Capital Flows, Cross-Border Banking and Global Liquidity*

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Abstract

We investigate the role of global factors in driving cross-border capital flows. We formulate a model of gross capital flows through the banking sector and derive a closed form solution that highlights the leverage cycle of global banks and its interaction with recipient country characteristics. We test the predictions of our model in a panel study of 46 developed and emerging economies and find empirical support for the key predictions of our model.

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1 Introduction

It is a cliché that the world has become more connected, but the financial crisis and the boom that preceded it have renewed attention on the global factors that drive financial conditions worldwide. Calvo, Leiderman and Reinhart (1993, 1996) famously distinguished the global “push” factors for capital flows from the country-specific “pull” factors, and emphasized the importance of external push factors in explaining capital flows to emerging economies in the 1990s.

Advanced economies have not been immune to reversals of capital flows. Whereas current account gaps have traditionally been considered as the determinant of capital flows, Obstfeld (2012a, 2012b) has drawn attention to the dramatic increase in gross capital flows that dwarf current account gaps in recent years, concluding that “large gross financial flows entail potential stability risks that may be only distantly related, if related at all, to the global configuration of saving-investment discrepancies.” (Obstfeld (2012b, p. 3). One reason for the caution is that the growth in gross capital flows was associated with increased leverage, and hence with financial fragility (see Borio and Disyatat (2011) and Gourinchas and Obstfeld (2012)).

The objective of our paper is to formulate a framework for the global factors behind capital flows. We make three main contributions.

First, we construct a model of global banking that builds on recent advances in understanding the banking sector, especially the procyclical nature of bank leverage in which leverage builds up in booms and falls in busts. The general equilibrium framework of Geanakoplos (1997, 2009) and Fostel and Geanakoplos (2008, 2012) has shed light on how the risk bearing capacity of the financial system fluctuates with the procyclical nature of leverage implicit in collateral requirements. Similarly, Gorton (2007, 2009) and Gorton and Metrick (2010) have explored the analogy between classical bank runs where depositors withdraw funds from conventional banks and the modern run in capital markets where runs are driven by increased collateral requirements (increased “haircuts”) and hence the reduced capacity to borrow. Adrian and Shin (2010) document the procyclical nature of leverage for US investment banks.
Our model of global banking builds on these earlier insights by combining the procyclicality of leverage with the interaction between local and global banks and the centralized funding and credit allocation decisions of international banks, as extensively documented by Cetorelli and Goldberg (2009, 2010). Thanks to the closed-form solution given by our model, we derive a number of crisp predictions on which global factors will drive capital flows through the banking sector. Our model highlights variables such as the net assets of foreign bank branches in the US vis-à-vis their headquarters, as well as the interactions between bank balance sheet quantities and Value-at-Risk. We also address the key institutional feature of banking sector capital flows where the US saw capital outflows through the banking sector during the boom years, which then reversed during the crisis. In addition, our focus is on the variation in leverage as the driver of capital flows rather than changes in net worth.

Our second contribution is to conduct an empirical investigation to see how closely the theoretical predictions are borne out empirically. Our sample is a panel of 46 countries - both advanced and emerging economies with significant and open banking sectors. We find support for the model’s prediction that the global factors driving capital flows can be found in the determinants of the balance sheet capacity of international banks. Adrian and Shin (2010, 2012) showed that the bank’s Value-at-Risk (a quantile measure of potential losses) is a key determinant of the leverage of the bank. In turn, fluctuations in Value-at-Risk are shown to be closely aligned with movements in the VIX index of implied volatility of S&;P 500 equity index options. A sharp prediction of our model, therefore, is that both the level of the VIX (which determines the rate at which one dollar’s increase in bank capital is turned into lending) and the change in the VIX (which determines the lending based on existing, or infra-marginal bank capital) should enter as being significant determinants of capital flows. We find that both these predictions receive strong empirical support. Our results therefore shed light both on Forbes and Warnock’s (2011) finding of the explanatory power of the VIX index for gross capital flows in surge episodes, as well as the importance of leverage as identified by Gourinchas and Obstfeld (2012). Our framework serves as the common thread that ties together these two strands of the literature.
The third contribution of our paper is to shed light on the impact of currency appreciation on capital flows through the risk-taking behavior of intermediaries. The banks in our model do not have currency mismatch on their balance sheets, but if they lend to borrowers who hold local currency assets funded with US dollars, then exchange rate movements impact the banks’ behavior through changes in the credit risk of the borrowers. In particular, our model has the feature that an appreciation shock to the local currency leads to subsequent acceleration of capital inflows. We find that this prediction receives strong support in our empirical investigation.

The role played by the US dollar as the currency that underpins the global banking system suggests that the value of the US dollar may thus be a bellwether for global financial conditions, as recently suggested by Lustig, Roussanov and Verdelhan (2012) and Maggiori (2010). More broadly, the role of the US dollar in the global banking system opens up important questions on the transmission of financial conditions across borders, a phenomenon often referred to as “global liquidity” by commentators and policy makers.1 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. Our framework suggests a way of identifying and measuring global liquidity in terms of the aggregate cross-border lending through the banking sector.

The outline of the paper is as follows. In the next section, we formulate our model of cross-border banking by first laying out the institutional backdrop for the global banking system and the key empirical features of balance sheet management that our model aims to capture faithfully. Our model of global banking then builds on this discussion. In Sections 3 and 4, we subject our predictions to an empirical investigation and presents robustness checks on our empirical results, and Section 5 concludes with a discussion of directions for future study.

1See the BIS report on global liquidity delivered to the G20, also known as the Landau report (BIS (2011)).
2 Model of Bank Capital Flows

2.1 Institutional Background

The structure of the global banking system examined in our paper is sketched in Figure 1. The direction of financial flows goes from right to left, to keep with the convention of having assets on the left hand side of the balance sheet and liabilities on the right. In Figure 1, global banks raise wholesale funding and then lend to local banks in other jurisdictions. The local banks draw on the cross-border funding (stage 2) in order to lend to their local borrowers (stage 3).

Our analysis applies irrespective of whether the local bank is separately owned from the global bank, or whether the local and global banks belong to the same banking organization. Cetorelli and Goldberg (2009, 2010) provide extensive evidence using bank level data that internal capital markets serve to reallocate funding within global banking organizations. Further details are discussed in a BIS (2010) study that describes how the branches and subsidiaries of foreign banks in the United States borrow from money market funds and then channel the funds to their headquarters.\(^2\)

A crucial piece of evidence on the activity of global banks borrowing in financial centers is given in Figure 2, which plots the assets and liabilities of foreign banks in the United States

\(^2\)See also Baba, McCauley and Ramaswamy (2009), McGuire and von Peter (2009), IMF (2011) and Shin (2012), who note that in the run-up to the crisis, roughly 50% of the assets of U.S. prime money market funds were obligations of European banks. The funds channeled by the branch to headquarters (interoffice assets) constitute gross capital outflows from the United States.
Figure 2. The left hand chart shows the assets and liabilities of foreign bank branches and subsidiaries (“foreign-related institutions”) in the US. The right hand chart shows the net interoffice assets of foreign banks in the US on their parent, given by the negative of the “net due to foreign-related offices”. (Source: Federal Reserve H8 series)

