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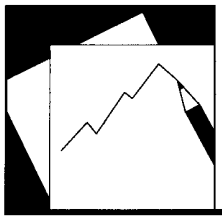

IMF Working Paper

Banks' Foreign Credit Exposures and Borrowers' Rollover Risks: Measurement, Evolution and Determinants

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Banks' Foreign Credit Exposures and Borrowers' Rollover Risks: Measurement, Evolution and Determinants [1]

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Abstract

The recent crises highlighted the role of cross-border banking linkages. This paper proposes two new measures for better capturing creditor banking systems' foreign credit exposures and borrower countries' reliance on foreign bank credit, by combining BIS data with bank-level data. The results indicate that the proposed refinements matter, especially when foreign bank affiliates' funding relies heavily on local deposits. In addition, after developing novel and necessary break-in-series and exchange rate variation adjustments, estimations looking at the driving factors of both measures during 2006-2012 highlight: (i) the role of systemic banking crises and global financial conditions in the evolution of banks' foreign credit exposures; (ii) the role of a larger set of factors in the case of the evolution of borrower countries' reliance on foreign bank credit—how countries borrowed, from whom they borrowed, and global financial and domestic demand conditions.

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I. INTRODUCTION

The recent financial crises highlighted the role of financial linkages between borrowers and creditors across countries and regions. Through chain-reactions triggered by common and idiosyncratic shocks, and transmitted by direct and indirect connections, numerous financial institutions and markets across many countries were affected by the problems that started in advanced countries.

Measuring cross-border banking linkages between creditor and borrowing countries, as well as analyzing their evolution and determinants, are key to understanding their role during the crisis. In this context, the objective of this paper is to improve the measurement of both the foreign credit rollover risks (*upstream exposure*) that borrowers face from a potential crisis in creditor foreign banking systems, and the creditor banks' foreign credit exposure *(downstream exposure)* to crises in countries that borrow from them. This paper measures the evolution of both foreign rollover risks and credit exposures overtime, and presents estimations of the main driving factors during the period 2006-2012. This time series analysis of BIS data is only possible thanks to a novel procedure to take into account particular break-in-series and exchange rate variations.

Existing studies, such as Goldberg (2005), Arvai et al (2009) and Buch et al (2010), among many others, have used BIS Consolidated Banking Statistics (BIS CBS)—which track banking sectors' worldwide consolidated gross claims and other exposures to individual countries (see Box 1)—to summarize creditor countries' banking sector exposure to their borrowing countries. The level of exposure to crisis in borrower countries, however, is often overstated by using simple BIS CBS balance sheet claims.[2] Although the parent bank exposure to its own direct cross-border and branch's claims are uncapped and equal to total claims, the exposure to a subsidiary is not legally equal to the total claims originating in that subsidiary. In principle, the legal exposure to a subsidiary in a host country is limited to the capital incorporated in that subsidiary plus non-capital debt owed by the subsidiary to the parent bank. The creditors' *downstream exposure* analysis developed in this paper takes into account this fact, and measures a creditor country's exposure to crises in countries that borrow from its banks.[3] It includes potential exposure through direct cross-border lending, lending by branches, and a proxy of foreign subsidiaries' non-parent funded claims. The

[2] The overall BIS CBS measure of on-balance sheet cross-border exposures is *foreign claims*, and it captures both direct cross-border and foreign affiliates' claims. See Cerutti, Claessens and McGuire (2011) for a review of the literature on global systemic risks, and an assessment of the available data and what additional data are needed to better measure systemic risks.

[3] Thus, the analysis focuses on adjusting BIS CBS overestimation of credit exposures with respect to legal considerations concerning subsidiaries. Beyond this aspect, there could be reputational cost arguments and the fact that certain countries might also limit banking groups' exposure to their branches in some particular extreme circumstances (e.g., war or civil conflicts). See footnotes 10 and 11 for more details.

analysis also includes banks' gross off-balance sheet accounts (derivatives, credit commitments and guarantees) in order to proxy the overall downstream exposure.

Similarly, other authors, like Peek and Rosengren (2000b), Martinez-Peria et al (2005), McGuire and Tarashev (2008), Kamil and Rai (2010), and Centorelli and Golberg (2011), among many others, summarize the increasing exposure of countries to international bank lending using BIS CBS. However, BIS CBS foreign claims overstate, in some cases significantly, borrower countries reliance on foreign bank lending. Foreign affiliates (branches and subsidiaries) funding models are not necessarily fully dependent on parent banks or foreign funding sources. Local resident domestic customer deposits are often the main funding source, and they do not constitute foreign rollover risks. Taking these important characteristics of the nature of cross-border banking linkages into consideration, this paper presents an *upstream exposure* analysis. It measures the foreign rollover risks that a borrowing country is facing with respect to direct cross-border borrowing from foreign banks, and the proportion of lending by foreign affiliates (both foreign branches and subsidiaries operating in the country) that was not funded by local costumer deposits. This is possible by combining BIS CBS with bank-level data. In addition, the use of BIS CBS data at ultimate risk basis permit the inclusion of existing credit commitments obtained from foreign banks in the analysis in order to capture a more comprehensive picture of on and off-balance sheet foreign rollover risks.[4]

This analysis based on combining BIS CBS data and more than 700 identified banking subsidiaries/branches operating in advanced and emerging markets, indicates that the proposed refinements in the foreign rollover risk exposures and, to a lower degree, in foreign credit exposures improve the measurement of exposures with respect to BIS CBS foreign claims. Improving the measurement of the reliance on foreign bank credit is especially useful in the case of emerging countries. Foreign affiliates in many of these countries are funded primarily by local deposits, and the share of direct cross-border lending in total foreign claims is generally lower than that for advanced countries. As a result, as of March 2012, the on-balance sheet upstream exposure of borrowers in Latin-America to creditor banks is, on average, only 45 percent of the foreign claims measure. Similarly, the average of the on-balance sheet upstream exposures for emerging Asia and Europe are 55 and 50 percent of foreign bank claims, respectively. By contrast, the figure for borrowers in advanced countries is 65 percent. The amount of credit commitments (off-balance sheet item) has an important

[4] The foreign rollover risk would be imprecisely captured using publicly available cross-border claims based on BIS locational data because it overestimates by about 1/3 total claims since intergroup bank lending is not netting out (McGuire and Wooldrige, 2005) and it is not possible to identify the ultimate banking sector holding the claims (e.g. the dependence on financial centers will be overestimated). Moreover, even though the overestimation of the role of financial centers could be addressed by combining confidential BIS locational banking statistics both at nationality and residence bases, there are still advantages to using consolidated statistics together with bank-level data because it allows the use of ultimate risk basis measures, which would capture the ultimate creditor holder of the risks, and, at the same time, include credit commitments in the calculations.

role in the overall upstream exposure figure in many countries, especially in some low income developing countries where BIS reporting banks' credit commitments represent more than ½ of on-balance sheet upstream exposures.

The downstream adjustment of on-balance sheet credit exposures is not as large in terms of foreign claims (e.g.; on average, downstream exposures are about 89 percent of foreign claims) as in the case of on-balance sheet upstream exposures, but this difference is still substantial in terms of most banking groups' Tier I Capital. There is also much heterogeneity across banking systems and borrowing regions. For example, in the case of exposure to developed countries borrowers, Canadian and Dutch downstream exposures are about 180 and 120 percentage points of banks' Tier I lower than what the use of only CBS foreign claims would indicate. By contrast, the differences are small for Swiss and Luxemburg banks. Once off-balance sheet items are included in the calculations, the level of downstream exposure of several countries increases substantially, especially in the case of US banks where gross off-balance sheet exposures are larger than on-balance sheet exposures.

In order to achieve a meaningful representation of the evolution of on-balance sheet upstream and downstream exposures, the analysis also shows that is necessary to take into account coverage break-in-series and the sharp exchange rate variations during the crisis.[5] The coverage break-in-series—those that reflect an expansion/reduction of BIS data coverage due to increase in reporting population or consolidation after a merger of domestic banks—are not only numerous (about 21 during the period 2006-12), but also very large on several occasions (e.g. USD 1.3 trillion in the first quarter of 2009 due to the inclusion of the claims of former US investment banks). Similarly, the high volatility in exchanges rates during the crisis implies that BIS CBS claims, which are reported in US dollars, have displayed important variation due to exchange rate movements.[6] In this context, the evolution of adjusted downstream and upstream shows substantial heterogeneity across national banking systems and borrower countries, with some countries suffering drastic reductions in exposures and others with current exposure levels above pre-crisis levels (e.g., upstream exposure of India, Indonesia and Turkey, and the downstream exposure of Spain and Sweden).

Finally, estimations looking at the driving factors of exposures during 2006-2012 show the important role of systemic banking crisis and global financial conditions in the evolution of

[5] These adjustments are not a minor task and, to my knowledge, have not been performed as extensively before (See Box 2 and Annex B). Due to data limitations in the exchange rate and break-in series adjustment of BIS data, the time series analysis of upstream and downstream exposures focuses only on on-balance sheet items.

[6] In a recent paper, Avdjiev, Kuti and Takas (2012) use BIS Locational Banking Statistics (by residence) to measure emerging markets economies' borrowing cross-border exposures. Although they recognize the advantages of using BIS consolidated banking statistics, they prefer using Locational BIS data since it is already exchange rate adjusted. The exchange rate (and coverage break-in-series) adjustments performed in this paper addresses their appropriate concerns.

banks' foreign credit exposures.[7] The large reduction in downstream exposures seems to have been driven by the presence of systemic banking crises in creditor countries, and it intensified during the peak of the crisis, when global risk aversion and funding pressures increased. The nature of the claims (direct cross-border claims vs. affiliate's claims) of creditor banking systems seems to not have mattered much from the creditor banks' perspective.

Instead, a larger set of factors seems to explain the variation in borrowers' upstream exposures. Even though there is some evidence that domestic demand conditions played a role, borrower countries experienced higher rollover problems as a function of three factors: (i) from whom they borrowed (e.g., systemic banking crisis in creditor banking systems translated into a decline in upstream exposures); (ii) how they borrowed (rollover of direct cross-border lending was much more difficult than of affiliates' lending); and (iii) global financial conditions (e.g., higher global risk aversion and/or bank funding costs). The policy implications of these findings indicate that policymakers should try to avoid relying on unstable creditor banking systems and excess concentration of direct cross-border borrowing. This does not imply that countries did not benefit from borrowing from abroad—an assessment beyond the scope of this paper—but highlights that the origin and composition of cross-border borrowing played a role during the crisis.

The structure of the rest of the paper is the following: the foreign credit exposure and rollover risk analyses are presented in the second and third sections, respectively. The evolution of both downward and upward exposures is depicted in the fourth section. The econometric analysis is performed in the fifth section, followed by the conclusion in the last section.

II. Measuring Banks' Foreign Credit Exposure: Downward Exposure

The level of international banks' exposure to a crisis in a borrower country is a function of both their balance sheets exposures and their organizational structure. Banks' foreign exposures originate in claims on the borrowers of a country either through direct cross-border lending (e.g. lending from the parent bank itself or its affiliates in a third country) or through the activities of affiliates (branches and/or subsidiaries) operating in that borrower country. In the case of branches and direct cross-border claims, a foreign bank group is fully exposed to losses on those claims, while subsidiaries' losses are technically capped at the parent's equity plus any non-equity intra-group claims.

[7] The analysis of the drivers builds on the existing literature, which mostly uses bilateral panel creditor-borrower data approach when analyzing international lending, but it separately considers creditors' downstream exposures and borrowers' upstream exposures. These two measures differ not only in the treatment of foreign branches' claims (at the bilateral level), but also on the fact that creditors' downstream exposures are aggregated across-borrowers, while borrowers' upstream exposures are aggregated across creditors. This different aggregation is important since a decrease in a creditor's downstream exposure would not necessarily translate into a borrower's decline in upstream exposures (e.g. substitution by borrowing from a different creditor banking system).

BOX 1 – BIS Consolidated Banking Statistics: Characteristics and Limitations

The BIS consolidated banking statistics (BIS CBS) provide quarterly data reported by 30 national regulators on aggregate consolidated foreign claims (assets) of internationally active banks headquartered in their jurisdiction (country). Banks' positions vis-à-vis residents of their home country are not included. This consolidation—netting out intergroup positions and consolidating positions across offices worldwide—makes for an internationally comparable measure of banking systems' risk exposures. This is a clear advantage over residency-based data, such as the BIS *locational banking statistics* and the IMF's Coordinated Portfolio Investment Survey (CPIS).

The BIS CBS on an ultimate risk basis is the best risk measure since it provides the residency of ultimate obligor, a clear breakdown into cross-border and affiliates' extended claims, and banks' maximum off-balance sheet exposures. Off-balance sheet items include derivative contracts and contingent exposures. Derivatives exposures include the positive market value of outstanding contracts covering foreign exchange, interest rate, equity, commodity and credit risks. Contracts with negative market value are classified as liabilities, and are not reported and/or netted out. Guarantees and credit commitments are reported at face value, i.e., at maximum possible exposures. See McGuire and Wooldridge (2005) for further discussion on the uses and structure of the BIS CBS on an ultimate risk basis. The main limitations of BIS CBS are:

-*Time-coverage:* Data are only available since 2005 at ultimate risk borrower basis.

-*Country Level vs. Bank level Analysis:* The country reporting level could mask banking group heterogeneity and bias the systemic risk analysis.

-*Overestimation of Credit Exposures and Rollover Risks*: A banking group exposure to its subsidiary in a borrowing country is limited to the capital incorporated in the subsidiary plus other non-equity lending from the parent bank to the subsidiary. Similarly, the funding risks faced by a borrowing country should not include the costumer deposit liabilities on affiliates' balance sheets. As shown in this paper, these biases can be mitigated with bank level data.

