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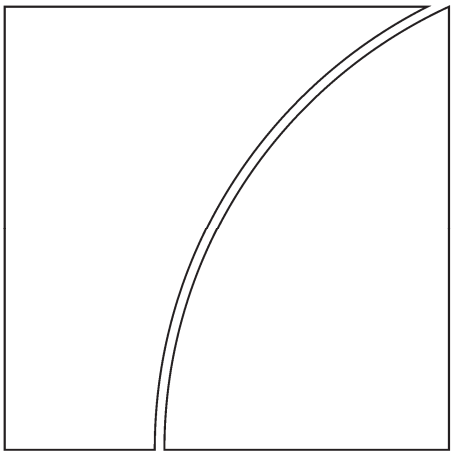

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Systemic Risks in Global Banking: What Can Available Data Tell Us and What More Data Are Needed?

by Eugenio Cerutti, Stijn Claessens and Patrick McGuire

Monetary and Economic Department

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Keywords: Systemic risks, banking system, international, contagion, vulnerabilities

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Systemic Risks in Global Banking: What Can Available Data Tell Us and What More Data Are Needed?

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Abstract

The recent financial crisis has shown how interconnected the financial world has become. Shocks in one location or asset class can have a sizable impact on the stability of institutions and markets around the world. But systemic risk analysis is severely hampered by the lack of consistent data that capture the international dimensions of finance. While currently available data can be used more effectively, supervisors and other agencies need more and better data to construct even rudimentary measures of risks in the international financial system. Similarly, market participants need better information on aggregate positions and linkages to appropriately monitor and price risks. Ongoing initiatives that will help close data gaps include the G20 Data Gaps Initiative, which recommends the collection of consistent bank-level data for joint analyses and enhancements to existing sets of aggregate statistics, and enhancements to the BIS international banking statistics.

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I. Introduction

The global crisis has shown how a shock that originates in one country or asset class can quickly propagate to other markets and across borders. As in the closed-economy case, the nature of the balance sheet linkages between financial institutions and markets will affect the size of spillovers and their direction of propagation. At the global level, however, financial linkages and channels of propagation are more complex. Many of the data needed for identifying and tracking international linkages, even at a rudimentary level, are not (yet) available, and the institutional infrastructure for global systemic risk management is inadequate or simply non-existent. This paper highlights some of the unique challenges to global systemic risk measurement with an eye toward identifying those high-priority areas where enhancements to data are most needed.

The starting point of systemic risk analysis in a single country is typically the banking system.[2] This is due to banks' significant role in financial intermediation and maturity transformation, and their highly leveraged operations. The approach often taken at central banks and supervisory agencies is to identify systemic risks using disaggregated data, including information on the composition of banks' assets and liabilities, maturity and currency mismatches, and other balance sheet and income metrics. These analyses attempt to capture systemic risks stemming from common exposures, interbank linkages, funding concentrations, and other factors that may have a bearing on income, liquidity and capital adequacy conditions.[3] This approach does not, however, directly extend to the multi-country level. At least three additional challenges arise:

(i) A lack of institutional mechanisms which ensure coordination of national approaches: International financial linkages, by definition, involve more than one legal jurisdiction. For various reasons (legal framework, accountability to parliaments and taxpayers, etc.), policy makers tend to focus on national objectives. At times, they may not even be aware of the international implications of their domestic actions or, conversely, of the effect of others' actions on their own economies. This raises a problem intrinsic to any system with multiple stakeholders: authorities in each jurisdiction pursue their own objectives, which do not necessarily maximize global welfare. In such a world, global financial stability may receive too little attention. A related problem is that many of the institutional mechanisms available at the national level to achieve (more) optimal outcomes before, during, and after a financial crisis are lacking at the global level. Although initiatives to enhance multilateral surveillance are underway, most regulatory oversight is still nationally oriented.[4] Supervision of large, internationally active financial institutions is dispersed among agencies in many countries, with imperfect sharing of information and limited tools to coordinate remedial actions.

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[2] Attention to systemic risk assessment and contagion has dramatically increased with the global financial crisis, although a precise definition of systemic risk is still lacking. See Borio and Drehmann (2009) and Kaufman and Scott (2003) for a discussion of the definition, and de Bandt et al. (2009) for a recent literature survey.