(left panel) and their “net interoffice assets” (right panel). Net interoffice assets measure the net claim of the branch or subsidiary of the foreign bank on its parent. Normally, net interoffice assets would be negative, as foreign bank branches act as lending outposts by drawing funding from headquarters. However, the decade between 2001 to 2011 was an exceptional period when net interoffice assets of foreign banks in the US turned sharply positive. Net interoffice assets returned to negative territory during the height of the European crisis in 2011. In effect, during the decade between 2001 and 2011, foreign bank offices became funding sources for the parent, rather than lending outposts. The right hand panel of Figure 2 therefore reflects the extent to which global banks were engaged in supplying US dollar funding to other parts of the world. Shin (2012) shows that the European banks were primarily responsible for the “round trip” capital flows, where deposit funding (including that raised from money market funds) is taken out of the US, only to re-enter the US through the purchase of non-Treasury securities. Our model is designed to capture the capital outflows through the intermediary sector, which then finances US dollar lending elsewhere in the world. This feature distinguishes our model from the consumption risk-sharing model of Maggiori (2011), in which deposit funding flows into the
US. Maggiori’s (2011) model reflects the aggregate US balance sheet, including the government. Our focus is on explaining flows in the banking sector alone.

In our empirical investigation below, we will use the growth of the net interoffice assets of foreign banks in the US as a key empirical proxy for the availability of wholesale bank funding. Stage 2 in Figure 1 corresponds to the lending by global banks with access to US wholesale funding to other parts of the world, and will be reflected in cross-border capital flows through the banking sector, as measured by the Bank for International Settlements (BIS).

Figure 3 plots the the cross-border claims of BIS-reporting banks on counterparties listed in the countries on the right. The series have been normalized to equal 100 in March 2003. Although the borrowers have wide geographical spread, we see a synchronized boom in cross-border lending before the recent financial crisis, suggesting a role for external global factors in the spirit of Calvo, Leiderman and Reinhart (1993, 1996).
2.2 Bank Leverage

Our model of bank credit supply is designed to capture some key features of bank balance sheet management. An illustration for a typical global bank is given in Figure 4 that shows the scatter chart of the two-year changes in debt, equity and risk-weighted assets (RWA) to changes in total assets of Barclays. Figure 4 plots $\{(\Delta A_t, \Delta E_t)\}, \{(\Delta A_t, \Delta D_t)\}$ and $\{(\Delta A_t, \Delta \text{RWA}_t)\}$ where $\Delta A_t$ is the two-year change in assets, and where $\Delta E_t$, $\Delta D_t$ and $\Delta \text{RWA}_t$ are the corresponding changes in equity, debt, and risk-weighted assets, respectively.

The first notable feature is how changes in assets are reflected dollar for dollar (or pound for pound) in the change in debt, not equity. We see this from the slope of the scatter chart relating changes in assets and changes in debt, which is very close to one. Leverage is thus procyclical; leverage is high when the balance sheet is large.

The second notable feature in Figure 4 is how the relationship between the changes in the total assets and its risk-weighted assets is very flat. In other words, the risk-weighted assets
barely change, even as the raw assets change by large amounts. The fact that risk-weighted
assets change little even as raw assets fluctuate by large amounts indicates the compression of
measured risks during lending booms and heightened measured risks during busts.

The equity in Figure 4 is book equity. An alternative measure of equity would have been
the bank’s market capitalization, which gives the market price of its traded shares. However,
since our interest is in the portfolio decision of the bank (i.e. its lending decision), book equity
is the appropriate notion. In particular, note that market capitalization may differ from the
marked-to-market value of book equity. The market capitalization reflects discount rates for cash
flows to shareholders, as well as the snapshot value of the bank’s portfolio. Since our concern is
with lending decisions of the banks, we focus on the bank’s portfolio, and hence the book value
of equity is the appropriate concept when measuring leverage. Our model attempts to capture
the two key features of Figure 4 - the procyclicality of leverage and the countercyclicality of
measured risk - and uses this combination to explain surges and reversals of capital flows.

2.3 Model

We now describe our formal model. We begin by summarizing the notation for cross-border
banking in our model, given in Figure 5. The regional banks provide private credit (denoted
$C$) to local 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 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.

2.3.1 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 based on the well-known Merton (1974) model of credit risk, with the additional feature the bank can diversify across many borrowers. The Vasicek (2002) model has been adopted by the Basel Committee for Banking Supervision as the basis for minimum bank capital requirements (BCBS (2005)).

There are many identical borrowers indexed by $j$. Figure 6 illustrates the value of an individual borrower’s project, whose value at date 0 is denoted by $V_0$. Each borrower $j$ has
debt with face value \( F \), maturing at date \( T \). The value of the borrower’s project at date \( T \) is denoted \( V_T \), and is a lognormal random variable given by

\[
V_T = V_0 \exp \left\{ \left( \mu - \frac{s^2}{2} \right) T + s \sqrt{T} W_j \right\}
\]

where \( W_j \) is a standard normal random variable, and \( \mu \) and \( s > 0 \) are constants. The borrower defaults when \( V_T < F \). In what follows, we set \( T = 1 \) and \( F = 1 \).

The probability of default viewed from date 0 is

\[
\text{Prob}(V_T < F) = \text{Prob} \left( W_j < -\frac{\ln (V_0/F) + \left( \mu - \frac{s^2}{2} \right) T}{s \sqrt{T}} \right)
\]

\[
= \Phi(-d_j)
\]

where \( \Phi(.) \) is the c.d.f. of the standard normal and \( d_j \) is the distance to default in units of standard deviations of the standard normal \( W_j \).

\[
d = \frac{\ln (V_0/F) + \left( \mu - \frac{s^2}{2} \right) T}{s \sqrt{T}}
\]

The standard normal \( W_j \) is given by the linear combination:

\[
W_j = \sqrt{\rho} Y + \sqrt{1 - \rho} X_j
\]

where \( Y \) and \( \{X_j\} \) are mutually independent standard normals. \( Y \) has the interpretation as the common risk factor for all borrowers in the region while each \( X_j \) are the idiosyncratic component of credit risk for borrower \( j \). The parameter \( \rho \in (0, 1) \) determines the weight given to the common factor \( Y \).

Thus, borrower \( j \) repays the loan when \( Z_j \geq 0 \), where \( Z_j \) is the random variable:

\[
Z_j = d_j + \sqrt{\rho} Y + \sqrt{1 - \rho} X_j
\]

\[
= -\Phi^{-1}(\varepsilon) + \sqrt{\rho} Y + \sqrt{1 - \rho} X_j
\]
where \( \varepsilon \) is the probability of default of borrower \( j \), defined as \( \varepsilon = \Phi(-d_j) \).

