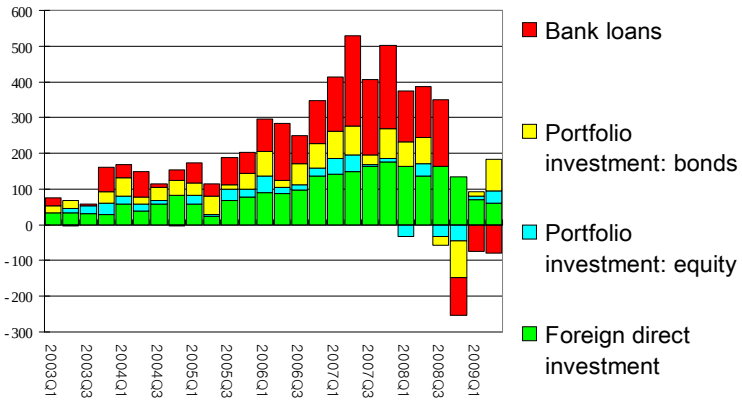

Figure 1. Categories of capital flows to 41 open emerging and advanced economies (in billions of dollars) (Source: IMF GFSR, April 2010, p. 123)

mitting credit availability conditions across borders. In a financial system with interlocking claims and obligations, one party's obligation is another party's asset. When global banks apply more lenient conditions on local banks, the more lenient credit conditions are transmitted to the recipient economy. In this way, more permissive liquidity conditions in the sense of greater availability of credit will be transmitted across borders through the interactions of global and local banks.

Understanding the institutional backdrop for global banking and the pivotal role of the U.S. dollar is important for the understanding of global liquidity. As well as being the world's most important reserve currency and an invoicing currency for international trade, the US dollar is the funding currency of choice for global banks. A recent BIS (2010) study notes that as of September 2009, the United States hosted the branches of 161 foreign banks who collectively raised over $1 trillion dollars' worth of wholesale bank funding, of which $645 billion was channeled for use by their headquarters. Money market funds in the United States are an important source of wholesale bank funding for global banks. Baba, McCauley and Ramaswamy (2009) note that by mid-2008, over 40% of the assets of U.S. prime money market funds were short-term obligations of foreign banks, with the lion's share owed by European banks.

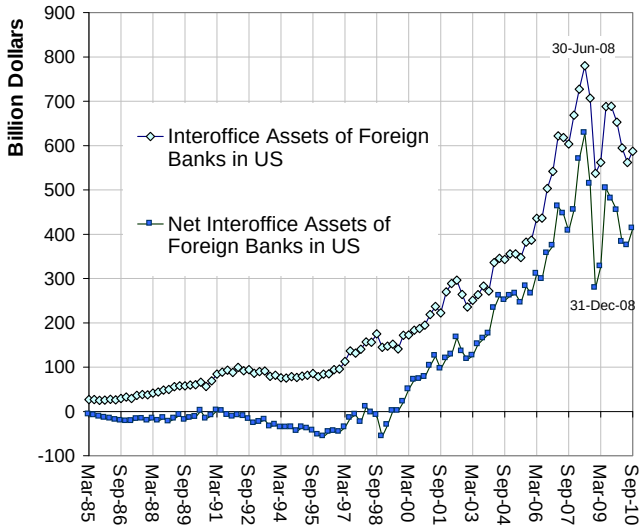

Figure 2. Interoffice assets of foreign bank in the United States (Source: Federal Reserve, series on "Assets and Liabilities of U.S. Branches and Agencies of Foreign Banks")

Even in *net terms*, foreign banks have been channeling large amounts of dollar funding to head office. That is, the funding channeled to head office is much larger than the funding received by the branch from head office. The BIS (2010) study finds that foreign bank branches had a net positive interoffice position in September 2009 amounting to $468 billion vis-à-vis their headquarters. Figure 2 plots the interoffice assets of foreign bank branches in the U.S. together with the net interoffice series. Interoffice assets increased steeply in the last two decades, saw a sharp decline in 2008, but bounced back in 2009. Net interoffice assets were negative in the 1980s and most of the 90s, but in 1999, net interoffice assets surged into positive territory and increased steeply thereafter.

Some of the funds channeled to headquarters may be redirected to the US to finance the purchase of mortgage-backed securities and other assets. However, as noted by the BIS (2010) report, many banks use a centralized funding model in which available funds are deployed globally through a centralized portfolio allocation decision.[2] At the margin, the shadow value

[2]Cetorelli and Goldberg (2009, 2010) provide extensive evidence that internal capital markets serve to real-

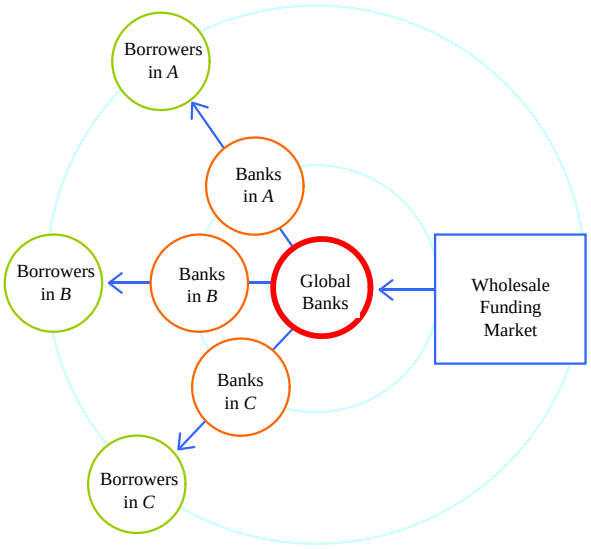

Figure 3. Structure of cross-border banking

of bank funding will be equalized across regions through the portfolio decisions of the global banks, so that global banks become carriers of dollar liquidity across borders. The role of the US dollar as the funding currency for global banking is key to understanding both the expansion phase of the financial cycle, as well as the acute dollar shortage that ensues in the subsequent reversal.[3]

The role of global banks highlights the importance of *gross* capital flows in influencing credit conditions, as emphasized by Forbes and Warnock (2011) and Borio and Disyatat (2011). Whereas net flows and the net external asset positions of countries are important for assessing the long-run sustainability of the current account[4], they may not be informative about credit conditions. European banks have played a key role in providing US dollar intermediation capacity, raising wholesale funds in the US and reinvesting it in US mortgage backed securities.

locate funding within global banking organizations.

[3]See McGuire and von Peter (2009) for an account of the dollar shortage in global banking in the recent financial crisis.

[4]See Lane and Milesi-Ferretti (2007) and Gourinchas and Rey (2007) and the post-crisis updated evidence in Gourinchas, Govillot and Rey (2010)

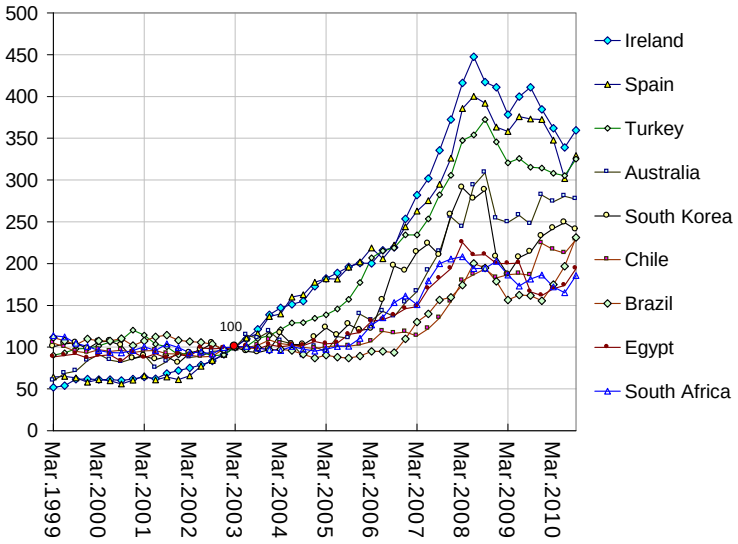

Figure 4. External claims (loans and deposits) of BIS reporting country banks on borrowers in countries listed. The series are normalized to 100 in March 2003 (Source: BIS Locational Banking Statistics, Table 7A)

However, since the eurozone has a roughly balanced current account while the UK is actually a deficit country, their collective *net capital flows* vis-à-vis the United States do not reflect the influence of their banks in setting overall credit conditions in the US.

The structure of the global banking system examined in our paper can be sketched in Figure 3. Global banks occupy the central position in the system, and supply cross-border funding to regional banks, who in turn provide private credit to firms and households in their respective regions. The empirical counterpart to the link from the global bank to the regional banks in Figure 3 can be found in the Bank for International Settlements (BIS) banking statistics.

Figure 4 plots the time series of the claims of the BIS reporting country banks on borrowers in countries listed on the right. The series have been normalized to equal 100 in March 2003. Although the borrowers have wide geographical spread, ranging from Australia, Chile, Korea and Turkey, there is a remarkable degree of synchronization in the boom in cross-border lending before the recent financial crisis.

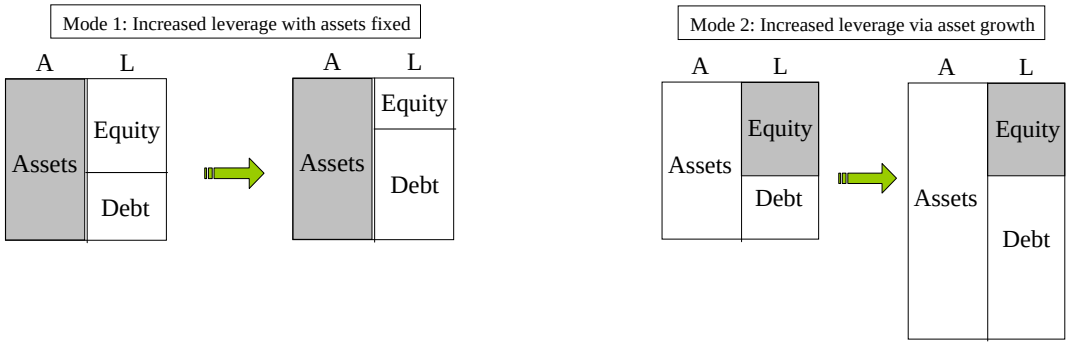

Figure 5. **Two Modes of Leveraging Up.** In the left panel, the firm keeps assets fixed but replaces equity with debt. In the right panel, the firm keeps equity fixed and increases the size of its balance sheet.

