The shifting drivers of international capital flows

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Abstract

Global factors, such as advanced economy monetary policies and global risk conditions, have historically been important drivers of international capital flows. Using the BIS international banking and international debt securities statistics for a large panel of countries over fourteen years, we show that the aftermath of the Global Financial Crisis has been characterized by a dramatic increase in the sensitivity of all major types of international financial flows to US monetary policy. The impact of global risk conditions has increased significantly for international bonds flows and has declined for cross-border loan flows, but remains qualitatively important. The post-crisis increases in the sensitivities to US monetary policy are driven mainly by behavioural, rather than compositional, shifts. National banking systems that were ex ante better-capitalized experienced smaller rises in sensitivities to US monetary policy and larger increases in international lending shares.

JEL-codes: G10, F34, G21
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1. Introduction

International capital flows are important for supporting real economic activity worldwide, channelling financial resources to public and private borrowers. The supply and sensitivities of these capital flows to global liquidity drivers and local factors are important for economic growth and associated risks. Cross-border bank-to-bank lending has dominated overall credit-based financing and has been particularly sensitive to global liquidity conditions, as captured by monetary policy factors and proxies for global risk conditions. Market-based financing, for example through international debt securities, has historically been less flighty. The patterns of drivers and their strength for various types of international capital flows and domestic versus foreign investors has been carefully documented (Forbes and Warnock (2012), Cerutti, Claessens, and Ratnovski (2014), Miranda-Agrippino and Rey (2015); Bruno and Shin (2015a)).

The aftermath of the global financial crisis was accompanied by an immediate international capital flow retrenchment, with some subsequent recovery (Milesi-Ferretti and Tille (2011)). The policy community proceeded with a range of reforms aimed at making banks safer and reducing systemic vulnerabilities. Such reforms include changed required capital and liquidity ratios for banks, newly developed prudential policy frameworks, enhanced stress-testing frameworks, and expanded regimes for bank holding company recovery and resolution in the event of a solvency event. Some globally-active banks reduced balance sheet leverage and evolved their business models. The decline in bank-based cross-border lending, particularly by eurozone banks, has been described as financial deglobalization (Rose and Wieladek (2011), Forbes et al (2015), Bussiere, Schmidt and Valla (2016)). For U.K. banks, prudential policies and unconventional monetary policy in the form of a funding for lending scheme jointly contributed to a retrenchment of cross-border lending (Forbes, Reinhardt, and Wieladek, forthcoming). More broadly, a shift occurred in the composition of international capital flows worldwide, as the first phase of global liquidity through banks was replaced to some degree by a second phase of global liquidity through corporate bond financing, particularly for emerging market borrowers (Shin 2013).[2]

All of these changes in international capital flow patterns raise the broader issue of whether this type of evolution has generated global capital flows that have more desirable properties than those that dominated flows prior to the global financial crisis. It also raises the issue of the reasons for the changes, and whether they are likely to persist. These issues motivate the current paper, which both documents changes in the strength of global capital flow drivers and explores whether these are explained by shifts in the composition or in the behaviour of creditors. We further tie these two themes to underlying measures of creditor and debtor ex ante conditions, as well as to changes in prudential instruments across countries and over time. Bremus and Fratzcher (2015) have conducted a pre- versus post-crisis assessment of the role of monetary policy versus regulatory strength in cross-border bank

[2] These observations pertain to volumes of cross-border flows, not to co-movements of asset prices. During this same broad period, co-movements in international asset prices continue to be at least as strong and sensitive to global risk sentiment and liquidity conditions as pre-crisis state. This type of evidence does not support de-globalization.

flows, concluding that cross-border bank lending has decreased in the post-crisis period and that expansionary monetary policy in source countries has encouraged cross-border lending.

Our approach instead provides time-series panel evidence on the importance of specific global and local drivers of cross-border loan and international debt securities flows, vis-à-vis both bank and nonbank borrowers. Our analysis uses detailed quarterly data for a panel of sixty-four countries for the period between 2000:Q1 and 2013:Q4. We combine the BIS International Banking Statistics (IBS) and the BIS International Debt Securities (IDS) Statistics to create a panel of international capital flows from the perspective of the recipient countries. Unlike most prior research on the topic, we explicitly separate cross-border bank loan financing flows from international bond financing flows.[3]

We document a set of intriguing changes in the pattern of sensitivities to global factors. First, we start by establishing the empirical importance of global risk and liquidity factors over the full sample period of the data, reaching conclusions that are qualitatively similar to the results of prior studies (e.g. Rey 2013). We then test for the presence of structural breaks in the sensitivity of cross-border credit flows to global factors. The evidence points to structural breaks around Lehman's default for both cross-border bank loans and international debt securities. Structural breaks are detected for all main drivers, but are particularly strong for global factors such as the VIX and the federal funds rate.

Our first key finding is that international capital flows' sensitivities to global factors have changed considerably since the Global Financial Crisis. Our results suggest that the impact of US monetary policy on both cross-border loans and international debt securities has increased considerably during the post-crisis period. Furthermore, we find that the sensitivity of market-based lending (through debt securities) to global risk conditions has also increased significantly. By contrast, the respective sensitivity to global risk conditions for cross-border bank loans has declined.

An important implication of the above findings is that cross-border bank loans and international debt securities have become more similar since the Global Financial Crisis in terms of their responsiveness to global factors. This could be interpreted as a manifestation of the fact that business models of bank and nonbank international lenders have become more similar. An important potential consequence of such a convergence would be that diversification across types of investors may be less of a market-based stabilizer to international flows than had previously been the case. Indeed, during the post-crisis period, *total* capital flow responsiveness to global liquidity conditions has increased substantially, while sensitivity to global risk has declined, but remains qualitatively important.

Our second key finding it that the post-crisis increases in the sensitivity of international bank lending flows to US monetary policy were driven by increases in the sensitivities of individual banking systems (i.e. by behavioral factors) rather than by a shift in the composition of international lending from less to more sensitive banking systems (i.e. by compositional

[3] McCauley et al (2015) also separate loan flows from international bond flows, but focus exclusively on credit denominated in US dollars. They analyse the links between US monetary policy and dollar credit extended to non-US borrowers and find that unconventional monetary policy contributed to shifting the balance of dollar credit transmission from global banks to global bond investors.

factors). We obtain similar results for the change in the sensitivity to the VIX of international bank lending flows to the public sector.

Our third key finding is that a significant part of the changes in sensitivities to global factors and of the composition of international lenders directly correlates with capitalisation levels. More concretely, national banking systems that were ex ante better-capitalized experienced smaller rises in sensitivities to US monetary policy and larger increases in international lending shares. Furthermore, higher ex ante shares of deposits in total funding and local claims in foreign claims were also associated with larger increases in international lending shares. Some prudential policy measures, such as local currency reserve requirements, were also positively correlated with the relative stability of loan supply.

The remainder of the paper is organised as follows. The next section reviews the literature on global drivers of international capital flows. Section 3 discusses the econometric methodology that we employ in our empirical investigation. Section 4 discusses the data. Section 5 goes over the most important stylized facts concerning international capital flows. Section 6 presents our main empirical results. Section 7 concludes.

2. Prior evidence on drivers of international flows

The distinction between push and pull factors for capital flows has been the dominant intellectual framework for classifying drivers since the focus of academic inquiry shifted to the role of external factors in the early 1990s. In the existing literature, domestic economic performance, asset return indicators, and country risk indicators stand out as important pull variables. Similarly, mature economy interest rates and global risk aversion are unambiguously important push factors and have significant explanatory power for capital flows movements (Cerutti et al (2014) and Koepke (2015)).

Virtually all papers in the existing empirical literature have concluded that banking flows respond negatively to increases in global risk conditions (Jeanneau and Micu (2002), Ferucci et al (2004), Takats (2010), Milesi-Ferretti and Tille (2011), Forbes and Warnock (2012), Rey (2013), Herrmann and Mihaljek (2013), Bruno and Shin (2015b)). In addition, there is also solid empirical evidence that global risk conditions have a strong negative impact on international bond flows (e.g., Milesi-Ferretti and Tille 2011; Broner et al. 2013).

The empirical evidence for the impact of US monetary policy on international capital flows is more nuanced. A number of empirical studies have documented a negative relationship (Cetorelli and Goldberg (2012), Ghosh et al. (2014), Bruno and Shin (2015a)). However, other papers have found mixed results (Goldberg (2002) and Cerutti et al. (2014)). Meanwhile, some studies have concluded that the relationship is positive (Jeanneau and Micu (2002) and Correa et al (2016)).

Numerous studies published over the past two decades have analyzed the relationship between portfolio flows and global interest rates (often proxied by US policy rates). The majority of them have concluded that an increase in global interest rates tends to have a negative impact on portfolio flows. Most studies find that bond flows are more sensitive to mature economy interest rates than equity flows (including Taylor and Sarno 1997; Koepke 2014, and Dahlhaus and Vasishtha 2014; an exception is Chuhan et al. 1998). Furthermore,

McCauley et al (2015) have recently demonstrated the existence of a negative and statistically significant relationship between the term premium on 10-year Treasury bonds and international bond issuance during the post-crisis period.

This paper also analyses the interactions between global drivers of cross-border flows and country-specific prudential measures. Buch and Goldberg (2016) use the dataset on prudential policy measures developed by Cerutti et al. (2015) to analyse cross-border prudential policy spillovers. They find that capital requirements, loan-to-value ratios and reserve requirements are most frequently spilled over across borders through bank lending. Previous papers have explored the role of prudential policies using alternative databases. Houston, Lin and Ma (2012) find that banks transfer funds to markets with fewer regulations when there is an effort by domestic regulators to limit bank risk-taking. These effects were particularly significant when the recipient country was a developed country with strong property rights and creditor rights. In a similar vein, Bremus and Fratzscher (2015) use the BIS international banking statistics to disentangle the role of monetary policies versus more stringent regulatory policies in explaining patterns of international flows around the global financial crisis period. Cross-border bank outflows were driven by expansionary monetary policies, while some flows were mitigated by tighter regulation. Both studies utilized the database of Barth, Caprio and Levine (2013).

Other studies rely on alternative prudential instrument databases and provide cross-country lessons usually using data on economic aggregates. Cerutti et al. (2015) use the 2013 IMF survey to create a database of prudential policy in 119 countries, and then sum across all policies – finding that EM credit growth is lower with tighter policies. Claessens, Ghosh and Mihet (2014) use annual data collected through an internal IMF survey of country desk economists and a sample of banks in 35 countries over 2000-2010. They conclude that caps on borrower and financial institutions' assets- and liabilities–based measures may be effective, while buffer-based policies seems to have little impact on asset growth. Overall, there is little evidence that the effectiveness of these tools varied by the intensity of the cycle, although the main impact of policies is in reducing vulnerabilities by decreasing risks during upswings.

3. Empirical strategy

Our formal empirical investigation is divided in two parts. In the first part of the analysis, we estimate the sensitivities of international flows to global and country-specific drivers. We then document the presence of a structural break around the peak of the global financial crisis and examine differences between the pre- and the post-break sensitivities. In the second part of the analysis, we explain the changes of the sensitivities to global shocks over time. More concretely, we examine the evidence for changes in behaviours by different types of creditors vis-à-vis different counterparties, the importance of changes in the composition of creditors and whether balance sheet characteristics or prudential policy actions may be responsible for either of those.

3.1 Baseline analysis

In the first part of the analysis our baseline model is the following:

$$GrRateY_t^j = \beta_1 \Delta FFR_t + \beta_2 logVIX_t + \beta_3 \Delta logGDP_t^j + \beta_4 \Delta SovRating_t^j + \beta_5 ChinnIto_t^j + \beta_6 \Delta logGlobalGDP_t + \mu^j + \varepsilon_t^j \quad (1)$$

where $j = 1, \dots, 64$ denotes one of 64 advanced and emerging economies and t is a quarter between 2000:Q1 and 2013:Q4. As detailed in the data section, we have broken down cross-border flows by instrument and by type of borrower. Therefore, Y can be cross-border loans - to all sectors, to banks, to non-banks - or international debt securities - issued by all sectors, by banks or by non-banks. As standard in the literature, the model is expressed in stationary variables to avoid problems of spurious correlations. The cross-border flows on the left-hand side of the equation are expressed in growth rates that filter out FX movements and breaks in the series from one quarter to the next.[4] The right-hand-side of the equation contains two global drivers, the Fed funds rate (capturing global funding conditions) and the VIX (representing global volatility), and a set of country-specific and global controls (sovereign rating, Chinn-Ito index and local and global GDP). The Fed funds rate and the sovereign ratings are in first differences, while the local and global GDP are in growth rates. The Chinn-Ito index is in levels and the VIX enters the equation in logs as both series are stationary.[5]

We estimate the model under the assumption that the two global drivers of interest, the Fed funds rate and the VIX, are exogenous when controlling for local and global GDP, government ratings and degree of financial openness. In particular, the inclusion of these variables allows us to control for the risk of the borrowing country. Local GDP growth measures overall economic performance. Sovereign ratings proxy the perceived creditworthiness of the borrowing country. The Chinn-Ito index measures the degree of capital account openness.

There is an abundance of anecdotal evidence that hints at the presence of a possible structural break around the global financial crisis. However, rather than exogenously imposing a particular break date, we conduct a formal search for an endogenous structural break in the parameters of the model. More concretely, we use the tools developed in Bai (1994, 1997), Kurozumi (2002) and Carrion-i-Silvestre and Sansó (2006). For each quarter T starting in 2007:Q1, we estimate the following equation

$$GrRateY_t^j = \beta' X_t^j + \mu^j + I(t \geq T)(\kappa + \gamma' X_t^j) + \varepsilon_t^j \quad (2)$$

where

$$X_t^j = (\Delta FFR_t, logVIX_t, \Delta logGDP_t^j, \Delta SovRating_t^j, ChinnIto_t^j, \Delta logGlobalGDP_t)'$$

and $I(t \geq T)$ is an indicator function that takes the value 1 when $t \geq T$ and 0 otherwise. Notice that for each candidate break date T, all the parameters of equation (2) are different. For each type of cross border flow Y and each quarter T we can compute the sum of squared residuals of the regression in order to get a sequence $\{SSR_T^Y\}_{T \geq 2007:Q1}$. The most likely candidate for the

[4] $GrRateY_t^j = AdjFlowY_t^j / Y_{t-1}^j$

[5] The Chinn-Ito index has a yearly frequency and therefore proceeds in steps. We have tested the robustness the results by using a quarterly linear interpolation of Chinn-Ito index and by eliminating the index from the regressions. In both cases the main results of the study are qualitatively similar.

break is the date that minimizes the sequence, hence maximizing the fit of the model: $T^{Y}_{break} = argmin_{T \geq 2007:Q1}\{SSR^{Y}_{T}\}$.