-*Shortcomings of Consolidated Balance sheets Analysis:* Even though the consolidated balance sheet analysis is appropriate for systemic risk analysis, it should be complemented with a more granular approach. A consolidated/aggregate analysis is implicitly assuming a frictionless flow of funds within a banking group. Locational data does not solve this problem necessarily, due to its duplication of exposure problems. Having access to granular bank-level is essential to estimating potential ring fencing risks. See Cerutti and Schmieder (2012).

-*Time Series Analysis:* The presence of numerous and some important break-in-series, as well as the impact of exchange rate movements should be taken into account when performing time series analysis. Banks' reported claims could change from one period to another even if the actual position remained unchanged, because claims in other currencies are converted by reporting banks into US dollars at end-of-quarter exchange rates. The BIS CBS break-in-series are not only numerous, but also significant and originated in different types of breaks-in-series (see Annex C).

-*Domestic Exposure Overestimation in Financial Centers:* Even though BIS CBS consolidates intragroup positions worldwide, not all "foreign" banks are excluded from national supervisor submissions to BIS data. In the case of Financial Centers, there could be a few foreign-owned banks incorporated in that country that are reported as domestic. Those foreign banks are owned by a foreign non-bank parent; hence, they are not reported by the supervisor of the country where the parent non-bank company is incorporated. For example, in the case of Ireland, BIS CBS foreign claims were much larger that an alternative domestic series reported by the Irish Central Bank on its webpage. This series does not aggregate foreign banks incorporated in Ireland but owned by non-bank companies (e.g., former German-owned Depfa bank).

-*Breakdowns only available at the aggregate***.** The maturity, sectoral, and currency breakdowns are only available for total foreign claims.

-*Lack of liability data and no-bank exposures:* BIS CBS does not include information on the structure of liabilities, and balance-sheet report of non-banks .

-*Gross off-balance sheet figures:* BIS CBS data are a proxy of the maximum potential off-balance sheet risks since they are not netted out (e.g. protection bought through CDS contracts are not taken into account).

The banks' on-balance sheet foreign claims (direct cross-border and affiliates claims) and off-balance sheet foreign claims (derivatives, credit guarantees, and credit commitments) can be obtained from BIS consolidated banking statistics, which collects internationally comparable measures of national banking systems' exposure to country risk (see BIS 2011). These statistics, however, do not preserve banks' multinational organizational structure and these are only available at the country level (not bank-level; see Box 1 for a brief summary of BIS CBS data limitations).

Until the ongoing efforts to improve international data collection materialize (see Cerutti, Claessens and McGuire, 2011), combining bank-level data with BIS CBS data is an alternative that allows for the capturing of how banks' organizational structure might affect banks' cross-border default vulnerabilities. The rest of this section describes the methodology used to capture downstream exposure, with and without off-balance sheet exposures, as well as the results obtained through the proposed refined downstream exposure measures.

A. On-Balance Sheet Downward Exposure Level

As highlighted, even though BIS CBS foreign claims—direct cross border plus affiliates claims—were designed to capture *on-balance sheet* foreign exposures, they do not take into account the branch/subsidiary structure of reporting BIS banks, and thus are an upper-bound measure of a banking system's foreign credit risk.

Since bilateral—an individual creditor banking system and a single borrower country pair—direct cross-border and total affiliates claims can be identified using BIS CBS, it is possible to combine bank-level data with BIS CBS data.[8] While capital can be easily identified in the collected bank-level data for subsidiaries, the non-equity lending from the parent bank cannot. It is not possible to disentangle non-equity lending from the parent bank from other subsidiary debt with the publically available bank-level data. Nevertheless, a bank's downstream exposure to its subsidiaries can be proxied by subtracting total customer deposits from total assets. In this context, it is possible to define more formally a creditor banking system *i*'s downstream *on-balance sheet exposure* to borrower country j as $A_{ij} + B_{ij} + C_{ij}$, where:

$A_{ij} = Cross\,border\,claims_{ij}$, capturing the direct cross-border exposure from creditor country banking system *i* on debtor country *j*;

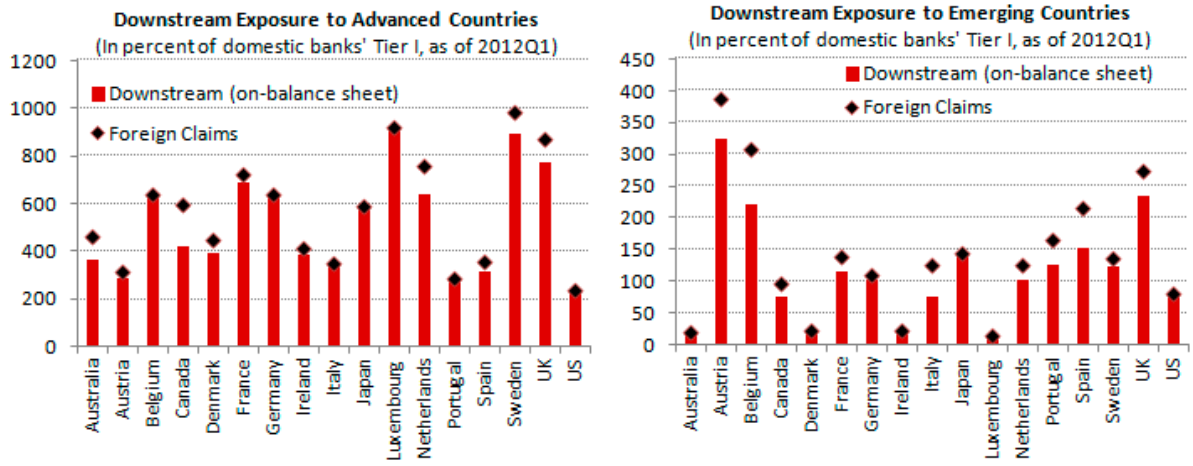
$B_{ij} = total\_assets_{ij}^{subs} - deposits_{ij}^{subs} + total\_assets_{ij}^{branch}$, capturing the full exposure to branches and the non-deposit fraction of subsidiaries' exposures; and finally

[8] See Annex A for more details on the coverage of bank-level dataset.

$C_{ij} = local\ claims_{ij} - \sum_{subs\ \&\ branch} total\_assets_{ij}$, capturing the non-identified exposures by bank level data with respect to BIS reported affiliates claims (i.e. individual bank-level data on branches is especially often not reported in many countries).[9]

Supplementing BIS CBS with bank-level data using the described proxy makes it possible to derive a *lower-bound* measure of downstream exposure that takes into account the variations in banks' organizational structure. Although we cannot also adjust non-deposit liabilities of subsidiaries with entities outside the bank group due to lack of data, the proposed measure would correct a large part of the BIS CBS foreign claims' overestimation of credit exposures with respect to legal considerations concerning subsidiaries. This is especially the case in emerging countries where large foreign subsidiaries are operating and fund themselves with local deposits. [10,11]

Figure 1: Comparing On-Balance Sheet Downstream Exposures Measures



Source: Author's estimations based on BIS, IFS, ECB, Bankscope and Central Banks' data.

[9] A much simpler and equivalent formula for downstream exposures would be BIS CBS foreign claims minus costumer deposits in foreign subsidiaries for each individual creditor country banking system *i* and borrower country *j*. The equivalent but more complex notation is used here, which highlights the different subcomponents, was chosen as a first stage for calculating expected downstream exposure losses later in this section.

[10] Beyond legal considerations, some parent banks rescued and recapitalized subsidiaries, even if they were not legally forced to do so, due to the reputational cost of abandoning their subsidiaries (see Cerutti et al, 2007). Nevertheless, reputational costs do not always prevail. As documented by Hryckiewicz and Kowelewski (2011), there were 149 episodes from 1997 and 2009 when parent banks abandoned their subsidiaries.

[11] There could be also legal considerations with respect to branches during crisis, but we did not include them in the downstream exposure calculations since they are a function of the characteristics of the potential crisis in the host country. For example, there are explicit provisions in US law establishing that parent banks are not required to repay the obligations of a foreign branch if the branch faces repayment problems due to extreme circumstances (such as war or civil conflict) or due to certain actions by the host government (e.g., exchange controls, expropriations, etc.). Cerutti et al (2007) found that international banks organizational choice were statistically sensitive to these contractual differences, since parent banks were more likely to operate as branches when risks were stemming from possible government intervention and other major political events.

Figure 1 shows the on-balance sheet downstream exposures—aggregated across either advanced or emerging/developing borrower countries for each banking system—compared with the original, upper-bound foreign claims measures as a percentage of domestically-owned banks' Tier I capital. On average, as of March 2012, the lower-bound downstream measure is about 50 and 25 percentage points of banks' Tier I capital below the upper-bound foreign claim measure across developed and emerging borrower countries, respectively. The lower and upper-bound measures differ little for some creditor banking systems, such as Luxembourg banks, despite their very large absolute level of on-balance sheet downstream exposures. In most cases, however, the differences are large in terms of banks' Tier I capital, which is the relevant metric when analyzing the impact of potential default shocks/scenarios on the capital buffers of banking systems.[12] For example, in the case of exposure to developed countries' borrowers, the Canadian and Dutch downstream exposures in terms of banks' Tier I are about 180 and 120 percentage points lower than their foreign claims' exposures in terms of banks' Tier I, respectively. Similarly, for Belgian, Austrian, and Spanish banks, the downstream exposures to emerging countries are about 60 to 90 percentage points of banks' Tier I capital below total foreign claim exposures.

B. On and Off-Balance Sheet Downstream Exposure Level

Off-balance sheet foreign exposures are included together with on-balance sheet foreign exposures in order to depict a complete picture of creditor banking systems' vulnerabilities to crises in borrower countries. BIS CBS reports banking systems' *gross* off-balance sheet foreign exposures—derivatives, guarantees and credit commitments—on an ultimate borrower risk consolidated basis. They are a proxy of the maximum potential off-balance sheet risks since they are not netted out.[13]

With the inclusion of off-balance sheet exposures (D_{ij}), we can now formally define the *downstream exposure* index ($Downstream_i$) as equal to:

$$Downstream_i = \sum_{j=1}^{N} \frac{A_{ij} + B_{ij} + C_{ij} + D_{ij}}{Z_i}$$

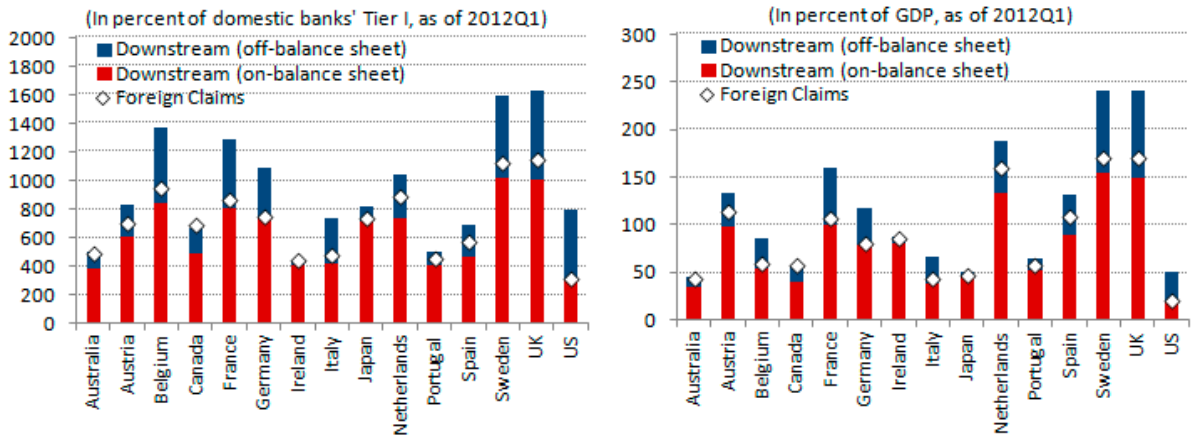
where: $D_{ij} = derivatives_{ij} + guarantees_{ij} + credit\_commitments_{ij}$ and captures the off-balance sheet exposure from country *i's* banks on country *j* based on BIS data; N is all the

[12] In this line, RES Banking Contagion Module is in effect using downstream exposures when modeling systemic risks for international banks (see Cerutti et al 2011 for more details).

[13] Also, having access to full net exposure measures would have been very useful, but they are not necessarily as relevant as gross off-balance sheet exposures during a crisis, when counterparty risk increase, in some cases, significantly.

BIS countries capture as borrowers, Z_i is a scaling factor (domestic banks' Tier I capital or GDP) in the creditor country i; A_{ij}, B_{ij}, and C_{ij} were defined in the previous subsection.

Figure 2: Downstream Exposures vs. Foreign Claims



Source: Author's estimations based on BIS, IFS, ECB, Bankscope and Central Banks' data.

With off-balance sheet items included as well in the measurement of downstream exposures (see Figure 2), banking systems' downstream exposures are all above foreign claims' exposures. This is especially the case in the US where off-balance sheet exposures are larger than on-balance sheet exposures. In Italy, Belgium, France, UK, Sweden, Germany, and Spain, off-balance sheet exposures represent about 40 to 30 percent of total downstream exposures. More generally, Figure 2 is showing that the levels of total downstream exposures are important in terms of both banks' Tier I capital and GDP (an average of 925 percent of banks' Tier I capital or 115 percent of GDP).

Based on available further breakdowns of downstream exposure levels, it is possible to highlight that: i) Swedish and Spanish banks are the two banking systems that are most exposed through their foreign affiliates' lending, even after discounting their locally funded claims; ii) Dutch, Canadian, and Italian banks are the other banking systems with important affiliate networks that are responsible for more than 50 percent of exposures to foreign affiliates; iii) The exposure of most BIS reporting banking systems remain almost exclusively within advanced countries—only Austria, Greece, and Spain have a relatively more balanced regional exposure. Austria and Greece are exposed to CEE countries, and Spain is mostly exposed to Latin America; and iv) Almost all banking systems are more exposed to the private non-bank sector on their on-balance sheet exposures rather than to the public and/or banking sectors.