Private credit extended by the bank is \( C \) at interest rate \( r \) so that the notional value of assets (the amount owed to the 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:

\[
w(Y) = (1 + r)C \cdot \Pr(Z_j \geq 0 | Y)
\]

\[
= (1 + r)C \cdot \Pr\left(\sqrt{\rho}Y + \sqrt{1 - \rho}X_j \geq \Phi^{-1}(\varepsilon) | Y\right)
\]

\[
= (1 + r)C \cdot \Phi\left(\frac{Y\sqrt{\rho} - \Phi^{-1}(\varepsilon)}{\sqrt{1 - \rho}}\right)
\]

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

\[
F(z) = \Pr(w \leq z)
\]

\[
= \Pr(Y \leq w^{-1}(z))
\]

\[
= \Phi\left(w^{-1}(z)\right)
\]

\[
= \Phi\left(\frac{\Phi^{-1}(\varepsilon) + \sqrt{1 - \rho}\Phi^{-1}(\varepsilon)}{\sqrt{\rho}}\right)
\]

Figure 7 plots the densities over asset realizations, and shows how the density shifts to changes in the default probability \( \varepsilon \) (left hand panel) or to changes in \( \rho \) (right hand panel). Higher values of \( \varepsilon \) imply a first degree stochastic dominance shift left for the asset realization density, while shifts in \( \rho \) imply a mean-preserving shift in the density around the mean realization \( 1 - \varepsilon \).

### 2.3.2 Value-at-Risk Rule

We now introduce our key behavioral assumption. The bank is risk-neutral, and the bank’s objective is to maximize expected profit subject only to its Value-at-Risk constraint that stipulates that the probability of default is no higher than some constant \( \alpha > 0 \).
The Value-at-Risk (VaR) constraint is well-known from the Basel bank capital regulations. However, our motivation for adopting the VaR constraint is not merely to appeal to the regulatory setting. Instead, our objective is to find a simple behavioral rule that conforms to the twin features that leverage is procyclical, and that fluctuations in leverage are driven by shifts in measured risks. As we see in our empirical section, these two features conform closely to actual behavior of international banks.

The reason for not appealing directly to the regulatory setting is twofold. First, the Basel regulators have motivated their adoption of the VaR rule in terms of following “private sector best practice”. In other words, the behavior conforming to the VaR rule is prior to the regulations.

Second, we know from Adrian and Shin (2012) that a contracting model with moral hazard can yield a VaR-type rule as the outcome of the optimal contracting problem, even without any formal regulation imposed from the outside. Under additional assumptions on the parameters
of the problem, Adrian and Shin (2012) show that the Value-at-Risk rule is an exact solution to the contracting problem. We will not address here the question of microfoundations or the welfare issues, but merely build on existing work by adopting the Value-at-Risk constraint as a simple modeling assumption that captures the way that banks react to changing perceptions of risk.

The benefit of adopting the VaR rule is that we can obtain simple closed-form solutions that captures the key behavioral trait of procyclical leverage. Therefore, in what follows we assume that the bank follows the Value-at-Risk (VaR) rule of maintaining sufficient equity to limit the insolvency probability to $\alpha > 0$. 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.

$$\Pr(w < (1 + f)L) = \Phi \left( \frac{\Phi^{-1}(\varepsilon) + \sqrt{1 - \rho} \Phi^{-1}(\frac{(1 + f)L}{1 + r})}{\sqrt{\rho}} \right) = \alpha$$  
(10)

Re-arranging (10), we can write the ratio of notional liabilities to notional assets as follows.

$$\frac{\text{Notional liabilities}}{\text{Notional assets}} = \frac{(1 + f)L}{(1 + r)C} = \Phi \left( \frac{\sqrt{\rho} \Phi^{-1}(\alpha) - \Phi^{-1}(\varepsilon)}{\sqrt{1 - \rho}} \right)$$  
(11)

We will use the shorthand:

$$\varphi(\alpha, \varepsilon, \rho) \equiv \Phi \left( \frac{\sqrt{\rho} \Phi^{-1}(\alpha) - \Phi^{-1}(\varepsilon)}{\sqrt{1 - \rho}} \right)$$  
(12)

Clearly, $\varphi \in (0, 1)$. From (11) and the balance sheet identity $ER + L = C$, we can solve for the bank’s supply of private credit. When private credit supply is positive, we have

$$C = \frac{ER}{1 - \frac{1 + r}{1 + f} \cdot \varphi}$$  
(13)

Note that $C$ is proportional to the bank’s equity $E_R$, and so (13) 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
\[
\text{Leverage} = \frac{1}{1 - \frac{1+\varphi}{1+f}}
\] (14)

On the liabilities side of the balance sheet, the regional bank’s demand for cross-border funding \( L \) can be solved from (11) and the balance sheet identity \( E_R + L = C \).
\[
L = \frac{E_R}{\frac{1+f}{1+r} \cdot \frac{1}{\varphi} - 1}
\] (15)

By equating (15) with the supply of loans by the global banks, we can solve for the equilibrium stock of cross-border lending. Thus, we now turn to the lending behavior of global banks.

### 2.3.3 Global Banks

The behavior of global banks is formalized in terms of 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 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 8.

The rectangle in Figure 8 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 (6), 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
\[
Z_{kj} \equiv -\Phi^{-1}(\varepsilon) + \sqrt{\rho}Y_k + \sqrt{1-\rho}X_{kj}
\] (16)

where
\[
Y_k = \sqrt{\beta}G + \sqrt{1-\beta}R_k
\] (17)
In (17), 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 $\alpha$) 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 (9), a regional bank $k$ defaults on its cross-border liability when

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

(18)

where $\varphi$ is the notional debt/assets ratio given in (12). A regional bank from $k$ defaults when
$\xi_k < 0$, where $\xi_k$ is the random variable:

$$
\xi_k \equiv \sqrt{\rho} Y_k - \Phi^{-1}(\varepsilon) - \sqrt{1 - \rho} \Phi^{-1}(\varphi)
$$

(19)

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

$$
w(G) = (1 + f) L \cdot \Pr (\xi_k \geq 0 | G)
= (1 + f) L \cdot \Pr \left( R_k \geq \frac{\Phi^{-1}(\varepsilon) + \sqrt{1 - \rho} \Phi^{-1}(\varphi)}{\sqrt{\rho(1 - \beta)}} \right)
= (1 + f) L \cdot \Phi \left( \sqrt{\frac{\beta}{1 - \beta}} G - \frac{\Phi^{-1}(\varepsilon) + \sqrt{1 - \rho} \Phi^{-1}(\varphi)}{\sqrt{\rho(1 - \beta)}} \right)
$$

(20)

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

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

where

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

(21)

The global bank follows the Value-at-Risk (VaR) rule of keeping enough equity to limit the insolvency probability to $\gamma > 0$. 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 $\gamma$. Hence,

$$
\gamma = \Pr (w(G) < (1 + i) M)
= \Phi \left( \sqrt{\frac{1 - \beta}{\beta}} \left[ \Phi^{-1} \left( \frac{(1 + i) M}{(1 + f) L} \right) + \frac{\Phi^{-1}(\varepsilon) + \sqrt{1 - \rho} \Phi^{-1}(\varphi)}{\sqrt{\rho(1 - \beta)}} \right] \right)
$$

(22)
Re-arranging (22), we can write the ratio of notional liabilities to notional assets of the global bank as:

\[
\frac{\text{Notional liabilities}}{\text{Notional assets}} = \frac{(1 + i) M}{(1 + f) L} = \Phi \left( \frac{\sqrt{\rho \Phi^{-1}(\gamma)} - \Phi^{-1}(\varepsilon) - \sqrt{1 - \rho \Phi^{-1}(\varphi)}}{\sqrt{\rho (1 - \beta)}} \right)
\]

\[= \psi (\beta, \gamma, \varepsilon, \rho) \quad (23)\]