The run-up in cross-border lending in Figure 4 closely mirrors the increase in wholesale funding raised by the global banks in Figure 2. In effect, Figure 2 reflects the liabilities side of global banks' balance sheets, while Figure 4 gives (a small part of) the asset side of global banks' balance sheets. This relationship will be examined as part of our empirical investigation.

We model the interaction of global and local banks through a "double decker" model of credit supply where the liabilities of local banks serve as the assets of the global banks, and the total cross-border capital flows through the banking sector is the result of the market clearing condition between the *demand* for wholesale (non-core) funding by the local banks and the *supply* of non-core funding by the global banks. Calvo, Leiderman and Reinhart (1996) distinguished the "push" and "pull" factors that drive capital flows into emerging economies. In our model, by solving explicitly for the demand and supply functions for non-core wholesale funding, we can quantify the relative importance of the "push" and "pull" factors in driving capital flows.

Our model of credit supply is the flip side of a credit risk model where lending expands to fill up any spare balance sheet capacity when measured risks are low. In textbook discussions of corporate financing decisions, the set of positive net present value (NPV) projects is often taken as being exogenously given, with the implication that the size of the balance sheet is fixed. Leverage increases by substituting equity for debt, such as through an equity buy-back financed by a debt issue, as depicted by the left hand panel in Figure 5.

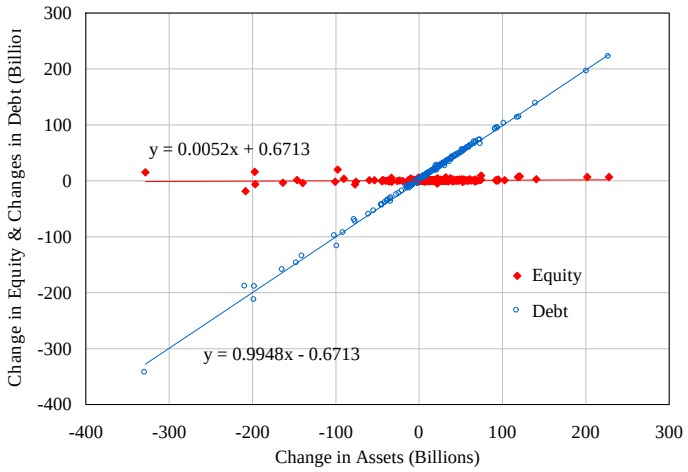

Figure 6. Scatter chart of $\{(\Delta A_{it}, \Delta E_{it}), (\Delta A_{it}, \Delta D_{it})\}$ of Five Wall Street Investment Banks (Source: Adrian and Shin (2008))

However, the left hand panel in Figure 5 turns out not to be a good description of the way that the banking sector leverage varies over the financial cycle. The distinguishing feature of the banking sector leverage cycle is that leverage fluctuates through fluctuations in the total size of the balance sheet with equity being the pre-determined variable. Hence, leverage and total assets tend to move in lock-step, as depicted in the right hand panel of Figure 5, as described by Adrian and Shin (2008, 2010).

Figure 6 is an illustration of the balance sheet management of the Wall Street investment banks from 1994 to 2010[5]. It plots the pairs of points $(\Delta A_{it}, \Delta E_{it})$ and $(\Delta A_{it}, \Delta D_{it})$, where ΔA_{it} is the (dollar) change in assets of bank i in quarter t, and ΔD_{it} and ΔE_{it} are the corresponding changes in the debt and equity of bank i in quarter t. Figure 6 shows that every dollar's increase in assets is financed with debt, while equity remains close to unchanged. Our model of bank credit supply below is faithful to this empirical feature of bank balance sheet management, where asset increases are driven by lower credit risk and the corresponding increase in "balance

[5]There are initially five at the beginning of the sample (Bear Stearns, Goldman Sachs, Lehman Brothers, Merrill Lynch and Morgan Stanley) but only Goldman Sachs and Morgan Stanley are included by the end of the sample period).

sheet capacity". For risk-neutral profit maximizing banks, the balance sheet constraint binds all the time, so that in periods of low measured risks, balance sheets must be large enough so that the risk constraint binds *in spite of* the low measured risks. The focus on the up-phase of the cycle in addition to the crisis dynamics distinguishes our approach from macro models of financial frictions that focus on constraints that keep lending inefficiently low and amplify crises in the downswing.[6]

By drawing attention to the expansion phase of bank lending, our theory is in the spirit of Borio and Disyatat (2011), who coined the term "excess elasticity" to describe the tendency of the banking system to expand when financial constraints are relaxed. We show how risk premiums in the capital recipient economy become compressed with increased capital inflows, although our model is not sufficiently refined to address issues of the optimal level of risk premium or quantity of credit.

The closed form solution for capital inflows in the recipient economy takes the form:

$$\begin{array}{c}\text{Total capital inflow} \\ \text{in banking sector}\end{array} = \frac{\text{Weighted bank capital (regional + global)}}{1 - \text{ spread} \times \begin{array}{c}\text{regional} \\ \text{leverage}\end{array} \times \begin{array}{c}\text{global} \\ \text{leverage}\end{array}} \tag{1}$$

where leverage is normalized to lie between 0 and 1. We know from Adrian and Shin (2008, 2010a) that the VIX index of implied volatility in equity index options is a good measure of the underlying Value-at-Risk measures that drive bank leverage, so that the VIX index can be predicted to play a pivotal role in fluctuations in capital flows. We find in our empirical investigation that the VIX index does, indeed, perform remarkably well as an explanatory variable both for cross-border capital flows in the banking sector as well as for domestic private credit in the recipient economy, echoing the earlier findings of Forbes and Warnock (2011). Our approach also complements macro business cycle studies such as Gourio, Siemer and Verdelhan (2010) and Adrian, Estrella and Shin (2010), who show that shocks to risk can generate macro

[6]See Devereux and Yetman (2010), Bianchi and Mendoza (2010), Dedola and Lombardo (2009) and Bacchetta and van Wincoop (2010) for alternative models of financial frictions in the downturn motivated by the recent financial crisis.

time series that match many of the stylized facts.

Our empirical investigation proceeds in three steps, in line with the three links in the radiating chain of Figure 3. First, we show that the funding decisions of global banks conform closely to the VIX index. Adrian and Shin (2008, 2010a) showed that repo financing of the Wall Street investment banks is explained by the VIX. Our results here suggest that European global banks that raise wholesale funding in the US dance to the same tune.

For the second link in the chain in Figure 3, we show that the VIX index and interoffice assets are highly significant in explaining banking sector capital flows, confirming the impact of fluctuations in bank leverage. VIX and the growth in interoffice assets remain significant even at the third (and final) stage of the radiating chart in Figure 3 for domestic private credit growth.

Taken together, our results suggest that global liquidity is a meaningful concept, explaining both the growth in private credit in recipient countries and cross-border lending. The VIX index is a key indicator of global liquidity due to its close association with banking sector leverage. The driving force behind capital flows turns out to be the leverage cycle of the global banks.

The outline of the paper is as follows. We begin by outlining our theoretical framework for the determination of global liquidity by formalizing a "double-decker" model of credit supply of the international banking system. We derive closed form solutions for total non-core funding of the global banks, banking sector capital flows and domestic private credit. By using the closed form solutions, we lay out the empirical hypotheses with an emphasis on the implications of the corporate finance of banking and the role of risk appetite and balance sheet capacity. The empirical investigation follows next, where the key predictions are put to the test. We conclude with an overview of some of the implications for the measurement of global liquidity.

2 Model of Global Banking

We begin by outlining the structure of cross-border banking in our model. The notation is summarized in Figure 7. The regional banks provide private credit (denoted C) to local

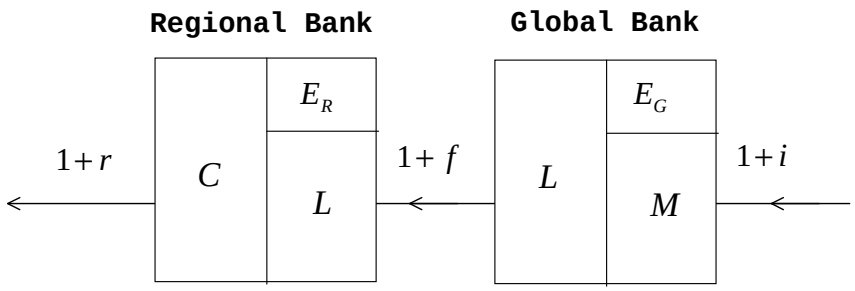

Figure 7. Regional and global bank balance sheets

borrowers at the rate $1 + r$. This private credit is funded by cross-border liabilities (denoted by L) drawn from the global banks at the funding rate $1 + f$. For the global banks, the cross-border lending L appears on the asset side of the balance sheet, and the funding rate $1 + f$ is the rate earned on its assets. The global banks finance themselves by drawing on wholesale money market funds M at the interest rate $1+i$. The equity of the regional bank is denoted by E_R while the equity of the global bank is denoted by E_G. As we will see shortly, our model has an aggregation property across banks, so that E_R and E_G can be interpreted as the aggregate banking sector capital of the regional banks and global banks, respectively.[7]

In our model, the exogenous variables are the equity terms E_R and E_G and the funding rate i for the global banks, which we assume is fixed by the Federal Reserve. The other variables will be solved within the model.