Expected Downstream Exposure Losses

An extension of the downstream exposure measure, which is often used in the context of the IMF Vulnerabilities Exercise for Advanced and Emerging Countries (VEA/VEE),[14] is the concept of *expected* downstream losses. These expected downstream losses can be estimated using downstream exposure levels, the probability of crisis in borrowing countries (something that is available from other modules in the VEA/VEE), and loss-given default (LGD) parameters for each borrower country. Moreover, since bank level data also provides an estimation of affiliates' liquid assets, it is possible to confine the application of the LGD only to the non-liquid affiliates' assets only. See Annex B for a description of the equations that can be used to estimate expected downstream losses.

C. Limitations in the Downstream Exposure Analysis

The refinements proposed in the downstream exposure analysis have shown that taking into account international banks' organizational and funding structure is important. Nevertheless, the analysis still has the following limitations due to data constraints and the fact that it is based on BIS CBS: (i) The on-balance sheet downstream exposure does not correct all the overestimation of BIS CBS foreign claims (from a legal/technical point of view) because it also includes non-parent bank wholesale funding; (ii) Downstream exposures can be calculated only at the level of banking systems rather than for individual banks due to the characteristics of BIS data; (iii) Off-balance sheet data refer to maximum possible exposures and it is available only for banking systems reporting BIS CBS data at ultimate risk basis (see Box 1); (iv) Bank-level data on subsidiaries are (for the most part) available only annually, and thus need to be interpolated to match to the quarterly BIS CBS data; (v) Mapping international banks' group structure and consistently matching it to the BIS CBS is difficult using commercial data (e.g., Bankscope, Bankers' Almanac, etc.) and publically available regulator data since not always all affiliates can be identified, especially not all branches (see Annex A); and (vi) As well as with the use of BIS CBS, the interpretation of the downstream figures on a country level basis need to be carefully executed due to specific country factors (e.g. some foreign-controlled banks are reported as "domestic" banks in BIS CBS when the parent institution is a non-bank—see example for Ireland in Box 1)

III. Measuring Borrowers' Foreign Rollover Risks: Upward Exposure

The analysis of upward exposures takes the perspective of the borrowers (all sectors) of a country, and refers to the cross-border rollover risk faced by those borrowers from problems in creditor banking systems that could interrupt the inflow of foreign credit. This type of upstream exposure analysis is important, especially during crises, because it provides a

[14] For more details see IMF (2012).

forward looking measure of the rollover risks that borrowers are exposed to with respect to crisis in a particular banking system or groups of banking systems.

Similar to the downstream analysis, the upstream analysis is also performed by combining BIS CBS and bank-level balance sheet data. BIS CBS foreign claims include worldwide consolidated direct cross-border claims on country *j* plus the positions booked by banking system *i*'s affiliates (subsidiaries *and* branches) on country *j*. This BIS measure does not capture a borrower country's rollover risks per se since it include *all* affiliates' assets. Nonetheless, it can be adjusted using bank-level data in order to reflect the type of funding that financed affiliates' claims. The rest of this section presents the methodology used to quantify the on-balance sheet and off-balance sheet upstream exposure measures and a brief description of the results obtained.

A. On-Balance Sheet Upstream Exposure Level

The on-balance sheet upstream exposure is the result of adding foreign banks' direct cross-border claims and foreign affiliates' claims that are not financed by local consumer deposits. In other words, a borrowing country j on-balance sheet *upstream exposure* index can be captured by:

$$Upstream_j = \sum_{i=1}^{N} \frac{Cross\ border\ claims_{ij} + Local\ claims_{ij} * (1 - Min(deposit\ loan\_ratio_{ij}, 1)}{Z_j} \qquad (2)$$

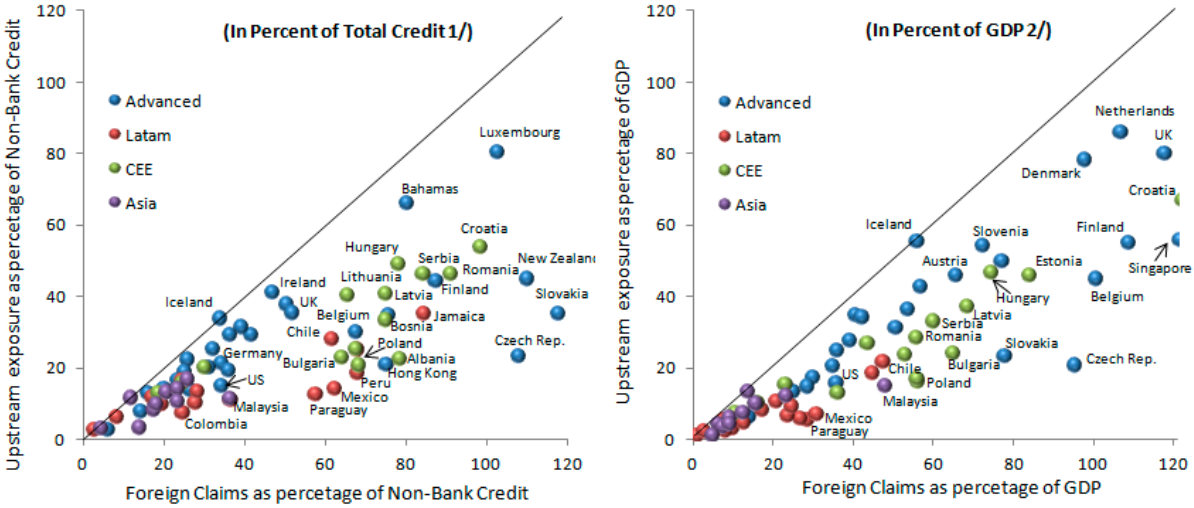
where: $Crossborder\ claims_{ij}$ captures the volume of direct cross-border claims from country banking system *i* on borrower country *j*; $Local\ claims_{ij}$ the volume of affiliates (both subsidiaries and branches) claims of parent banks from country *i* on borrower country *j*; $1 - Min(deposit\ loan\_ratio_{ij}, 1)$ is a proxy of the proportion of loans not financed by local consumer deposits; N is the total number of BIS CBS reporting countries; and Z_j is a scaling factor (GDP or bank credit to the local non-bank private and public sectors in country j). The deposit to loan ratio is equal to:

$$deposit\ loan\_ratio_{ij} = \left(\sum_{Subs\ from\ i} deposits_{ij}^{subs} + \sum_{Branch\ from\ i} deposits_{ij}^{branch} \right) \Bigg/ \left(\sum_{Subs\ from\ i} loan_{ij}^{subs} + \sum_{Branch\ from\ i} loan_{ij}^{branch} \right)$$

and calculated base on developed and emerging markets bank-level data, or national country data in the cases where affiliates' bank level data is not available (e.g., borrower low income countries). The higher the deposit to loan ratio, the lower is the share of local claims financed by parent bank resources and/or wholesale financing. Problems to rollover wholesale funding are assumed to be positive correlated with potential parent bank problems, something that was frequent during the recent crisis. Using affiliates' total assets minus deposits, like in the case of the downstream exposure to subsidiaries, as the proxy of the amount of lending by

affiliates funded by their parent banks produce similar results but much lower country coverage.[15]

Figure 3: On-Balance Sheet Upstream Exposures vs. Foreign Claims



Source: Author's estimations based on BIS, IFS, ECB, Bankscope and Central Banks' data.
1/ Total credit is measured as the addition of local and direct cross-border banks claims on non-banks (see Annex A for more details).
2/ Only foreign claims up to 120 percent of GDP are displayed. Luxembourg (970 percent of GDP), Bahamas (324 percent), Ireland (210), Honk Kong (210 percent), New Zealand (170 percent), and Cyprus (150 percent) are not plotted.

The difference between the foreign claims and the on-balance sheet upstream exposure is important. As shown in Figure 3 by the vertical distance of each point to the 45 degree line, this is especially the case for borrowers in emerging countries and newly developed countries (e.g., Czech Republic and Slovakia).[16] Not only is the share of direct cross-border lending in

[15] Without the proposed definition the calculations would be only possible for the sample of 26 developed and emerging countries for which bank-level data were collected. The proposed definition enlarges the sample to 53 countries (see full sample of 193 countries in map Figure 4). The correlation between the proposed definition of on-balance sheet upstream exposures and an alternative definition using affiliates' total assets minus deposits is about 85 percent for all developed and emerging countries with bank-level data (above 90 percent when the sample is restricted to only emerging countries). For some more financially developed emerging countries, such as Mexico, Chile and Poland, the proposed upstream exposure is lower than the alternative definition because non-deposit/wholesale funding (domestic and/or foreign) is a non-negligible source of funding for loans. In the case of several advanced countries, the proposed upstream measurement is sometimes larger because the alternative measure using the loan to deposit ratio does not take into account more complex balance sheets, where wholesale borrowing might also be funding non-standard loans claims.

[16] Figure 3, right hand side panel, shows that there are 4 countries for which BIS foreign claims as a percentage of non-bank credit are larger than 100 percent. In the case of the Czech Republic, where there is a very important presence of foreign affiliates funded through local deposits, the above 100 percent figure is driven by the fact that foreign claims include not only affiliates' claims on non-banks but also affiliates' claims on the central bank and claims on other banks. In the case of New Zealand, direct cross-border claims include a large proportion of direct credit to domestic banks, which seems to be used not only as a funding source for domestic assets. The cases of Slovakia and Luxembourg reflect a combination of the two described cases above.

total foreign claims generally lower in those countries than that for advanced countries, but also the large foreign affiliates in many of these emerging countries are funded primarily by local deposits. For example, the on-balance sheet upstream exposure of borrowers in Latin-America (red circles) to creditor banks is, on average, only 45 percent of the foreign claims measure. Similarly, the upstream exposures for emerging Asia and Europe are on average only 55 and 50 percent of foreign bank claims. By contrast, the share for borrowers in advanced countries is somewhat higher and around 65 percent.

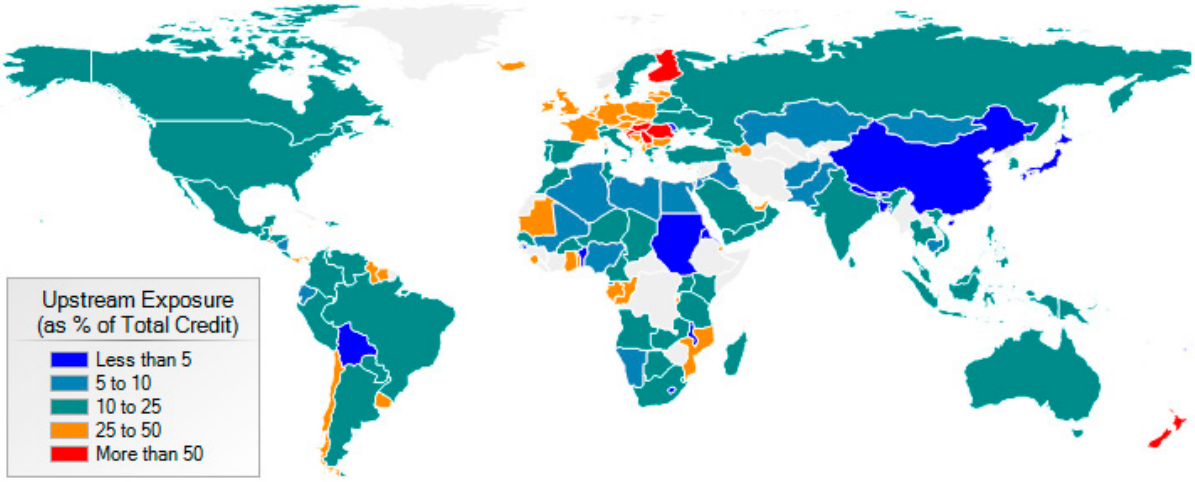
Figure 3 (left hand side) shows that on-balance sheet upstream exposure levels are higher in Europe, driven by the high financial interlinkages among EU countries. The countries with the highest levels in Europe are Luxemburg (80 percent of total—local and direct cross-border—non-bank credit), Croatia (54 percent), Hungary (49 percent), Serbia (46 percent), and Romania (46 percent). Outside Europe, the most exposed countries are Bahamas (66 percent) and New Zealand (45 percent). Some emerging markets like Chile (28 percent), Uruguay (25 percent), and Turkey (20 percent) are facing larger upstream exposures than the most other non-European EMs, especially many Asian countries. The right hand side of figure 3 offers the same comparisons between on-balance sheet upstream exposures and foreign claims, but as percent of borrowing countries GDP.[17] The results highlight the relatively high exposure of developed European countries in terms of upstream exposures levels—the exposure levels in several countries in Latin America and Eastern Europe are relatively lower in GDP terms since they are less-financially-developed.

B. On- and Off-Balance Sheet Upstream Exposure

The described on-balance sheet upstream exposure captured a borrower country foreign rollover exposure through both direct cross-border lending by international banks and the proportion of lending by foreign affiliates that were funded by their parent banking system. It is necessary to add the credit commitments that a borrower country has secured from BIS reporting banks in order to capture the full upstream exposure. All these foreign rollover risks that a borrowing country faces with respect to problems in the creditor country's banking systems are captured in the upstream exposure (see Figure 4).

[17] Financial centers are not plotted in the figure because their large exposure in terms of GDP (see footnote 2 in Figure 3). Using total credit in the denominator is the more appropriate measure than GDP for analyzing rollover risks since it captures the fact that countries have different financial deepening levels.