Clearly \(\psi \in (0, 1)\). From (23) and the balance sheet identity \(E_G + M = L\) of the global bank, we can solve for the supply of cross-border lending as

\[
L = \frac{E_G}{1 - \frac{1 + f}{1 + r} \psi} \quad (25)
\]

\(L\) is proportional to equity \(E_G\), and so (25) 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:

\[
\text{Leverage} = \frac{1}{1 - \frac{1 + f}{1 + r} \psi} \quad (26)
\]

### 2.4 Closed-Form Solution

From the demand and supply relationships for \(L\) in (15) and (25), we will solve for the equilibrium \(L\) and \(f\) in closed form. The market clearing condition for \(L\) is

\[
\frac{E_R}{1 + f} \cdot \frac{1}{\varphi} - 1 = \frac{E_G}{1 - \frac{1 + f}{1 + r} \psi} \quad (27)
\]

The funding rate \(f\) can be solved as

\[
1 + f = \frac{1}{\mu (1 + r) \varphi} + (1 - \mu) \frac{\psi}{1 + r} \quad (28)
\]
where
\[ \mu = \frac{E_G}{E_G + E_R} \] (29)

We can then solve for the private credit in the regions by substituting (28) into the supply of private credit given by (13), giving the succinct expression:

\[ C = \frac{E_G + E_R}{1 - \frac{1+r}{1+i} \varphi \psi} \] (30)

This expression can be written in long hand as:

\[
\text{Total private credit} = \frac{\text{Aggregate bank capital (regional + global)}}{1 - \text{spread} \times \frac{\text{regional leverage}}{\text{global leverage}}} \tag{31}
\]

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

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 (25), we can solve for the equilibrium stock of cross-border lending \( L \) as

\[ L = \frac{E_G + E_R \cdot \frac{1+r}{1+i} \varphi \psi}{1 - \frac{1+r}{1+i} \varphi \psi} \] (32)

In long hand, we can express equilibrium \( L \) as

\[
\text{Total cross-border lending} = \frac{\text{Global and weighted regional bank capital}}{1 - \text{spread} \times \frac{\text{regional leverage}}{\text{global leverage}}} \tag{33}
\]

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 is our 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. The distinction between the demand and supply of wholesale funding harks back to Calvo, Leiderman and Reinhart (1993, 1996), who distinguished the “push” and “pull” factors that drive capital flows into emerging economies. However, although demand and supply factors can be distinguished in theory, the closed form solution in (33) shows that both demand and supply factors enter co-mingled in the closed form solution, making it difficult fully to disentangle the two forces in practice.

2.5 Global Factors in Capital Flows

In preparation for our empirical investigation, we draw implications for global factors that determine capital flows from our closed form solution for \( L \) given by (32). Consider the impact on \( L \) of shocks to global bank equity \( E_G \) and global bank (normalized) leverage \( \psi \). Then, neglecting the interest spread term for notational economy, the comparative statics impact on \( L \) can be written as

\[
\Delta L \approx \frac{\partial L}{\partial E_R} \Delta E_G + \frac{\partial L}{\partial \psi} \Delta \psi
\]

\[
= \frac{1}{1 - \varphi \psi} \Delta E_G + \left( \frac{(1 - \varphi \psi) E_R \varphi - (E_G + E_R \varphi \psi) (-\varphi)}{(1 - \varphi \psi)^2} \right) \Delta \psi
\]

\[
= \frac{1}{1 - \varphi \psi} \Delta E_G + \frac{\varphi}{1 - \varphi \psi} \Delta \psi
\] (34)

where \( C \) is private credit in the recipient economy, as given in (30).

The first term in (34) gives the impact of a marginal increase in global bank equity \( \Delta E_G \) through the leverage of the banking sector. When global bank leverage is high (\( \psi \) is high), each dollar of global bank equity translates into higher capital flows through the coefficient \( 1 / (1 - \varphi \psi) \). Thus, the first term in (34) suggests that capital flows are increasing in global bank equity, banking sector leverage (in levels), as well as the interaction between leverage and the change in equity. We will check for all three effects in our empirical investigation below.

The second term in (34) gives the impact of the change in the leverage of global banks, given by \( \Delta \psi \). The intuition is that the change in leverage will impact lending through the existing infra-marginal capital held by global banks, where each dollar of the global bank’s existing
The empirical counterpart for the leverage of the global banks will be the VIX index of implied volatility of S&P 500 index options. Adrian and Shin (2010, 2012) show that banks' Value-at-Risk is closely tracked by the VIX index. Other measures of risk such as spreads of individual bank credit default swaps (CDS) and the implied volatility of the banks’ equity options are shown to be closely related to leverage decisions, but the VIX index is not bank-specific, and hence can serve as our candidate for the global factor.

Figure 8 plots the leverage of Goldman Sachs and Morgan Stanley through the crisis period. Leverage is measured in units of standard deviations from the mean during the period 2001Q3 - 2006Q4. Also plotted is the VIX index and the implied volatility embedded in the equity options of the two banks. All series are measured in standard deviations from the mean during 2001Q3 - 2006Q4. We see that leverage of both Goldman Sachs and Morgan Stanley move in the opposite direction to the VIX, increasing in the period before the crisis, only to fall sharply with the onset of the 2008 crisis.

The consequence of shifting VIX for capital flows is captured in Figure 10, which shows the
fluctuations in gross capital flows in the banking sector from 1996, as measured by the cross-border claims of developed economy banks compiled by the Bank for International Settlements (BIS). Gross banking flows are large when the VIX index is low, but crash when the VIX index spikes with the onset of the financial crisis. And as the acute phase of the crisis passes, gross flows resume once more. The reflected symmetry of the two series is striking.

2.6 Effect of Currency Appreciation

A distinctive feature of our model is the impact of currency appreciation on capital flows. When regional banks lend in dollars, but the borrowers holds local currency assets, changes in the exchange rate have an impact on default probability $\varepsilon$, since borrowers with currency mismatch are sensitive to currency movements. Local borrowers could be either household or corporate borrowers. For corporate borrowers, incurring liabilities in foreign currency is one way for exporters to hedge their export receivables, or they may simply engage in outright speculation. For households, mortgage borrowing in foreign currency (Swiss francs and euros) was prevalent in Hungary and other countries in emerging Europe.
Figure 11. The borrower defaults when asset realization falls short of notional debt $F$. When the borrower has local currency assets but dollar liabilities, the effect of the local currency appreciation is to shift the outcome density upward, lowering the default probability $\varepsilon$.

Figure 11 illustrates the impact of currency appreciation when borrowers from local banks have a currency mismatch. An appreciation of the local currency results in a decline in the default probability $\varepsilon$ due to the greater value of the borrowers assets relative to the dollar debt $F$. Recall that the normalized leverage $\varphi$ is a decreasing function of the probability of default $\varepsilon$, given by

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

(35)

An appreciation shock to the local currency lowers the probability of default $\varepsilon$, and thus raises $\varphi$. In turn, our closed form solution for $L$ given by

$$
L = \frac{E_G + E_R \cdot \frac{1+r}{1+i} \varphi(\varepsilon) \psi}{1 - \frac{1+r}{1+i} \varphi(\varepsilon) \psi}
$$

(36)

which is an increasing function of $\varphi$. Taken together, we have the implication that an appreciation shock which leads to a decline in $\varepsilon$ results in greater cross-border lending.