2.1 Regional Banks

We first consider the credit supply decision of a regional bank. Each regional bank has a well diversified loan portfolio consisting of loans to many borrowers. Credit risk follows the Vasicek (2002) model, which is the model adopted by the Basel Committee as the basis for the Basel capital requirements (BCBS (2005)). Borrower j repays the loan when $Z_j > 0$, where Z_j is the

[7]In our model, we will abstract away from the fluctuations in exchange rates and conduct our analysis as if the global and regional banks use the same currency. However, it should be borne in mind that fluctuations in risk premiums will have an impact on exchange rate movements (see Adrian, Etula and Shin (2009)).

random variable given by

$$Z_j = -\Phi^{-1}(\varepsilon) + \sqrt{\rho}Y + \sqrt{1-\rho}X_j \tag{2}$$

where $\Phi(.)$ is the c.d.f. of the standard normal, ε is the probability of default on the loan and Y and $\{X_j\}$ are mutually independent standard normal random variables. Y is the common risk factor while each X_j are the idiosyncratic component of credit risk for the particular borrower j. The parameter $\rho \in (0,1)$ is the weight given to the common factor Y. To verify that ε is the probability of default, note that

$$\begin{aligned}
\Pr(Z_j < 0) &= \Pr\left(\sqrt{\rho}Y + \sqrt{1-\rho}X_j < \Phi^{-1}(\varepsilon)\right) \\
&= \Phi\left(\Phi^{-1}(\varepsilon)\right) = \varepsilon
\end{aligned}$$

Private credit extended by the bank is C at interest rate r so that the notional value of assets (the amount due to the regional bank at date 1) is $(1+r)C$. Conditional on Y, defaults are independent. Taking the limit where the number of borrowers becomes large while keeping the notional assets fixed, the realized value of the bank's assets can be written as a deterministic function of Y, by the law of large numbers. The realized value of assets at date 1 is the random variable $w(Y)$ defined as:

$$\begin{aligned}
w(Y) &\equiv (1+r)C \cdot \Pr(Z_j \geq 0|Y) \\
&= (1+r)C \cdot \Pr\left(\sqrt{\rho}Y + \sqrt{1-\rho}X_j \geq \Phi^{-1}(\varepsilon)\,|Y\right) \\
&= (1+r)C \cdot \Phi\left(\tfrac{Y\sqrt{\rho} - \Phi^{-1}(\varepsilon)}{\sqrt{1-\rho}}\right)
\end{aligned} \tag{3}$$

The c.d.f. of the realized value of the loan portfolio at date 1 is given by

$$\begin{aligned}
F(z) &= \Pr(w \leq z) \\
&= \Pr\left(Y \leq w^{-1}(z)\right) \\
&= \Phi\left(w^{-1}(z)\right) \\
&= \Phi\left(\frac{1}{\sqrt{\rho}}\left(\Phi^{-1}(\varepsilon) + \sqrt{1-\rho}\Phi^{-1}\left(\frac{z}{(1+r)C}\right)\right)\right)
\end{aligned} \tag{4}$$

As prescribed by the Basel capital requirements (BCBS (2005))[8], assume that the regional bank follows the Value-at-Risk (VaR) rule of keeping enough equity to limit the insolvency probability to $\alpha > 0$. The bank is risk-neutral otherwise. The bank's objective is to maximize expected profit subject only to its Value-at-Risk constraint. The bank remains solvent as long as the realized value of $w(Y)$ is above its notional liabilities at date 1. Since the funding rate on liabilities is f, the notional liability of the bank at date 1 is $(1+f)L$. The bank grants private credit C so that its VaR constraint just binds.

$$\Pr\left(w < (1+f)L\right) = \Phi\left(\frac{\Phi^{-1}(\varepsilon) + \sqrt{1-\rho}\Phi^{-1}\left(\frac{(1+f)L}{(1+r)C}\right)}{\sqrt{\rho}}\right) = \alpha \tag{5}$$

Re-arranging (5), we can write the ratio of notional liabilities to notional assets as follows.

$$\frac{\text{Notional liabilities}}{\text{Notional assets}} = \frac{(1+f)L}{(1+r)C} = \Phi\left(\frac{\sqrt{\rho}\Phi^{-1}(\alpha) - \Phi^{-1}(\varepsilon)}{\sqrt{1-\rho}}\right) \tag{6}$$

We will use the shorthand:

$$\varphi(\alpha, \varepsilon, \rho) \equiv \Phi\left(\frac{\sqrt{\rho}\Phi^{-1}(\alpha) - \Phi^{-1}(\varepsilon)}{\sqrt{1-\rho}}\right) \tag{7}$$

Clearly, $\varphi \in (0,1)$. From (6) and the balance sheet identity $E_R + L = C$, we can solve for the bank's supply of private credit. When private credit supply is positive, we have

$$C = \frac{E_R}{1 - \frac{1+r}{1+f} \cdot \varphi} \tag{8}$$

Note that C is proportional to the bank's equity E_R, and so (8) also denotes the *aggregate* supply of private credit as a function of the *aggregate* equity of the sector. The leverage of the bank (and the sector) is the ratio of assets to equity, and is

$$\text{Leverage } = \frac{1}{1 - \frac{1+r}{1+f} \cdot \varphi} \tag{9}$$

[8]The regulatory requirement was intended to emulate private sector best practice. See Adrian and Shin (2008) for a possible derivation of the VaR rule in a contracting setting.

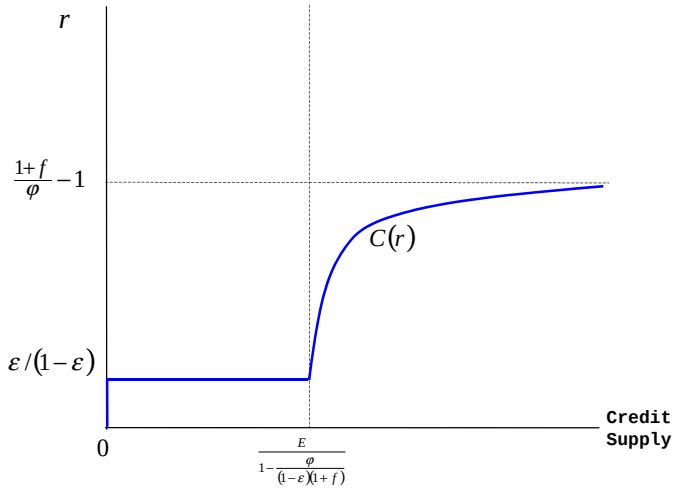

Figure 8. Supply of private credit by regional banks

Since the probability of default on private credit is ε, the expected profit to the bank from one unit of private credit is

$$(1-\varepsilon)(1+r)-1 \tag{10}$$

Therefore $C=0$ when $(1-\varepsilon)(1+r)<1$. Figure 8 illustrates the supply of private credit as function of the lending rate r.

On the liabilities side of the balance sheet, the regional bank's demand for cross-border funding L can be solved from (6) and the balance sheet identity $E_R+L=C$.

$$L=\frac{E_R}{\frac{1+f}{1+r}\cdot\frac{1}{\varphi}-1} \tag{11}$$

By equating (11) with the supply of loans by the global banks, we can solve for the equilibrium stock of cross-border lending.

2.2 Global Banks

We will construct a "double-decker" version of the Vasicek model as follows. There are many regions and each global bank has a well-diversified portfolio of cross-border loans to regional

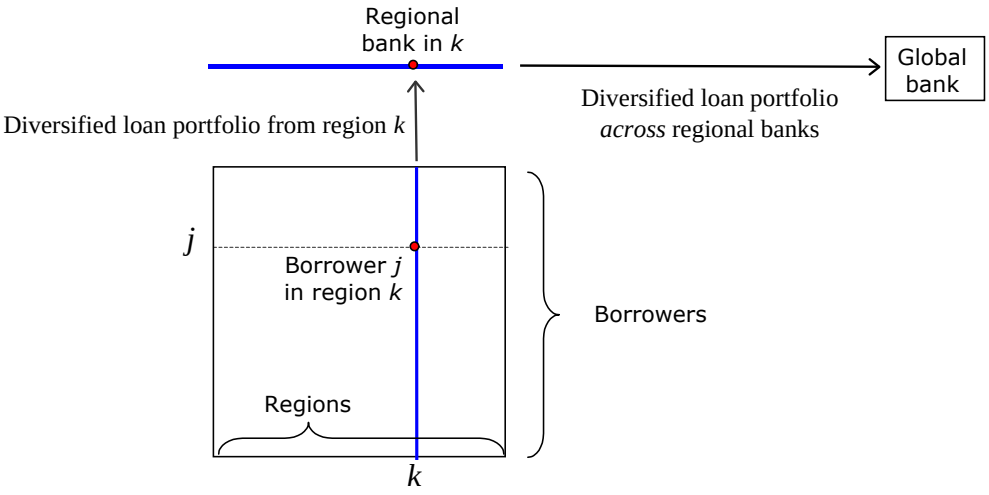

Figure 9. Global and regional banks

banks across many regions. However, the global banks bear global risk that cannot be diversified away. The credit risk structure for global banks is depicted in Figure 9.

The box in Figure 9 represents the population of borrowers across all regions. Regional bank k holds a portfolio that is diversified against idiosyncratic shocks, but not to regional shocks. Global banks hold a portfolio of loans to regional banks, and is diversified against regional shocks, but it faces undiversifiable global shocks.

In equation (2), we introduced the random variable Z_j that determined whether a particular borrower j defaults or not. We now introduce a subscript k to indicate the region that the borrower belongs to. Thus, let

$$Z_{kj} \equiv -\Phi^{-1}(\varepsilon) + \sqrt{\rho} Y_k + \sqrt{1-\rho} X_{kj} \tag{12}$$

where

$$Y_k = \sqrt{\beta} G + \sqrt{1-\beta} R_k \tag{13}$$

In (13), the risk factor Y_k is further decomposed into a regional risk factor R_k that affects all the private credit recipients in region k and a global risk factor G that affects all private credit

recipients everywhere. The random variables $G, \{R_k\}$ and $\{X_{kj}\}$ are mutually independent standard normals.

The credit risk borne by a global bank arises from the possibility (which happens with the VaR threshold probability α) that a regional bank defaults on the cross-border loan granted by the global bank. Although each regional bank has a diversified portfolio against the idiosyncratic risk of its regional borrowers, it bears the risk Y_k, which is the linear combination of the global risk G and the region-specific risk R_k.