Once we have detected the endogenous date for the break (T^{Y}_{break}), we then re-estimate the baseline model with the appropriate break dummy

$$GrRateY^{j}_{t} = \beta' X^{j}_{t} + \mu^{j} + I\left(t \geq T^{Y}_{break}\right)\left(\kappa + \gamma' X^{j}_{t}\right) + \varepsilon^{j}_{t} \quad (3)$$

and we use a Wald test on κ and γ' to determine whether the break is statistically significant.

β' contains the sensitivities of cross-border flows to the drivers in X^{j}_{t} before the break. The sum $\beta' + \gamma'$ contains the post-break sensitivities.

In the next step of our analysis, we use the BIS consolidated banking statistics (CBS). This dataset contains information on banks' international claims (defined as the sum of cross-border claims and local claims denominated in foreign currencies). The data is bilateral – it contains information on the nationality of the lending banks (*i*) and on the residence of the borrower (*j*).

Thus, the CBS data allow us to add the lending country dimension to the analysis. We exploit this additional dimension in two ways. First, we include both lending-country and borrowing-country fixed effects into the model. Second, we include prudential variables both on the lender side and on the borrower side. Since the data are now very granular, we control for the effects of outliers on the results by winsorizing the growth rates of cross-border loans at the 10% level.

The baseline model is the same as model (1), with the inclusion of lending-country fixed effects θ^{i}:

$$\begin{aligned} GrRateY^{ij}_{t} = {} & \beta_1 \Delta FFR_t + \beta_2 logVIX_t + \beta_3 \Delta logGDP^{j}_{t} + \beta_4 \Delta SovRating^{j}_{t} \\ & + \beta_5 ChinnIto^{j}_{t} + \beta_6 \Delta logGlobalGDP_t + \theta^{i} + \mu^{j} + \varepsilon^{ij}_{t} \end{aligned} \quad (4)$$

$GrRateY^{ij}_{t}$ no longer filters out FX movements and breaks in the series as these refinements are not available in the BIS consolidated dataset.

We search for an endogenous break date using the SSR procedure. Once we find the break date T^{Y}_{break} we estimate the following equation:

$$GrRateY^{ij}_{t} = \beta' X^{j}_{t} + \theta^{i} + \mu^{j} + I\left(t \geq T^{Y}_{break}\right)\left(\kappa + \gamma' X^{j}_{t}\right) + \varepsilon^{ij}_{t} \quad (5)$$

where $X^{j}_{t} = \left(\Delta FFR_t, logVIX_t, \Delta logGDP^{j}_{t}, \Delta SovRating^{j}_{t}, ChinnIto^{j}_{t}, \Delta logGlobalGDP_t\right)'$. We use a Wald test on κ and γ' to determine whether the break is statistically significant. β' contains the pre-break sensitivities, while $\beta' + \gamma'$ contains the post-break ones.

3.2 Decomposing the post-crisis shifts in sensitivities

In the next step of our analysis, we decompose the shifts in the sensitivities of external flows to global factors into a *behavioral* component and a *compositional* component. More concretely, we show that the aggregate sensitivities of international bank lending flows to global factors (β_1 and β_2) can be expressed as weighted averages of the national banking system-specific sensitivities to global factors (β^{i}_{1} and β^{i}_{2}).

We start our derivation by re-writing specification (1) as:

$$\frac{S_t^j}{S_{t-1}^j} - 1 = \beta_1 \Delta FFR_t + \beta_2 logVIX_t + \beta_3 \Delta logGDP_t^j + \beta_4 \Delta SovRating_t^j + \beta_5 ChinnIto_t^j + \beta_6 \Delta logGlobalGDP_t + \mu^j + \varepsilon_t^j \quad (6)$$

where S_t^j is the outstanding stock of international bank lending to the residents of country *j* at the end of period *t*.

Defining $S_t^{i.j}$ as the outstanding stock of international lending extended by banks from country *i* to the residents of country *j* at the end of period *t*, we can write the national banking system-specific counterpart to specification (1) as:

$$\frac{S_t^{i.j}}{S_{t-1}^{i.j}} - 1 = \beta_1^i \Delta FFR_t + \beta_2^i logVIX_t + \beta_3^i \Delta logGDP_t^j + \beta_4^i \Delta SovRating_t^j + \beta_5^i ChinnIto_t^j + \beta_6^i \Delta logGlobalGDP_t + \mu^{i,j} + \varepsilon_t^{i,j} \quad (7)$$

Expanding and simplifying[6]:

$$\frac{S_t^j}{S_{t-1}^j} - 1 = \frac{\sum_i S_t^{i.j}}{\sum_i S_{t-1}^{i.j}} - 1 = \sum_i \left(\frac{S_t^{i.j}}{S_{t-1}^{i.j}} * \frac{S_{t-1}^{i.j}}{\sum_i S_{t-1}^{i.j}} \right) - 1 = \sum_i \left\{ \left(\frac{S_t^{i.j}}{S_{t-1}^{i.j}} - 1 \right) w_{t-1}^{i.j} \right\} \quad (8)$$

where $w_{t-1}^{i.j} = \frac{S_{t-1}^{i.j}}{\sum_i S_{t-1}^{i.j}}$.

Combining (7) and (8), the baseline regression specification implies that the sensitivity to the federal funds rate (β_1) can actually be expressed as a weighted average of the respective sensitivities for the individual lending national banking systems (β_1^i):

$$\beta_1 = \sum_i \{ w_{t-1}^{i.j} \beta_1^i \}$$

Similarly, the sensitivity to the VIX (β_2) can be expressed as a weighted average of the respective sensitivities for the individual lending national banking systems (β_2^i):

$$\beta_2 = \sum_i \{ w_{t-1}^{i.j} \beta_2^i \}$$

In both cases, the weight for each banking system is equal to the respective share of the outstanding stock of loans for which it accounts: $w_{t-1}^{i.j} = \frac{S_{t-1}^{i.j}}{\sum_i S_{t-1}^{i.j}} = \frac{S_{t-1}^{i.j}}{S_{t-1}^j}$.

The above expressions decompose the estimated sensitivities to global factors into a compositional component (captured by the $w_1^{i\prime}s$ and the $w_2^{i\prime}s$) and a behavioral component (captured by the $\beta_1^{i\prime}s$ and the $\beta_2^{i\prime}s$). The compositional factors (the $w_1^{i\prime}s$ and the $w_2^{i\prime}s$) are directly observable and can be obtained from the CBS matrix of bilateral stocks of international claims. Meanwhile, the behavioral factors (the $\beta_1^{i\prime}s$ and the $\beta_2^{i\prime}s$) are estimated in our framework.

[6] The details of all derivations in this section are presented in Annex A.

The (pre-crisis versus post-crisis) changes in the sensitivities to the federal funds rate and the VIX can be expressed as:

$$\beta_{1,post} - \beta_{1,pre} = \sum_i \{\beta^i_{1,post} w^i_{post} - \beta^i_{1,pre} w^i_{pre}\}$$
$$= \sum_i \{(\beta^i_{1,post} - \beta^i_{1,pre}) w^i_{pre} + (w^i_{post} - w^i_{pre}) \beta^i_{1,post}\} \quad (9)$$

$$\beta_{2,post} - \beta_{2,pre} = \sum_i \{\beta^i_{2,post} w^i_{post} - \beta^i_{2,pre} w^i_{pre}\}$$
$$= \sum_i \{(\beta^i_{2,post} - \beta^i_{2,pre}) w^i_{pre} + (w^i_{post} - w^i_{pre}) \beta^i_{2,post}\} \quad (10)$$

The first terms on the right-hand side of equations (9) and (10) capture the behavioral components of the post-crisis shift in sensitivities for the individual lending national banking systems. The second terms capture the changes in the importance of lending banking systems in international bank lending. Using the above conceptual framework, we quantify the relative contributions of behavioral changes versus lender composition.

3.3 Estimating the drivers of the shifts in sensitivities and in weights

First, we investigate the empirical link between behavioral shifts in sensitives to global factors and several potential drivers of those shifts. More specifically, we examine how such shifts are linked to the initial level of bank capitalization and other ex ante banking system characteristics. Bank capital has been proved to be used as a buffer against contingencies in the case of monetary policy shocks (Gambacorta and Shin, 2016) but it can also be used to limit the effect of a credit crunch in a crisis characterized by increased global uncertainty and volatility. We also control if such shifts have been influenced by prudential policy actions prior to the break and post the break (in particular Loan-to-value (LTV) limits, Local currency reserve requirements; Capital requirements). We also use a prudential measure index that is constructed by summing up all the impulse measures undertaken by a given country. The balance sheet characteristics that we use are constructed using bank-level Bankscope data aggregated at the country level as detailed in Section 4.

To evaluate what are the main drivers in the shift in sensitivities to global factors we will run simple models in which the structural change in the coefficients is regressed on a set of pre-crisis variables. For example, in the case of the structural change of the coefficient for the federal fund rate we have:

$$(\beta^{PostBreak}_{1,c,k} - \beta^{PreBreak}_{1,c,k}) = \alpha CAP^{2008}_c + \beta PRU^{2008}_c + \theta_k + \varepsilon_{c,k} \quad (11)$$

where $(\beta^{Postbreak}_{1,c,k} - \beta^{PreBreak}_{1,c,k})$is the difference in coefficients for ΔFFR taken from equation (5), estimated for lending country c and borrowing sector *k* (banks, non-banks and public sector), CAP^{2008}_c is the pre-break capital ratio for the lending country c, PRU^{2008}_c is the pre-break cumulative prudential index for country *c* and θ_k is a vector of fixed effect for the borrowing sectors. We use pre-break characteristics to limit endogeneity issues.

Second, we examine the drivers of the shift in weights. We regress the difference in lending national banking system weights before and after the break ($w_{\mathrm{c,k}}^{PostBreak} - w_{\mathrm{c,k}}^{PreBreak}$) on a set of pre-crisis business model indicators. In particular, we have:

$$(w_{\mathrm{c,k}}^{PostBreak} - w_{\mathrm{c,k}}^{PreBreak}) = \alpha' X_c^{2008} + \beta PRU_c^{2008} + \theta_k + \varepsilon_{c,k} \qquad (12)$$

where X_c^{2008} is a vector of banking system characteristics evaluated at the end of 2008. We use also in this case pre-break characteristics to limit endogeneity issues. The vector X_c^{2008} includes four banking system indicators: i) the capital to asset ratio; ii) the deposit to total funding ratio; iii) the average bank size; iv) local claims over foreign claims.

4. Data

International capital flows

We construct our cross-border credit flows series by combining two Bank for International Settlements (BIS) datasets – the BIS Locational International Banking Statistics (LIBS) and the BIS International Debt Securities Statistics (IDSS).

We obtain data on external bank lending from the BIS LIBS, which capture the outstanding claims and liabilities of internationally active banks located in 44 BIS LIBS reporting countries[7] against counterparties residing in more than 200 countries. Banks record their positions on an unconsolidated basis, including intragroup positions between offices of the same banking group. The data are compiled following principles that are consistent with balance of payments statistics. The LIBS statistics capture around 95% of all cross-border interbank business (BIS, 2015).

In addition to providing a geographical breakdown of reporting banks' cross-border claims and liabilities, the BIS LIBS also provide information about the currency composition and the counterparty sector of banks' cross-border positions. The availability of a currency breakdown in the LIBS, coupled with the reporting of breaks in series arising from changes in methodology, reporting practices or reporting population, enables us to calculate break- and exchange rate- adjusted changes in amounts outstanding. Such adjusted changes approximate underlying flows during a quarter.[8] At the same time, the counterparty sector breakdown available in the BIS LIBS enables us also to distinguish between cross-border bank lending to bank and non-bank borrowers.

The BIS IDSS data capture borrowing in money and bond markets. International debt securities (IDS) are defined as those issued in a market other than the local market of the

[7] More information is provided at http://www.bis.org/statistics/rep_countries.htm.

[8] Adjusted changes may over- or underestimate underlying flows because adjusted changes may also be affected by changes in valuations, write-downs, the underreporting of breaks, and differences between the exchange rate on the transaction date and the quarterly average exchange rate used by the BIS to convert non-dollar amounts into US dollars.

country where the borrower resides (Gruić and Wooldridge (2012)). They encompass what market participants have traditionally referred to as foreign bonds and eurobonds.

Our sample consists of quarterly data from Q1 2000 to Q4 2013. On the borrowing side, we focus on a set of 64 countries, which includes both, Advanced Economies (AEs) and Emerging Market Economies (EMEs). On the bank lending side, we use data on the positions of all 44 BIS LIBS and 31 CBS reporting countries.[9]

Global drivers

We focus on three global factors in our analysis. The first one, global real GDP growth, measures global economic activity. The second global factor that we use in our analysis is related to the stance of US monetary policy. We proxy that with the US Federal Funds target rate. More precisely, we use a combination of the effective US Federal Funds target rate prior to Q4 2008 and the Wu-Xia (2015) estimates of the shadow Federal Funds rate from Q1 2009 onwards (Graph 1, left-hand panel). The third and final global factor that we include in our analysis is a measure of global risk aversion. We measure that with the VIX index of the implied volatility in S&P500 stock index option prices from Chicago Board Options Exchange (CBOE). This variable is plotted in the right-hand panel Graph 1.

[Graph 1]

Other potential drivers and additional controls

In line with the literature on drivers of international capital flows, we examine three borrowing country variables (i.e. pull factors) - local real GDP growth, sovereign ratings and the degree of financial openness. For each borrowing country, the sovereign ratings variable is defined as the average ratings across the three major credit ratings agencies (S&P, Moody's and Fitch). The degree of financial openness is captured by the Chinn-Ito index (2008), normalized between 0 and 1.