Figure 4: Upstream Exposures as Percentage of Total Credit as of March 2012



Source: Author's estimations based on BIS, IFS, ECB, Bankscope and Central Banks' data.

As of March 2012, the countries most exposed, as a percentage of their upstream exposure to their total credit, are in Europe, with Luxembourg (90 percent of total credit), Croatia (63 percent), Hungary (58 percent), Romania (55 percent), Serbia (54 percent), Finland (54 percent), and Slovakia (50 percent). Outside Europe, the most exposed borrowers are Seychelles (69 percent) and Cape Verde (56 percent) in Africa; Samoa (89 percent) and New Zealand (57 percent) in Asia, and Panama (38 percent) and Chile (36 percent) in Latin America.[18] Finally, it is important to highlight that the upstream exposure levels presented in Figure 4 are illustrative of the potential total rollover risks faced by borrowers. The upstream exposure value would correspond to a worst case scenario—losing without possibility of domestically or externally replacing all BIS reporting banks bank financing.

Expected Upstream Exposure Credit Losses

Similar to the case of downstream exposures, it is also possible to calculate *expected* upstream losses as a combination of upstream exposures and the probability of crisis in creditor countries. These types of calculations are often included in the IMF Vulnerability exercises, where crisis country probabilities are available from other modules (see IMF 2012). See Annex B for a description of the equations that can be used to estimate expected upstream losses.

C. Limitations in the Upstream Exposure Analysis

The data limitations discussed in the downstream analysis apply to the upstream analysis as well. Two additional limitations are: (i) Granular data on banks' internal capital markets and

[18] The figures in the case of many developing countries are driven through their ties with their former colonial countries' financial centers. The amount of credit commitments (off-balance sheet item) has an important role in the overall upstream exposure figure in many African countries. For example, credit commitments represent about 24 percent and 18 percent of total credit in the case of Cape Verde and Seychelles, respectively.

wholesale sources of funds (e.g., interbank repo market borrowing, and other non-deposit funding, etc) are generally not available; (ii) Not all potential creditor banking systems are included in the calculations since only claims from the 30 BIS CBS reporting countries are taken into account—nevertheless the coverage would be very high because the BIS CBS covers the largest banking systems, and the fact consolidated data include lending by affiliates of BIS reporting countries (e.g. the lending to a Lithuanian corporate by a subsidiary of a Spanish bank incorporated in Poland); and (iii) As well as in the case of BIS foreign claims, the interpretation of the upstream measures figures on a country level basis need to be carefully considered due to the potential presence of country specific factors (e.g. BIS reporting banks' claims on Liberia are largely driven by the fact the country has the second-largest maritime registry in the world).

IV. Downward and Upward Exposures: A Time Series Perspective

Up to now, the analysis has focused on the measurement of downstream and upstream exposures as of March 2012. However, it is also possible to estimate the evolution of both on-balance sheet downstream and upstream exposures before and after the crisis. This is not straightforward due to the need to first adjust for exchange rate movements and selected BIS CBS break-in-series.

The necessary adjustments to BIS CBS data for calculating the adjusted time series of downstream and upstream exposures are not directly available from BIS CBS, but can be estimated by combining both Locational and Consolidated BIS data (see adjustments details in Box 2 and Annex C). The high volatility in exchanges rates during the crisis implies that BIS CBS claims, which are reported in US dollars, have often displayed important variation due to exchange rate movements rather than due to changes in the actual underlying positions of the claims. The adjusted figures show that the impact of exchange rate movements has been very important—triggering negative and positive adjustments of up to 5 percent of foreign claims at different points of time. In addition, the size of some break-in-series in BIS CBS is such that time series analysis using BIS SBC are not *meaningful* without adjusting for breaks related to changes in the coverage of the series (e.g. the inclusion of the claims of former investment banks—such as Goldman Sachs and Morgan Stanley—in US BIS CBS triggered a coverage break-in-series of about USD 1.3 trillion in the first quarter of 2009).

The rest of this section presents the evolution of the upstream and downstream exposures, especially from the peak before the crisis.

BOX 2 – Adjusting BIS CBS for Coverage Break-in-Series and Exchange Rate Movements

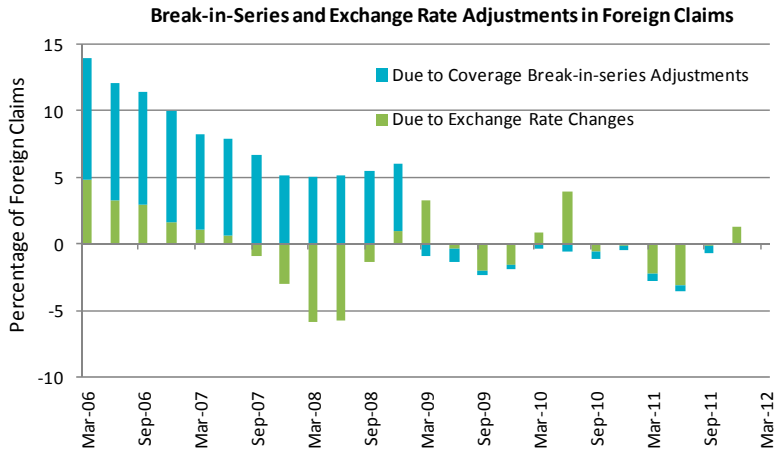
The fact that BIS CBS at ultimate borrower basis is available since mid 2005 make performing time series analysis very appealing for depicting the recent crisis. Nevertheless, two adjustments must be performed in order to avoid misleading conclusions: (i) the BIS CBS break-in-series are not only numerous, but also significant; and (ii) claims in US dollars could change from one period to another even if the actual underlying position remained unchanged since BIS CBS claims in other currencies are converted by reporting banks into US dollars at end-of-quarter exchange rates. The magnitude of these adjustments is important (almost up to 15 percent of total foreign claims in 2006) as shown in the figure below and Annex D.

Adjustment for Coverage Break-in-Series

BIS reports 84 series breaks during 2006-12 in BIS consolidated banking statistics at ultimate borrower risk basis. About 61 breaks are due to mergers and acquisitions among foreign banks, thus reflecting a change in exposure levels at the bilateral borrower-creditor level but not across all BIS reporting bank level (e.g. the acquisition of a Belgium sub in Turkey by a French bank would not change the total claims on Turkey). Other 23 coverage break-in-series are driven by an expansion of the banking sector coverage (e.g., increase in reporting population due to inclusion of former investment banks, merger of domestic banks that triggered a consolidation of foreign claims, etc.). This type of coverage break-in-series deserves special attention because the increases in exposure levels were already present before they started to be reporting to BIS. An important example is the US 2009Q1 USD 1,334 billion break-in-series, when the former investment banks become banks (e.g. Goldman Sach's foreign claims existed before 2009Q1). Performing time series analysis without correcting the original BIS data will lead to wrong conclusions (e.g. both US cross-border and US local claims have decreased during the crisis not increase as the unadjusted series would indicate). The fact that BIS reports the value of the series without the break helps offsetting the break impact.

Adjustment for Exchange Rate Variations

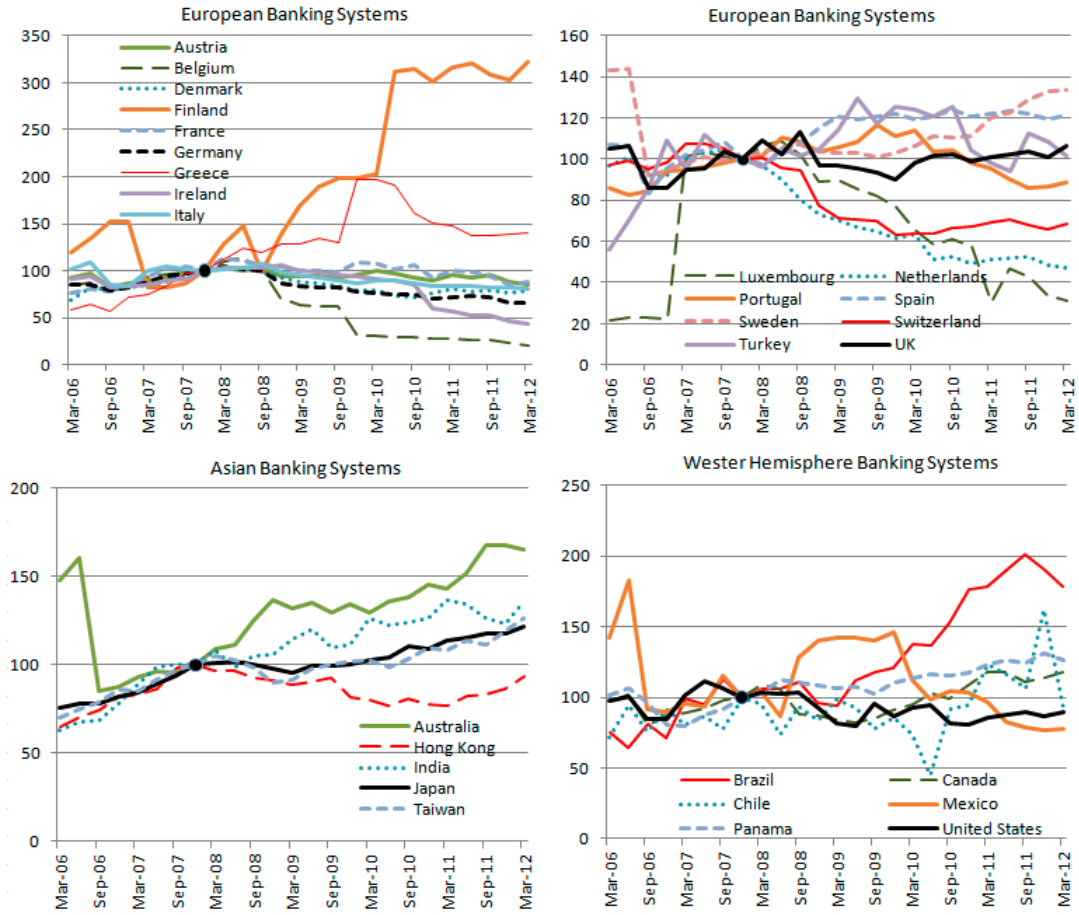
The impact of exchange rate movements was important during the crisis, when there was high volatility among countries exchange rates. Three corrections are performed to address this problem at the bilateral creditor national banking system-borrower country level. First, the domestic-currency denominated local affiliates claims are corrected following the bilateral US dollar domestic currency exchange rate. The domestic-currency denominated local affiliates' claims are proxied by using its share of total BIS CBS foreign claims at immediate borrower basis. Second, at the same time, this procedure allows to identify the amount foreign-currency denominated local affiliates' claims, which are assumed to be in Euros in Europe and US dollars in the rest of the countries. Finally, bilateral CBS cross-border claims positions are adjusted using, as proxy, the currency breakdown currency (among US. Dollar, Euro, British Pound, Japanese Yen, and Swiss Francs) available from the BIS locational banking statistics (LBS).



A. Evolution of On-Balance Sheet Downstream Exposures

The evolution of on-balance sheet downstream exposures shows high heterogeneity levels across creditor banking systems after the crisis (see Figure 5), with mostly non-European banking system registering exposures larger in March 2012 than in their respective pre-crisis peaks. Within Europe, only the Spanish, Swedish, Finnish, Turkish and Greek banking sectors have seen an increase of their on-balance sheet downstream exposures from the pre-crisis peaks.[19] All other European banks reduced their exposures with respect to pre-crisis peaks. In particular, Belgian and Dutch banks drastically reduced their downstream exposure levels (e.g., about 80 and 70 percent lower levels as of March 2012 with relation to December 2007, respectively). These lower levels of downstream exposures are also reflecting the recent crisis that many European banking sectors have experienced. With the exception of Sweden, all European banking systems have experienced a decline or stop of their 2010 rebound in downstream exposures.

Figure 5: Evolution of On-Balance Sheet Downstream Exposures (Index Dec 2007=100)



Source: Author's estimations based on BIS, IFS, ECB, Bankscope and Central Banks' data.

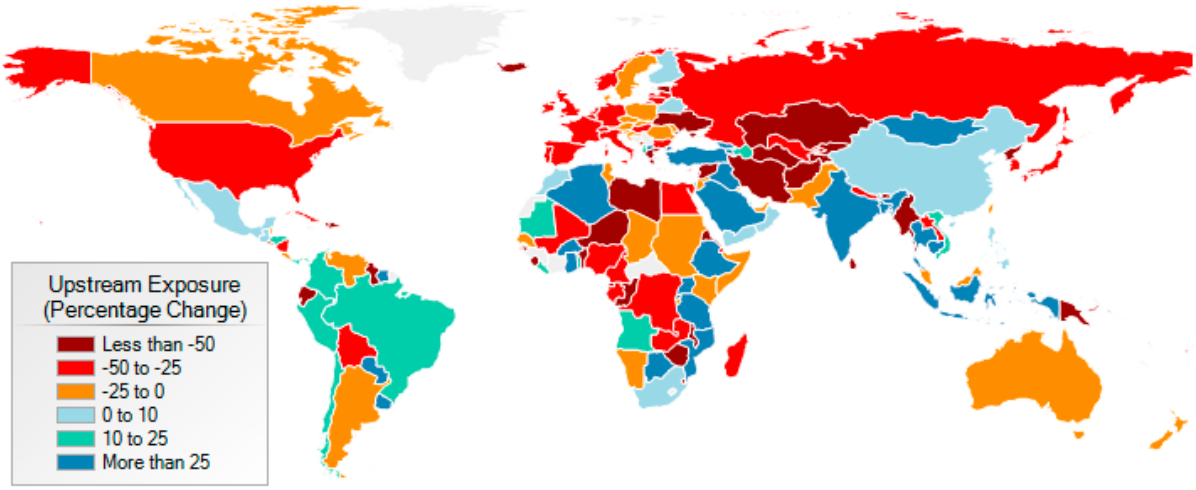
[19] The increase in downstream exposures in Greece was driven by the transformation of a foreign bank into a domestic bank at the end of 2009. Similarly, most jumps in other countries downstream exposures are reflecting non-coverage break-in-series. See Appendix C for more details.