A global bank has a fully-diversified portfolio across regions, and it can diversify away the regional risks R_k in the sense that the number of borrower regions becomes large for a fixed size of notional assets. From (4), a regional bank k defaults on its cross-border liability when

$$Y_k < w^{-1}\left(\left(1+f\right)L\right) = \tfrac{1}{\sqrt{\rho}}\left(\Phi^{-1}\left(\varepsilon\right) + \sqrt{1-\rho}\Phi^{-1}\left(\varphi\right)\right) \tag{14}$$

where φ is the notional debt/assets ratio given in (7). A regional bank from k defaults when $\xi_k < 0$, where ξ_k is the random variable:

$$\begin{aligned} \xi_k &\equiv \sqrt{\rho}Y_k - \Phi^{-1}\left(\varepsilon\right) - \sqrt{1-\rho}\Phi^{-1}\left(\varphi\right) \\ &= \sqrt{\rho\beta}G + \sqrt{\rho\left(1-\beta\right)}R_k - \Phi^{-1}\left(\varepsilon\right) - \sqrt{1-\rho}\Phi^{-1}\left(\varphi\right) \end{aligned} \tag{15}$$

For a global bank with notional assets of $\left(1+f\right)L$ which is fully diversified across regions, its asset realization is a deterministic function of the global risk factor G only, and is given by

$$\begin{aligned} w\left(G\right) &= \left(1+f\right)L \cdot \Pr\left(\xi_k \geq 0 | G\right) \\ &= \left(1+f\right)L \cdot \Pr\left(R_k \geq \tfrac{\Phi^{-1}(\varepsilon)+\sqrt{1-\rho}\Phi^{-1}(\varphi)}{\sqrt{\rho(1-\beta)}} - \sqrt{\tfrac{\beta}{1-\beta}}G \middle| G\right) \\ &= \left(1+f\right)L \cdot \Phi\left(\sqrt{\tfrac{\beta}{1-\beta}}G - \tfrac{\Phi^{-1}(\varepsilon)+\sqrt{1-\rho}\Phi^{-1}(\varphi)}{\sqrt{\rho(1-\beta)}}\right) \end{aligned} \tag{16}$$

The quantiles of the asset realizations follow from the c.d.f. of $w\left(G\right)$.

$$\begin{aligned} F\left(z\right) &= \Pr\left(w\left(G\right) \leq z\right) \\ &= \Pr\left(G \leq w^{-1}\left(z\right)\right) \\ &= \Phi\left(w^{-1}\left(z\right)\right) \end{aligned}$$

where

$$w^{-1}(z) = \sqrt{\tfrac{1-\beta}{\beta}}\left[\Phi^{-1}\left(\tfrac{z}{(1+f)L}\right) + \tfrac{\Phi^{-1}(\varepsilon)+\sqrt{1-\rho}\Phi^{-1}(\varphi)}{\sqrt{\rho(1-\beta)}}\right] \tag{17}$$

The global bank follows the Value-at-Risk (VaR) rule of keeping enough equity to limit the insolvency probability to $\alpha > 0$. The bank is risk-neutral and aims to maximize expected profit subject to its Value-at-Risk constraint. The bank remains solvent as long as the realized value of assets is above its notional liabilities. The notional liability of the global bank is $(1+i)M$. The probability that its asset realization falls short of this level is set equal to α. Hence,

$$\begin{aligned} \alpha &= \Pr\left(w(G) < (1+i)M\right) \\ &= \Phi\left(\sqrt{\tfrac{1-\beta}{\beta}}\left[\Phi^{-1}\left(\tfrac{(1+i)M}{(1+f)L}\right) + \tfrac{\Phi^{-1}(\varepsilon)+\sqrt{1-\rho}\Phi^{-1}(\varphi)}{\sqrt{\rho(1-\beta)}}\right]\right) \end{aligned} \tag{18}$$

Re-arranging (18), we can write the ratio of notional liabilities to notional assets of the global bank as:

$$\begin{aligned} \frac{\text{Notional liabilities}}{\text{Notional assets}} &= \frac{(1+i)M}{(1+f)L} \\ &= \Phi\left(\tfrac{\sqrt{\rho}\beta\Phi^{-1}(\alpha)-\Phi^{-1}(\varepsilon)-\sqrt{1-\rho}\Phi^{-1}(\varphi)}{\sqrt{\rho(1-\beta)}}\right) &(19)\\ &\equiv \psi(\alpha,\beta,\varepsilon,\rho) &(20) \end{aligned}$$

Clearly $\psi \in (0,1)$. From (19) and the balance sheet identity $E_G + M = L$ of the global bank, we can solve for the supply of cross-border lending as

$$L = \frac{E_G}{1-\frac{1+f}{1+i}\psi} \tag{21}$$

L is proportional to equity E_G, and so (21) also denotes the *aggregate* supply of cross-border lending as a function of the *aggregate* equity of the global banking sector. The leverage of the global bank (and of the sector) is the ratio of assets to equity:

$$\text{Leverage} = \frac{1}{1-\frac{1+f}{1+i}\psi} \tag{22}$$

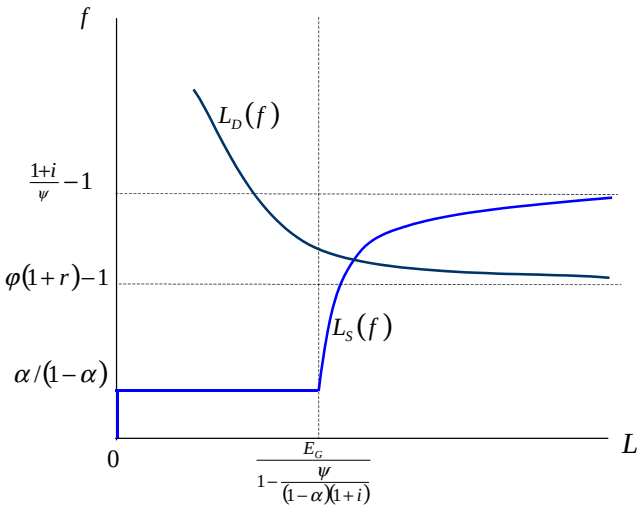

Figure 10. Equilibrium cross-border lending L

Since the probability of default on cross-border lending is α, the expected profit to the global bank (and hence the risk premium) from one unit of lending is

$$(1-\alpha)(1+f)-1 \tag{23}$$

Since global banks are risk-neutral profit maximizers, $L=0$ when $(1-\alpha)(1+f)<1$. From the demand and supply relationships for L in (11) and (21), we will solve for the equilibrium L and f in closed form. Figure 10 illustrates the demand and supply curves for L.

2.3 Capital Flows and Domestic Credit

We can now solve explicitly for cross-border lending and private credit. Begin with the market clearing condition for L, which is

$$\frac{E_R}{\frac{1+f}{1+r}\cdot\frac{1}{\varphi}-1}=\frac{E_G}{1-\frac{1+f}{1+i}\psi} \tag{24}$$

The funding rate f can be solved as

$$1+f=\frac{1}{\mu\frac{1}{(1+r)\varphi}+(1-\mu)\frac{\psi}{1+i}} \tag{25}$$

where

$$\mu = \frac{E_G}{E_G + E_R} \tag{26}$$

We can then solve for the private credit in the regions by substituting (25) into the supply of private credit given by (8), giving the succinct expression:

$$C = \frac{E_G + E_R}{1 - \frac{1+r}{1+i}\varphi\psi} \tag{27}$$

This is a useful expression, which we can re-write in long hand as:

$$\begin{array}{c}\text{Total private} \\ \text{credit}\end{array} = \frac{\text{Aggregate bank capital (regional + global)}}{1 - \text{ spread} \times \begin{array}{c}\text{regional} \\ \text{leverage}\end{array} \times \begin{array}{c}\text{global} \\ \text{leverage}\end{array}} \tag{28}$$

The variables φ and ψ can be seen as normalized leverage measures (regional and global) that lie in the unit interval $(0, 1)$.

Our model address how domestic risk premiums are affected by global "push" factors. Note that since the default probability of loans is ε, the risk premium in the domestic credit market in the recipient country is given by

$$\pi \equiv (1 - \varepsilon)(1 + r) - 1 \tag{29}$$

For any downward-sloping credit demand curve, the risk premium π is a monotonic function of the total supply of credit, given by (28). Since domestic private credit supply in the recipient country is a function of global factors (such as leverage of global banks) as well as local factors, we can appeal to the formula (28) in attributing (at least in principle) the compression of risk premiums to global and local factors - i.e. to "push" and "pull" factors.

We now turn to cross-border lending and the consequent capital inflows through the banking sector. Substituting the solution for the funding rate f into (21), we can solve for the equilibrium stock of cross-border lending L as

$$L = \frac{E_G + E_R \cdot \frac{1+r}{1+i}\varphi\psi}{1 - \frac{1+r}{1+i}\varphi\psi} \tag{30}$$

In long hand, we can express equilibrium L as

$$\begin{array}{c}\text{Total cross-}\\ \text{border lending}\end{array} = \frac{\text{Global and weighted regional bank capital}}{1 - \text{ spread} \times \begin{array}{c}\text{regional}\\ \text{leverage}\end{array} \times \begin{array}{c}\text{global}\\ \text{leverage}\end{array}} \tag{31}$$

Thus, the predicted total cross-border lending has qualitatively similar features to the predictions regarding regional private credit. The BIS banking statistics on external claims would be the empirical counterpart to L. The important point to note is that cross-border banking sector flows are a combination both of "push" and "pull" factors. Push factors include the capital of global banks the leverage of global banks. Pull factors include the capital of regional banks and the leverage of regional banks.

2.4 Empirical Implications for Capital Flows

In preparation for our empirical investigation, we draw some implications for the interaction between "push" and "pull" factors in bank capital flows from our closed form solution for L given by (30). Consider banking sector capital flows driven by two archetypal push and pull factors - local bank equity E_R that expands capacity to borrow (pull factor) and global bank leverage ψ that increases loan supply (push factor). Global bank equity E_G would have a similar effect to ψ. Then, neglecting the interest spread term for notational economy, banking sector capital flows can be written as

$$\begin{aligned}\Delta L &\simeq \frac{\partial L}{\partial E_R}\Delta E_R + \frac{\partial L}{\partial \psi}\Delta\psi \\ &= \frac{\varphi\psi}{1-\varphi\psi}\Delta E_R + \left(\frac{\left(1-\varphi\psi\right)E_R\varphi - \left(E_G + E_R\varphi\psi\right)\left(-\varphi\right)}{\left(1-\varphi\psi\right)^2}\right)\Delta\psi \\ &= \frac{\varphi\psi}{1-\varphi\psi}\Delta E_R + C\frac{\varphi}{1-\varphi\psi}\Delta\psi \end{aligned} \tag{32}$$

where C is private credit in the recipient economy, as given in (27).