This result is counterintuitive in that a higher relative price of the local currency increases the capital flows into that country, rather than diminish it. However, the theme of currency appreciation in times of capital inflows is a familiar one from the emerging market crisis lit-
erature. Indeed, Calvo, Leiderman and Reinhart (1993) focused on the relationship between capital inflows into Latin America and the appreciation of the capital recipient country currencies. Indeed, we find evidence of precisely such an effect in our empirical section, where past currency appreciation is followed by acceleration of capital inflows.

In general, the impact of capital flows on exchange rates suggests that the role of the US dollar is special given the dollar’s status as the currency that underpins the global banking system. Lustig, Roussanov and Verdelhan (2012) find that the US dollar tends to appreciate when US interest rates are low relative to interest rates for other currencies, and coin the concept of the “dollar carry trade”. Adrian, Etula and Shin (2009) show that the dollar tends to appreciate when US-dollar based intermediaries are expanding borrowing. Our framework may potentially shed light on both sets of results, since both phenomena are closely linked to the operation of global banks using US dollars.

We now turn to our empirical investigation.

3 Data Description and Methodology

Our sample draws on data from 46 countries, encompassing both developed economies and emerging and developing economies, but excluding offshore financial centers. Because we wish to analyze the channel through which global banks channel funds internationally, the criterion for inclusion is whether foreign banks play an economically significant role in the country’s financial system. In addition to the banking systems in developed economies, we select countries with the largest foreign bank penetration, as measured by the number of foreign banks and by 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, Lithuania, Malaysia, Malta, Mexico, Netherlands, Norway, Poland, Portugal, Romania, Russia, Slovakia,
Table 1. **Summary Statistics.** This table summarizes our key variables classified into global variables and local variables. We indicate their frequency (quarterly or annual), and give the mean, standard deviation, minimum and maximum.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Frequency</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global Variables</td>
<td></td>
<td></td>
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<tr>
<td>ΔEquity</td>
<td>Annual</td>
<td>14</td>
<td>0.13</td>
<td>0.22</td>
<td>-0.27</td>
<td>0.70</td>
</tr>
<tr>
<td>Interoffice</td>
<td>Quarter</td>
<td>64</td>
<td>0.11</td>
<td>0.82</td>
<td>-2.98</td>
<td>4.71</td>
</tr>
<tr>
<td>VIX</td>
<td>Quarter</td>
<td>64</td>
<td>3.05</td>
<td>0.35</td>
<td>2.43</td>
<td>3.79</td>
</tr>
<tr>
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<td></td>
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</tr>
<tr>
<td>RER</td>
<td>Quarter</td>
<td>2990</td>
<td>1.46</td>
<td>2.20</td>
<td>-1.00</td>
<td>10.17</td>
</tr>
<tr>
<td>ΔM2</td>
<td>Annual</td>
<td>592</td>
<td>0.12</td>
<td>0.14</td>
<td>-0.25</td>
<td>1.22</td>
</tr>
<tr>
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<td>Annual</td>
<td>592</td>
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<td>0.08</td>
<td>-0.21</td>
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<tr>
<td>RLR</td>
<td>Annual</td>
<td>532</td>
<td>0.05</td>
<td>0.09</td>
<td>-0.39</td>
<td>1.13</td>
</tr>
</tbody>
</table>

Slovenia, South Korea, Spain, Sweden, Switzerland, Thailand, Turkey, Ukraine, United Kingdom and Uruguay. Table 1 gives the main summary statistics of our sample of 46 countries.

We track the global consequences of the channeling of funds raised in the US through the quarterly growth in external claims of BIS reporting country banks. 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. We use the series on net interoffice assets of foreign banks in the United States published by the Federal Reserve in its H8 data on commercial banks, for the specific category of foreign-related institutions.

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. As discussed already, we will use the VIX index as our empirical proxy for the (inverse) leverage of the global banks. In our regressions, we will use the log of VIX. In addition
to the log VIX in levels, we will also include the quarterly log difference of the VIX (denoted by \( \Delta VIX \)), as one of the variables predicted by the theory.

The other global variable predicted by the theory is the growth in the equity of global banks (\( \Delta \text{Equity} \)). Non-US global banks, especially European global banks, were active in US dollar intermediation, as documented in detail by Shin (2012). To capture the role of global banks’ equity, we use the change in the total book value of equity of the largest (top 10) non-US commercial banks by assets from Bankscope as a proxy for the growth in equity of international banks. Bankscope has historical banking data from 1997, hence \( \Delta \text{Equity} \) is available since 1998.

We also include several local control variables as possible push and pull factors of capital flows. We include the log real exchange rate (RER), where RER is computed as the log of nominal exchange rate*(US CPI/local CPI). The nominal exchange rate is in units of national currency per U.S. Dollar (from the IMF’s IFS database).

The annual growth rate in money supply (\( \Delta M2 \)) is measured as the difference in end-of-year totals relative to the level of M2 in the preceding year (from the World Bank WDI).

GDP growth and Inflation are the country percentage change in GDP and Inflation, respectively, from the previous year (data from the WEO). Debt to GDP is the government gross debt as percentage of the GDP (from WEO). The sample period spans from the first quarter of 1996 (the first date covered in Table 7A of the BIS locational data) or from the first quarter of 1998 (the first \( \Delta \text{Equity} \) available data) to the last quarter of 2011.

4 Empirical Findings

4.1 Determinants of Bank Capital Flows

We now report our key findings on the determinants of banking sector capital flows. Our closed-form solution for banking sector capital flows is given by (33), and the empirical predictions on capital flows follow from (34). They suggest 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:

\[
\Delta L_{c,t} = \beta_0 + \beta_1 \cdot \Delta \text{Interoffice}_{t-1} + \beta_2 \text{VIX}_{t-1} + \beta_3 \cdot \Delta \text{VIX}_t \\
+ \beta_4 \Delta \text{Equity}_t + \beta_5 \text{VIX}_{t-1} \ast \Delta \text{Equity}_t + \text{controls}_{c,t} + \epsilon_{c,t}
\]  

(37)

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 \(t - 1\); \(\text{VIX}_{t-1}\) is the end of the quarter log of the VIX index; \(\Delta \text{Interoffice}_{t-1}\) is the growth in net interoffice assets of foreign banks in the US from the quarter before. Both VIX and \(\Delta \text{Interoffice}\) are lagged by one quarter. \(\Delta \text{Equity}_{c,t}\) is the change in equity of global banks, not lagged. \(\Delta \text{VIX}\) is the log difference in the VIX from the previous quarter, not lagged.

Note that we have VIX entering both in levels and in changes, and it interacts with \(\Delta \text{Equity}\) in accordance with the comparative statics predictions in equation (34). Other controls are as described in the data section and they aim at capturing local conditions that could drive capital flows. In addition we use country-fixed effects to control for any additional country-level effect not captured by our control variables, including controlling for changes in credit demand at the country level. The results are presented in Table 2.

In Table 2, the global variables are listed in the top half of the table, with the local variables listed in the bottom half. Columns 1 to 4 in Table 2 show the regressions using global variables (but with country fixed effects). The VIX in levels, in its growth \(\Delta \text{VIX}\) and the \(\Delta \text{Interoffice}\) variables are highly significant and of the predicted sign. Indeed, looking across the columns of Table 2, we see that the coefficients on these variables remain stable to different specifications and highly significant throughout.