[3] Examples of such quantitative approaches are Boss et al. (2006) and Alessandri et al. (2009) for Austria and the UK, respectively. Much of the work done under the Financial Stability Assessment Program (FSAP)—a joint IMF/World Bank effort introduced in 1999—has documented and analyzed such risks in individual countries. And global systemic risks are being analyzed in the joint IMF-FSB Early Warning Exercise (IMF (2011b)), and by the Committee on the Global Financial System (2010a, 2010b, 2010c).

[4] The crisis also showed that international institutions' surveillance was often not effective in bringing about policy adjustment in key countries and did not highlight enough global risks (IMF (2011a)).

Moreover, a global framework for the resolution of these institutions is lacking.[5] And there is no formal lender of last resort to address liquidity problems in foreign currencies.[6]

(*ii) Greater complexity in the international context:* Differences in firms' organizational structures and legal status, which play limited roles in a strictly national context, complicate systemic risk measurement and (crisis) management internationally. Large global banks are composed of thousands of entities located in many countries. They can lend cross-border directly from headquarters, and/or be active in host countries through subsidiaries or branches that also take local deposits. Analyzing vulnerabilities related to banks' operational structure purely using *group-level* consolidated data can be problematic. Such data implicitly assume that resources available at one office location can be freed up and immediately used elsewhere—a very strong assumption.[7] Similarly, group-level (consolidated balance sheet) data obscure hierarchical ownership structure, thus making it difficult to accurately compare a bank's global exposures to a particular asset class to the capital in the banking group.[8] And from a borrower country's perspective, assessing the fragility of credit received *from* foreign banks (either cross-border or local) requires information on the types of funding which support these banks' credit.

(iii) Scarcity of data that capture the international dimensions of systemic risk: Supervisors in each jurisdiction have access to granular data for banks operating in their jurisdiction. However, the supervision of the activities of internationally active institutions relies on data collection practices that tend to differ across jurisdictions. Moreover, confidentiality concerns generally restrict the sharing of data, even within the supervisory community. Publicly disclosed bank-level data (e.g. from commercial vendors) generally lack (consistent) information about banks' international activities (e.g. cross-currency and cross-border positions). The BIS international banking statistics, which track internationally active banks' foreign positions, are a key source of information for many analytical questions. But these statistics are aggregated across banks and have limited breakdowns of assets and liabilities, and are thus not appropriate for many analytical questions.

The following section briefly summarizes the literature on systemic risk assessment, and highlights some of the unique challenges which arise in the global context. This discussion is followed by four examples of data-related challenges: (i) accurately measuring banks' foreign asset exposures; (ii) measuring a borrower country's reliance on credit from foreign banks; (iii) tracking banks' cross-currency funding and maturity transformation activities; and (iv) capturing the endogenous interactions of asset and funding positions in scenario analyses. These examples demonstrate that many aspects of global systemic risk simply cannot be captured using existing data.

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5 See IMF (2010) and Claessens et al. (2010).

6 A domestic central bank can supply liquidity in its domestic currency. But liquidity provision in foreign currencies is limited by the available foreign exchange reserves or borrowing capacity of the central bank.

7 Market frictions, illiquid asset markets or government interventions can limit an institution's ability to unwind intragroup funding and/or transfer funds across locations, especially during times of financial turmoil. Cerutti et al. (2010) document that some host regulators in Eastern Europe ring-fenced foreign affiliates in their territory during the recent crisis. They quantify that banking groups' inability to re-allocate funds from subsidiaries with excess capital to those in need of capital would imply substantially larger capital buffers at the parent and/or subsidiary level. Similarly, the crisis showed that netting a bank's balance sheet positions across offices, through consolidating statements, can mask funding risks (Fender and McGuire (2010)).

8 For example, while a group is fully exposed to all losses at its local branches and through direct cross-border exposures, its losses from subsidiaries are capped by the parent's equity plus any non-equity intragroup claims. For more details on the differences between branches and subsidiaries, see Cerutti et al. (2007).