The first term in (32) is the *levels* effect of ψ that interacts with equity growth, while the second term is the change effect of ψ. Banking sector capital flow (ΔL) is therefore increasing in ψ and in $\Delta\psi$. Since ψ is inversely related to VIX (Adrian and Shin (2008, 2010a)), banking sector capital flow (ΔL) is decreasing in VIX and the change in VIX. Moreover, we should also expect to see the growth in bank equity as well as the interaction between VIX and bank equity growth to be positively related to capital flows.

Having laid out the logic of our argument and the role of specific variables in influencing capital flows and private credit, we will investigate these empirical hypotheses more closely.

3 Data Description and Methodology

Our sample comprises data on 47 countries, encompassing both developed economies and emerging and developing economies, but excluding offshore financial centers. The criterion for inclusion is whether foreign banks play an economically significant role in the country's financial system. We select countries with the largest foreign bank penetration, as measured by the number of foreign banks and on the share of domestic banking assets held by foreign-owned local institutions. We use the ranking on foreign banks penetration from Claessens, van Horen, Gurcanlar and Mercado (2008).

The countries included in our sample are Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, Cyprus, Czech Republic, Denmark, Egypt, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Indonesia, Ireland, Israel, Italy, Japan, Latvia, Lebanon, Lithuania, Malaysia, Malta, Mexico, Netherlands, Norway, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, South Korea, Spain, Sweden, Switzerland, Thailand, Turkey, Ukraine, United Kingdom and Uruguay. Table 1 gives the main summary statistics of our sample of 47 countries. As well as data from the capital flow recipient countries, we use the series on interoffice assets of foreign banks in the United States published by the Federal Reserve.[9]

[9]Series on "Assets and Liabilities of U.S. Branches and Agencies of Foreign Banks" Federal Reserve http://www.federalreserve.gov/econresdata/releases/assetliab/current.htm

Table 1. **Summary Statistics.** This table summarizes our key variables in terms of their frequency (quarterly or annual), mean, standard deviation, minimum and maximum.

Variable	Frequency	Obs	Mean	Std. Dev.	Min	Max
External Loans Growth	quarter	2572	0.030	0.102	-0.777	0.655
VIX	quarter	56	22.135	8.310	11.035	58.596
ΔVIX	quarter	56	0.010	0.207	-0.332	0.849
Interoffice Assets Growth	quarter	56	0.038	0.095	-0.274	0.211
Interest Spread	quarter	56	-0.356	1.487	-2.833	2.417
Private Credit Growth	year	636	0.148	0.183	-0.685	1.774
VIX	year	14	22.137	6.378	12.807	32.693
Interoffice Assets Growth	year	14	0.148	0.130	-0.060	0.373
Interest Spread	year	14	-0.356	1.482	-2.521	1.979
ΔMoney Stock	year	14	0.056	0.053	-0.023	0.138
Global Growth	year	14	3.376	1.651	-1.111	4.998
ROE	year	636	0.087	0.146	-0.768	0.500
Openness	year	636	1.362	1.383	-1.844	2.478
Bank Crisis	year	636	0.135	0.342	0.000	1.000
ΔInflation	year	609	0.062	0.136	-0.046	2.450
Creditor Rights	year	296	2.010	0.983	0.000	4.000

We track the global consequences of the channeling of funds raised in the US through two key variables: the annual growth in private credit and the quarterly growth in external claims of BIS reporting country banks. Private credit is the annual average domestic credit provided by the banking sector (IFS line 22d). Quarterly external loans of BIS reporting banks are obtained from the BIS locational statistics data (Table 7A). The key organizational criteria of the BIS locational statistics data are the country of residence of the reporting banks and their counterparties as well as the recording of all positions on a gross basis, including those vis-à-vis own affiliates. This methodology is consistent with the principles underlying the compilation of national accounts and balances of payments, thus making the locational statistics appropriate for measuring capital flows in a given period.

To address the role of banking sector leverage and measured risks, we use the Chicago Board Options Exchange (CBOE) Volatility Index (*VIX*) of implied volatility in S&P 500 stock index option prices. The VIX Index is generally considered the barometer of investor sentiment and

market volatility. For us, the more specific justification is the close link between the VIX index and measures of bank Value-at-Risk, so that banking sector leverage is closely tied empirically to the VIX index (Adrian and Shin (2008, 2010a)).

We also control for additional push and pull factors that the literature has identified as determinants of cross-border bank flows. Global push factors include interest rates, money stock, and GDP growth. We use the country-level banking series constructed by Beck and Demirgüç-Kunt in the World Bank (2009) Financial Structure Database. We use the spread between the ECB repo rate and the US Fed Fund target rate (*Interest Spread*) to assess the role of interest rate spreads in affecting capital flows.[10] The annual growth in the global money supply (Δ*Money stock*) is calculated as the sum of M2 in the US, Eurozone and Japan and M4 in the UK (from the IFS); global GDP growth (*Global Growth*) is computed as the volume change from the previous year (from the IFS). Domestic pull factors include the annual average return on equity for banks (Net Income/Total Equity, ROE) from Beck and Demirguc-Kunt (2009), winsorized at the 1% percentile. We include a dummy which equals 1 in the years a country suffers a banking crisis and 0 otherwise (Bank Crisis), taken from the Laeven and Valencia (2010) IMF Bank Crisis Database, and the Chinn-Ito Index of *Capital Account Openness*, based on the binary dummy variables that codify the tabulation of restrictions on cross-border financial transactions reported in the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER). The BIS locational data (7A) are available from December 1995. Since some of our data series are annual series available up to 2009, we work with the sample period of 1996 to 2009.

4 Empirical Findings

4.1 Funding of Global Banks

We first investigate how the fluctuations in the interoffice assets of foreign banks in the US relate to the VIX index and the interest rate spread between the Euro repo rate and the Fed Funds

[10] We use the Lombard rate instead of the ECB repo rate before 1999.

Table 2. **Determinants of Interoffice Assets.** The dependent variable is the quarterly growth in the Interoffice Assets of foreign banks in the US. VIX is the quarterly average of the CBOE Volatility Index. Interest Spread is the spread between the ECB repo rate and the US Fed Fund target rate, averaged within quarter. ΔMoney stock is the annual growth in the global money supply calculated as the sum of M2 in the US, eurozone and Japan and M4 in the UK (from the IFS). Global Growth is the global GDP, volume change from the previous year (from the IFS). Data are for 1996-2009. p-values are in parantheses.

	1	2	3	4
VIX	-0.0043**		-0.0039*	-0.0049**
	[0.036]		[0.070]	[0.015]
Interest Spread		-0.0143	-0.0042	-0.0043
		[0.159]	[0.627]	[0.755]
ΔMoney stock				-0.0089
				[0.546]
Global Growth				-0.2358
				[0.411]
Constant	0.1326***	0.0327**	0.1236***	0.1882**
	[0.002]	[0.025]	[0.009]	[0.014]
Observations	56	56	56	56
R-squared	0.141	0.05	0.144	0.183

rate from the following regression.

$$\Delta\text{Interoffice}_t = \alpha + \beta\text{VIX}_t + \gamma\text{Spread}_t + \delta\text{Controls} + \varepsilon_{i,t} \tag{33}$$

$\Delta Interoffice_t$ is the one quarter log difference in the interoffice assets of foreign banks in the US. *VIX* is the within-quarter average of the VIX index. *Spread* is the difference between the ECB Repo rate and the US Fed Fund target rate, averaged over the quarter. As controls we use the annual growth in the global money stock (Δ*Money stock*), global GDP growth (*Global Growth*). Data are for 56 quarters for the period 1996 to 2009.

Table 2 shows the results. We see that the VIX Index is the only explanatory variable that is statistically significant in the regression and it has a negative sign, as hypothesized. Adrian and Shin (2008, 2010a) showed that the leverage of the five Wall Street investment banks varies inversely with the VIX index, where VIX proxies for Value-at-Risk. The significant effect of VIX on the interoffice assets of *non-US* banks suggest that the leverage of these banks also dances to the tune of the VIX. Baba, McCauley and Ramaswamy (2009) show that European

banks are heavily represented in the group of foreign banks that channel US dollar funding to head office by tapping of the prime money market funds in the United States.

Interestingly, the interest rate spread between the ECB Repo rate and the US Fed Funds rate does not show up as being significant in Table 2. Indeed, the insignificance of the interest rate spread variable turns out to be a consistent theme throughout our empirical investigation. One likely reason why the interest rate spread does not turn out to be significant is the central banks' decisions concerning the policy rate react to financial conditions. We return to this issue shortly.

4.2 Capital Flows

Next we investigate the determinants of banking sector capital flows. We do this by investigating the external claims from BIS reporting country banks to our sample of 47 countries. We employ a panel regression with quarterly data. Our closed-form solution for banking sector capital flows is given by (31), and the empirical predictions on capital flows follow from (32). They suggests that VIX should enter both in levels and in changes (both negatively) while the growth in banking sector equity should enter positively with a positive interaction term with leverage.

We run panel regressions with quarterly data with country fixed effects and clustered standard errors at the country level of the form:

$$\begin{aligned} \Delta L_{c,t} &= \beta_0 + \beta_1 \cdot \Delta\text{Interoffice}_t + \beta_2 \text{VIX}_{t-1} + \beta_3 \cdot \Delta\text{VIX}_{t-1} \\ &\quad + \beta_4 \text{ROE}_{c,t} + \beta_5 \text{VIX}_{t-1} * \text{ROE}_{c,t} + \text{controls}_{c,t} + e_{c,t} \end{aligned} \tag{34}$$

where $\Delta L_{c,t}$ is banking sector capital inflow into country c in period t, as given by the quarterly log difference in the external claims of BIS reporting country banks on country c between quarters t and $t-1$; VIX_{t-1} is the within-quarter average of the VIX index lagged by one quarter; $\Delta\text{Interoffice}_t$ is the growth in interoffice assets of foreign banks in the US from the quarter before given by the quarterly log difference. $\text{ROE}_{c,t}$ is the country-level return on equity in country c in period t, as a measure of the growth in banking sector equity. Note that we have VIX entering both in levels and in changes, and it interacts with ROE also, in

accordance with the predictions in equation (32). Other controls are as described in the data section. The results are presented in Table 3.