Prudential measures

We employ a new dataset constructed by Cerutti et al. (2015). The dataset covers widely-used prudential instruments, keeping track of the intensity of their usage in 64 countries between 2000 and 2014 (at a quarterly frequency). Information has been gathered both from regulatory sources in the individual countries, as well as extending and utilizing the Global Macro Prudential Instruments (GMPI) survey which the IMF conducted in 2013. The instruments that are covered are: general capital requirements, sector-specific capital requirements (split into

[9] The complete lists of all borrowing countries and lending national banking systems are available in Annex B.

real estate credit, consumer credit, and other), interbank exposure limits, concentration limits, loan-to-value (LTV) ratio limits, and (local currency and foreign currency) reserve requirements.

Each of the above variables comes in two versions. The first is an impulse version, which records the prudential measure undertaken in a given quarter. It can take positive and negative values, indicating a tightening or loosening of the policy, respectively, and it also takes into account the intensity of the prudential measure. The second version is a cumulative one. For every quarter and every country, it is constructed by summing up all the impulse measures undertaken by that country up to that quarter.

We focus on the three macroprudential instruments that have been shown to have the largest impact on international bank lending: loan-to-value ratio caps, capital requirements and local currency reserve requirements (Avdjiev et al (2016) and Buch and Goldberg (2016)). Table C1 contains summary statistics for those three variables. Each of the above three prudential policy tools has been used in more than half of the countries in our sample. Local currency reserve requirements have been used most often (on 297 occasions). Capital requirements and LTV caps have been employed in roughly 100 episodes each.

The split between loosening and tightening episodes varies quite a bit across the three prudential tools. For local currency reserve requirements, the number of loosening episodes (166) slightly exceeds the number of tightening episodes (131). By contrast, roughly three quarters of all LTV policy actions have been in the tightening direction. Finally, capital requirements have been tightened in each of the 100 instances in which they have been changed.

Banking system characteristics

The balance sheet characteristics of national banking systems that we use in our empirical analysis are constructed using Bankscope data. More concretely, we start by obtaining the balance sheet items of interest for the set of internationally active banks that report to the BIS consolidated banking statistics. Next, we aggregate bank-level characteristics to national banking system-wide variables, using weighted averages across the individual banks of a given nationality. The data are adjusted for mergers and acquisitions (see Brei et al., 2013) to avoid balance sheet jumps that are unrelated to lending.

Summary statistics for all of the explanatory variables used in our empirical analysis are presented in Table 1.

[Table 1]

5. Broad patterns and trends in international capital flows

The behaviour of international capital flows over the past several decades has been well-documented in the existing literature. Nevertheless, focusing on the aggregate series conceals considerable heterogeneity among the main components. At a global level, IDS have exhibited

higher growth rates than cross-border bank loans for virtually the entire sample period that we focus on (Graph 2).

[Graph 2]

As Table 2 reveals, the average quarterly growth rate of IDS (2.7%) has been more than a full percentage point higher than that of cross-border bank loans (1.3%). This relative ranking of growth rates holds true not only for aggregate global flows, but also across borrowing countries (advanced economies and emerging market economies) and sectors (banks and non-banks).

[Table 2]

Nevertheless, a deeper look into the data reveals several important differences between international capital flows to advanced economies and emerging markets. In the former case, the growth rate of IDS exceeded that of cross-border loans before, during and after the Global Financial Crisis (Graph C1). By contrast, cross-border loans to EMEs grew at a much higher rate during the pre-crisis period than international debt securities issued by EME residents (Graph C2). This trend is primarily driven by lending to non-banks. During the crisis, the contraction in loan flows to EMEs was much larger than the contraction in bond flows. In this case, the main driver of the divergence was credit to banks in EMEs.

Table C2 reveals that the two main types of international capital flows that we examine tend to be highly correlated not only with each other, but also with the two major global factors (the federal funds rate and the VIX). The correlation between cross-border loans and international debt securities is positive and strongly statistically significant. This is especially true for international credit to bank borrowers. In line with the findings of the empirical literature, international capital flows tend to be highly negative correlated with the VIX. Interestingly, the correlation between international capital flows and the federal funds rate tends to be positive and, in several cases, statistically significant. As we demonstrate in our formal econometric analysis below, this positive relationship disappears once all the relevant control variables are included. Intuitively, both international capital flows and the federal funds rate tend to be high when global economic growth is high. Once the latter variable is accounted for, the relationship between the former two variables becomes negative.

6. Results

6.1 Baseline results

We start our formal empirical investigation by estimating the baseline specification given in equation (1). Table 3 shows the estimated coefficients for the entire sample 2000:Q1 – 2013:Q4. The results are largely in line with those obtained in the existing literature. An increase in global volatility (measured by the VIX) has a negative and strongly statistically significant effect on all types of international capital flows, regardless of the instrument and the sector of the borrower. The US federal funds rate has a sharply negative impact on loans. Its estimated

impact on international debt securities is also negative, albeit only marginally statistically significant. Local drivers are also significant drivers. Borrowing countries with higher GDP growth rates (i.e. with more attractive real rates of return) and with better sovereign credit ratings (i.e. with healthier public finances) attract more cross-border loans. Meanwhile, the degree of financial openness has a positive (and statistically significant) effect on the international debt securities, especially those issued by banks[10].

[Table 3]

In the next step of our empirical analysis, we formally test whether the above estimated coefficients from equation (1) are stable over time. More concretely, rather than exogenously imposing an ad-hoc break date, we test for its presence and exact timing endogenously. In particular, as explained in Section 3, for each type of cross-border flow *Y*, Graph C3 shows the sequences of sums of square residuals (SSRs) from the estimation of equation (2). The minimum of each SSR series identifies the most likely quarter in which a structural break may have occurred.

The SSR series plotted in Graph C3 suggest the most likely break date for both cross-border loans and international debt securities is 2009:Q1. Nevertheless, as already stressed, this econometric exercise only identifies the most likely dates on which a structural break may have occurred, but does not formally test for the existence of such a break. In order to do that, we conduct Wald (or Chow) tests on the coefficients κ and γ' in equation (3). The F-statistic of the Wald tests, along with the respective p-values are displayed in Graph C3. The break is significant for both types of international capital flows (cross-border loans and international debt securities) that we examine.

Table C3 displays the estimated parameters from the model with structural breaks (3). A large number of the interaction terms between the explanatory variables and the dummy break are statistically significant, indicating considerable shifts in the estimated sensitivities of international capital flows to global factors. In particular, it appears that the impact of US monetary policy (proxied by the federal funds rate) strengthens during the post-crisis period. By contrast, the sensitivities of international capital flows to global GDP growth and the borrowing country's degree of openness decline. The estimated impacts of the VIX and of the borrowing country's sovereign credit ratings weaken for cross-border loans, but strengthen for IDS. Finally, the sensitivity of most types of international financial flows to the borrowing country's GDP growth remains virtually unchanged during the post-crisis period.

In order to formally test whether the post-crisis impact of the respective drivers are statistically significant, we construct a post-crisis impact estimate for each explanatory variable defined as the sum of the coefficient on the respective stand-alone (i.e. pre-crisis) variable and the interaction term of that variables with the crisis dummy. We then test whether the resulting sum is statistically significant.

Table 4 summarizes the estimated sensitivities to the main global drivers (the VIX and the federal funds rate) during the pre-break and the post-break periods, respectively. The results

[10] Similar results are obtained using the Bauer-Rudebusch (2015) and the Krippner (2014) rate.

confirm that the relationship between the main global factors and international capital flows has changed profoundly since the Global Financial Crisis.

[Table 4]

More concretely, the sensitivity of international capital flows to the federal funds rate has increased sharply during the post-crisis period. This is true across the board – for all instruments and for all borrowing sectors that we examine. For example, the estimated coefficient for cross-border loans to all sectors, which was already negative and highly significant before the crisis, doubles in the post-crisis period (from -3.15 to -6.35). The estimated sensitivity for cross-border lending to non-banks follows a similar pattern, falling sharply from -3.39 in the per-crisis period to -5.19 after the crisis. The increase in sensitivity of cross-border interbank loans is even greater: from -3.36 pre-crisis to -8.36 post-crisis.

The rise in the sensitivity of IDS to the federal funds rate is even more remarkable than that for cross-border loans. The estimated coefficient on IDS (issued by all sectors), which was negative but insignificant before the crisis, becomes negative and highly statistically significant after the crisis. Furthermore, its magnitude rises more than four times (from -1.45 to -6.42). The overall increase in the sensitivity of IDS to the federal funds rate is driven primarily by IDS issued by non-banks, whose estimated coefficient switches from being insignificant during the pre-crisis period to being negative and highly statistically significant after the crisis. Its magnitude increases by more than a factor of six (from -0.94 to -6.37). The absolute value of the estimated coefficient for IDS issued by banks also increases dramatically: from -1.19 before the crisis to -14.67 after the crisis. Nevertheless, it remains insignificant due to the considerable post-crisis rise in the volatility of the series for IDS issued by banks, which increases the standard errors of the estimated coefficients.

The results presented in Table 4 further suggest that the sensitivities of international capital flows to the VIX have also changed considerably since the Global Financial Crisis. Most notably, the negative impact of the VIX on IDS (issued by all sectors), which was insignificant before the crisis, has become statistically significant during the post-crisis period. The evolution of the estimated sensitivity of IDS issued by non-banks to the VIX has followed the same pattern – it is insignificant before the crisis, but negative and significant after the crisis. By contrast, the impact of the VIX on IDS issued by banks goes from negative and significant before the crisis to being insignificant after the crisis.

Table 4 also reveals that the estimated impact of the VIX on cross-border loans has declined during the post-crisis period. The fall appears to be driven primarily by interbank loans, whose sensitivity to the VIX goes from negative and highly statistically significant during the pre-crisis period to being insignificant after the crisis. The estimated magnitude of the negative impact of the VIX on cross-border loans to non-banks also drops after the crisis (from -4.32 to -2.52), but remains highly statistically significant.

The three right-hands side columns in table 4 provide a slightly different angle. They show the estimated sensitivities of aggregate international flows, defined as the sum of cross-border loans and international debt securities. The main takeaways are fully consistent with the ones discussed above. Namely, the sensitivity of aggregate international flows to the federal funds

rate has increased sharply during the post-crisis period. By contrast, the post-crisis sensitivity to the VIX has declined a bit, but remains highly statistically significant. The fall is driven entirely by international flows to banks, while the impact of the VIX on aggregate flows to non-banks remains relatively stable over time.

In order to further investigate the main drivers of the above changes in sensitivities, we split our main sample in two sub-samples - borrowers from Advanced Economies (AEs) and borrowers Emerging Market Economies (EMEs). The results presented in Table C4 reveal that the sharp increases in the post-crisis sensitivities of international capital flows to the federal funds rate are for both, AE and EME borrowers. That said, the increases in the impact of the federal funds rate are more dramatic in the case of AEs. This is especially true for IDS issued by AE borrowers – their sensitivity to the federal funds rate increases by a factor of four and has switched from being insignificant to being highly significant. The increase in the estimated impact of the VIX on IDS appears to be driven primarily by borrowers in EMEs.

To sum up the results reveal that international flows that involve banks either as a borrower or as a lender are less flighty in response to global volatility (i.e. the VIX), but more flighty in response to US monetary policy (i.e. the federal funds rate). International flows that do not involve banks either as a borrower or as a lender are more flighty with respect to both global volatility and US monetary policy.

In our empirical analysis up to this point, we have controlled for heterogeneity among borrowing countries. Nevertheless, we have not controlled for heterogeneity among lending banking systems. This is mainly due to data constraints – both the BIS LBS data and the BIS IDS do not contain information on the nationality of the lender, which could be used as a proxy for the relevant decision-making unit on the lending side (just as the country of the borrower is used as a proxy for the relevant decision-making unit on the borrowing side). That is why in the next step of our empirical investigation, we turn to the BIS Consolidated Banking Statistics (CBS), which contain information about both, the residence of the borrower as well as the nationality of the lending bank.

More specifically, we re-estimate all specifications from the section 3 using the CBS data. This allows us to explicitly control not only for heterogeneity among borrowers (as we did in the specifications based on cross-border loans and IDS), but also for heterogeneity among lenders.

Overall the results are roughly in line with the ones we obtained using the Locational Banking Statistics (LBS). Table C5 reveals that, in the CBS specifications (just as in the LBS specifications), the coefficients of the federal funds rate and the VIX are both negative and highly statistically significant in the full-sample estimation (i.e. in the estimation which does not allow for the existence of a structural break). Furthermore, the structural break test we conduct using the CBS data identifies the exact same break date (2009:Q1) as the structural break test based on the LBS data.

In the CBS specifications (just as in the LBS specifications), the negative impact of the federal funds rate increases considerably in the post-crisis period (table 5). Both AE and EME borrowers saw a sharp rise in the sensitivities of international capital flows to the federal funds rate after the crisis (Table C6).

[Table 5]

Despite the large number of similarities between the LBS and the CBS estimates, there are also several important differences between the two sets of results. Most importantly, the post-break coefficient on the VIX in the CBS estimates, is virtually equal to its pre-break counterpart. This is in sharp contrast to the LBS estimates, in which the pre-break impact of the VIX is considerably larger than its post-break impact.

The differences between the results obtained using the CBS data (which contain information on both the borrower country and the lending bank nationality dimensions) and the LBS data (which contain information only on the borrower country dimension) highlight the importance of taking advantage of both (lender and borrower) dimensions. For instance, the most likely explanation for the fact that the post-crisis sensitivity of cross-border loans to the VIX changes considerably between the LBS and the CBS estimations is that the latter controls for heterogeneity among lending banking systems. It is entirely possible that different national baking systems have business models which differ with respect to their sensitivity to undiversifiable global risk (proxied by the VIX in our econometric specifications). As a consequence, controlling for heterogeneity among lending national banking systems increases the post-crisis sensitivity of the VIX relative to the respective LBS estimates, which ignore the lender dimension.