The economic magnitudes are also sizeable. From columns 2 and 4, the coefficient on the VIX level when only global variables enter the regression is around 6 to 7%. The size of the coefficient implies a large impact of the VIX level on capital flows. For instance, compare the VIX index at 25 and the index at 15. In log term, the comparison is between 3.22 and 2.71, so that the difference is 0.51. Our results indicate that the difference in quarterly capital
Table 2. **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 external loans by BIS reporting banks given by BIS Locational Statistics Table 7A. VIX(-1) is the log of the end-quarter VIX index lagged one quarter. ΔInteroffice(-1) is the quarterly log difference in net interoffice assets of foreign banks in the US lagged one quarter. ΔEquity is the change in the dollar value of equity of the top 10 non-US banks from the quarter before (not lagged). ΔVIX is the log difference of VIX from the quarter before (not lagged). ΔRER(-1) is the log difference of the real exchange rate (lagged by one quarter). Other local variables are GDP growth, Debt to GDP ratio, growth of M2 money stock and Inflation, all measured at the end of the most recent calendar year. p-values are reported in parantheses. Standard errors are clustered at the country level.

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<th>4</th>
<th>5</th>
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<td>ΔInteroffice(-1)</td>
<td>0.0103***</td>
<td>0.0061**</td>
<td>0.0059**</td>
<td></td>
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<td></td>
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<td></td>
<td>[0.000]</td>
<td>[0.020]</td>
<td>[0.024]</td>
<td></td>
<td></td>
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<tr>
<td>VIX(-1)</td>
<td>-0.0679***</td>
<td>-0.0603***</td>
<td>-0.0443***</td>
<td></td>
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<td></td>
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<tr>
<td>ΔVIX</td>
<td>-0.0241***</td>
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<td>-0.0258***</td>
<td></td>
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<td>ΔEquity</td>
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<td>0.3378**</td>
<td>0.2046*</td>
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<tr>
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<td>-0.0749*</td>
<td></td>
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<td></td>
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<td>ΔRER(-1)</td>
<td></td>
<td>-0.1517***</td>
<td>-0.1262***</td>
<td>-0.0925**</td>
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<td>ΔM2</td>
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<td>0.0184</td>
<td></td>
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<td>Debt/GDP</td>
<td></td>
<td>-0.0939**</td>
<td>-0.1032***</td>
<td></td>
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<td></td>
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<td>Inflation</td>
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<td>-0.3179***</td>
<td>-0.2157***</td>
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<tr>
<td>Constant</td>
<td>0.0240***</td>
<td>0.2314***</td>
<td>0.0208***</td>
<td>0.2085***</td>
<td>0.0249***</td>
<td>0.0559***</td>
<td>0.2027***</td>
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<td>[0.000]</td>
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<td>[0.006]</td>
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<td>2.990</td>
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<td>0.003</td>
<td>0.065</td>
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<td>0.075</td>
<td>0.111</td>
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<td>46</td>
<td>46</td>
<td>46</td>
<td>46</td>
<td>46</td>
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</tr>
</tbody>
</table>
inflow rate with VIX at 15% versus 25% is roughly 0.51 × 0.06 ≈ 0.031, implying a difference in quarterly flows of 3.1%. When annualized, this translates into a roughly 12% difference. This sizeable impact illustrates well the important role played by measured risks in determining capital flows.

We also note that ∆Equity and its interaction with VIX(-1) also figures prominently in the regressions with the predicted sign. Thus, we verify both the impact of the marginal bank equity that interacts with the level of leverage, as well as the impact of the change in leverage, for the existing infra-marginal units of equity. In particular, the significance of the interaction term ∆Equity*VIX(-1) strongly suggests that changing balance sheet capacity of global banks are important determinants of capital flows.

Taking the comparative statics from equation (34) as a package, we conclude that the theoretical predictions receive broad support from Table 2. As discussed already, global banks reallocate internal funds raised in the US across locations which impacts capital flows. Cetorelli and Goldberg (2009, 2010) have documented such reallocations, providing evidence of cross border, intra-bank funding flows between US global banks and their foreign operations which has an impact on foreign lending decisions. Our results build on their discussion of interoffice dynamics by showing the consequences of the internal capital market reallocations on aggregate outcomes and the global nature of the bank leverage channel.

Turning now to columns 5 to 7, we first focus on the impact of currency appreciation on capital flows. The variable RER is the price of dollars in local currency in real terms, so that a fall in RER represents an appreciation of the local currency. The variable ∆RER(-1) is the quarterly log difference of the real exchange rate to the US dollar lagged by one quarter. We see that the coefficient on this variable is negative and highly significant, indicating that a real appreciation between date $t − 1$ to date $t$ is associated with acceleration in bank capital flows between date $t$ to date $t + 1$.

The slow-moving nature of the impact of currency appreciation implied by our finding is striking, and poses challenges for traditional models with forward-looking behavior and rational expectations. In our model, the banks act myopically, constrained only by their Value-at-
Risk constraint, and the increase capital inflows reflect additional lending following a decline in measured credit risk.

From columns 5 to 7, we see that the addition of other country-level control variables does not diminish the role of global variables. Higher GDP growth, proxing for high domestic demand conditions, is positively associated with capital flows, whereas the deterioration of lending conditions (higher inflation) and of public debt conditions act as push factors against cross-border lending. The expansion of the domestic money stock is also associated with capital flows, albeit this evidence is less robust. Our results in columns 5 to 7 are qualitatively unchanged if we use the four quarter lagged values of the local macro variables (the data frequency for money stock, GDP and debt are annual).

The $R^2$ statistics reported in Table 2 are the “within” panel $R^2$ numbers for deviations from individual country means. Table 2 shows that global variables alone explain 6.5% of variation in capital flows (column 4) which is almost as large as when local variables are used ($R^2 = 7.5\%$, column 6). In unreported regressions we re-ran the regressions by OLS and find that the adjusted $R^2$ confirms the importance of both global and local variables.

### 4.2 Incremental Country Effects

We complement our panel regressions with an investigation of the sensitivity of individual countries to fluctuations in the VIX and $\Delta$Interoffice variables. For a particular country $c$, the residuals from our benchmark panel regression (37) reflect the amount of capital flows into that country that is left unexplained by the coefficients on the explanatory variables in (37), which were obtained to fit the full sample. We could then ask whether the residuals from this regression reveal any additional sensitivity of country $c$ to global factors over and above the estimates that are designed to fit the whole sample of countries. If a country is particularly sensitive to global conditions, we should expect the residuals for that country in the panel regression to be correlated with the global factors themselves.

We operationalize this idea of examining incremental country-specific sensitivities by running an augmented panel regression with country interaction terms designed to capture the
incremental impact of global factors on a particular country. In particular, our augmented panel regressions have the following specification with country fixed effects and standard errors clustered at the country level:

\[
\Delta L_{c,t} = \beta_{c,0} + \beta_{c,1} VIX_{t-1} + \beta_{c,2} VIX_{t-1} \times \text{Country}_c \\
+ \beta_{c,3} \Delta \text{Interoffice}_{t-1} + \text{controls}_{c,t} + \epsilon_{c,t}
\]  

(38)

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 \text{Country}_c\) is a dummy equal to 1 for country \(c\) and 0 otherwise. The key feature in (38) is the interaction term \(VIX_{t-1} \times \text{Country}_c\), which gives the excess sensitivity of country \(c\) to VIX. The controls and the additional global variables are as in Table 2.