Outside Europe, in most cases, the crisis decreased or slowed down the increase in on-balance sheet downstream exposures during 2008-09, but the impact of the most recent financial turmoil in Europe has not reversed recent positive trends. The US and Hong Kong banking systems were particularly affected during the 2008-09 crisis and their levels are still below the December 2007 pre-crisis level.[20] At the lowest point, the US and Hong Kong banking sectors decrease in downstream exposures were about 15 percent and 25 percent with respect to the December 2007 pre-crisis level, respectively.

B. Evolution of On-Balance Sheet Upstream Exposures

The global deleveraging process triggered by the 2008-09 crisis, which was captured by the evolution of downstream exposures, is also reflected in the evolution of upstream exposures. The reduction of on-balance sheet upstream exposures signals lower rollover risks going forward, but it is also clear evidence of the stress that some economies went through during the crisis. On average there has been a reduction in the 2012Q1 level of upstream exposures of 131 countries (out of 193 covered) with respect to pre-crisis levels (see Figure 6). Only about ¼ of the borrower countries—which includes many emerging markets such as India, Indonesia, Turkey, and Brazil—have experienced a double digit increase in upstream exposures with respect to the pre-crisis heights.

Figure 6: Evolution of On-Balance Sheet Upstream Exposures
(Percentage change with respect pre-crisis peak)



Source: Author's estimations based on BIS, IFS, ECB, Bankscope and Central Banks' data.

[20] The adjustment of US downstream exposures by coverage break-in-series is key in the analysis since the level would be certainly above the pre-crisis levels without including in the analysis the adjustment of US banks' break-in-series at the end of 2009.

V. Determinants of the Evolution of Downward and Upward Exposures

The review of the evolution of on-balance sheet downstream and upstream exposures showed that there was large heterogeneity across countries and periods. This section analyzes the main drivers behind each exposure index during the period 2006-2012.

The literature using BIS data that has analyzed the determinants of either foreign credit to borrower countries or creditor banking systems' foreign exposures provides some guidance on the choice of possible explanatory variables. Several papers (e.g., World Bank 2008, McGuire and Tarashev 2008, Herrmann and Mihaljek 2009, Kamil and Rai 2010, etc.) highlight the role of global financial conditions in the form of either global risk aversion or funding pressures in global interbank markets. Creditor banking systems' health (e.g., balance sheet or market based financial soundness indicators) and macroeconomic controls (e.g. debtor real GDP growth) are also included in the empirical estimations. The analysis below builds on that literature, but it also takes into account the numerous systemic banking crises in the period under study, as well as the fact that the analysis of the evolution of upstream and downstream exposures could be biased using usual bilateral panel creditor-borrower data approach when analyzing international lending. For example, the acquisition of a subsidiary operating in host country J by a bank of creditor country A from a bank of credit country B would trigger an increase in country A downstream exposures, a decrease in country B downstream exposures, and no-change in country J upstream exposure. In this context, and taking into account the previously discuss difference between upstream and downstream exposures (e.g. regarding the treatment of branches and how one is aggregated across-borrowers and the other across creditors) the analysis of both exposure measures needs to be performed separately.

A. Drivers of On-Balance Sheet Downstream Exposures

The baseline empirical analysis of on-balance sheet downstream exposures is based on a reduced-form model specification given by:

$$\Delta D_{it} = \beta_0 + \beta_1 \Delta GDP_{ijt} + \beta_2 \text{Creditor\_Bank}_{\text{it}} + \beta_3 Global_t + \tau_t + \gamma_i + \varepsilon_{it} \qquad (3)$$

where the dependent variable ΔD_{it} is the quarterly growth rate in the adjusted (both coverage break-in-series and exchange rate variations) stock of on-balance sheet downstream exposure of creditor banking system i in quarter t. The explanatory variables used in the analysis are as follow:

- ΔGDP_{ijt} is the creditor banking system i weighted average of the GDP growth in its borrower countries j in quarter t (with the weight for each creditor banking system built as a function of this creditor banking system foreign claims to each of its borrower countries). The expected relationship with downstream exposures is positive, reflecting the fact that higher economic growth in borrower countries is associated with an increase in lending growth.

- Creditor_Bank$_{it}$ captures the evolution of credit bank fundamentals and characteristics through mainly three measures: a) A dummy reflecting the presence of systemic banking crisis in banking system i in quarter t (**Cred_Systemic_Crisis**), based on Laeven and Valencia (2012) and with negative expected sign; b) The ratio of Deposit to Loans (**Cred_DLR**) in the creditor banking system i as a proxy of its funding strategy; a positive relationship with the evolution of downstream exposures since the lower the deposit to loan ratio the more dependence on wholesale markets; and c) The share of direct cross-border lending in total foreign claims (**Cred_CB_Share**), which, in principle, would have a negative expected sign since banks cut especially direct cross-border claims during the crisis, and, unlike the case of affiliate claims, bank regulators in borrowing countries do not have any control.

- Global$_t$ captures global financial conditions through two measures: a) The spread between three-month US dollar Libor and the three-month US treasury bill rate (**TED spread**), which reflect liquidity strains in global inter-bank markets, and b) The normalized quarterly volatility of the S&P 500 financial index (**VIX**), which captures global risk aversion. The expected sign in both cases is negative, an increase in TED spreads or VIX are related to funding pressures and higher risk aversion in global financial markets.

- The panel data estimations control for γ_i fixed effects to each creditor banking system, in order to account for time invariant and unobserved factors driving the evolution creditor banking system downstream exposures. Quarter time dummies τ_t are also included in order to capture seasonal effects and the fact that the bank balance sheet data used to build downstream exposures are only available in annual frequency.

In addition, the specifications used in the regressions also include specifications where global financial factors enter in the estimation as interacted with credit bank characteristics. For robustness purposes, time dummies (time fixed effects) are included in some specifications instead of quarter dummies, in order to control for impacts common to all creditors that change over time. Due to data limitations (e.g., there was limited coverage of data for Norway, Singapore, Taiwan, and Mexico), the analysis covers 26 of the 30 countries reporting BIS CBS during the period 2006Q2-2012Q1. See Annex D descriptive statistics.

Empirical Results

The estimations show that most variables have the expected sign and are statistically significant when considered individually (see columns 1 to 6 in Table 1). Higher global risk aversion and the presence of systemic bank crisis in creditor banking systems are linked with a reduction in downstream exposures. An increase in borrower countries' GDP growth or in the deposit to loan ratio of the creditor banking systems display a positive significant relationship with variations in downstream exposures. Instead, the TED spread—the other global financial measured used—as well as the share of direct cross-border in total lending (Credit_CB_Share) do not display statistically significant correlations when considered individually.

Table 1: Determinants of the Change in Downstream Exposures

2006Q2-2012Q1 - Panel OLS with Fixed Effects - Dependent variable: Change in Adjusted Downstream Exposure (in percent)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ΔGDP_{ijt}	1.391**						0.458	-0.998	0.755	0.549
	(0.693)						(0.934)	(1.110)	(0.623)	(0.800)
Cred_Systemic_Crisis		-4.471***					-3.723***	-3.152**	-2.227**	-3.058***
		(0.997)					(1.042)	(1.266)	(0.953)	(0.969)
Cred_DLR			10.99*				8.448	7.386	10.57	7.527
			(5.633)				(5.893)	(5.755)	(7.322)	(6.190)
Cred_CB_Share				0.0465			0.0159	-0.0283		
				(0.0697)			(0.0673)	(0.0709)		
VIX					-0.104**		-0.0517	0.441		
					(0.0526)		(0.0789)	(0.6513)		
TED Spread						-0.0044	-0.0021	-1.910		
						(0.0073)	(0.0055)	(1.3678)		
TED * Cred_Systemic_Crisis									-0.0369***	
									(0.0122)	
TED * Cred_DLR									-0.0295	
									(0.0315)	
TED * Cred_CB_Share									0.0376	
									(0.0431)	
VIX * Cred_Systemic_Crisis										-0.134**
										(0.0617)
VIX * Cred_DLR										-0.166
										(0.189)
VIX * Cred_CB_Share										0.164
										(0.318)
Quarterly Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Time Fixed Effects	No	No	No	No	No	No	No	Yes	No	No
Creditor Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	622	622	622	622	622	622	622	622	622	622
Number of Creditor Banks	26	26	26	26	26	26	26	26	26	26
R2	0.082	0.092	0.081	0.074	0.084	0.074	0.102	0.164	0.111	0.108

Note: This table reports the baseline panel fixed effect described in equation (3) in the text, and some alternative specifications through the use of interacted terms. Robust standard errors are in parentheses and they are clustered at the creditor banking system level. Asterisks denote significant of coefficients, with ***, **, * indicating significance at 1%, 5% and 10% level, respectively.

Nevertheless, once all variables are estimated together in columns 7-10 of table 1, it is clear that only two relationships seem to remain statistically significant. The presence of a systemic banking crisis in the creditor banking system is a good indicator of a decline in downstream exposures. A systemic banking crisis would trigger about a 3 percent decline in downstream exposures in a given quarter. This finding is robust to the introduction of time fixed effects (column 8), indicating that the explanatory power of the presence of a systemic banking crisis is not only based on the fact that most systemic banking crises started in the second half of the sample. In addition, when global financial variables are interacted with creditor systemic crisis, both an increase in global risk aversion or funding spreads would reinforce the fall in downstream exposures. At the peak of the global financial variables in our sample, the presence of a systemic banking crisis would be associated with a decline in downstream exposures of about 8 and 11 percent, depending if we use the specification with risk aversion (column 9) or ted spreads (column 10), respectively.[21]

[21] A one standard deviation increase in global financial variables, together with the presence of a systemic banking crisis, would be associated with a decline in downstream exposures of about 4½ percent.

In sum, the analysis highlights that creditor banking systems' foreign exposures were driven by the presence of bank systemic crisis and global financial conditions. The characteristic of the lending—through either direct cross-border or affiliate lending—does not seem to be as relevant. Similarly, demand factors in borrowing countries—at least the ones that we proxy with borrowers GDP growth—and the credit banks' funding structure characteristics do not seem to be statistically significant drivers.[22]

B. Drivers of On-Balance Sheet Upstream Exposures

The baseline empirical analysis of on-balance sheet upstream exposures is similar to the one performed on downstream exposures, but now the analysis is from the borrowing country perspective. So, the baseline equation is now as shown in equation 4.

$$\Delta U_{jt} = \beta_0 + \beta_1 \Delta GDP_{jt} + \beta_2 \text{Creditor\_Crisis}_{\text{ijt}} + \beta_3 Borrower_{jt} + \beta_4 Global_t + \tau_t + \gamma_j + \varepsilon_{jt} \quad (4)$$

where the dependent variable ΔU_{jt} is the quarterly growth rate in the adjusted (both coverage break-in-series and exchange rate variations) stock of on-balance sheet upstream exposure of borrower country j in quarter t. The explanatory variables used in the analysis are as follow:

- Δ**GDP$_{jt}$** is the borrower country j GDP growth in quarter t.[23] The expected relationship with upstream exposures is positive, reflecting the fact that higher economic growth in borrower countries is usually associated with an increase in foreign borrowing bank credit demand.

- **Creditor_Crisis$_{ijt}$** captures the proportion of creditor banking systems that are experiencing systemic crisis for each borrower country during each given quarter. It is constructed for each borrowing country j as a weighted average of the dummy Creditor_Systemic_Crisis—as defined in the downstream analysis and indicates whether a credit banking system was experiencing or not a systemic banking crisis in quarter t. The weight used was built as a function of the share of the bilateral creditor-borrower foreign claims on the total BIS reporting banks foreign claims on the borrower country. The expected sign is negative, since, as found in the downstream exposure analysis, a creditor banking system in the middle of a systemic banking crisis would likely reduce its foreign lending.

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[22] Including other bank characteristics in the estimations was not possible for the full sample. At the cost of reducing ¼ of the sample and an imbalanced panel in terms of time coverage, the inclusion of creditor banks' Tier I ratio in the estimations seems to indicate that the level of bank solvency might have also played a role, with a positive and statistically significant coefficient (at 10 percent level). The results with respect to the importance of the presence of systemic banking crises and their interaction with global financial variables remain valid.

[23] Borrowing country GDP growth in quarter t is measuring the change in annual GDP (sum of most recent four quarters) with respect to annual GDP from the previous quarter. The GDP series used took into account the fact that some countries report GDP quarterly series already at an annual measure (sum of most recent four quarterly GDP) and others only the GDP corresponding to each specific country. See Appendix D.

- $Borrower_{jt}$ captures borrower countries characteristics in terms of: a) a lag of the share of direct cross-border in borrower country foreign borrowing (**Borrower_CB_share**); b) domestic banking system funding mix, measure by its deposit to loan ratio (**Borrower_DLR**). Since a large part of our sample cover the crisis, we expect a negative sign in Borrower_CB_share, indicating that the higher is the share of direct cross-border in borrower country foreign borrowing, the larger would be the fall in upstream exposures. Not only were direct cross-border flows particularly affected during the crisis, but also host regulators in borrowing countries had practically no control over them. Instead, the expected sign of the variable Borrower_DLR is positive since more reliance on domestic deposits could isolate foreign affiliates from the external financial turmoil.[24]

- $Global_t$ captures, as in the case of downstream exposures, global financial conditions through two measures: a) The spread between three-month US dollar Libor and the three-month US treasury bill rate (**TED spread**), which reflect liquidity strains in global inter-bank markets, and b) The normalized quarterly volatility of the S&P 500 financial index (**VIX**), which captures global risk aversion. The expected sign in both cases is negative, an increase in TED spreads or VIX are related to funding pressures and higher risk aversion in global financial markets, which would, in principle, reduce the supply of foreign borrowing.