6.2 Decomposing the shifts in sensitivities to global factors

As described in Section 3.2, the shifts in the sensitivities of external flows to global factors can be decomposed into a compositional component and a behavioral component. The factors that capture the composition of lending national banking systems (the $w_1^i's$ and the $w_2^i's$) are directly observable and can be obtained from the CBS matrix of bilateral stocks of international claims. Meanwhile, the factors that capture the behavioral component, i.e. the national banking system-specific sensitivities to global factors (the $\beta_1^i's$ and the $\beta_2^i's$), can be obtained as the estimated coefficients on the respective global factors in the national banking system-specific regressions presented in equation (7).

Graph 3 presents the lending national banking system weights for the pre- and post-crisis periods. It illustrates that the post-crisis periods has seen a pullback from euro area banks and an expansion by banks from advanced economies outside the euro area. Most notably, there have been sizeable declines in the international lending shares of German, Belgian and Dutch banks. By contrast, the international presence of US, Japanese and Canadian and Australian banks has grown significantly during the same period. The above general pattern tends to hold for international lending to banks (Graph 3, top panel) and the non-bank private sector (Graph 3, bottom panel).

[Graph 3]

Having obtained the pre- and post-crisis lender-specific weights and lender-specific sensitivities, we estimate the behavioral components (the first terms on the right-hand side of

equations (9) and (10)) and compositional components (the second terms on the right-hand side of equations (9) and (10)) of the shifts in sensitivities.[11] The results from the above decompositions are summarized in Graph 4.

[Graph 4]

According to our results, the behavioral component is the exclusive driver of the shifts in sensitivities to US monetary policy (Graph 4, left-hand panel). For all three borrowing sectors that we examine, the estimated contributions of the behavioral component are negative (i.e. they increase the absolute value of the estimated sensitivity). Furthermore, the contributions of the behavioral component dominate the contributions of the compositional component (which are positive in all three cases). In other words, our decomposition results imply that the post-crisis increases in the sensitivity of international bank lending flows to US monetary policy are driven by increase in the sensitivities of individual banking systems rather than by a shift in the composition of international lending from less to more sensitive banking systems.

The results from the decomposition of the sensitivities to the VIX are qualitatively similar, but quantitatively different from the ones for US monetary policy (Graph 4, right-hand panel). Once again, the contributions of the behavioral component are negative (i.e. they increase the absolute value of the estimated sensitivity), while those of the compositional component are positive (i.e. they decrease the absolute value of the estimated sensitivity). Nevertheless, the compositional component is not as dominant as in the case of the US monetary policy sensitivities. The behavioral component is considerably larger than the compositional component only for lending to the public sector. When it comes to lending to the non-bank private sector and interbank lending, the two components are of similar magnitudes and roughly offset each other.

It is notable that the sensitivities of international bank lending flows to the public sector increase considerably during the post-crisis period vis-à-vis both the US monetary policy and the VIX. These results could be interpreted as evidence that banks have adjusted treatment of sovereign risk since the crisis. It has been documented that banks treated (most of) their sovereign exposures as virtually risk-free before the crisis, but have started to assess sovereign risk in a more realistic manner after the crisis (Acharya et al (2013), Farhi and Tirole (2016), De Grauwe and Ji (2013)). Thus, our findings about the post-crisis shifts in public sector lending sensitivities shed further light on the post-crisis dynamics of the international dimension of the bank-sovereign nexus.

[11] It is important to note that, by design, these decompositions represent approximations of the underlying estimation procedure. Consequently, even though the "synthetic" sensitivities derived as a weighted average of the lender-specific sensitivities tend to be very close to the global sensitivities obtained using the benchmark regression specification, the two measures do not overlap perfectly.

6.3 Identifying the main determinants of the shifts in sensitivities

In order to identify the main drivers of the shift in the lender-specific sensitivities to global factors, we regress the change in the (pre- and post-break) coefficients on a small set of potential explanatory (pre-crisis) variables (see equation 6). Since the dependent variable in those regressions is a function of estimated coefficients, each with an associated standard error around it, we use meta-analyses techniques.

The results from the above regressions for changes in the sensitivities to US monetary policy ($\beta_{1,c,k}^{PostBreak} - \beta_{1,c,k}^{PreBreak}$) are reported in Columns (I) – (III) of Table 6. They indicate that banking systems that were better capitalised at the point in time when the structural break occurred (end-2008) experienced a smaller change in the sensitivity of their international lending to US monetary policy.[12] This result is in line with the strand of literature which argues that well-capitalised banks are perceived as less risky by depositors and other bank creditors, have easier access to funding, and are, consequently less affected by fluctuations in funding costs (Gambacorta and Shin, 2016).

We examine the robustness of the above result to controlling for various measures of the prudential policy stance at the time of the structural break. Graph C4 shows the evolution of the three prudential policy indices we investigate. It turns out that the statistical significance of the banks' capitalization levels is robust to controlling not only for the cumulative prudential measure index (Columns (I)), but also to controlling for the cumulative loan-to-value ratio cap index (Columns (II)) and cumulative local currency reserve index (Columns (III)). None of the above three cumulative prudential control variables is statistically significant. [13]

The right-hand panel (Columns (IV) – (VI)) of Table 6 investigates the determinants of the structural break in the sensitivity of international bank lending to global risk. The dependent variable in those specifications is $\beta_{2,c,k}^{Postbreak} - \beta_{2,c,k}^{PreBreak}$ (estimated from equation (5)), for lending country *c* and borrowing sector *k*. As in the case of the sensitivities to US monetary policy, the main determinant of the changes in the sensitivities to global risk also appears to be the capitalization level of the respective national banking system. More concretely, the better capitalized a given banking system was at the time of the structural break, the more likely it was that the sensitivity of its international lending to global risk declined during the post-crisis period. The above result is robust to controlling for each of the three cumulative prudential control variables we examine.

[Table 6]

Furthermore, our results indicate the cumulative index for local reserve requirements is also a statistically significant determinant of the changes in the sensitivities to global risk. More concretely, jurisdictions with tighter local reserve requirements at the time of the break experienced a smaller change in the sensitivity of their cross-border lending to global risk. By

[12] Since the differences between the (pre- and post-break) estimated parameters tend to be negative, a positive value of the coefficients in the meta-regressions implies a smaller change in the (pre- and post-break) sensitivities.

[13] We could not include the cumulative index for capital requirements measure since all policy actions for that measure have taken place during the post-crisis period (see the middle panel of Graph C4).

contrast, the cumulative prudential measure index and the cumulative loan-to-value ratio cap index are not statistically significant.

Next, we examine the main drivers of the shifts in the composition of international lending (approximated by the lending weights defined above) between the pre- and the post-crisis periods. More specifically, we estimate specification (11), in which the difference in lending national banking system weights before and after the break ($w_{c,k}^{PostBreak} - w_{c,k}^{PreBreak}$) is regressed on a set of pre-crisis business model indicators. From a graphical point of view the dependent variable can be visualised as the differences in the pre- and the post-crisis weights displayed in the histograms in Graph 3.

The results, reported in the first column of Table 7, indicate that banking systems that were better capitalized prior to the break, had a higher share of deposits funding and had a larger portion of foreign claims held by subsidiaries, were more likely to experience an increase in their lending weights during the post-crisis period. Average bank size is weakly correlated with the increase in lending weight, as the effect is not statistically different from zero.

[Table 7]

The result that links cross-border lending expansion to deposit ratios is interesting as market funding was under stress during the global financial crisis. The ratio of deposits to total liabilities is typically used to measure a bank's contractual strength. Banks that have a large deposit base suffer lower adjustment costs in their funding (Berlin and Mester (1999)).

Our result accords with the fact that a key transmission channel of the crisis was the dislocation in bank funding markets. Amiti et al (2016) find that banks which relied more on wholesale funding and cross-currency swaps found themselves unable to roll over their positions during the most severe quarters of the crisis. These results are in line with Gambacorta and Marques (2011), who find that the proportion of deposit funding was a key element in assessing banks' ability to withstand adverse shocks. The results seem also match the finding of the IBRN research initiative on the impact of prudential policy on international bank lending (see Buch and Goldberg, 2016). More concretely, spillovers of interbank exposure limits through foreign bank affiliates differ in degree across banks not only in relation to banks' illiquid asset shares but also with respect to deposit shares, and the internal capital market positions with their parent banks.

The ratio of local claims over foreign claims indicates the business model used by a banking system to lend abroad. The higher the ratio of local to foreign claims, the more a banking system relies on its subsidiaries and branches abroad as opposed to obtaining foreign claims by dealing with borrowers directly from its headquarters. Local claims have been relatively stable after the crisis, because banks have reduced foreign lending by cutting down operations from their headquarters (Gambacorta and van Rixtel, 2013). Indeed, the latter require a well-functioning wholesale and interbank market, which are very vulnerable to global uncertainty. De Haas and van Horen (2012) find that banks reduced credit less to markets where they operated a subsidiary and where they were integrated into a network of domestic co-lenders. We find that banking systems with higher local lending are more resilient and have

increased their lending weight at the expense of banking systems with a different business model.

The above results do not change when controlling for various prudential policy measures. The only prudential tool that is statistically significant is the cumulative index for local reserve requirements (see column (III)): jurisdictions that experienced a tightening in local reserve requirements in the pre-crisis period expanded their cross-border lending by more during the post-crisis period.

6.4 Robustness checks

We conduct a couple of sets of robustness checks. First, we re-estimate all of our benchmark specifications using alternative shadow federal funds rates. Next, we re-run all bond flow regressions using an alternative international bond flow measure.

Alternative shadow policy rates

Our baseline results for the sensitivities to US monetary policy are in part obtained using a constructed measure of the federal funds rate (i.e. a shadow policy rate). More concretely, in our benchmark analysis, we use the Wu and Xia (2015) shadow rate. It is generated by a multi-factor shadow rate term structure model and is assumed to be a linear function of three latent variables, which follow a VAR (1) process. The latent factors and the shadow rate are estimated with the extended Kalman filter. The model used by Wu and Xia (2015) is in discrete time and can be applied directly to the data. As a consequence, the Wu-Xia (2015) shadow rate is not prone to the numerical approximation errors associated with alternative shadow rates.

The evolving shadow rates literature has generated several alternative measures, each with its own advantage and disadvantages (for a discussion of the trade-offs among the alternative measures, see Lemke (2015)). For robustness, we also consider two alternative shadow rates. The first one estimated by Krippner (2014) is based on a two state-variable shadow yield curve model. It is estimated using the iterated extended Kalman filter on month-end US yield curve data from 1985 with times to maturity spanning 0.25 to 30 years. The shadow rate of Bauer and Rudebusch (2015) replaces the affine short-rate specification of standard DTSMs with an identical affine process for an unobserved shadow short rate. Graph C5 plots the above three alternative shadow policy rates. It illustrates that the shadow rate that we use in our benchmark analysis (Wu and Xia (2015)) tends to be somewhere in between the two alternative shadow rates that we use in our robustness checks. This is the case for both levels (Graph C5, left-hand panel) and first differences (Graph C5, right-hand panel).

We perform our baseline estimations using two alternative shadow rates by Krippner (2014) and Bauer and Rudebusch (2015). Table C7 contains the estimate of the baseline model. The coefficients of the alternative shadow rates are still negative and significant, consistently with the results we obtain using the Wu-Xia rate in Table 3.

Alternative international bond flow measures

Our benchmark regressions use the international debt securities as our measure of bond flows. As discussed in the Data section below, international debt securities are defined as those issued in a market other than the local market of the country where the borrower resides (Gruić and Wooldridge (2012)).

For most borrowing countries and sectors, the universe of international debt securities tends to largely overlap with the universe of debt securities held by external investors. That said, the match is not perfect in all cases for two main reasons. First, securities issued in foreign markets may be purchased and held by domestic residents. Second, domestically issued debt securities could be bought by external investors.

We check the robustness of our results by replacing the international debt securities series used in our benchmark regressions with data on portfolio debt from the Balance of Payments (BoP). More concretely, we define our alternative dependent variable as the quarterly growth rate of the respective (gross) outstanding IIP stocks. We obtain the data from the World Bank quarterly external debt statistics.

Table C8 shows the estimates we obtain without any structural breaks. As in our baseline results in Table 3, the estimated impact of US monetary policy and global uncertainty on portfolio debt flows is negative and statistically significant. This is true not only for aggregate flows, but also for their main sectoral (bank and non-bank) components. As in our baseline estimates, borrower-country GDP growth, sovereign ratings and financial openness have a positive effect debt securities inflows.

Table C9 presents the estimates of the two global factors before and after the structural break. The pre-break coefficient of the FFR is not significant, while the coefficient of the VIX is significant for all borrowers and non-banks using adjusted flows. Both post-break coefficients are larger in absolute value using growth rates of outstanding stocks, consistently with our baseline estimates. We obtain these results by imposing a break date in 2009:Q1. However, the estimates are robust to the endogenous estimation of the break date for the alternative measure of portfolio debt flows. Summing up, the above results show that our benchmark findings about the sensitivity of debt securities flows to global factors are robust to using alternative bond flow measures.

7. Conclusions

The stability and drivers of international capital flows are critically important to the macroeconomic stabilization and growth performance of both advanced and emerging market economies. In the aftermath of the global financial crisis, the composition of these capital flows has changed, with both substantial reductions in bank-to-bank lending and large increases in the use of international debt securities. We examine the importance of global factors for cross-border loans and international debt securities flows using the BIS international banking and international debt securities statistics for a large panel of countries over fourteen years. We find that the sensitivity of all major types of international financial flows to US monetary policy has increased dramatically since the Global Financial Crisis.

Sensitivity to global risk conditions has increased significantly for international bonds flows and has declined for cross-border loan flows, but remains qualitatively important.

These changes raise important questions around the evolving business models of the bank and nonbank providers of international credit. The detailed data we analyse provides scope for this investigation. After documenting the respective shifts in the sensitivities to global factors over time for different types of counterparty flows, we decompose the changes in sensitivities into two components. First, a compositional component could explain changes if international creditors have distinct characteristics and there is a change in the distribution of those creditors. Second, international creditors may have changed their behaviors. For example, bank business models might change to be more sensitive to short rates and less sensitive to risk. Non-bank financiers of international debt securities may have become more sensitive to risk conditions as they extended the scale of credit provision to international borrowers.