The panel regression (38) 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 \(\Delta \text{Interoffice}\) as follows.

\[
\Delta L_{c,t} = \beta_{c,0} + \beta_{c,1} \Delta \text{Interoffice}_{t-1} + \beta_{c,2} \Delta \text{Interoffice}_{t-1} \times \text{Country}_c \\
+ \beta_{c,3} VIX_{t-1} + \text{controls}_{c,t} + \epsilon_{c,t}
\]  

(39)

Again, the sum of the coefficients \(\beta_{c,1} + \beta_{c,2}\) measures the total effect of \(\Delta \text{Interoffice}\) 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 from different geographical areas): Estonia, Latvia, Lithuania, Romania, Turkey, Brazil, Chile, Spain, Ireland, UK, Germany, France, Italy, Japan. Table 3 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 \(\beta_{c,2}\).
Table 3. **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 2. See text for explanation of methodology. p-values are reported in parantheses. Standard errors are clustered at the country level.

<table>
<thead>
<tr>
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<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Range of the ( \beta_{c,1} ) coefficient estimated from the individual countries regressions</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>( \beta_{c,1} ) VIX</td>
<td>-0.0354****/</td>
<td>-0.0383***</td>
<td>( \Delta )Interoffice</td>
<td>0.011****/</td>
</tr>
<tr>
<td></td>
<td>[0.000]</td>
<td>[0.000]</td>
<td>[0.000]</td>
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<tr>
<td><strong>Individual countries interaction coefficients ( \beta_{c,2} ) derived from separate regressions</strong></td>
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<tr>
<td>( \beta_{c,2} )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VIX*Estonia</td>
<td>-0.0033 0.0900</td>
<td>Reject ( \Delta )Interoffice*Estonia</td>
<td>0.0189*** [0.000]</td>
<td>Reject ( \beta_{c,1} + \beta_{c,2} = 0 )</td>
</tr>
<tr>
<td>VIX*Latvia</td>
<td>-0.0235** [0.027]</td>
<td>Reject ( \Delta )Interoffice*Latvia</td>
<td>0.0063** [0.017]</td>
<td>Reject</td>
</tr>
<tr>
<td>VIX*Lithuania</td>
<td>-0.0098*** [0.000]</td>
<td>Reject ( \Delta )Interoffice*Lithuania</td>
<td>0.0045* [0.074]</td>
<td>Reject</td>
</tr>
<tr>
<td>VIX*Romania</td>
<td>-0.0479*** [0.000]</td>
<td>Reject ( \Delta )Interoffice*Romania</td>
<td>-0.0043 [0.121]</td>
<td>Reject</td>
</tr>
<tr>
<td>VIX*Turkey</td>
<td>-0.0052 [0.533]</td>
<td>Reject ( \Delta )Interoffice*Turkey</td>
<td>-0.0031 [0.350]</td>
<td>Reject</td>
</tr>
<tr>
<td>VIX*Brazil</td>
<td>-0.0033 [0.511]</td>
<td>Reject ( \Delta )Interoffice*Brazil</td>
<td>-0.0064** [0.014]</td>
<td>Reject</td>
</tr>
<tr>
<td>VIX*Chile</td>
<td>0.0811*** [0.000]</td>
<td>Reject ( \Delta )Interoffice*Chile</td>
<td>-0.0121*** [0.000]</td>
<td>Do not Reject</td>
</tr>
<tr>
<td>VIX*Spain</td>
<td>0.0378*** [0.000]</td>
<td>Do not Reject ( \Delta )Interoffice*Spain</td>
<td>0.0147*** [0.000]</td>
<td>Reject</td>
</tr>
<tr>
<td>VIX*Ireland</td>
<td>0.0517*** [0.000]</td>
<td>Do not Reject ( \Delta )Interoffice*Ireland</td>
<td>-0.0041 [0.292]</td>
<td>Reject</td>
</tr>
<tr>
<td>VIX*UK</td>
<td>0.0051 [0.395]</td>
<td>Reject ( \Delta )Interoffice*UK</td>
<td>-0.0156*** [0.000]</td>
<td>Reject</td>
</tr>
<tr>
<td>VIX*Germany</td>
<td>0.0162*** [0.002]</td>
<td>Reject ( \Delta )Interoffice*Germany</td>
<td>-0.0021 [0.384]</td>
<td>Reject</td>
</tr>
<tr>
<td>VIX*France</td>
<td>-0.0020 [0.699]</td>
<td>Reject ( \Delta )Interoffice*France</td>
<td>-0.0038 [0.144]</td>
<td>Reject</td>
</tr>
<tr>
<td>VIX*Italy</td>
<td>-0.0007 [0.896]</td>
<td>Reject ( \Delta )Interoffice*Italy</td>
<td>0.0049** [0.048]</td>
<td>Reject</td>
</tr>
<tr>
<td>VIX*Japan</td>
<td>0.0706*** [0.000]</td>
<td>Reject ( \Delta )Interoffice*Japan</td>
<td>-0.0327*** [0.000]</td>
<td>Reject</td>
</tr>
<tr>
<td>Constant Y</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Controls Y</td>
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<td></td>
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</tr>
<tr>
<td>Observations</td>
<td>2,368</td>
<td></td>
<td>2,368</td>
<td></td>
</tr>
<tr>
<td># of countries</td>
<td>46</td>
<td></td>
<td>46</td>
<td></td>
</tr>
</tbody>
</table>
Column 1 shows that the VIX interaction terms $\beta_{c,2}$ for the Baltic countries Latvia and Lithuania, and for Romania are highly negative and significant, indicating greater incremental sensitivity to VIX relative to other countries in the sample. The $\beta_{c,2}$ interaction terms for Chile, Spain, Ireland, Germany, and Japan are positive and significant, suggesting that, the impact of global liquidity for these countries is mitigated. The overall impact remains negative for Germany (the F-test in column 2 rejects that the sum of the coefficients $\beta_{c,1} + \beta_{c,2}$ is equal to zero), zero for Spain and Ireland (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), and it actually turns positive for Chile and Japan. Global liquidity as measured by VIX does not seem to have a differential impact for all the other countries (Estonia, Turkey, Brasil, UK, France and Italy).

Column 3 reports the results where the $\Delta$Interoffice variable is interacted with each individual country dummy instead of VIX. The coefficient estimates $\beta_{c,2}$ of the Baltic countries, Spain and Italy are positive and highly significant with large coefficients. This indicates that the marginal effect $\beta_{c,2}$ of $\Delta$Interoffice 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 Brasil, Chile, UK and Japan 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 $\Delta$Interoffice is reversed (i.e., becomes negative) for Chile and Japan and also UK with a smaller magnitude. Taken together, these results suggest that the Baltic countries have been the most sensitive to global liquidity in the sample period. For other countries, like Spain, Ireland, Germany, Italy, the sensitivity to global conditions can be seen more through the Interoffice channel than through the leverage channel (VIX). This suggests the presence of country heterogeneity to global conditions, most likely driven by different liquidity and exposure conditions in the US.