The VIX level and ΔInteroffice variables are highly significant and of the predicted sign. Indeed, looking across the columns of Table 3, we see that the coefficients on these variables remain stable to different specifications and highly significant throughout (the p-values being zero to three decimal places in every instance except one). The ΔVIX variable is significant when it enters by itself, but is knocked out when appearing with VIX levels. The ROE variable and its interaction with VIX also figures prominently in the regressions with the predicted sign.

Taking the comparative statics from equation (32) as a package, the theoretical predictions receive broad support from Table 3. The only slight disappointment is that ΔVIX does not appear as resiliently as the other variables from the theoretical prediction.

The interest spread variable in the policy rate between the ECB repo and Fed Funds rate is insignificant, echoing the earlier findings in Forbes and Warnock (2011). Given the endogenous response of central banks to financial conditions, a deeper study of the link between monetary policy and global liquidity would be warranted. Bekaert, Hoerova, and Lo Duca (2010) find in structual vector autoregression studies that low policy rates are followed by low VIX levels around five months later, while distressed financial conditions lead to lowering of policy rates, as one might expect. In any case, the arguments associated with the "risk-taking" channel of monetary policy (Borio and Zhu (2008) and Adrian and Shin (2010b)) suggest the need for further study of the role of the banking sector in the monetary transmission mechanism. In contrast to Forbes and Warnock (2011) we also find that the growth of the G4 money stock is an important determinant of banking sector capital flows. During a banking crisis capital flows decrease, but the coefficients of VIX and of ΔInteroffice remain highly significant. Our results do not change after including trade openness, country GDP growth, inflation, or when we use the annual growth in external loans in lieu of the quarterly growth (results not shown).

Table 3. **Determinants of banking sector capital flows.** This table reports the panel regressions for banking sector capital flows with country fixed effects. The dependent variable is the quarterly log difference of BIS reporting bank external loans (BIS Table 7A). VIX is the within-quarter average VIX index lagged one quarter. ΔInteroffice is the growth in interoffice assets of foreign banks in the US from the quarter before. ROE is the banking sector return on equity. Interest spread is the difference between the ECB Repo rate and the US Fed Fund target rate, quarter average lagged one quarter. ΔMoney stock is the annual growth in sum of M2 in the US, eurozone and Japan and M4 in the UK (from the IFS). Global Growth is the global GDP volume change from previous year (from the IFS). Openness is the Chinn-Ito index of capital account openness. Bank crisis is a crisis year dummy. p-values are reported in parantheses. Standard errors are clustered at the country level. Data are for 1996-2009.

	1	2	3	4	5	6	7
ΔInteroffice	0.1080***			0.0992***	0.1085***	0.1194***	0.1147***
	[0.000]			[0.000]	[0.000]	[0.000]	[0.000]
VIX		-0.0023***		-0.0023***	-0.0020***	-0.0018***	-0.0019***
		[0.000]		[0.000]	[0.000]	[0.001]	[0.000]
ΔVIX			-0.0281***	0.0074	0.0084	0.0131	0.0145
			[0.005]	[0.437]	[0.397]	[0.130]	[0.105]
ROE					0.1407***	0.1342***	0.1093**
					[0.001]	[0.002]	[0.011]
ROE*VIX					-0.0037***	-0.0037***	-0.0033**
					[0.003]	[0.004]	[0.014]
Interest spread					0.0021	-0.0017	-0.0025
					[0.241]	[0.434]	[0.231]
ΔMoney stock						0.1926***	0.2093***
						[0.000]	[0.000]
Global growth						-0.0015	-0.0046**
						[0.493]	[0.033]
Openness						0.0082**	0.0064
						[0.038]	[0.131]
Bank crisis							-0.0396***
							[0.000]
Constant	0.0255***	0.0796***	0.0299***	0.0760***	0.0645***	0.0425**	0.0630***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.024]	[0.001]
Observations	2,572	2,572	2,572	2,572	2,572	2,572	2,572
R-squared	0.01	0.037	0.003	0.045	0.052	0.065	0.079
Countries	47	47	47	47	47	47	47

4.3 Domestic Private Credit

Next we investigate the determinants of private credit growth. The role of the VIX index as an explanatory variable follows from our theoretical prediction given by (28). Since the relationship between domestic private credit growth and the leverage of the global banks is indirect (going through an extra layer of financial intermediation domestically), we might conjecture that the effects are somewhat weak and open to a range of possible confounding effects. Nevertheless, we show that the VIX and interoffice asset growth retain considerable explanatory roles.

We run panel regressions with annual data with country fixed effects and clustered standard errors at the country level of the form:

$$\begin{aligned} \Delta C_{c,t} &= \beta_0 + \beta_1 \cdot \Delta\text{Interoffice}_t + \beta_2 \text{VIX}_{t-1} + \beta_4 \text{ROE}_{c,t} \\ &\quad + \beta_5 \text{VIX}_{t-1} * \text{ROE}_{c,t} + \text{controls}_{c,t} + e_{c,t} \end{aligned} \tag{35}$$

where $\Delta C_{c,t}$ is annual growth in private credit in country c in year t, as given by the annual log difference in private credit (from IFS); VIX_{t-1} is the within-year average of the VIX index lagged by one year; $\Delta\text{Interoffice}_t$ is the growth in interoffice assets of foreign banks in the US from the year before, given by the annual log difference. $\text{ROE}_{c,t}$ is the country-level return on equity in country c in year t. We include the control variables described in the data section (ΔMoney stock, Global Growth, Openness, and Banking Crisis). As additional control variables, we include the annual log difference in the consumer price index (Inflation) and the Djankov, McLiesh, and Shleifer (2007) Creditor Rights Index which is only available until 2002.

The results are presented in Table 4. Although the statistical significance falls relative to Table 3, we see that the key role played by the VIX and growth of interoffice assets remains in place, adding weight to the main predictions given by our theory that global liquidity spills over into the domestic private credit growth of the recipient economies. In contrast to the panel regression for banking sector capital flows, neither the ROE variable, nor the interaction term with VIX appears as being significant. The growth in money supply also ceases to be significant, except for the final specification when the creditor rights variable (only available until 2002) enters the regression for a truncated sample period.

Table 4. **Determinants of private credit growth.** The dependent variable is the annual log difference of private credit (IFS). VIX is the within-year average VIX index lagged one year. ΔInteroffice is the growth in interoffice assets of foreign banks in the US from the year before. ROE is the banking sector return on equity. Interest Spread is the difference between the ECB Repo rate and the US Fed Fund target rate, annual average lagged one year. Other variables are defined in the text. p-values are reported in parantheses. Standard errors are clustered at the country level. Data are for 1996-2009.

	1	2	3	4	5	6	7
ΔInteroffice	0.2728***		0.1739***	0.1495**	0.1520**	0.1389**	0.4773**
	[0.000]		[0.004]	[0.034]	[0.039]	[0.050]	[0.013]
VIX		-0.0058***	-0.0039***	-0.0043**	-0.0050**	-0.0035**	-0.0193**
		[0.000]	[0.001]	[0.014]	[0.016]	[0.027]	[0.049]
ROE				-0.1185	-0.1133	0.0275	-0.0384
				[0.607]	[0.628]	[0.901]	[0.944]
ROE*VIX				0.0042	0.0042	-0.0009	0.004
				[0.621]	[0.631]	[0.916]	[0.867]
Interest Spread				-0.0035	-0.003	-0.006	-0.0334**
				[0.599]	[0.654]	[0.351]	[0.034]
ΔMoney stock					0.0115	0.1643	3.0882**
					[0.931]	[0.198]	[0.041]
Global growth					-0.0035	-0.0093*	0.016
					[0.443]	[0.086]	[0.218]
Openness					-0.0135	-0.0038	0.0054
					[0.188]	[0.480]	[0.808]
Inflation						0.5235***	0.5533***
						[0.000]	[0.000]
Bank crisis						-0.0906***	
						[0.005]	
Creditor Rights							0.1651***
							[0.002]
Constant	0.1070***	0.2681***	0.2020***	0.2168***	0.2595***	0.2067***	-0.0516
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.763]
Observations	636	636	636	636	636	609	282
R-squared	0.057	0.06	0.076	0.078	0.083	0.254	0.269
Countries	47	47	47	47	47	46	41

Taken together, the results from Tables 3 and 4 suggest that global liquidity consistently explains both the growth in private credit in recipient countries and cross-border lending. The VIX index is a key indicator of global liquidity due to its close association with banking sector leverage. In this respect, the significance of the interoffice assets series sheds much light on the precise mechanism for why the VIX index is so significant. The driving force behind emerging economy capital flows turns out to be the leverage cycle of the global banks.

4.4 Individual Countries Effects

We complement our panel regressions with an investigation of the sensitivity of individual countries to fluctuations in the VIX and ΔInteroffice variables. We make use of the panel structure to run panel regressions with country fixed effects and standard errors clustered at the country level of the form:

$$\begin{aligned} \Delta L_{c,t} &= \beta_{c,0} + \beta_{c,1}\text{VIX}_{t-1} + \beta_{c,2}\text{VIX}_{t-1} * \text{Country}_c \\ &\quad + \beta_{c,3}\Delta\text{Interoffice}_t + \text{controls}_{c,t} + e_{c,t} \end{aligned} \tag{36}$$

where $\Delta L_{c,t}$ is banking sector capital flows given by the quarterly log difference in the external claims of BIS reporting country banks to country c, as before, and Country_c is a dummy equal to 1 for country c and 0 otherwise. The key feature in (36) is the interaction term $\text{VIX}_{t-1}*\text{Country}_c$, which gives the excess sensitivity of country c to VIX. The controls are as in Table 3.