We find that the post-crisis increases in the sensitivity of international bank lending flows to US monetary policy were driven by increase in the sensitivities of individual banking systems rather than by a shift in the composition of international lending from less to more sensitive banking systems. Moreover, these changes were especially strong in the component of flows associated with public sector financing. Both country composition and behavioral changes are important for explaining the shifts in credit sensitivities to VIX, but in opposing directions. International bank lending to the public sector has experienced the largest shift in sensitivity to the VIX.

We consider the drivers of these evolving shares and sensitivities in panel specifications. We find that national banking systems that were ex ante better-capitalized experienced smaller increases in sensitivities to US monetary policy and larger increases in their market shares in international lending. Higher ex ante shares of deposits in total funding and local claims in foreign claims were also associated with larger increases in international lending market share. Some prudential policy measures, such as local currency reserve requirements were associated with gains in the relative stability of international loan supply. Balance sheet conditions and regulatory changes may be driving the post-crisis shifts in capital flow type composition and international lenders' market shares. Moreover, banks appear to have adjusted their treatment of sovereign risk since the crisis by assessing sovereign risk to a greater degree. Interestingly, many of the changes in behaviors appear dominated by the flows from private creditors to public borrowers, with relatively less adjustment in the behavior around the non-bank private sector debtors. The full set of reasons for changing behaviors remains an important and open question, with the role of macroeconomic environmental factors and financial sector reforms still open for study and interpretation.

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Table 1. Descriptive statistics of the explanatory variables used in the estimation

Variables	Obs.	Mean	Std. Dev.	Min	Max
Global factors					
ΔFed fund rates (1)	3,840	-0.13	0.50	-1.73	1.00
Log (VIX)	3,776	2.97	0.35	2.40	4.07
ΔGlobal GDP	3,840	3.68	1.73	-2.49	5.75
Country-specific variables					
ΔGDP	3,430	3.19	3.90	-19.30	27.15
ΔSovereign ratings (2)	3,660	0.01	0.27	-4.67	2.43
Chinn-Ito index (3)	3,416	0.74	0.32	0.00	1.00
Prudential tools (4)					
PruC (5)	3,840	0.05	0.39	-1.00	1.00
LTV (6)	1,298	0.04	0.27	-1.00	1.00
ResReq (7)	3,840	-0.01	0.32	-3.00	5.00
CapReq (8)	3,420	0.03	0.17	0.00	1.00
CumPruC (9)	3,584	0.58	3.42	-9.00	25.00
CumLTV (10)	1,149	0.47	1.73	-3.00	8.00
CumCapReq (11)	3,192	0.16	0.41	0.00	2.00
CumResReq (12)	3,584	-0.49	1.98	-7.00	13.00

Notes: The sample includes quarterly data for 64 recipient countries over the period 2000:Q1 - 2013:Q4. (1) Effective federal funds rate for the period 2001:Q1 – 2008:Q4, Wu-Xia Shadow rate for the period 2009:Q1 – 2013:Q4. (2) LT foreign currency, average across 3 agencies. (3) Chinn and Ito (2006) measure of financial openness. (4) A higher prudential index indicates a tightening. (5) Composite prudential index. (6) Caps on loan to value ratio. (7) Reserve requirements in local currency. (8) Capital requirements. (9) Cumulative composite prudential index. (10) Cumulative caps on loan to value ratio. (11) Cumulative reserve requirements in local currency. (12) Cumulative capital requirements. Each cumulative prudential index is obtained in each quarter by adding the non-cumulative prudential index up to that quarter.

Table 2. Summary statistics, whole sample

		Mean			Standard deviation		
Sector	*Region*	XBL	IDS	XBL+IDS	XBL	IDS	XBL+IDS
All	All	1.28	2.69	1.86	3.17	1.96	2.22
	AE	1.18	2.77	1.86	3.42	2.20	2.43
	EME	1.68	2.15	1.83	4.01	1.82	2.92
Banks	All	1.13	2.88	1.58	3.37	2.73	2.90
	AE	1.04	2.89	1.55	3.60	2.87	3.08
	EME	1.53	2.91	1.69	5.02	3.52	4.60
Non-banks	All	1.63	2.59	2.20	3.51	1.86	1.76
	AE	1.55	2.70	2.26	3.91	2.15	2.01
	EME	1.94	1.97	1.95	3.43	1.85	1.86

Notes: XBL = Cross-border loans: Quarterly Growth $Rate_t$ = Adjusted $Flows_t$ / Outstanding $Stock_{t-1}$; IDS = International Debt Securities: Quarterly Growth $Rate_t$ = Net $Issuance_t$ / Outstanding $Stock_{t-1}$. Sources: BIS Locational Banking Statistics by residence; BIS International Debt Securities Statistics.

Table 3 – Locational baseline regressions (by borrowing country)

	Dependent variable: ΔCross-border loans †			Dependent variable: ΔInternational debt securities ‡		
Explanatory variables	All	to banks	to non-banks	All	by banks	by non-banks
ΔFed funds rate (1)	-1.876***	-2.074***	-2.108***	-1.348*	-1.336	-1.051
	(0.412)	(0.646)	(0.431)	(0.776)	(1.116)	(0.817)
Log(VIX)	-4.455***	-4.294***	-4.895***	-3.275***	-7.260***	-2.488***
	(0.640)	(1.058)	(0.684)	(0.829)	(2.118)	(0.930)
ΔReal GDP	0.565***	0.597***	0.524***	0.187*	0.246	0.182
	(0.0762)	(0.119)	(0.0757)	(0.102)	(0.285)	(0.136)
ΔSovereign rating (2)	2.491**	4.207***	-0.567	1.459*	-1.830	1.146
	(1.055)	(1.411)	(0.775)	(0.788)	(3.102)	(1.002)
Chinn-Ito index (3)	-0.118	-1.079	1.337	8.705***	13.45***	5.191
	(1.876)	(2.991)	(1.876)	(3.133)	(5.108)	(3.275)
ΔReal global GDP	0.215	0.465*	0.100	-0.317	-0.618	-0.477
	(0.156)	(0.239)	(0.153)	(0.276)	(0.837)	(0.323)
Observations	2,903	2,903	2,903	2,903	2,572	2,902
R-squared	0.124	0.082	0.080	0.060	0.031	0.038

Notes: The sample includes quarterly data on cross-border flows (loans and debt securities) for 64 recipient countries over the period 2000:Q1 - 2013:Q4. The regressions include a full set of country fixed effects. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. † to borrowers in country j. ‡ issued by borrowers in country j. (1) Effective federal funds rate for the period 2001:Q1 – 2008:Q4, Wu-Xia Shadow rate for the period 2009:Q1 – 2013:Q4. (2) LT foreign currency, average across 3 agencies. (3) Chinn and Ito (2006) measure of financial openness.

Table 4 - Locational baseline regressions (by borrowing country) with structural breaks

	Dependent variable: ΔCross-border loans †			Dependent variable: ΔInternational debt securities ‡			Dependent variable: ΔTotal cross-border flows (loans and debt securities)		
	All	to banks	to non-banks	All	by banks	by non-banks	All	to banks	to non-banks
Pre-break									
VIX[1]	-3.91***	-4.36***	-4.32***	-1.09	-5.58**	-0.23	-3.10***	-3.24**	-2.69***
	(0.94)	(1.63)	(1.07)	(1.29)	(2.67)	(1.57)	(0.66)	(1.30)	(0.69)
ΔFF[2]	-3.15***	-3.36***	-3.39***	-1.45	-1.19	-0.94	-2.07***	-2.75***	-2.10***
	(0.49)	(0.81)	(0.56)	(1.03)	(1.37)	(1.19)	(0.36)	(0.66)	(0.37)
Post-break									
VIX[1]	-1.56*	-0.22	-2.52***	-2.97**	-3.39	-2.31*	-2.24***	-0.84	-2.26***
	(0.93)	(1.47)	(0.90)	(1.36)	(4.66)	(1.36)	(0.70)	(1.34)	(0.65)
ΔFF[2]	-6.35***	-8.36***	-5.19***	-6.42***	-14.67	-6.37***	-6.59***	-7.69***	-5.67***
	(1.14)	(1.78)	(1.04)	(2.17)	(10.70)	(2.21)	(0.84)	(1.27)	(0.79)
Obs.	2,903	2,903	2,903	2,903	2,572	2,902	2,903	2,572	2,902
R^2	0.165	0.105	0.105	0.070	0.035	0.044	0.182	0.128	0.121

Notes: The sample includes quarterly data on cross-border flows (loans and debt securities) for 64 recipient countries over the period 2000:Q1 - 2013:Q4. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. † to borrowers in country j. ‡ issued by borrowers in country j. [1] Log(VIX). [2] Effective federal funds rate for the period 2001:Q1 – 2008:Q4, Wu-Xia Shadow rate for the period 2009:Q1 – 2013:Q4. The regressions include ΔReal GDP, ΔSovereign Ratings, Chinn-Ito Index, ΔReal Global GDP and their interaction with a break dummy that takes value 1 after the break date (2009:Q1). The regressions also include a full set of country fixed effects.

Table 5 – Consolidated baseline regressions (by lender-borrower pair) with structural breaks

	Dependent variable: ΔInternational claims			
Explanatory variables	All	to banks	to the public sector	to non-banks (private)
Pre-break				
Log(VIX)	-2.921***	-4.986***	-1.295	-2.955***
	(0.433)	(0.819)	(0.853)	(0.430)
ΔFed funds rate (1)	-0.872***	-0.305	0.865*	-1.820***
	(0.225)	(0.424)	(0.444)	(0.222)
Post-break				
Log(VIX)	-2.926***	-3.565***	-4.774***	-2.671***
	(0.422)	(0.841)	(0.881)	(0.391)
ΔFed funds rate (1)	-4.802***	-5.721***	-8.505***	-4.346***
	(0.524)	(1.025)	(1.086)	(0.480)
Observations	68,258	59,970	42,157	63,298
R-squared	0.025	0.015	0.015	0.026

Notes: The sample includes quarterly data on international claims (all, to private banks, to public banks, to non-banks) from lending banks in 30 countries to recipients in 64 countries over the period 2000:Q1 - 2013:Q4. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. (1) Effective federal funds rate for the period 2001:Q1 – 2008:Q4, Wu-Xia Shadow rate for the period 2009:Q1 – 2013:Q4. The regressions include ΔReal GDP, ΔSovereign Ratings, Chinn-Ito Index, ΔReal Global GDP and their interaction with a break dummy that takes value 1 after the break date (2009:Q1). The regressions also include a full set of borrowing country and lending country fixed effects.

Table 6: Drivers of the structural break in lender-specific sensitivities

	Dependent variable: Structural change in the coefficient for ΔFed funds rate $\beta_1^{PostBreak} - \beta_1^{PreBreak}$			Dependent variable: Structural change in the coefficient for Log(VIX) $\beta_2^{PostBreak} - \beta_2^{PreBreak}$		
Explanatory variables	(I)	(II)	(III)	(IV)	(V)	(VI)
Pre-break Capital ratio (2008)	0.4684*	0.4811*	0.4705*	0.4514**	0.5802***	0.3962*
	(0.2580)	(0.2689)	(0.2657)	(0.2280)	(0.2164)	(0.2083)
Pre-break Prudential index (2008)	-0.3226			0.5204		
	(0.3951)			(0.4153)		
Pre-break LTV index (2008)		-0.7509			-0.6421	
		(1.0311)			(1.0109)	
Pre-break Local reserve requirement index (2008)			-0.6965			2.7192***
			(0.9948)			(0.9438)
Sectoral fixed effects	yes	yes	yes	yes	yes	yes
Observations	87	87	87	87	87	87
Q(1)	212.6	217.6	213.3	186.3	185.9	174.2
Degrees of Freedom test Q	82	82	81	82	82	82
$I^2(2)$	0.619	0.614	0.623	0.560	0.559	0.529
$\tau^2(3)$	25.42	25.22	25.62	23.12	22.92	18.83
Adjusted R-squared	15.41	15.34	15.17	13.73	12.60	21.27

Note: Coefficients are obtained from the baseline model with structural breaks (equation 5). This model is estimated for each of the available 29 lending countries (we excluded South Korea for which data are not available in the pre-break period) and for three different borrowers: banks, public sector and non-banks. We obtain therefore 29*3=87 observations. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. (1) The Q Measure evaluates the level of homogeneity/heterogeneity among studies. It is calculated as the weighted squared difference of the estimated effects with respect to the mean. The statistical distribution of this measure follows a $\chi 2$ distribution. The null hypothesis of the test assumes homogeneity in the effect sizes. (2) This percentage represents the magnitude of the level of heterogeneity in effect sizes and it is defined as the percentage of the residual variation that it is attributable to between study heterogeneity. It is defined as the difference between the Q measure and the degrees of freedom divided by the Q measure. Although there can be no absolute rule for when heterogeneity becomes important, Higgins et al. (2003) tentatively suggest adjectives of low for I^2 values between 25% and 50%, moderate for 50%-75% and high for values larger than 75%. (3) τ^2 is a measure of population variability in effect sizes. It depends positively on the observed heterogeneity (Q measure) and its difference with respect to the degrees of freedom. The expected value of Q measure under the null hypothesis of homogeneity is equal to the degrees of freedom; a homogeneous set of studies will result in this statistic equal to zero. Under the presence of heterogeneity this estimate should be different from zero.