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.\textsuperscript{3} Japan is by far the most prominent outlier in this case, as its sensitivity to global factors is the opposite of the typical country in our sample. Capital inflows in Japan is higher during periods of market stress, rather than during boom times. The findings for Japan is consistent with the role played by Japan as the recipient of flight to safely flows of capital during crises.

### 4.3 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? 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 (2012) 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, and Figure 2 on the net interoffice assets of foreign banks in the US also suggests that decade of the 2000s represents a special period in terms of the activities of global 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. We do so by introducing dummy variables that can be interacted with the $\Delta$Interoffice and VIX variables and test for the significance of the incremental effects. Specifically, we examine the results of regressions of the form

$$
\Delta L = \beta_1 \Delta \text{Interoffice}_{t-1} + \gamma_1 \text{VIX}_{t-1} + \beta_2 \Delta \text{Interoffice}_{t-1} \ast \text{dummy} \\
+ \gamma_2 \text{VIX}_{t-1} \ast \text{dummy} + \text{controls}(t) + e(t)
$$

We then examine the incremental effect of the dummy ($\beta_2$ and $\gamma_2$) as well as the total effect,

\textsuperscript{3}We are grateful to Rodrigo Cifuentes for pointing out this particular feature of Chile’s financial system.
given by the sum of the coefficients $\beta_1 + \beta_2$ and $\gamma_1 + \gamma_2$. Table 4 reports regression results for banking sector capital flows.

Column 1 of Tables 4 reports the robustness checks for the crisis and non-crisis periods. The NBER identifies the period of the great financial crisis\(^4\) from December 2007 to June 2009. VIX remains negative and significant at 1% in all periods, with an incremental effect of $-0.013$ during crisis periods. This result suggests that the predictive role of the VIX does not disappear when confining attention to non-crisis periods. However, we also verify the additional kick given by crisis periods. The total effect is very substantial (F-value = 31.25, $p = 0.000$). A similar pattern occurs for the growth in interoffice assets. We see from Table 4 that $\Delta$Interoffice (by itself) remains positive (0.0089) and the incremental effect of the crisis period is large, at 0.0482 and highly significant ($p = 0.000$) demonstrating the impact of the interoffice variable is amplified during the crisis period.

This evidence is consistent with the findings in De Haas and Van Horen (2012), who find that during crisis banks curtail lending abroad, and with the findings in Cetorelli and Goldberg (2010), who find that during crisis lenders depending on US dollar funding curtailed cross-border lending. Our results show that the cross-border lending reduction happened through the de-leveraging channel of global banks.

Column 2 of Table 4 examines whether our results hold both for developed and developing economies. We create a dummy equal to 1 when a country is a developed economy, and 0 otherwise.\(^5\) We interact the dummy with $\Delta$Interoffice and VIX. Both $\Delta$Interoffice and VIX by themselves are significant, while their interaction terms with the dummy equal to 1 for developed countries are not significant. This suggests that there is little difference between the group of developing countries from the developed countries and that bank leverage decisions have global impact that is not confined to emerging markets.

In our final set of robustness checks, we now turn to column 3 of Table 4, which addresses

\(^4\)http://www.nber.org/cycles.html

\(^5\)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.
Table 4. **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 parentheses. Standard errors are clustered at the country level.

<table>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>ΔInteroffice</td>
<td>0.0089***</td>
<td>0.0117**</td>
<td>0.0103***</td>
</tr>
<tr>
<td></td>
<td>[0.002]</td>
<td>[0.010]</td>
<td>[0.000]</td>
</tr>
<tr>
<td>ΔInteroffice*Crisis</td>
<td>0.0482***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td>ΔInteroffice*Developed</td>
<td>-0.0025</td>
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<td>0.134</td>
</tr>
<tr>
<td></td>
<td>[0.596]</td>
<td></td>
<td>[0.232]</td>
</tr>
<tr>
<td>ΔInteroffice*pre 1999</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VIX</td>
<td>-0.0324***</td>
<td>-0.0401***</td>
<td>-0.0360***</td>
</tr>
<tr>
<td></td>
<td>[0.000]</td>
<td>[0.000]</td>
<td>[0.000]</td>
</tr>
<tr>
<td>VIX*Crisis</td>
<td>-0.0130***</td>
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</tr>
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<td></td>
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<tr>
<td>VIX*Developed</td>
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<td>[0.515]</td>
<td></td>
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<tr>
<td>VIX*pre 1999</td>
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<td>-0.0164***</td>
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<td></td>
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<tr>
<td>ΔVIX</td>
<td>-0.0184**</td>
<td>-0.0227***</td>
<td>-0.0252***</td>
</tr>
<tr>
<td></td>
<td>[0.016]</td>
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<td>[0.001]</td>
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<tr>
<td>RER</td>
<td>-0.0701***</td>
<td>-0.0792***</td>
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<tr>
<td>ΔEquity</td>
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<td>0.2684**</td>
<td>0.2453***</td>
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<td>[0.020]</td>
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<td>[0.042]</td>
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<tr>
<td>ΔEquity*VIX</td>
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<td>-0.0986**</td>
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<tr>
<td>ΔM2</td>
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<td>0.0301</td>
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<td>GDP growth</td>
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<td>0.3570***</td>
<td>0.3613***</td>
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<td>Debt to GDP</td>
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<td>Constant</td>
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<td>46</td>
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</table>
the possible structural change 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. Interestingly, we find that the interaction term with VIX is highly significant even before 1999. Since our data for global bank equity is only available from 1998, the pre-1999 dummy picks up just the impact of 1998 alone. Since 1998 was the year associated with the financial distress generated by the near collapse of the hedge fund LTCM and the Russian default, the fact that the interaction of the time dummy with the VIX index is not a surprise. Note, however, that the pre-1999 time dummy interacted with the ΔInteroffice term is not significant.

5 Directions for Further Research

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), Obstfeld (2012a, 2012b) and Gourinchas and Obstfeld (2012) on the importance of gross capital flows between countries in determining financial conditions. The current account and net external asset positions of countries are clearly important for assessing the long-run sustainability of the current account (see Hau and Rey (2011), Lane and Milesi-Ferretti (2007) and Gourinchas and Rey (2007) and the post-crisis updated evidence in Gourinchas, Govillot and Rey (2010) and Gourinchas, Rey and Truempler (2011)). Nevertheless, gross flows, and in particular measures of banking sector liabilities may hold important information for risk premiums and hence financial sector vulnerability.\(^6\)

For the European financial crisis, the important distinction is less between net and gross flows, but instead whether the flows have been financed by the banking sector or through some

\(^6\)See Rose and Spiegel (2009), Shin and Shin (2010) and Hahm, Shin and Shin (2011) for empirical analyses of this issue.
other channel. In practice, the credit boom in countries such as Ireland and Spain were financed primarily through the banking sector (see Allen, Beck, Carletti, Lane, Schoenmaker and Wagner (2011) and Lane and Pels (2011)). Therefore, the mechanisms outlined here on the link between capital flows and leverage are relevant in understanding the European crisis.

Our findings highlight the role of financial intermediaries in driving fluctuations in risk premiums and financial conditions, especially in connection with the growing use of wholesale 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.

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) and Obstfeld (2012a, 2012b) on the importance of gross capital flows between countries in determining financial conditions, rather 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.⁷

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