- The panel data estimations control for $\boldsymbol{\gamma_j}$ fixed effects to each borrower country, in order to account for time invariant and unobserved factors driving the evolution of borrower upstream exposures. Quarter time dummies $\boldsymbol{\tau_t}$ are also included in order to capture seasonal effects and the fact that the bank balance sheet data used to build upstream exposures are only available in annual frequency.

In addition, the specifications used in the regressions also include specifications where global financial factors, borrower country deposit lo loan ratio, creditor bank systemic crisis enter in the estimation as interacted with borrower country characteristics. Again for robustness purposes, time dummies (time fixed effects) are also included in some specifications instead of quarter dummies, in order to better control for impacts common to all borrower countries that change from one quarter to the other.[25] Due to data limitations, the analysis covers 112 borrower countries, during the period 2006Q2-2012Q1. See Annex D descriptive statistics.

[24] Note Borrower_CB_share is calculated as a percentage of foreign claims, since calculating it as a percentage of upstream exposure would also implicitly include the borrowers' deposit to loan ratio—used to calculate upstream exposure. The Borrower_CB_share is the average for the local bank sector based on IFS data—not the weighted average used in the upstream calculations based on bank level data. The use of more general definition allows for the isolation of the different channels and for larger consistency across countries (bank level data were collected only for developed and emerging markets).

[25] The inclusion of time dummies is of course at the cost of not being able to assess the significance of global financial variables which only vary across time.

Empirical Results

The estimations show that a larger set of factors has a role in explaining the evolution of upstream exposures than in the case of downstream exposures. Table 2 only includes TED spreads from global financial variables in order to present more interaction variables. The VIX variable, the other global financial condition variables, is presented in the table D.3 in Annex D, and results are very similar. The reading of the results highlights that:

Table 2: Determinants of the Change in Upstream Exposures

2006Q2-2012Q1 - Panel OLS with Fixed Effects - Dependent variable: Change in Adjusted Upstream Exposure (in percent)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ΔGDP_{ijt}	0.470**					0.284*	0.149	0.252*	0.284*	0.244*
	(0.188)					(0.149)	(0.139)	(0.138)	(0.149)	(0.140)
Cred_Syst_Crisis		-9.58***				-12.54***	-5.46*	-6.09***	-18.74***	
		(1.172)				(1.285)	(3.159)	(1.713)	(3.306)	
Borrower_CB_Share			-0.250***			-0.311***	-0.310***	-0.289***	-0.268***	-0.290***
			(0.071)			(0.066)	(0.063)	(0.066)	(0.096)	(0.065)
Borrower_DLR				5.479		1.569	0.645	0.683		1.761
				(4.499)		(4.653)	(4.667)	(4.509)		(4.346)
TED Spread					-0.0126**	-0.0315***	0.3222		-0.0655***	-0.0030
					(0.0055)	(0.0060)	(0.7527)		(0.0168)	(0.0091)
TED * Cred_Syst_Crisis								-0.111***		-0.106***
								(0.025)		(0.026)
TED * Borrower_CB_Share								-0.00029*		
								(0.00016)		
TED * Borrower_DLR								0.0183*	0.0368**	
								(0.0097)	(0.0174)	
Borrower_DLR * Cred_Syst_Crisis									6.593*	1.739
									(3.727)	(1.747)
Borrower_DLR * Borrower_CB_Share									-0.056	
									(0.083)	
Cred_Syst_Crisis * Borrower_CB_Share										-0.153***
										(0.035)
Quarterly Dummies	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Time Fixed Effects	No	No	No	No	No	No	Yes	No	No	No
Borrower Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,458	2,458	2,458	2,458	2,458	2,458	2,458	2,458	2,458	2,458
Number of borrower countries	112	112	112	112	112	112	112	112	112	112
R2	0.057	0.078	0.065	0.055	0.055	0.107	0.154	0.116	0.112	0.118

Note: This table reports the baseline panel fixed effect described in equation (4) in the text, and some alternative specifications through the use of interacted terms. Robust standard errors are in parentheses and they are clustered at the borrower country level. Asterisks denote significant of coefficients, with ***, **, * indicating significance at 1%, 5% and 10% level, respectively.

First, from whom a country borrows was important. Borrowing countries operating with creditor banking systems that were experiencing systemic banking crisis suffered a negative change in upstream exposures (up to -12 percent if all creditor banking systems were through systemic banking crisis).[26] This impact was larger during high TED spreads as highlighted in

[26] Although at a lower significance level, this finding is robust to the introduction of time fixed effects (column 7). The explanatory power of the proportion of systemic banking crisis in creditor banking systems is not only based on the fact that most systemic banking crises in creditor banking systems started in the second half of the sample. In addition, this is consistent with the evidence found by Avdjev, Kuti and Takas (2012) that the deterioration of the health of particular banking systems—proxied by each creditor banking system simple average of its banks' CDS spreads—was a key variable for explaining the variation of emerging markets' cross-border bank borrowing (measured using Locational BIS data).

the interactive coefficient of column 8, indicating that countries were not fully able to substitute a creditor banking system in crisis with another. Instead, the negative impact of systemic banking crisis in creditor banking systems was lower, the higher the borrower deposit to loan ratio (see interaction coefficient column 9). This suggests that countries with domestic banking systems with lower exposure to non-deposit funding were able insulate themselves better during the crisis. This is in line with Claessens et al (2010) that shows that banks' dependence on wholesale funding help to account for the amplification and global spread of the financial crisis.

Second, how a country borrows was also important. The results indicate that the larger was the share of cross-border on total borrower foreign claims, the further the decline in upstream exposures. This is consistent with Herrero and Martinez Peria (2007) that finds that foreign claim volatility is lower in countries with a larger share of local claims. Even though there was no evidence in the analysis of downstream exposures that composition of exposures matters in explaining its evolution, it seems to matter from a borrowing countries' perspective. This divergence between downstream and upstream analyses could be driven by the fact that the sale/acquisition of a foreign affiliate can have a different impact on them. In the case of upstream exposures, in several cases, the affiliate lending (non-funded with local deposits) did not change (much) from the borrowing country perspective, since the acquisition of the foreign affiliate only changed the name of creditor banking system. This was not the case with cross-border borrowing where a creditor banking system reduction in its exposures did not necessarily imply substitution from another creditor banking system.[27] With respect to interacted channels, the interaction term with the share of cross-border and TED spread was also statistically significant, showing that the deterioration in upstream exposures during the peak of the crisis was even higher in the presence of larger direct cross-border. Similarly, the interaction term with the share of cross-border and Cred_Syst_Crisis (column 10) was also statistically significant and negative, highlighting that the presence of systemic bank crisis in creditor countries increased the negative effect of large direct cross-border share in upstream exposures.

Third, international financial conditions were also a key driver during the period. This is consistent with findings in the literature measuring the determinants of foreign lending (e.g. World Bank 2008, McGuire and Tarashev 2008, and Kamil and Rai 2010). In the baseline specification (column 6 in Table 2), a one standard deviation increase in TED spreads reduced upstream exposures by 1¾ percentage points. As described before, interacted with

[27] The fact that Borrower_CB_Share is still significant at 1 percent level after the inclusion of time dummies (see column 7) indicates that the divergence between downstream and upstream analyses with regard to the composition of exposures are not driven by different time effects.

other borrower countries variables, it increased their negative impact in the evolution of upstream exposures.[28]

Finally, not all was driven by external factors. Although only significant at 10 percent significance level in a few specifications, as expected, the coefficient of GDP growth in borrowing countries was positive. In the sample, a one percent increase in GDP gowth increase upstream exposures by up to 1/3 of a percent.[29]

VI. CONCLUSIONS

The global financial crisis highlighted the role of bank linkages between borrowers and creditors across countries and regions, but the available unadjusted BIS aggregate data are not enough to effectively measure cross-border banking linkages and to perform time series analysis of their evolution and determinants.[30]

The combination of BIS CBS aggregate data with bank-level data presented in this paper improves, especially in the case of emerging markets, the measurement of both creditor banking systems' foreign credit exposures (downstream exposure) and borrower countries' reliance on foreign bank credit (upstream exposure). Taking into account international banks' organizational and/or funding structure is essential to correct BIS overestimation of exposure levels and to uncover the heterogeneity in exposures across borrowing and creditor countries.

Similarly, the empirical results highlight the need to perform careful time series analysis when using BIS data. Only after taking into account coverage break-in-series and the sharp exchange rate variations during the crisis, can the evolution of downstream/upstream exposures be effectively analyzed. In the case of foreign credit exposures, the results highlight that several creditor banking systems' downstream exposures have not recovered to pre-crisis exposure levels, and in some cases have experienced substantial reductions. This phenomenon seems to have been driven mostly by the presence of systemic banking crisis, and intensified during the peak of the crisis, when risk aversion increased and bank funding costs were more expensive. The nature of the claims (direct cross-border claims vs. affiliate's claims) of the creditor banking systems seems not to have mattered much, since, during the period 2008-12, several creditor banking systems seemed to be able to also reduce foreign downstream exposure by selling their subsidiaries.

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[28] The results are similar when using global risk aversion (VIX) instead of TED spreads. See table D.3 in Annex D.

[29] The fact that GDP growth was positive and significant indicates, in principle, that domestic borrower country's demand factors played a role. Nevertheless, the estimation procedure was not seeking to break-down supply and demand factors. A difference-in-difference procedure using bilateral creditor-borrower data, such as in Cetorelli and Goldberg (2011), would be necessary to perform this type of analysis.

[30] See Cerutti, Claessens, and McGuire (2011) for more details on data shortcoming to measure global financial risks.

In the case of reliance on foreign bank lending, in almost all advanced countries and many emerging markets (EM) countries, upstream exposures remain below pre-crisis levels, owing to the international deleveraging process triggered by the global financial crisis. Only some EMs—especially large EMs such as India, Indonesia, Turkey and Brazil—have seen an increase of their upstream exposure levels to above pre-crisis levels. More factors had a role in explaining the evolution of upstream exposures. In general, borrower countries experienced higher rollover problems as a function of: i) from whom they borrowed (e.g., where or not the creditor banking system were experiencing systemic banking crisis); ii) how they borrowed (rollover of direct cross-border lending was much more difficult than of affiliates' lending); iii) global financial conditions. Looking forward, given that borrower countries do not have control over global financial conditions, policymakers should try to avoid (to the extent possible) relying on unstable creditor banking systems and excess weight on direct cross-border borrowing. Following direct cross-border lending is many times difficult for policymakers in borrower countries because bank lending statistics/analysis are often focused on the domestic banking sector, where more data are available. In this context, the crisis has stressed the need to improve data, measurement, and analysis of cross-border bank interlinkages. These data and analysis are important not only for policymakers/analysts in core countries of the financial global architecture, but also in peripheral borrowing countries.

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ANNEX A – DATA SOURCES: BIS CBS, BANK-LEVEL, AND IFS DATA

BIS Consolidated Banking Statistics

There are 30 countries that report consolidated banking statistics to BIS, of which 24 of them (Australia, Austria, Belgium, Canada, Chile, Finland, France, Germany, Greece, India, Ireland, Italy, Japan, Netherlands, Norway, Portugal, Singapore, Spain, Sweden, Switzerland, Turkey, UK, and US) report both at ultimate borrower risk basis and immediate risk basis. Brazil, Denmark, Hong Kong, Luxembourg, Mexico, and Panama only report at immediate risk basis.

The data at ultimate risk basis is the main source used in the calculations because such data offer: (i) A breakdown of foreign claims (on-balance sheet claims) into cross-border and affiliates claims; and (ii) Off-balance sheet claims, which are broken down into derivatives, credit commitments and guarantees. For countries reporting only at immediate risk basis or when the breakdown at ultimate risk basis was not available (e.g. the dataset used was based on publically available and restricted but not confidential BIS CBS data), the on-balance sheet breakdown was calculated based on data at immediate risk basis and bank level data. At immediate risk basis, the measurement of international claims (cross-border plus local affiliates claim in foreign currency) is available. So, the cross-border claims figures were calculated based on bilateral international claims and the claims of their subs and branches overseas (from the bank level data, see below). More specifically, cross-border claims are equal to total claims minus subs/branches assets, and always lower/or equal than international claims.

Complementary Bank Level Dataset

The foreign bank presence in the form of subsidiary and/or branches in 26 developed and 53 emerging countries was surveyed through their national regulators' web-pages. Based on the domestic regulators' list of bank (deposit taking institutions) in each country, we then proceeded to identify which were foreign banks, and the nationality and some characteristics of their owners (e.g., banks or no-banks parent institutions) through Bankscope, Bankers' Almanac, national regulators' webpages, and banks' webpages. Finally, balance sheet data for the affiliates, whose owner was a bank headquartered in one of the BIS CBS reporting countries, were obtained through Bankscope and national regulators' web-pages. For example, for December 2010 (see Table A.1), we found data for 93 branches and 637 affiliates (very good coverage of subsidiaries, but not as good in the cases of branches, especially branches in developed countries).[31] Finally, the balance sheet of these subsidiaries and branches were separately aggregated following the nationality of the parent bank and the host country, in order to match the country level BIS CBS data. The available bank-level data is annual, for the period 2006-2011.

[31] Although number of indentified branches is relatively small in the aggregate, several identified branches are not small (e.g. Citibank Argentina) and there are countries with more branches than subs (e.g. India and Spain).