Table 7: Drivers of the structural break in lender-specific weights

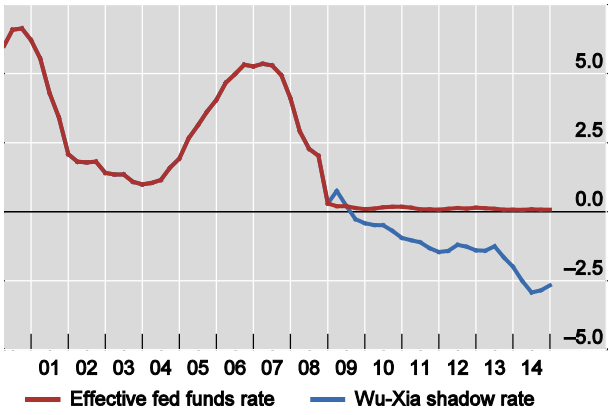
	Dependent variable: Change in the lending national banking system weights $w^{Postbreak} - w^{PreBreak}$		
Explanatory variables	(I)	(II)	(III)
Pre-break Capital ratio (2008)	0.0016*	0.0015**	0.0008
	(0.0005)	(0.0002)	(0.0003)
Pre-break Prudential index (2008)	-0.0010		
	(0.0005)		
Pre-break LTV index (2008)		-0.0036	
		(0.0013)	
Pre-break Local reserve requirement index (2008)			0.0054**
			(0.0009)
Pre-break Deposits to total funding ratio (2008)	0.0002**	0.0002**	0.0001**
	(0.0000)	(0.0000)	(0.0000)
Pre-break Average bank size (2008)	0.0044	0.0041	0.0044
	(0.0019)	(0.0017)	(0.0017)
Local claims over Foreign claims (2008)	0.0201*	0.0222*	0.0305**
	(0.0067)	(0.0054)	(0.0054)
Sectoral fixed effects	yes	yes	yes
Observations	75	75	75
Adjusted R-squared	0.0805	0.0810	0.1190

Note: The dependent variable is the difference in lending national banking system weights. Weights are available for 29 lending countries (we excluded South Korea for which data are not available in the pre-break period), while Local claims over Foreign claims are available for 25 countries (not for Chile, Hong Kong, Luxemburg and Mexico) and for three different borrowers: banks, public sector and non-banks. We obtain therefore 25*3=75 observations. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

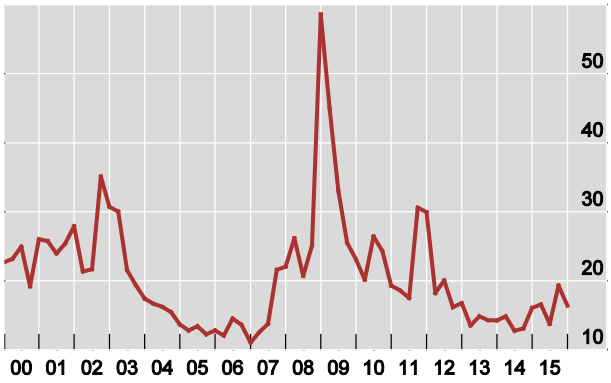
US policy rates and the VIX

Graph 1

US policy rates



VIX



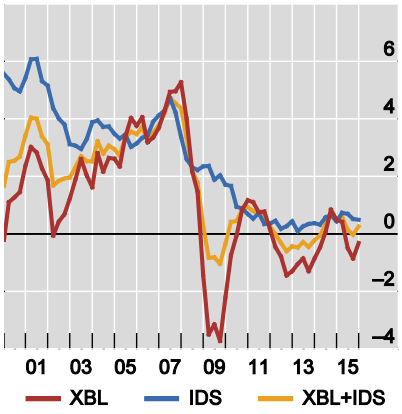
Sources: Wu and Xia (2015); Datastream.

External debt flows, all borrowers

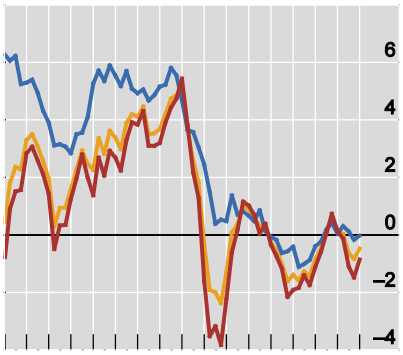
Four-quarter moving average of quarterly growth rates, in per cent

Graph 2

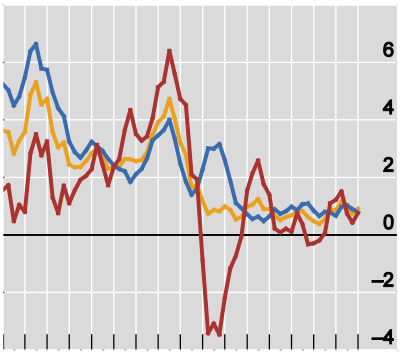
All sectors



Banks



Non-banks

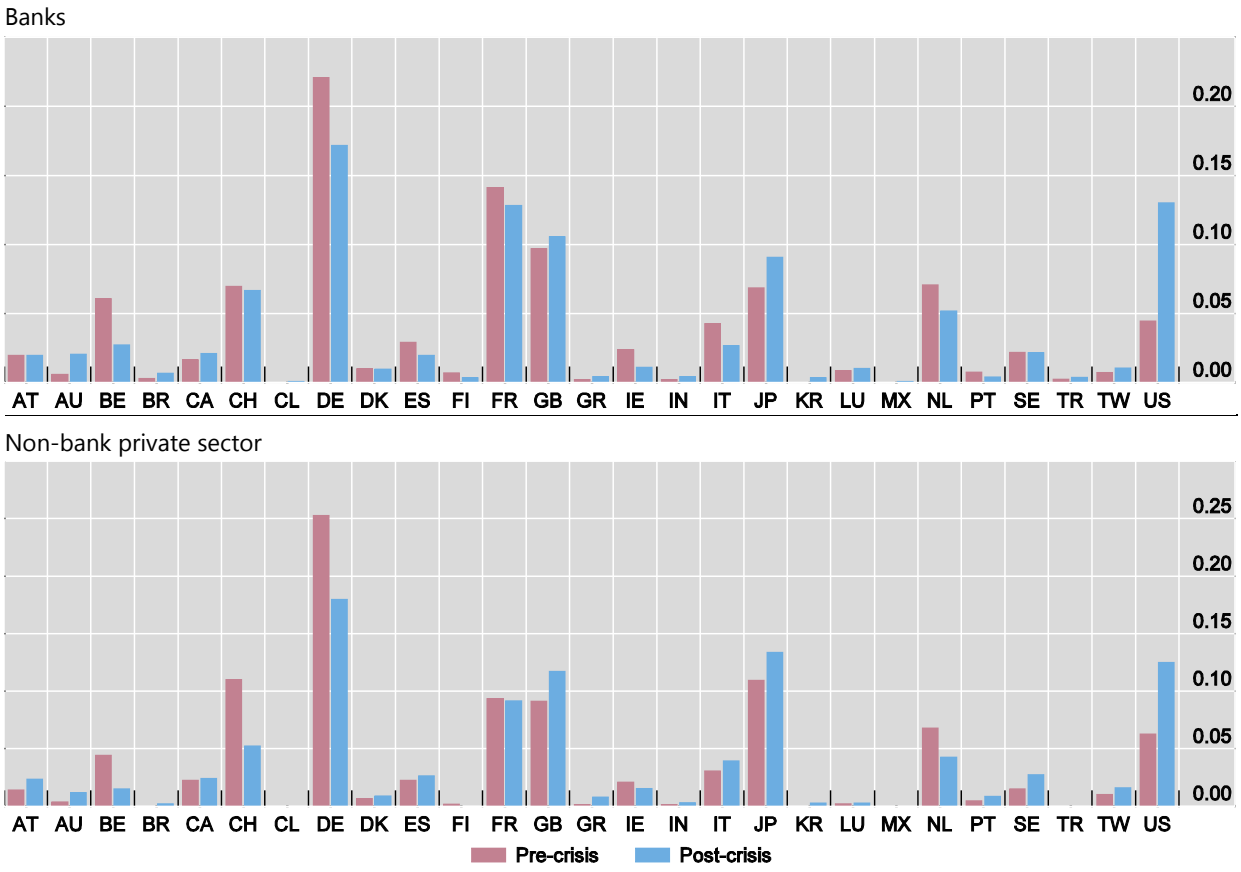


XBL = Cross-border loans: Quarterly Growth Rate$_t$ = Adjusted Flows$_t$ / Outstanding Stock$_{t-1}$; IDS = International Debt Securities: Quarterly Growth Rate$_t$ = Net Issuance$_t$ / Outstanding Stock$_{t-1}$.

Sources: BIS Locational Banking Statistics by residence; BIS International Debt Securities Statistics.

Lending national banking system weights

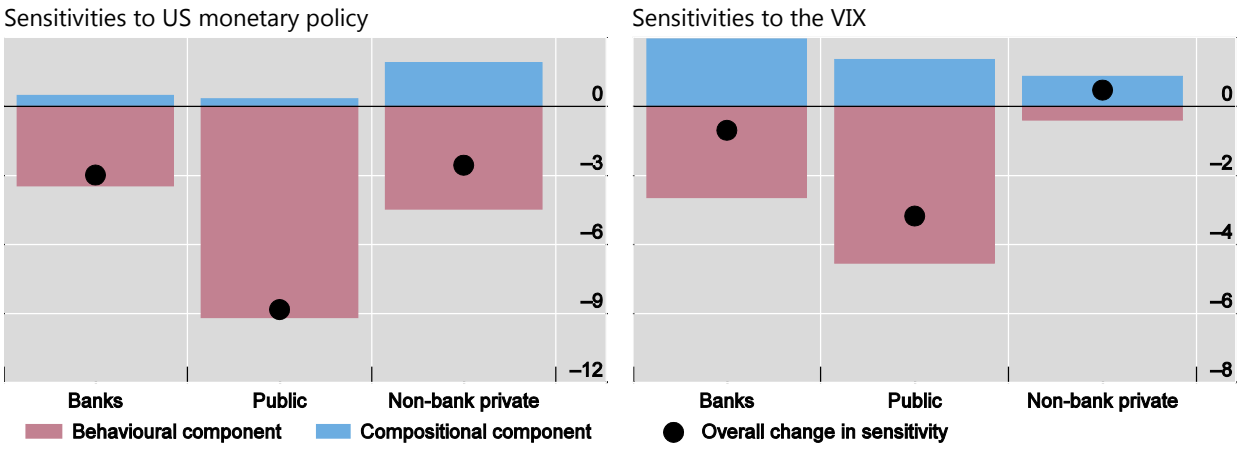
Graph 3



Sources: BIS consolidated banking statistics; authors' calculations.

Decomposing the shifts in lender-specific sensitivities, by borrowing sector

Graph 4



Annex A: Decomposing the post-crisis shifts in sensitivities, detailed derivations

We start our derivation by re-writing specification (1) as:

$$\frac{S_t^j}{S_{t-1}^j} - 1 = \beta_1 \Delta FFR_t + \beta_2 logVIX_t + \beta_3 \Delta logGDP_t^j + \beta_4 \Delta SovRating_t^j + \beta_5 ChinnIto_t^j + \beta_6 \Delta logGlobalGDP_t + \mu^j + \varepsilon_t^j$$

Where S_t^j is the outstanding stock of international bank lending to the residents of country *j* at the end of period *t*.

Defining $S_t^{i.j}$ as the outstanding stock of international lending by banks from country *i* to the residents of country *j* at the end of period *t*, we can write the national banking system-specific counterpart to specification (1) as:

$$\frac{S_t^{i.j}}{S_{t-1}^{i,j}} - 1 = \beta_1^i \Delta FFR_t + \beta_2^i logVIX_t + \beta_3^i \Delta logGDP_t^j + \beta_4^i \Delta SovRating_t^j + \beta_5^i ChinnIto_t^j + \beta_6^i \Delta logGlobalGDP_t + \mu^{i,j} + \varepsilon_t^{i,j} \quad \text{(A1)}$$

$$\frac{S_t^j}{S_{t-1}^j} - 1 = \frac{\sum_i S_t^{i.j}}{\sum_i S_{t-1}^{i.j}} - 1 = \sum_i \left(\frac{S_t^{i.j}}{S_{t-1}^{i,j}} * \frac{S_{t-1}^{i.j}}{\sum_i S_{t-1}^{i.j}} \right) - 1 =$$

Setting $w_{t-1}^{i.j} = \frac{S_{t-1}^{i.j}}{\sum_i S_{t-1}^{i.j}}$, we have:

$$\frac{S_t^j}{S_{t-1}^j} - 1 = \sum_i \left(\frac{S_t^{i.j}}{S_{t-1}^{i,j}} * w_{t-1}^{i.j} \right) - 1$$

Since $\sum_i (w_{t-1}^{i.j}) = 1$, we can write:

$$\frac{S_t^j}{S_{t-1}^j} - 1 = \sum_i \left(\frac{S_t^{i.j}}{S_{t-1}^{i,j}} * w_{t-1}^{i.j} \right) - \sum_i (w_{t-1}^{i.j})$$

$$\frac{S_t^j}{S_{t-1}^j} - 1 = \sum_i \left\{ \left(\frac{S_t^{i.j}}{S_{t-1}^{i,j}} - 1 \right) w_{t-1}^{i.j} \right\} \quad \text{(A2)}$$

Inserting (A1) into the right-hand side of (A2), we get:

$$\frac{S_t^j}{S_{t-1}^j} - 1 = \sum_i \{ (\beta_1^i \Delta FFR_t + \beta_2^i logVIX_t + \beta_3^i \Delta logGDP_t^j + \beta_4^i \Delta SovRating_t^j + \beta_5^i ChinnIto_t^j + \beta_6^i \Delta logGlobalGDP_t + \mu^{i,j} + \varepsilon_t^{i,j}) w_{t-1}^{i.j} \}$$

Replacing the left-hand side of (1) with the right-hand side of (1) in the above expression, we obtain:

$$\beta_1 \Delta FFR_t + \beta_2 logVIX_t + \beta_3 \Delta logGDP_t^j + \beta_4 \Delta SovRating_t^j + \beta_5 ChinnIto_t^j + \beta_6 \Delta logGlobalGDP_t + \mu^j + \varepsilon_t^j$$
$$= \sum_i \{(\beta_1^i \Delta FFR_t + \beta_2^i logVIX_t + \beta_3^i \Delta logGDP_t^j + \beta_4^i \Delta SovRating_t^j + \beta_5^i ChinnIto_t^j + \beta_6^i \Delta logGlobalGDP_t + \mu^{i,j} + \varepsilon_t^{i,j}) w_{t-1}^{i.j}\}$$

Matching the coefficient on the global factors, we obtain the following expressions:

$$\beta_1 = \sum_i \{\beta_1^i w_{t-1}^{i.j}\}$$
$$\beta_2 = \sum_i \{\beta_2^i w_{t-1}^{i.j}\}$$

The (pre-crisis versus post-crisis) changes in the sensitivities to the federal funds rate and the VIX can be expressed as:

$$\beta_{1,post} - \beta_{1,pre} = \sum_i \{\beta_{1,post}^i w_{post}^i\} - \sum_i \{\beta_{1,pre}^i w_{pre}^i\} = \sum_i \{\beta_{1,post}^i w_{post}^i - \beta_{1,pre}^i w_{pre}^i\}$$
$$= \sum_i \{(\beta_{1,post}^i - \beta_{1,pre}^i) w_{pre}^i + (w_{post}^i - w_{pre}^i) \beta_{1,post}^i\}$$

$$\beta_{2,post} - \beta_{2,pre} = \sum_i \{\beta_{2,post}^i w_{post}^i\} - \sum_i \{\beta_{2,pre}^i w_{pre}^i\} = \sum_i \{\beta_{2,post}^i w_{post}^i - \beta_{2,pre}^i w_{pre}^i\}$$
$$= \sum_i \{(\beta_{2,post}^i - \beta_{2,pre}^i) w_{pre}^i + (w_{post}^i - w_{pre}^i) \beta_{2,post}^i\}$$

Annex B: Country lists

Destination countries (64)

Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, China, Colombia, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Korea, Kuwait, Latvia, Lebanon, Lithuania, Luxembourg, Malaysia, Malta, Mexico, Mongolia, Netherlands, New Zealand, Nigeria, Norway, Peru, Philippines, Poland, Portugal, Romania, Russia, Saudi Arabia, Serbia, Singapore, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Taiwan, Thailand, Turkey, Ukraine, United Kingdom, United States, Uruguay, Vietnam.