The panel regression (36) is run separately for each individual country c. Thus, the coefficients $\{\beta_{c,i}\}$ have a country subscript c. The coefficient $\beta_{c,1}$ indicates the average effect of VIX on all countries except country c, whereas the coefficient $\beta_{c,2}$ indicates the incremental effect for country c. The sum of the coefficients $\beta_{c,1} + \beta_{c,2}$ measures the total effect of VIX on country c.

We run analogous panel regressions to show the country-level effects of ΔInteroffice as follows.

$$\begin{aligned} \Delta L_{c,t} &= \beta_{c,0} + \beta_{c,1}\Delta\text{Interoffice}_t + \beta_{c,2}\Delta\text{Interoffice}_t * \text{Country}_c \\ &\quad + \beta_{c,3}\text{VIX}_{t-1} + \text{controls}_{c,t} + e_{c,t} \end{aligned} \tag{37}$$

Again, the sum of the coefficients $\beta_{c,1} + \beta_{c,2}$ measures the total effect of ΔInteroffice on country c. For reasons of space, we select and show the results of the interaction term coefficients for the following countries (a mix of developing and developed countries): Estonia, Latvia, Lithuania, Romania, Turkey, Brazil, Chile, Spain, Ireland, UK, Germany, France, Italy, Australia. Table 5 shows the results.

The first row reports the $\beta_{c,1}$ coefficient estimate interval. Because the regressions are run separately for each country, the average effect $\beta_{c,1}$ varies slightly across regressions. The subsequent rows report the individual countries interaction coefficients $\beta_{c,2}$.

Column 1 shows that that the VIX interaction terms $\beta_{c,2}$ for the Baltic countries, Romania, Turkey and Brazil are highly negative and significant, indicating greater sensitivity relative to other countries in the sample. The $\beta_{c,2}$ interaction terms for Chile, Spain, Ireland, Germany, Italy, and Australia are positive and significant, suggesting that at the margin, the impact of global liquidity for these countries is mitigated. The overall impact remains negative for Spain, Ireland, Italy and Australia (the F-test in column 2 rejects that the sum of the coefficients $\beta_{c,1} + \beta_{c,2}$ is equal to zero) or zero for Chile and Germany (the F-test in column 2 does not reject that the sum of the coefficients $\beta_{c,1} + \beta_{c,2}$ is different from zero). Global liquidity as measured by VIX does not seem to have a differential impact for UK or France.

Column 3 reports the results where the ΔInteroffice variable is interacted with each individual country dummy instead of VIX. The coefficient estimates $\beta_{c,2}$ of the Baltic countries and Brazil are positive and highly significant with large coefficients. As in the case for VIX, the marginal effect $\beta_{c,2}$ of ΔInteroffice for these countries is higher than the average effect for the others, suggesting that these countries are relatively more sensitive to fluctuations in the leverage of global banks. The marginal effect $\beta_{c,2}$ for all the other countries is not different from the average effect $\beta_{c,1}$, with the exception of Chile, Germany, and Australia for which the effect of the interoffice variable at the margin is lower than the average. Interestingly, as in the case of VIX, the total impact of ΔInteroffice is zero for Chile (the F-test in column 4 does not reject $\beta_{c,1} + \beta_{c,2} = 0$). Taken together, these results suggest that developing economies (especially emerging Europe and the Baltic countries) have been the most sensitive to global liquidity in

Table 5. **Individual country sensitivity analysis.** This table summarizes panel regressions run for each country with an interaction country dummy with VIX or interoffice asset growth. The dependent variable is the quarterly log difference of BIS reporting bank external loans (BIS Table 7A), as in Table 3. See text for explanation of methodology. p-values are reported in parantheses. Standard errors are clustered at the country level. Data are for 1996-2009.

		1	2		3	4
	Range of the $\beta_{c,1}$ coefficient estimated from the individual countries regressions					
$\beta_{c,1}$	VIX	-0.0022***/ -0.0023*** [0.000]		ΔInteroffice	0.1076***/ 0.1199*** [0.000]	
	Individual countries interaction coefficients $\beta_{c,2}$ derived from separate regressions					
			$\beta_{c,1}+\beta_{c,2}=0$			$\beta_{c,1}+\beta_{c,2}=0$
$\beta_{c,2}$	VIX*Estonia	-0.0034*** [0.000]	Reject	ΔInteroffice*Estonia	0.4104*** [0.000]	Reject
$\beta_{c,2}$	VIX*Latvia	-0.0033*** [0.000]	Reject	ΔInteroffice*Latvia	0.4439*** [0.000]	Reject
$\beta_{c,2}$	VIX*Lithuania	-0.0025*** [0.000]	Reject	ΔInteroffice*Lithuania	0.2192*** [0.000]	Reject
$\beta_{c,2}$	VIX*Romania	-0.0030*** [0.000]	Reject	ΔInteroffice*Romania	0.0205 [0.316]	Reject
$\beta_{c,2}$	VIX*Turkey	-0.0013*** [0.002]	Reject	ΔInteroffice*Turkey	-0.0258 [0.404]	Reject
$\beta_{c,2}$	VIX*Brazil	-0.0012*** [0.000]	Reject	ΔInteroffice*Brazil	0.0792*** [0.003]	Reject
$\beta_{c,2}$	VIX*Chile	0.0022*** [0.000]	Do not Reject	ΔInteroffice*Chile	-0.1263*** [0.000]	Do not Reject
$\beta_{c,2}$	VIX*Spain	0.0013*** [0.000]	Reject	ΔInteroffice*Spain	0.0566** [0.027]	Reject
$\beta_{c,2}$	VIX*Ireland	0.0012*** [0.001]	Reject	ΔInteroffice*Ireland	-0.0028 [0.912]	Reject
$\beta_{c,2}$	VIX*UK	-0.0001 [0.827]	Reject	ΔInteroffice*UK	0.0025 [0.924]	Reject
$\beta_{c,2}$	VIX*Germany	0.0020*** [0.000]	Do not Reject	ΔInteroffice*Germany	-0.0636** [0.015]	Reject
$\beta_{c,2}$	VIX*France	0.0004 [0.251]	Reject	ΔInteroffice*France	-0.0161 [0.529]	Reject
$\beta_{c,2}$	VIX*Italy	0.0014*** [0.000]	Reject	ΔInteroffice*Italy	-0.0085 [0.739]	Reject
$\beta_{c,2}$	VIX*Australia	0.0010*** [0.001]	Reject	ΔInteroffice*Australia	-0.0516** [0.019]	Reject
	Constant	Y			Y	
	Controls	Y			Y	
	Observations	2572			2572	
	Number of countries	47			47	

the sample period.

The result that Chile is an exception among emerging economies in being relatively immune to global liquidity conditions is a notable result and the institutional features that lead to such a feature is worthy of further investigation. Chile's funded public pension system and the buffering role through repatriation of overseas holdings during financial crises is likely to be an important factor.[11]

5 Robustness Checks

We examine the robustness of our empirical findings along three dimensions motivated by the following questions. First, to what extent are the empirical results driven by the recent financial crisis period? Any sharp asymmetry between the crisis and non-crisis periods should be of concern to empirical researchers.

Second, to what extent is global liquidity a recent phenomenon accompanying the rapid growth of the global banks? A useful benchmark date is 1999. Shin (2011) argues that this date is significant in that it coincides with the introduction of the euro, paving the way for rapid growth of global banking spurred on by the growth of cross-border lending in Europe. Some evidence of the importance of 1999 as a threshold can be seen from Figure 2 on the interoffice assets of foreign bank branches in the United States. Before 1999, foreign bank branches had negative net interoffice assets, implying that they were lending outposts of foreign banks, while after 1999, net interoffice assets turned strongly positive, implying that they had become funding vehicles for foreign banks.

Third, to what extent are the results driven by emerging and developing economies, rather than developed economies? Addressing this question would be important for the debates about the relative vulnerability of developing versus developed economies to global liquidity conditions.

We address these three questions by running robustness checks on our regressions for banking sector capital flows and private credit. We do so by introducing dummy variables that can be

[11] We are grateful to Rodrigo Cifuentes for pointing out this particular feature of Chile's financial system.

interacted with the ΔInteroffice and VIX variables and test for the significance of the incremental effects. Specifically, we examine the results of regressions of the form

$$\begin{aligned} \Delta L &= \beta_1 \Delta\text{Interoffice} + \gamma_1 \text{VIX} + \beta_2 \Delta\text{Interoffice*dummy} \\ &\quad + \gamma_2 \text{VIX} * \text{dummy} + \text{controls} \end{aligned} \tag{38}$$

and

$$\begin{aligned} \Delta C &= \beta_1 \Delta\text{Interoffice} + \gamma_1 \text{VIX} + \beta_2 \Delta\text{Interoffice*dummy} \\ &\quad + \gamma_2 \text{VIX} * \text{dummy} + \text{controls} \end{aligned} \tag{39}$$

We then examine the incremental effect of the dummy (β_2 and γ_2) as well as the total effect, given by the sum of the coefficients $\beta_1 + \beta_2$ and $\gamma_1 + \gamma_2$. Table 6 reports regression results for banking sector capital flows, while Table 7 reports the corresponding results for growth of private credit in the recipient economy. The F-values for the null that the total effect is zero is given at the bottom of the two tables.

5.1 Crisis and Non-Crisis Periods

Column 1 of Tables 6 and 7 reports the robustness checks for the crisis and non-crisis periods. Rather than using our own arbitrary definition of the crisis period, we use the NBER recession periods for the United States as our criterion. The NBER identifies two recession periods during our sample period[12], from March 2001 to November 2001 and from December 2007 to June 2009. In Table 6, the first column includes the dummy variable set to 1 during the NBER recession quarters and 0 otherwise. In the private credit (annual) regression the dummy variable is set to 1 in years 2001, 2008 and 2009. The dummy is then interacted with ΔInteroffice and VIX.

Table 6 shows that for banking sector capital flows, VIX remains negative and significant at 1% in all periods, with an incremental effect of −0.0016 during crisis periods. This result suggests that the predictive role of the VIX does not disappear when confining attention to

[12]http://www.nber.org/cycles.html,

Table 6. **Banking sector capital flows.** This table summarizes the robustness check regressions for banking sector capital flows. See text for explanation of methodology. p-values are reported in parantheses. Standard errors are clustered at the country level.