The final section discusses the most significant data limitations and provides a brief overview of international initiatives to deal with them. First, the ongoing G20 initiative to close data gaps (see IMF-FSB (2009) and Box 2) has put forth 20 recommendations which call for improvements to bank-level and aggregate statistics, a framework for the collection and sharing of these data across jurisdictions, and rules governing access and use of the data. The recommendations specifically highlight the need for more *bank-level* data, including information on firm-level *bilateral* linkages, banks' organizational structures, and broad breakdowns of banks' total assets and liabilities (e.g. by instrument, counterparty country, counterparty sector, currency, and residual maturity). Second, enhancements to the *aggregate* BIS international banking statistics, which cover a much wider universe of banks, are also moving forward. These enhancements will shed more light on how banks organize their operations across jurisdictions. Together, these enhancements will go some way in providing a public good—financial data—that is fundamental to the ability to provide global perspectives on potential risks and financial stability concerns and conduct (multilateral) surveillance.

II. Measuring Systemic Risk Globally

The literature on systemic risk assessment can be divided into three broad categories, each primarily focused on banks. In the first category, the focus is on how balance sheet linkages can amplify the size of shocks and influence the direction of propagation across borders. A second category takes advantage of abundant market data and uses the information embedded in credit spreads and equity (and other asset) prices to measure systemic risk premia and the correlation of shocks across markets. The third category takes a more forward-looking perspective and relies on simulations to better understand how specific types of shocks may escalate into more severe systemic events. All three types of analyses consider risks originating from the asset side (e.g. credit, country, and market risk) and the liability side (e.g. funding risk) of banks' balance sheets, as well as risks which arise from the interaction between the two sides (e.g. liquidity and/or currency mismatches).

Most studies in the first category rely on *aggregate* banking data, since data with information on the counterparty location (country) are generally only available in aggregate form (e.g. BIS banking statistics, Coordinated Portfolio Investment Survey (CPIS) data, and balance of payments data for some countries). These data are useful in cross-country (or cross-banking system) comparisons, particularly during periods of financial stress. Using aggregate BIS data, Peek and Rosengren (2000b) analyze how foreign banks reacted to the 1990s crises in Argentina, Brazil, and Mexico, and Kaminsky and Reinhart (2003) study how reliance on a common lender led to problems in multiple countries during the East Asian crisis. Focusing on Latin America, Martinez-Peria et al. (2005) and Kamil and Rai (2010) find that conditions in parent countries importantly explain changes in international lending. Similarly, McGuire and Tarashev (2008) find that negative shocks to BIS reporting banks' health were associated with a slowdown in international credit to emerging markets more generally. More recently, Cetorelli and Goldberg (2011) document how adverse liquidity shocks in the largest banking systems in 2007-09 affected emerging countries through both cross-border and affiliates' lending and, finally, McCauley et al. (2010) show a long-term shift towards affiliate lending in lieu of direct cross-border lending, while highlighting that direct cross-border credit remains substantial for many borrower countries.

Bank-level and individual loan-level data (e.g. data on cross-border syndicated loans) have also been used to study the international propagation of shocks. For example, De Haas and van Lelyveld (2010) and Barba Navaretti et al. (2010) find that banks support their foreign affiliates in distress through internal capital markets. And using bank-level cross-border syndicated loan data, De Haas and van Horen (2011) show that, during the most recent crisis, foreign banks continued to lend to countries that are geographically close and

integrated in the network of domestic co-lenders, and to those countries where banks had established relationships.[9]

These papers also highlight the limitations of existing data. Analyses of cross-border country exposures rely primarily on data aggregated at the level of countries, and hence overlook bank-level heterogeneity. Studies using bank-level data also face limitations. For example, only a fraction of the participation share of each creditor bank in a syndicated loan is known (typically less than half of the total syndicated loan amount). Last but not least, papers analyzing intragroup activity are based on indirect evidence obtained from subsidiaries' overall lending levels, not from actual intragroup activities.

The second category in the literature has relied primarily on higher-frequency market data (e.g. equity prices, CDS spreads, and bond spreads) to extract information about how risks are correlated across markets. Studies in this category complement balance sheet-based studies since market data can capture contagion channels other than those related to direct balance sheet linkages between banks (see, for example, Acharya et al. (2010)). Market data are particularly useful in the international context since comparable balance sheet data are scarce and often only available at a low frequency. Moreover, balance sheet data are costly to put together, whereas market prices are easy to obtain, at least for recent periods.[10] That said, market price-based indicators are not always reliable risk measures. Studies implicitly assume that market prices correctly embed all publicly available information about individual banks' asset and liability side risks, as well as banks' interconnections (common exposures, interconnections, etc.). More often than not, however, prices are contemporaneous measures of market stress rather than leading indicators (Borio and Drehmann (2009)). On the eve of the crisis, for example, credit spreads and volatilities for virtually every asset class were at record lows, even though underlying stresses had been building for years. It can also often be difficult to disentangle the factors driving asset prices, especially during periods of turmoil.