Lending bank nationalities (31)

Australia, Austria, Belgium, Brazil, Canada, Chile, Denmark, Finland, France, Germany, Greece, Hong Kong, India, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, Norway, Panama, Portugal, Singapore, Spain, Sweden, Switzerland, Taiwan, Turkey, United Kingdom, United States.

Annex C: Additional tables and graphs

Table C1. Incidence of prudential changes

	Distinct countries	Episodes	Tightening episodes	Loosening episodes
General capital requirements	55	100	100	0
Loan to value ratio limits	36	97	72	25
Reserve requirements (local)	46	297	131	166

Source: Cerutti et al (2015).

Table C2. Correlations, whole sample

Sector	*Region*	XBL, IDS	XBL, VIX	XBL, FF	IDS, VIX	IDS, FF
All	All	0.44***	–0.41***	0.30**	–0.11	–0.01
	AE	0.50***	–0.33**	0.29**	–0.06	–0.03
	EME	0.24*	–0.52***	0.14	–0.45***	0.29**
Banks	All	0.63***	–0.35***	0.30**	–0.34**	0.22
	AE	0.67***	–0.28**	0.28**	–0.30**	0.21
	EME	0.43***	–0.47***	0.15	–0.57***	0.31**
Non-banks	All	0.13	–0.45***	0.21	0.14	–0.19
	AE	0.18	–0.39***	0.21	0.17	–0.22
	EME	0.02	–0.47***	0.05	–0.29**	0.23*

Notes: *** p<0.01, ** p<0.05, * p<0.1. XBL = Cross-border loans: Quarterly Growth Rate$_t$ = Adjusted Flows$_t$ / Outstanding Stock$_{t-1}$; IDS = International Debt Securities: Quarterly Growth Rate$_t$ = Net Issuance$_t$ / Outstanding Stock$_{t-1}$; VIX = log of VIX; FF = ΔEffective federal funds rate for the period 2001:Q1–2008:Q4, ΔWu-Xia Shadow rate for the period 2009:Q1–2013:Q4. Sources: Wu and Xia (2015); Bloomberg; BIS Locational Banking Statistics by residence; BIS International Debt Securities Statistics.

Table C3 - Locational baseline regressions (by borrowing country) with structural breaks

	Dependent variable: ΔCross-border loans †			Dependent variable: ΔInternational debt securities ‡		
Explanatory variables	All	to banks	to non-banks	All	by banks	by non-banks
ΔFed funds rate (1)	-3.151***	-3.360***	-3.392***	-1.451	-1.188	-0.937
	(0.491)	(0.805)	(0.559)	(1.030)	(1.366)	(1.194)
Log(VIX)	-3.906***	-4.362***	-4.322***	-1.090	-5.576**	-0.230
	(0.937)	(1.631)	(1.072)	(1.288)	(2.671)	(1.567)
ΔReal GDP	0.396***	0.423**	0.434***	-0.0684	0.431	0.00359
	(0.102)	(0.175)	(0.109)	(0.132)	(0.354)	(0.191)
ΔSovereign rating (2)	4.029**	6.916***	0.0890	0.880	-1.950	-0.255
	(1.765)	(2.529)	(1.081)	(1.092)	(2.137)	(1.642)
Chinn-Ito index (3)	1.142	0.644	2.082	8.707***	16.63**	5.609
	(1.890)	(3.108)	(1.897)	(3.305)	(6.904)	(3.509)
ΔReal global GDP	1.672***	1.820***	1.438***	0.980	0.338	0.643
	(0.273)	(0.472)	(0.286)	(0.601)	(0.739)	(0.803)
Break dummy (4)	1.916	-3.556	2.678	10.41	3.250	11.54
	(4.847)	(8.180)	(5.098)	(7.724)	(17.44)	(8.530)
ΔFed funds rate*Break	-3.195***	-5.003**	-1.792	-4.969**	-13.48	-5.437**
	(1.237)	(1.956)	(1.179)	(2.420)	(10.82)	(2.536)
Log(VIX)*Break	2.347*	4.143*	1.805	-1.877	2.183	-2.078
	(1.327)	(2.197)	(1.404)	(1.912)	(5.428)	(2.112)
ΔReal GDP*Break	0.179	0.136	0.0549	0.535***	-0.402	0.372*
	(0.134)	(0.219)	(0.142)	(0.171)	(0.717)	(0.211)
ΔSovereign rating*Break	-3.927**	-6.288**	-2.068	0.342	-0.838	1.938
	(1.987)	(2.911)	(1.463)	(1.489)	(6.080)	(1.733)
Chinn-Ito Index*Break	-5.278***	-6.743***	-4.080***	0.299	-8.409	-1.188
	(1.338)	(2.248)	(1.372)	(1.650)	(6.748)	(1.969)
ΔReal global GDP*Break	-2.021***	-1.861***	-1.814***	-1.970***	-1.030	-1.659**
	(0.323)	(0.510)	(0.339)	(0.635)	(1.065)	(0.819)
Observations	2,903	2,903	2,903	2,903	2,572	2,902
R-squared	0.165	0.105	0.105	0.070	0.035	0.044

Notes: The sample includes quarterly data on cross-border flows (loans and debt securities) for 64 recipient countries over the period 2000:Q1 - 2013:Q4. The regressions include a full set of country fixed effects. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. † to borrowers in country j. ‡ issued by borrowers in country j. (1) Effective federal funds rate for the period 2001:Q1 – 2008:Q4, Wu-Xia Shadow rate for the period 2009:Q1 – 2013:Q4. (2) LT foreign currency, average across 3 agencies. (3) Chinn and Ito (2006) measure of financial openness. (4) The break dummy equals 1 for every period after (and including) the break date (2009:Q1).

Table C4 – Disentangling the effects in advanced and emerging market economies

	Dependent variable: ΔCross-border loans †		Dependent variable: ΔInternational debt securities ‡	
Explanatory variables	Advanced economies	Emerging economies	Advanced economies	Emerging economies
Pre-break				
Log(VIX)	-4.023***	-4.176***	1.051	-3.898***
	(1.231)	(1.425)	(2.124)	(1.278)
ΔFed funds rate (1)	-2.180***	-4.561***	-2.539	-0.647
	(0.662)	(0.731)	(1.881)	(0.732)
Post-break				
Log(VIX)	-1.696	-1.965	-0.626	-4.816***
	(1.288)	(1.296)	(2.212)	(1.563)
ΔFed funds rate (1)	-6.406***	-5.874***	-10.22***	-2.909*
	(1.596)	(1.531)	(3.917)	(1.669)
Observations	1,479	1,424	1,479	1,424
R-squared	0.220	0.157	0.071	0.122

Notes: The sample includes quarterly data on cross-border flows (loans and debt securities) for 64 recipient countries (29 advanced economies and 35 emerging economies) over the period 2000:Q1 - 2013:Q4. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. † to borrowers in country j. ‡ issued by borrowers in country j. (1) Effective federal funds rate for the period 2001:Q1 – 2008:Q4, Wu-Xia Shadow rate for the period 2009:Q1 – 2013:Q4. The regressions include ΔReal GDP, ΔSovereign Ratings, Chinn-Ito Index, ΔReal Global GDP and a break dummy that takes value 1 after the break date (2009:Q1). The regressions also include a full set of country fixed effects.

Table C5 – Consolidated baseline regressions (by lender-borrower pair)

	Dependent variable: ΔInternational claims			
Explanatory variables	All	to banks	to the public sector	to non-banks (private)
ΔFed funds rate (1)	-0.414**	0.00252	0.0385	-0.986***
	(0.182)	(0.341)	(0.359)	(0.176)
Log(VIX)	-4.515***	-5.943***	-4.858***	-4.380***
	(0.290)	(0.560)	(0.586)	(0.278)
ΔReal GDP	0.367***	0.526***	0.254***	0.288***
	(0.0301)	(0.0598)	(0.0609)	(0.0289)
ΔSovereign rating (2)	2.192***	4.210***	3.108***	0.900***
	(0.286)	(0.595)	(0.573)	(0.282)
Chinn-Ito index (3)	1.659**	2.639*	-1.863	1.214*
	(0.650)	(1.355)	(1.398)	(0.644)
ΔReal global GDP	-0.168***	-0.266**	-0.675***	-0.0280
	(0.0616)	(0.120)	(0.125)	(0.0580)
Observations	68,258	59,970	42,157	63,298
R-squared	0.018	0.012	0.012	0.018

Notes: The sample includes quarterly data on International claims (all, to private banks, to public banks, to non-banks) from lending banks in 30 countries to recipients in 64 countries over the period 2000:Q1 - 2013:Q4. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. (1) Effective federal funds rate for the period 2001:Q1 – 2008:Q4, Wu-Xia Shadow rate for the period 2009:Q1 – 2013:Q4. (2) LT foreign currency, average across 3 agencies. (3) Chinn and Ito (2006) measure of financial openness. The regression includes lending country and borrowing country fixed effects.

Table C6 – Disentangling the effects in advanced and emerging market economies

	Dependent variable: ΔInternational claims	
Explanatory variables	Advanced economies	Emerging economies
Pre-break		
Log(VIX)	-2.524***	-3.530***
	(0.612)	(0.609)
ΔFed funds rate (1)	-0.128	-1.867***
	(0.321)	(0.317)
Post-break		
Log(VIX)	-3.688***	-2.250***
	(0.606)	(0.593)
ΔFed funds rate (1)	-5.191***	-4.269***
	(0.756)	(0.718)
Observations	35,952	32,306
R-squared	0.025	0.031

Notes: The sample includes quarterly data on international claims (all) from lending banks in 30 countries to recipients in 64 countries over the period 2000:Q1 - 2013:Q4. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. (1) Effective federal funds rate for the period 2001:Q1 – 2008:Q4, Wu-Xia Shadow rate for the period 2009:Q1 – 2013:Q4. The regressions include ΔReal GDP, ΔSovereign Ratings, Chinn-Ito Index, ΔReal Global GDP and a break dummy that takes value 1 after the break date (2009:Q1). The regressions also include a full set of borrowing country and lending country fixed effects.

Table C7 – Locational baseline regressions (by borrowing country) with alternative shadow rates

	Dependent variable: ΔCross-border loans †			Dependent variable: ΔInternational debt securities ‡		
Explanatory variables	All	to banks	to non-banks	All	by banks	by non-banks
ΔKrippner (1)	-0.938***	-0.524	-1.064***	-0.683	-1.549*	-0.605
	(0.283)	(0.400)	(0.309)	(0.574)	(0.844)	(0.582)
Log(VIX)	-4.718***	-3.770***	-5.205***	-3.478***	-8.833***	-2.762***
	(0.734)	(1.201)	(0.802)	(0.991)	(2.679)	(0.987)
ΔReal GDP	0.570***	0.604***	0.530***	0.191*	0.248	0.184
	(0.0766)	(0.120)	(0.0758)	(0.102)	(0.285)	(0.135)
ΔSovereign rating (2)	2.429**	4.105***	-0.636	1.415*	-1.812	1.117
	(1.041)	(1.402)	(0.750)	(0.786)	(3.117)	(0.990)
Chinn-Ito index (3)	-0.0292	-0.910	1.436	8.768***	13.50***	5.230
	(1.883)	(2.997)	(1.878)	(3.139)	(5.094)	(3.280)
ΔReal global GDP	0.0734	0.355	-0.0592	-0.419*	-0.797	-0.563*
	(0.154)	(0.241)	(0.151)	(0.252)	(0.857)	(0.291)
Observations	2,903	2,903	2,903	2,903	2,572	2,902
R-squared	0.121	0.080	0.077	0.059	0.031	0.038
ΔBauer-Rudebush (4)	-1.623***	-1.653**	-1.846***	-1.926*	-0.0235	-1.548
	(0.441)	(0.648)	(0.493)	(1.013)	(1.558)	(1.054)
Log(VIX)	-4.443***	-4.175***	-4.897***	-3.835***	-6.402***	-2.959***
	(0.672)	(1.108)	(0.720)	(0.819)	(2.263)	(0.956)
ΔReal GDP	0.572***	0.605***	0.532***	0.192*	0.250	0.186
	(0.0764)	(0.119)	(0.0757)	(0.102)	(0.287)	(0.134)
ΔSovereign rating (2)	2.509**	4.215***	-0.545	1.538*	-1.909	1.212
	(1.038)	(1.399)	(0.770)	(0.791)	(3.106)	(1.002)
Chinn-Ito index (3)	-0.0630	-1.003	1.397	8.669***	13.57***	5.159
	(1.880)	(2.998)	(1.879)	(3.118)	(5.119)	(3.260)
ΔReal global GDP	0.163	0.408*	0.0428	-0.351	-0.653	-0.503
	(0.156)	(0.239)	(0.152)	(0.268)	(0.839)	(0.313)
Observations	2,903	2,903	2,903	2,903	2,572	2,902
R-squared	0.122	0.081	0.078	0.061	0.030	0.039

Notes: The sample includes quarterly data on cross-border flows (loans and debt securities) for 64 recipient countries over the period 2000:Q1 - 2013:Q4. The regressions include a full set of country fixed effects. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. † to borrowers in country j. ‡ issued by borrowers in country j. (1) Krippner (2005) estimate of the Fed fund shadow rate. (2) LT foreign currency, average across 3 agencies. (3) Chinn and Ito (2006) measure of financial openness. (4) Bauer-Rudebusch (2015) estimate of the Fed fund shadow rate.