	1	2	3
Dependent Variable	Banking sector capital flows		
$\Delta_{\text{Interoffice}}$	0.0400*	0.1356***	0.1222***
	[0.087]	[0.000]	[0.001]
VIX	-0.0017***	-0.0016***	-0.0025***
	[0.000]	[0.001]	[0.000]
$\Delta_{\text{interoffice*Crisis Period dummy}}$	0.3183***		
	[0.000]		
VIX*Crisis Period dummy	-0.0016**		
	[0.015]		
$\Delta_{\text{interoffice* Developed countries dummy}}$			-0.0142
			[0.734]
VIX*Developed countries dummy			0.0012**
			[0.040]
$\Delta_{\text{interoffice*pre 1999 dummy}}$		-0.0669*	
		[0.064]	
VIX* pre 1999 dummy		0.0014	
		[0.107]	
Δ_{VIX}	0.0313***	0.0044	0.0147
	[0.006]	[0.650]	[0.104]
ROE	0.1291***	0.1177***	0.1123***
	[0.004]	[0.007]	[0.008]
ROE*VIX	-0.0031**	-0.0033**	-0.0036***
	[0.029]	[0.012]	[0.008]
Interest Spread	0.0015	-0.0019	-0.0025
	[0.522]	[0.384]	[0.224]
$\Delta_{\text{Money stock}}$	0.2035***	0.2645***	0.2101***
	[0.000]	[0.000]	[0.000]
Global Growth	-0.0022	-0.003	-0.0048**
	[0.351]	[0.192]	[0.025]
Openness	0.0097**	0.0085**	0.0063
	[0.015]	[0.039]	[0.135]
Bank Crisis		-0.0396***	-0.0419***
		[0.000]	[0.000]
Crisis Period dummy	0.0137		
	[0.421]		
pre 1999 dummy		-0.0044	
		[0.807]	
Constant	0.0471***	0.0395**	0.0640***
	[0.008]	[0.033]	[0.001]
Observations	2,572	2,572	2,572
R-squared	0.089	0.086	0.082
# countries	47	47	47
	F value	F value	F value
$\Delta_{\text{interoffice}} + \Delta_{\text{interoffice*dummy=0}}$	72.750	6.530	26.870
	[0.000]	[0.014]	[0.000]
VIX+ VIX*dummy=0	14.170	0.060	4.530
	[0.000]	[0.807]	[0.039]

Table 7. **Increase in private credit.** This table summarizes the robustness check regressions for the increase in private sector credit. See text for explanation of methodology. p-values are reported in parantheses. Standard errors are clustered at the country level.

	1	2	3
Dependent Variable	Private Credit		
$\Delta_{\text{Interoffice}}$	0.1774**	-0.0071	0.1273*
	[0.017]	[0.903]	[0.073]
VIX	-0.0039**	-0.0045**	-0.0090***
	[0.043]	[0.034]	[0.000]
$\Delta_{\text{interoffice*Crisis Period dummy}}$	-0.1853		
	[0.171]		
VIX*Crisis Period dummy	-0.0067**		
	[0.019]		
$\Delta_{\text{interoffice* Developed countries dummy}}$			0.0000*
			[0.087]
VIX*Developed countries dummy			0.0075***
			[0.000]
$\Delta_{\text{interoffice*pre 1999 dummy}}$		0.3205**	
		[0.035]	
VIX* pre 1999 dummy		0.0007	
		[0.889]	
Δ_{VIX}			
ROE	-0.0995	-0.0727	-0.1634
	[0.675]	[0.738]	[0.465]
ROE*VIX	0.0042	0.0025	0.004
	[0.632]	[0.759]	[0.631]
Interest Spread	-0.0043	-0.0109*	-0.0042
	[0.569]	[0.075]	[0.540]
$\Delta_{\text{Money stock}}$	-0.1075	0.2337**	-0.0667
	[0.565]	[0.030]	[0.675]
Global Growth	-0.0101	-0.0049	-0.007
	[0.336]	[0.350]	[0.216]
Openness	-0.0107	-0.0102	-0.0183*
	[0.288]	[0.317]	[0.078]
Bank Crisis		-0.0670*	-0.0786**
		[0.056]	[0.032]
Crisis Period dummy	0.1501**		
	[0.036]		
pre 1999 dummy		-0.0193	
		[0.832]	
Constant	0.2629***	0.2525***	0.2907***
	[0.000]	[0.000]	[0.000]
Observations	636	636	636
R-squared	0.091	0.124	0.126
# countries	47	47	47
	F value	F value	F value
$\Delta_{\text{interoffice}} + \Delta_{\text{interoffice*dummy=0}}$	0.000	4.000	3.370
	[0.957]	[0.051]	[0.073]
VIX+ VIX*dummy=0	10.360	0.500	0.730
	[0.002]	[0.484]	[0.396]

non-crisis periods. However, we also verify the additional kick given by crisis periods. The total effect is very substantial (F-value = 14.17, $p = 0.000$). For the growth in interoffice assets, the results are somewhat weaker. We see from Table 6 that ΔInteroffice (by itself) remains positive (0.04) but is significant only at the 10% level ($p = 0.087$). The incremental effect of the crisis period is large, at 0.3183 and highly significant ($p = 0.000$) demonstrating the impact of the interoffice variable derives from crisis periods.

In the private credit regression, ΔInteroffice is positive (0.177, $p = 0.017$) for the non crisis period and not significant for the crisis period. VIX is negative for both crisis and non crisis periods, with a bigger negative impact during the crisis periods (as we saw for capital flows). The Crisis Period dummy by itself is positive and significant.

5.2 Pre 1999 and Post 1999

We now turn to the effect of the structural changes in the global banking sector with 1999 as the threshold point. We create a dummy equal to 1 (pre 1999 dummy) for all the quarters (or years) before 1999 and 0 otherwise. We interact the dummy with ΔInteroffice and VIX, as well as including the dummy by itself. The results are reported in the second columns of Tables 6 and 7.

In the capital flows regression (Table 6), the effect of ΔInteroffice after 1999 is positive (0.1356) and significant ($p = 0.000$). As predicted, the incremental effect before 1999 is negative (-0.0669) and significant at the 10% level ($p = 0.064$), but the total effect of ΔInteroffice before 1999 is positive and significant (F-test = 6.53, $p = 0.014$). This suggests that the change in interoffice assets of foreign banks in the US has a positive impact before and after 1999, but at the margin the effect is lower before 1999. This finding supports the contention that the impact of global banks has increased after 1999. VIX is negative and significant for the after 1999 period, whereas is not significant (both incremental and total effect) before 1999. Hence, the negative effect of VIX holds only after 1999.

5.3 Developed vs. Developing countries

In our final set of robustness checks, we create a dummy equal to 1 when a country is a developed economy, and 0 otherwise.[13] We interact the dummy with ΔInteroffice and VIX. The results are reported in column 3 of Tables 6 and 7.

In the capital flows regression in Table 6, ΔInteroffice is positive and significant, while the interaction term ΔInteroffice*Developed is not significant, but the sum ΔInteroffice + ΔInteroffice*Developed is positive and significant (F-test=26.87, p=0.000). This suggests that the effect of ΔInteroffice is positive for both developed and developing countries.

VIX is negative for developing countries. The incremental effect for developed countries is positive (0.0012) and significant (p=0.040), but the total effect is still negative and significant (F test=4.53, p=0.039). This suggests that the VIX effect is negative for both developed and developing countries, but the negative effect is larger for developing.

In the private credit regression, ΔInteroffice is positive and significant and the interaction term ΔInteroffice*Developed is significant with a coefficient close to zero. This suggests that ΔInteroffice has a positive impact for both developed and developing with a magnitude very similar for both categories. VIX has a negative impact for developing countries but a total impact that is not significant (F-test=0.73) for developed countries. So the impact of the VIX appears to exert a significant negative impact only for developing economies.

6 Concluding Remarks

The evidence in our paper suggests that the driving force behind banking sector capital flows is the leverage cycle of the global banks. Furthermore, credit growth in the recipient economy is explained, in part, by the fluctuations in global liquidity that follow the leverage cycle of the global banks. Our findings reinforce the argument in Borio and Disyatat (2011) on the importance of *gross* capital flows between countries in determing financial conditions, rather

[13]The list of developed countries as classified by the BIS in its Locational Statistics Table 7A, is: Australia, Austria, Belgium, Canada, Cyprus, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Malta, Netherlands, Norway, Portugal, Slovakia, Slovenia, South Korea, Spain, Sweden, Switzerland, and UK.

than *net* flows. Gross flows, and in particular measures of banking sector liabilities should be an important source of information for risk premiums and hence financial sector vulnerability.[14] We conclude with some remarks on measuring global liquidity.

The distinction between core and non-core bank liabilities depends on the particular economy and the context of financial development. For advanced economies with developed debt markets, non-core liabilities will include non-deposit funding that is raised in the wholesale bank funding market, such as repos or financial commercial paper. We may conjecture that core liabilities, such as retail deposits, are more stable (or "sticky") than non-core liabilities.

For financial systems at an early stage of development or where the banking sector is restricted by regulation from having access to the global banking system, the distinction between core and non-core liabilities will fall within M2, depending on who holds the claim. When the domestic banking sector is mostly closed, it may be more meaningful to decompose M2 itself into its core and non-core components. The non-core component of deposits then may includes the deposits of non-financial companies who end up recycling funding within the economy and hence become integrated into the intermediary sector itself. China and India are two examples where this distinction between core and non-core liabilities may be usefully employed.

The detailed classifications will need to build on further analytical study of the attributes of various funding aggregates of the intermediary sector. For countries with open capital markets, international capital flows into the banking sector will be key indicators of financial vulnerability. For countries with relatively closed financial systems, where domestic banks do not have ready access to funding provided by the global banking system, a better approach would be to adapt existing conventional monetary aggregates to address financial stability concerns. The distinction between household retail deposits and corporate deposits in the banking sector could play an important role in this regard.

[14] See Shin and Shin (2010) and Hahm, Shin and Shin (2011) for empirical analyses of this issue.

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