Table A.1 – Branches and Subsidiaries in the Bank-Level Dataset in December 2010

OECD Branches and Subsidiaries included in the Bank-Level Dataset				EM Branches and Subsidiaries included in the Bank-Level Dataset				EM Branches and Subsidiaries included in the Bank-Level Dataset			
Country	**Subsidiaries**	**Branches**	**Total Assets**	**Country**	**Subsidiaries**	**Branches**	**Total Assets**	**Country**	**Subsidiaries**	**Branches**	**Total Assets**
Australia	4	0	63.3	Albania	5	0	5.6	Jordan	0	0	0.0
Austria	8	0	304.9	Algeria	2	0	3.9	Kazakhstan	4	0	54.6
Belgium	11	0	889.5	Argentina	10	6	29.2	Latvia	4	0	20.9
Canada	19	6	136.3	Armenia	2	0	0.8	Lebanon	0	0	0.0
Czech Republic	13	1	189.2	Barbados	4	0	5.5	Lithuania	3	0	25.4
Denmark	7	0	299.7	Belarus	2	0	2.2	Malaysia	11	0	76.2
Finland	2	0	354.4	Bolivia	1	2	0.6	Mexico	15	0	270.0
France	13	0	852.5	Bosnia	4	0	6.0	Morocco	3	0	22.6
Germany	13	0	900.1	Brazil	29	3	361.6	Nicaragua	3	0	1.6
Greece	3	0	181.8	Bulgaria	10	0	31.7	Pakistan	2	0	4.9
Hungary	12	11	100.8	Chile	8	4	78.2	Panama	3	5	20.3
Ireland	17	0	830.7	China	17	0	105.3	Paraguay	4	2	5.1
Italy	9	0	297.9	Colombia	4	0	7.3	Peru	7	0	22.4
Korea	2	0	103.8	Costa Rica	6	0	6.0	Philippines	2	0	0.6
Luxemburg	62	0	853.9	Croatia	6	0	54.2	Romania	9	1	71.7
Netherlands	9	0	1481.9	Czech Republic	7	0	160.3	Russia	14	0	82.2
New Zeland	4	4	251.8	Dominican Republic	0	2	1.3	Serbia	5	0	8.8
Norway	1	0	92.4	Ecuador	2	2	1.1	Slovakia	6	0	47.4
Poland	21	0	209.2	Egypt	5	0	21.4	Slovenia	7	0	46.9
Portugal	8	0	107.4	El Salvador	3	1	6.8	Thailand	2	0	14.8
Slovakia	10	0	65.8	Estonia	2	0	38.4	Trinidad and Tobago	3	0	6.1
Spain	11	30	405.0	Georgia	1	0	0.5	Tunisia	2	0	3.2
Sweden	0	0	0.0	Guatemala	3	1	6.2	Turkey	9	0	101.6
Switzerland	49	0	280.6	Honduras	6	0	2.7	Ukraine	8	0	22.2
UK	29	0	1978.8	India	1	5	71.4	Uruguay	5	3	10.9
US	11	0	1486.1	Indonesia	15	2	37.4	Venezuela	0	2	2.0
Total OECD	**348**	**52**	**12717.7**	Jamaica	3	0	4.4	**Total**	**289**	**41**	**1992.5**

Source: Bankscope, Bankers' Almanac, national regulators' webpages, and affiliate banks' webpages.

Combining IFS and BIS data: Total Bank Credit

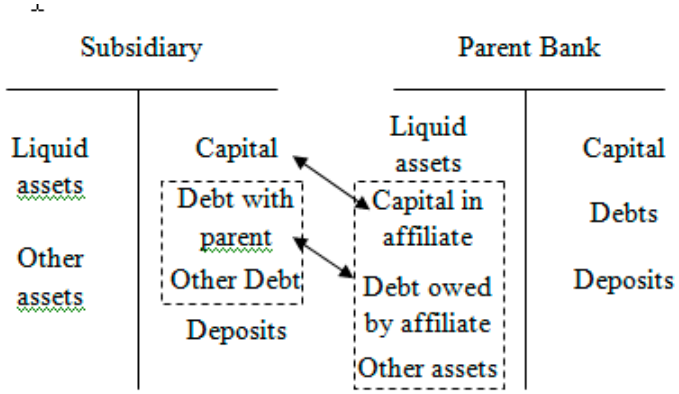
It is possible to calculate the total credit received from banks (both locally incorporated and direct cross-border credit) to the no-bank sector of a borrowing country. IMF International Financial Statistics provide a measure of local (both domestic and foreign owned) banks' claims (loans, securities other than shares, and shares and other equities) on non-bank borrowers. The cross-border borrowing by the non-bank sector can be proxied using BIS locational banking statistics. More specifically, BIS Location Banking Statistics Table 6B, provide a measure of BIS reporting banks' direct cross-border claims on non-bank public and private sectors. The total bank credit to the non-bank sector used as a scaling factor in the upstream exposure index is the addition of both IFS local banks' claims and BIS cross-border claims on the non-bank sector.

ANNEX B – CALCULATION OF DOWNSTREAM AND UPSTREAM EXPOSURES

B.1 - Downstream Analysis

The downstream analysis quantifies a creditor country's vulnerability to crises in countries that borrow from its banks. For each creditor banking system, the analysis captures the exposures on direct cross-border lending, off-balance sheet positions (derivatives, credit guarantees, and credit commitments), and affiliates' claims on borrowing countries.

As discussed in the text, it is possible to obtain the quantification of cross-border lending and off-balance sheet positions from BIS data. Nevertheless, the downstream exposure to banks' affiliates (subsidiaries and/or branches) in a borrowing country is not as straightforward. Using BIS data on affiliates' claims overstates, in many cases significantly, the legal exposure of parent banks to their subsidiaries, which is limited to the capital incorporated in the subsidiary plus other non-equity lending from the parent bank to the subsidiary (see figure below). Since there are not enough detailed cross-country balance sheet data on parent banks' non-equity lending to their subsidiaries, this exposure is proxied, using bank-level data, by subtracting total customer deposits from total assets. On the other hand, the downstream exposure to creditor banks' branches in a borrowing country is legally equal to the entire branch assets.



Therefore, a creditor country i *downstream exposure* would be equal to;

$$Downstream\_Exposure_i = A_{ij} + B_{ij} + C_{ij} + D_{ij}$$

where:

$A_{ij} = Cross\ border\ claims_{ij}$ and captures the direct cross-border exposure from creditor country i on debtor country j;

$B_{ij} = total\_assets_{ij}^{subs} - deposits_{ij}^{subs} + total\_assets_{ij}^{branch}$ captures the exposure to subsidiaries and branches, taking into account the legal differences between them;

$C_{ij} = local\ claims_{ij} - \sum_{subs\ \&\ branch} total\_assets_{ij}$ represents the non-identified exposure by bank level data with respect to BIS reported affiliates claims (i.e. individual bank-level data on branches is especially often not reported in many countries); and

$D_{ij} = derivatives_{ij} + guarantees_{ij} + credit\_commitments_{ij}$ captures (gross) off-balance sheet exposure from country *i* banks on country *j* based on BIS data.

Expected Downstream Exposure Losses

The level of downstream exposure can be combined with the probability of crisis in a borrowing country and with the loss-given default (LGD) estimations in order to estimate potential expected downstream exposure losses. So, that the *expected downstream index* (D_i) can be estimated as follows:

$$D_i = \sum_{j=1}^{N} \frac{A_{ij}LGD_j + B_{ij}LGD_j + C_{ij}LGD_j + D_{ij}LGD_j}{Z_i} \Pr ob\_Crisis_j$$

where: Z_i is a scaling factor (Tier I Capital or total banking sector assets in country *i*); $\Pr ob\,crisis_j$ is the probability of crisis in borrower country j, and the LGD_j is the loss-given default in borrower country j.

Moreover, given the availability of bank level balance sheet data for several subsidiaries and branches, the application of loss given default ratio can distinguish between banks' liquid assets—where the loss given default is close to zero—and other assets. Taking into account these differences, then, the term $B_{ij}LGD_j$ would capture the interaction of parent banks legal ceiling exposure to subsidiaries and the losses on non-liquid assets, and cab be written as:

$$B_{ij}LGD_j = \min(other\_assets_{ij}^{sub} * LGD_j, total\_assets_{ij}^{subs} - deposits_{ij}^{subs}) + other\_assets_{ij}^{branch} * LGD_j$$

B.2 - Upstream Analysis

The upstream vulnerability analysis focuses on a borrowing country's funding risk to crises in its creditor banking systems. For each borrowing country, it summarizes the potential rollover risks with regard to direct cross-border borrowing as well as the borrowing from foreign affiliates funded by their creditor countries' parent banks. Therefore, a borrowing country j *upstream exposure* can be captured by:

$$Upstream\ Exposure_j = Cross\,border\ claims_{ij} + Local\ claims_{ij} * (1 - Min(deposit\ loan\_ratio_{ij}, 1)$$

where: $Crossborder\ claims_{ij}$ captures the volume of direct cross-border claims from country *i* on country *j*; $Local\ claims_{ij}$ the volume of affiliates (subsidiaries and branches) claims of parent banks from country *i* on country *j*; and $1 - Min(deposit\ loan\_ratio_{ij}, 1)$ is a proxy of the proportion of loans not financed by local consumer deposits. The higher the deposit to loan ratio, the lower is the share of local claims financed by parent bank resources and/or wholesale financing, which is implicitly assumed to be correlated with the parent bank problems.

Expected Upstream Exposure Losses

As in the case of downstream analysis, it is possible to combine upstream exposures with crisis probabilities in order to estimate potential expected upstream losses. More formally, the *expected upstream index* (U_j) is calculated as:

$$U_j = \sum_{i=1}^{N} \frac{Cross\ border\ claims_{ij} + Local\ claims_{ij} * (1 - Min(deposit\ loan\_ratio_{ij}, 1)}{Z_j} \Pr obCrisis_i$$

where Z_j is a scaling factor (e.g., GDP or total banking sector credit in country j); and $\Pr ob\ crisis_i$ is the probability of a banking crisis in country i.

ANNEX C – ADJUSTING FOR BREAK-IN-SERIES AND EXCHANGE RATE VARIATIONS

The fact that BIS CBS at ultimate borrower basis is available since mid 2005 make performing time series analysis very appealing for depicting the recent crisis. Nevertheless, coverage break-in-series and exchange rate adjustments must be performed in order to avoid misleading conclusions.

1) Adjustment for Coverage Break-in-Series

BIS reports 84 series breaks during 2006-12 in BIS consolidated banking statistics at ultimate borrower risk basis. About one quarter of those break-in-series are driven by an expansion of the banking sector coverage. These 21 breaks are identified in Table C.1 and are denominated "coverage" break-in-series in this paper.[32] This type of coverage break-in-series deserves special attention because they highlight situations where increases in BIS banking statistics series are not associated with true changes in the underlying upstream or downstream exposures. For example, the increase in reporting population in 2009Q1 in the US—reflecting the inclusion of investment banks in US series after they became traditional banks during the crisis in order to improve access to FED resources—triggered a US 1.3 trillion accounting increase in US exposures, which were already present before they started to be reported in BIS series. Similarly, although a merger of domestic banks would trigger a consolidation of foreign claims, the change in the exposure level is only reflecting a reporting feature (e.g. the merger of domestic banks in France in 2009Q3 triggered a USD 234 billion decrease in foreign claims)

The fact that BIS reports what would have been the value of the series without the break facilitates the adjustment. Cross-border and affiliate claims series are adjusted, at the bilateral creditor-borrower level, using the pre-break series. The adjustment of the series before the coverage breaks are performed such the growth rates in both adjusted and unadjusted series are the same in the periods without coverage breaks. The assumption is that the size of the adjustment before the break evolved at the same pace as the unadjusted series.[33]

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[32] The identification of coverage break-in-series was done based on the explanation of the break published by BIS in their Break in Series report and other relevant available information (e.g. BIS Quarterly Reviews, merger and acquisitions data, etc). A few potential coverage break-in-series were not included due to lack of data (they are classified as confidential by BIS reporting banks). Comments and suggestions by Stephan Binder are acknowledged.