Table C8 – Baseline model with alternative measures of portfolio debt flows

	Dependent variable: ΔPortfolio debt flows †		
Explanatory variables	All	by banks	by non-banks
ΔFed funds rate (1)	-0.895***	-1.406**	-1.214***
	(0.318)	(0.625)	(0.339)
Log(VIX)	-3.668***	-6.229***	-3.083***
	(0.506)	(0.988)	(0.525)
ΔReal GDP	0.0670	0.150	0.0601
	(0.0532)	(0.106)	(0.0547)
ΔSovereign rating (2)	1.524***	2.691***	0.860
	(0.420)	(0.959)	(0.647)
Chinn-Ito index (3)	4.428***	8.961***	0.527
	(1.490)	(3.431)	(1.510)
ΔReal global GDP	-0.149	0.0234	-0.196*
	(0.108)	(0.206)	(0.111)
Observations	2,198	2,063	2,198
R-squared	0.081	0.078	0.066

Notes: The sample includes quarterly data on cross-border flows (loans and debt securities) for 64 recipient countries over the period 2000:Q1 - 2013:Q4. The regressions include a full set of country fixed effects. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. † growth rate of outstanding stocks of debt issued by borrowers in country j, winsorized at the 10% level. (1) Effective federal funds rate for the period 2001:Q1 – 2008:Q4, Wu-Xia Shadow rate for the period 2009:Q1 – 2013:Q4. (2) LT foreign currency, average across 3 agencies. (3) Chinn and Ito (2006) measure of financial openness.

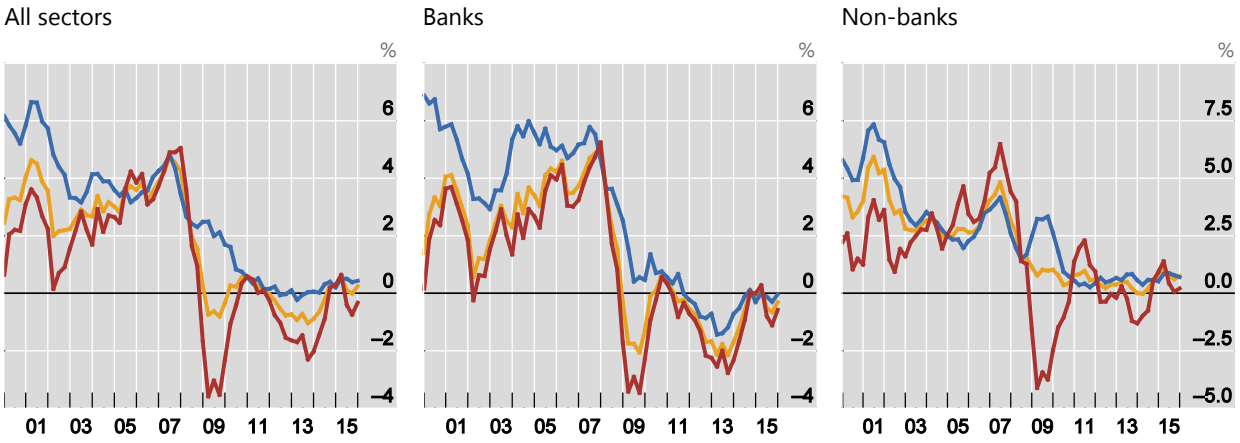
Table C9 - Baseline model with structural breaks and alternative measures of portfolio debt flows

	Dependent variable: ΔPortfolio debt flows †		
Explanatory variables	All	to banks	to non-banks
Pre-break			
Log(VIX)	-0.619	-2.146	-1.070
	(0.902)	(1.896)	(0.972)
ΔFed funds rate (1)	-0.0476	-1.112	-0.633
	(0.459)	(0.969)	(0.495)
Post-break			
Log(VIX)	-2.458***	-4.806***	-1.666**
	(0.672)	(1.321)	(0.690)
ΔFed funds rate (1)	-5.834***	-5.339***	-5.847***
	(0.761)	(1.453)	(0.787)
Observations	2,198	2,063	2,198
R-squared	0.126	0.102	0.101

Notes: The sample includes quarterly data on cross-border flows (loans and debt securities) for 64 recipient countries over the period 2000:Q1 - 2013:Q4. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. . † growth rate of outstanding stocks of debt issued by borrowers in country j, winsorized at the 10% level. (1) Effective federal funds rate for the period 2001:Q1 – 2008:Q4, Wu-Xia Shadow rate for the period 2009:Q1 – 2013:Q4. The regressions include ΔReal GDP, ΔSovereign Ratings, Chinn-Ito Index, ΔReal Global GDP and their interaction with a break dummy that takes value 1 after the break date (2009:Q1). The regressions also include a full set of country fixed effects.

External debt flows, AE borrowers

Four-quarter moving average of quarterly growth rates — Graph C1

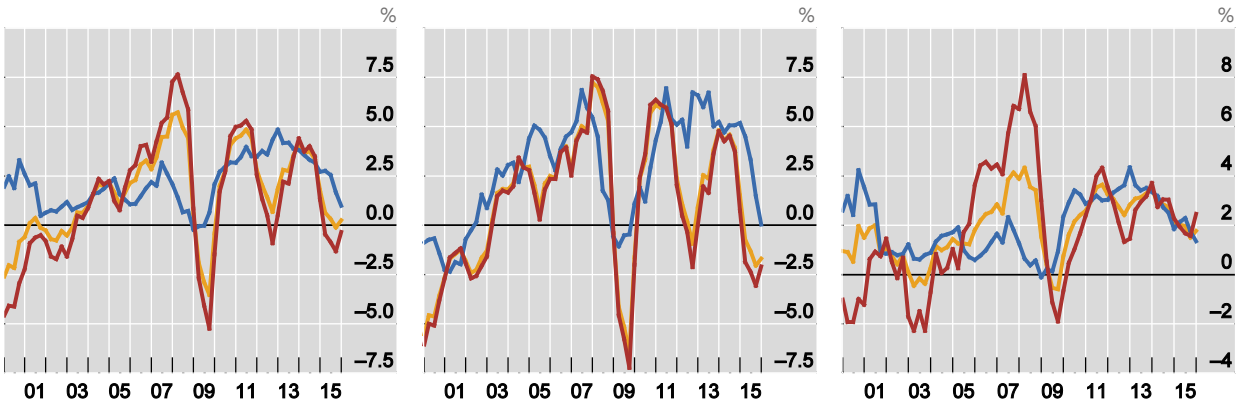


XBL = Cross-border loans: Quarterly Growth Rate$_t$ = Adjusted Flows$_t$ / Outstanding Stock$_{t-1}$; IDS = International Debt Securities: Quarterly Growth Rate$_t$ = Net Issuance$_t$ / Outstanding Stock$_{t-1}$.

Sources: BIS Locational Banking Statistics by residence; BIS International Debt Securities Statistics.

External debt flows, EME borrowers

Four-quarter moving average of quarterly growth rates — Graph C2



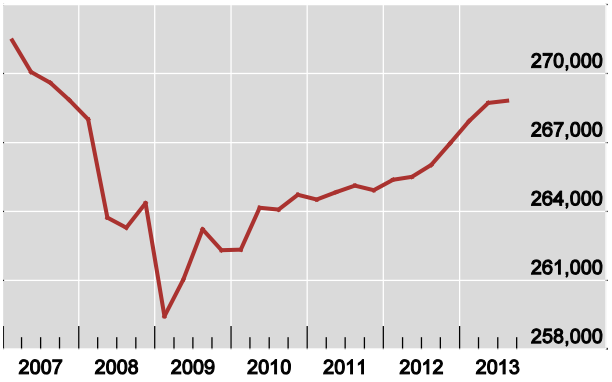
XBL = Cross-border loans: Quarterly Growth Rate$_t$ = Adjusted Flows$_t$ / Outstanding Stock$_{t-1}$; IDS = International Debt Securities: Quarterly Growth Rate$_t$ = Net Issuance$_t$ / Outstanding Stock$_{t-1}$.

Sources: BIS Locational Banking Statistics by residence; BIS International Debt Securities Statistics.

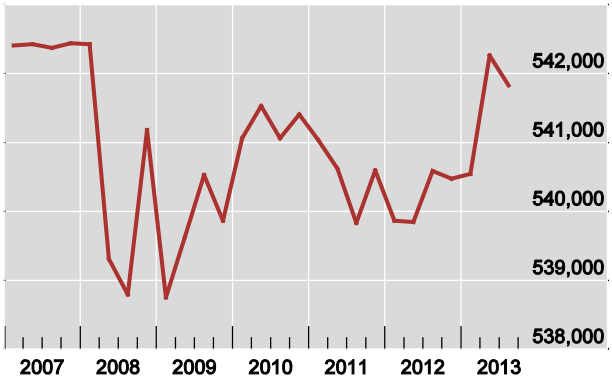
Sum of square residual (SSR) test on structural breaks for all parameters

Locational baseline regressions by borrowing country — Graph C3

Cross-border loans



International debt securities

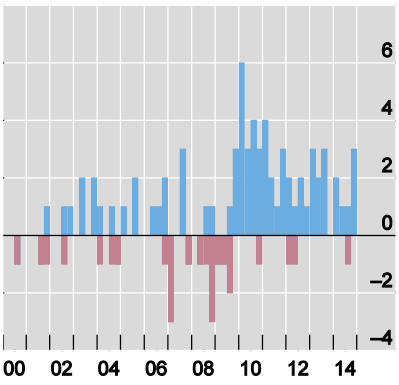


Notes: The tests have been performed in the following way. For every date t in the x-axis, we have created a time dummy that takes value 1 if the date is greater than t and 0 elsewhere. Then we have run the regression of cross-border loans and international debt securities on ΔFed fund rates, log(VIX), ΔReal GDP, ΔSovereign Ratings, Chinn-Ito Index, ΔReal Global GDP, the time dummy and the interaction of each explanatory variables with the time dummy. Each panel reports the sequence of sum of squared residuals (SSR) of each of these regressions, obtained by varying the time dummy. When the sequence of SSR's attains its minimum, then the fit of the model is the greatest and this is due to the presence of a specific time dummy. Therefore, the date when the SSR is at its minimum is the most likely candidate for a structural break. For cross-border loans, the break date is 2009:Q1, with F(7,2834) = 21.29 and p-value = 0.0000. For international debt securities, the break date is 2009:Q1, with F(7,2834) = 3.63 and p-value = 0.0007.

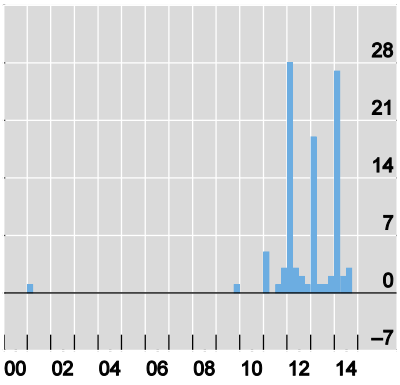
Changes in prudential policies

Graph C4

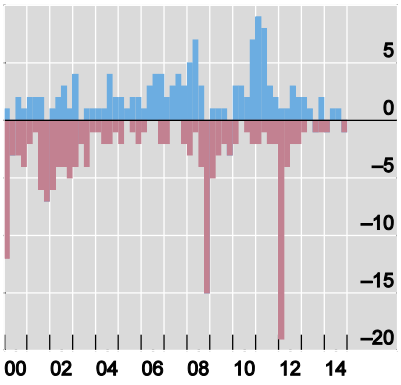
Loan to value ratio limits



General capital requirements



Reserve requirements (local)

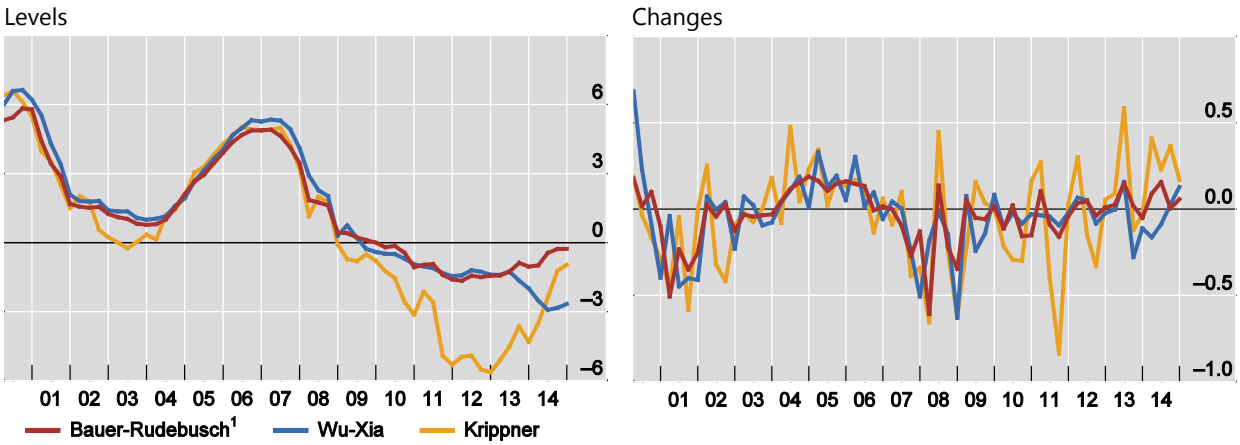


Source: Cerutti et al (2015).

Shadow rates

In per cent

Graph C5



[1] Median of 12 shadow rate estimates.

Sources: Bauer and Rudebusch (2015); Krippner (2014); Wu and Xia (2015).