[33] In the cases where the pre-break series were available (e.g. due to the confidentiality of the data), the adjustments are based on the available aggregate data for the creditor banking system. More specifically, a proportional break adjustment to bilateral exposure positions is performed following the characteristics of the coverage break in the aggregate. This procedure was only applied when both the evolution of the bilateral and aggregate series were

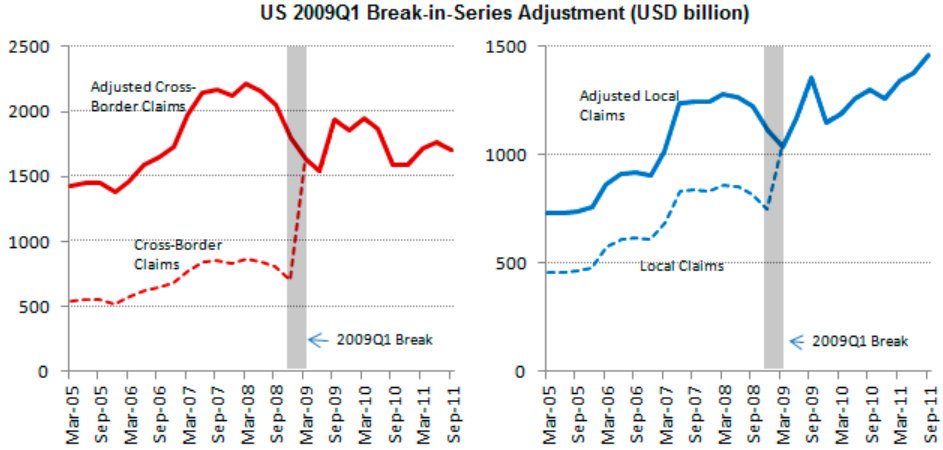
Table C.1 - Coverage Break-in-Series by Type in BIS Consolidated Banking Statistics on Ultimate Risk Basis

year	quarter	Country	BIS Description	Type of break 1/	Change in Foreign claims (Billions USD)
2011	4	Ireland	Decrease in domestic banks reporting population	coverage	-125.6
2011	3	Germany	Methodological revision	coverage	0.0
2011	1	France	Reclassification of accrual accounts	coverage	-69.4
2011	1	Germany	Inclusion of securities held in the trading book	coverage	35.4
2011	1	Spain	Increase in domestic banks reporting population	coverage	22.1
2010	4	Sweden	Change in reporting population	coverage	-0.9
2010	4	Turkey	Reclassification of reporting institutions	coverage	-0.5
2010	2	Germany	Change in population of domestic banks	coverage	11.4
2010	2	Ireland	Change in reporting population	coverage	13.6
2010	1	Australia	Improved data quality and better allocation of counterparty country.	coverage	9.9
2009	4	Sweden	Change of reporting population	coverage	3.1
2009	3	Australia	Change of reporting methodology by major reporting bank	coverage	-1.8
2009	3	France	Merger of domestic banks	coverage	-234.0
2009	1	Sweden	Change in reporting population	coverage	2.5
2009	1	United Kingdom	Increase in reporting population due to inclusion of building societies	coverage	33.6
2009	1	United States	Increase in reporting population, inclusion of the former Investment Banks	coverage	1333.7
2007	4	France	Reclassification of one institution	coverage	312.0
2007	1	Italy	Inclusion of new foreign subsidiaries as domestic bank	coverage	621.8
2006	4	Austria	Increase in reporting population (inclusion of additional foreign branches of domestic banks)	coverage	27.1
2006	1	Canada	Four large Canadian banks started consolidating the positions of their investment dealer subsidiaries	coverage	61.1
2006	1	Netherlands	Increase in reporting population	coverage	55.7
2006	1	Sweden	Increase in reporting population	coverage	18.1
2006	1	United States	Increase in reporting population	coverage	59.6

Source: BIS Banking Statistics

Footnote: The classification responds to the creteria developed in this paper based on available information. A few potential coverage breaks were not included in the table and estimations due to lack of data (They are classified as confidential by BIS reporting banks).

Performing time series analysis without correcting the original BIS data will lead to wrong conclusions. As depicted in Figure C.1, both US cross-border and US local claims have decreased during the crisis not increased as the unadjusted series would indicate. Once all coverage break-in-series adjustments are performed, the adjusted series reflect the level of exposures over time without the coverage breaks and using the most recent point in time—2012Q1 in this paper— as the base (e.g. adjusted series would include former US investment banks during all the 2006-12 period).



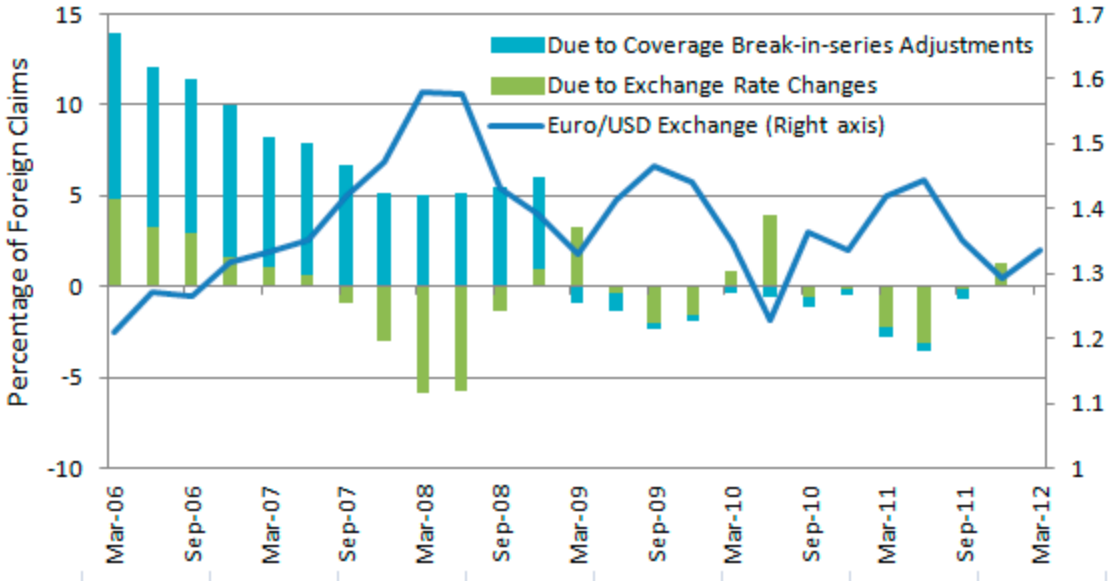
2) Adjustment for Exchange Rate Variations

BIS CBS are reported in US dollars, so changes in the series from one period to another could only reflect exchange rate movement if the actual underlying position remained unchanged. Adjusting series for exchange rate movements is important for the period 2006-12, when there was high volatility among countries exchange rates.

Three corrections are performed to address this problem at the bilateral creditor national banking system-borrower country level. First, the domestic-currency denominated local affiliates claims are corrected following the bilateral US dollar domestic currency exchange rate. The domestic-currency denominated local affiliates' claims are proxied by using its share of total BIS CBS foreign claims at immediate borrower basis. Second, at the same time, this procedure allows the identification of the amount of foreign-currency denominated local affiliates' claims, which are assumed to be in Euros in Europe and US dollars in the rest of the countries. Finally, bilateral CBS cross-border claims positions are adjusted using, as a proxy, the currency breakdown currency (among US. Dollar, Euro, British Pound, Japanese Yen, and Swiss Francs) available from the BIS locational banking statistics.

As shown in Figure C.2, the size of the exchange rate movement adjustments is not small in levels (about five percent of total foreign claims in a few quarters) and many times larger than the coverage break-in-series adjustments. As expected, the evolution of the US/EURO exchange rate exchange rate had a large influence on the exchange rate adjustments.

Figure C.2 - Break-in-Series and Exchange Rate Adjustments in Foreign Claims



Adjustment of Downstream and Upstream Exposures

The coverage break-in-series and exchange rate adjusted cross-border and affiliate claim series can be used for adjusting on-balance sheet downstream and upstream exposures. Due to data limitations in performing the adjustments in off-balance sheet claims (e.g. the currency breakdown of off-balance sheet items is not available in BIS CBS and it cannot be proxy using BIS location data), the time series analysis of upstream and downstream exposures focuses only on on-balance sheet items.

The adjustment of on-balance sheet downstream exposures ($A_{ij} + B_{ij} + C_{ij}$) can be performed in two steps. First the adjusted cross-border exposures are used instead of the unadjusted series (A_{ij}). Second, the adjustment of the downstream exposures to subsidiaries and branches ($B_{ij} + C_{ij}$) is a bit more complicated because the currency breakdown of the bank-level data, which is also denominated in US dollars, is not available. In this context, a simple assumption is that the currency breakdown of assets would be similar for liabilities (local deposits), so we could write: $\left(B_{ij} + C_{ij}\right)^{adjusted} = \left(B_{ij} + C_{ij}\right)\frac{local\ claims_{ij}^{adjusted}}{local\ claims_{ij}}$

The adjustment of upstream exposures is simpler since both cross-border and local claims enter in a multiplicative form. The adjusted on-balance sheet exposures would be equal to:

$$Upstream\ Exposure_{j}^{adjusted} = Cross\ border\ claims_{ij}^{adjusted} + Local\ claims_{ij}^{adjusted} * (1 - Min(deposit\ loan\ \_ratio_{ij}, 1)$$

ANNEX D – STATISTICAL APPENDIX OF THE ECONOMETRIC ANALYSIS

An additional advantage of the downstream and upstream analysis performed in this paper is that the aggregation of bilateral creditor-borrower data (from either the creditor or borrower perspective) reduces the number of outliers in the dependent variable. This is a problem common in the literature (e.g. McGuire and Tarashev 2008 and Kamil and Rai 2010 exclude and/or create dummies for dependent variables that fell in the 5 percent lower and upper percentage of the distribution). After taking into account coverage break-in-series, there are a few cases of outliers (e.g. more than 3 standard deviations) in our sample (2 cases in the downstream analysis out of 624 observations, and 43 cases in the upstream analysis out of 2591 observations). Although they do not alter the results of the analysis, these observations have been excluded from the sample. They reflect relatively small nominal variations over very small bases.

The rest of this annex presents summaries of the variables used in the downstream and upstream analysis, and an additional specification of the upstream regressions using VIX instead of TED spreads. It is not convenient to include both variables together in the upstream analysis since they are highly correlated (about 0.65).

Table D1 - Variables used in Downstream Estimations

Variable	Definition	Data Source	Mean	Median	Std Dev	Min	Max
ΔDit	Growth rate (in percent) of the adjusted on-balance sheet downstream exposure of creditor banking system i in quarter t (Used as dependent variable)	BIS CBS, IFS	0.63	0.63	10.44	-49.85	55.12
ΔGDP_{ijt}	Creditor banking system i weighted average of the GDP growth in its borrower countries j in quarter t (in percent)	IFS	0.40	0.55	0.74	-2.6	2.8
Cred_Systemic_Crisis	A dummy reflecting the presence of systemic banking crisis in banking system i in quarter t	Laeven and Valencia (2012)	0.22	0.00	0.41	0.0	1.0
Cred_DLR	Ratio of bank deposit to loans in the creditor banking system i	IFS	0.78	0.71	0.35	0.2	2.6
Cred_CB_Share	The share of direct cross-border lending in total foreign claims (in percent)	BIS CBS	63.90	62.60	24.30	16.9	100.0
VIX	The normalized quarterly volatility of the S&P 500 financial index	Bloomberg	2.00	-0.03	10.38	-10.8	36.8
TED Spread	Spread between three-month US dollar Libor and the three-month US treasury bill rate	Bloomberg	64.01	40.63	56.25	15.5	245.2

Table D2 - Variables used in Upstream Analysis

Variable	Definition	Data Source	Mean	Median	Std Dev	Min	Max
ΔUjt	Growth rate (in percent) of the adjusted on-balance sheet upstream exposure of borrower country j in quarter t (Used as dependent variable)	BIS CBS, IFS	2.08	1.59	16.87	-85.65	96.51
ΔGDP_{jt}	Borrower country j GDP growth in quarter t (in percent)	IFS	0.996	1.14	2.95	-26.39	15.56
Creditor_Crisis	Proportion of creditor banking systems of borrower country j that are experiencing systemic banking crisis in quarter t	Laeven and Valencia (2012)	0.22	0.00	0.29	0.00	0.93
Borrower_DLR	Ratio of bank deposit to loans in the borrower country j	IFS	0.88	0.84	0.49	0.32	4.08
Borrower_CB_Share	Share of direct cross-border in borrower country foreign borrowing (lag one period; in percent)	BIS CBS	46.7	44.0	18.9	9.4	100.0
VIX	The normalized quarterly volatility of the S&P 500 financial index	Bloomberg	2.4	0.2	11.4	-10.8	36.8
TED Spread	Spread between three-month US dollar Libor and the three-month US treasury bill rate	Bloomberg	74.9	44.9	60.0	15.5	245.2

Table D.3: Determinants of the Change in Upstream Exposures

2006Q2-2012Q1 - Panel OLS with Fixed Effects - Dependent variable: Change in Upstream Exposure (in percent)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ΔGDP_{ijt}	0.470**					0.156	0.149	0.193	0.158	0.163
	(0.188)					(0.132)	(0.139)	(0.129)	(0.132)	(0.132)
Cred_Syst_Crisis		-9.581***				-7.576***	-5.462*	-7.604***	-11.01***	
		(1.172)				(1.240)	(3.159)	(1.176)	(2.496)	
Borrower_CB_Share			-0.250***			-0.322***	-0.310***	-0.318***	-0.306***	-0.296***
			(0.071)			(0.064)	(0.063)	(0.064)	(0.098)	(0.065)
Borrower_DLR				5.479		0.736	0.645	1.346		1.315
				(4.499)		(4.677)	(4.667)	(4.730)		(4.515)
VIX					-0.311***	-0.258***	0.396		-0.348***	-0.137**
					(0.031)	(0.033)	(0.926)		(0.082)	(0.066)
VIX * Cred_Syst_Crisis								-0.470***		-0.378**
								(0.145)		(0.164)
VIX * Borrower_CB_Share								-0.003***		
								(0.001)		
VIX * Borrower_DLR								0.087	0.097	
								(0.070)	(0.091)	
Borrower_DLR * Cred_Syst_Crisis									3.678	1.164
									(2.549)	(1.569)
Borrower_DLR * Borrower_CB_Share									-0.025	
									(0.085)	
Cred_Syst_Crisis * Borrower_CB_Share										-0.156***
										(0.029)
Constant	1.21*	3.26***	11.88***	-3.46	1.65**	16.87***	17.20***	16.18***	17.75***	14.92***
	(0.67)	(0.71)	(3.00)	(3.78)	(0.64)	(5.01)	(5.89)	(5.08)	(2.74)	(4.91)
Quarterly Dummy	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Time Fixed Effects	No	No	No	No	No	No	Yes	No	No	No
Borrower Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,458	2,458	2,458	2,458	2,458	2,458	2458	2,458	2,458	2,458
Number of borrower countries	112	112	112	112	112	112	112	112	112	112
R2	0.057	0.078	0.065	0.055	0.090	0.119	0.154	0.124	0.122	0.125

Note: This table reports the baseline panel fixed effect described in equation (4) in the text, and some alternative specifications through the use of interacted terms. Robust standard errors are in parentheses and they are clustered at the borrower country level. Asterisks denote significant of coefficients, with ***, **, * indicating significance at 1%, 5% and 10% level, respectively.