Some approaches combine balance sheet-based and asset price-based analyses, but this is difficult in a global context. For example, Drehmann and Tarashev (2011) analyze the systemic importance of interconnected banks in the absence of bilateral data, in which case the researcher needs to decide how to populate the matrix of interbank positions. They find that the conclusions reached under the common "maximum entropy" assumption—i.e. that interbank positions are distributed as uniformly as possible across counterparties—can differ materially from those reached under alternative assumptions that are also consistent with the available data. The maximum entropy assumption is a common approach in studies of interbank contagion at the national level, where most potential counterparty banks are included in the samples. However, as highlighted by Upper (2011), this assumption has

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[9] Other examples of studies using bank-level data are Peek and Rosengren (2000a), who relied on US call reports and Japanese parent bank reports to show that Japanese banks transmitted shocks from Japan to the United States in early 1990s, and Goldberg (2002), who used US country exposure reports to assess whether US banks transmitted US business fluctuations to their foreign borrowers.

[10] Using stock-market data, Lehar (2005) and Bartram et al. (2007) estimate default probabilities for globally active financial institutions to derive measures of systemic risk. Segoviano and Goodhart (2009) exploit the information embedded in large international banks' credit spreads to construct a banking stability index and estimate cross-border interbank dependence for tail events. González-Hermosillo and Hesse (2009) examine when key global market conditions (e.g. VIX, forex swap, TED spread) move into a high volatility regime. Lopez et al. (2011), extending the CoVAR methodology of Adrian and Brunnermeier (2009) to 54 international banks, find that the short-term debt to assets ratio affects systemic risk, with no evidence that bank size increases systemic risks. Other recent market-based models are Acharya et al. (2010) and Huang et al. (2009).

many drawbacks in a global context since not all potential counterparties are included in the small sample of large global banks.

The third category in the literature conducts simulations and scenario analysis, and also relies on balance sheet-based interconnections (using mostly aggregate, sometimes bank-level data). It tries to assess the path of contagion via interbank balance sheet linkages as well as the spillover effects to non-bank sectors. Many studies of this type analyze creditor countries' exposures to an initial shock in borrower countries. Arvai et al. (2009), for example, highlight that, when taking into account common lender effects, Western European banks' exposure to Central, Eastern, and Southern European (CESE) countries is far smaller than that of CESE countries to Western European banks (except for Austria and Sweden).

The interaction of funding and credit risk exposures has been analyzed using similar techniques, often using network measures which take into account the distribution of nodes and intensity and complexity of connections. The IMF cross-border bank contagion module (described in more detail in IMF (2011b), Tressel (2010), and Section III) uses a multilateral Leontief-type input-output matrix of cross-border lender-borrower exposures based on BIS consolidated banking statistics. This matrix is then used to perform scenario analyses, which include several rounds of asset and funding shocks. Following an initial shock, the framework captures the banking sector's losses on exposures to specific countries, with losses triggering further bank deleveraging if capital buffers and/or recapitalization efforts are insufficient. Espinoza-Vega and Sole (2010) also conduct network analyses using BIS statistics and highlight the need to consider off-balance sheet exposures.

Nevertheless, these balance sheet-based analyses cannot fully take into account the greater complexity in the international context, since existing data limitations do not permit the full capturing of banks' organizational structures and legal status, and do not preserve the geographic structure of banks' operations.

Measuring Systemic Risks: Examples and Challenges

While progress has been made in measuring global systemic risks, further improvements are possible, especially in the analysis of banks' contribution to systemic risk. This section highlights four data challenges which arise internationally: (i) accurately measuring banks' foreign asset exposures; (ii) measuring a borrower country's reliance on credit from foreign banks; (iii) tracking banks' cross-currency funding and maturity transformation activities; and (iv) capturing the endogenous interaction of asset and funding positions in scenario analysis.

A key input here is the BIS international banking statistics (IBS), which track developments in banks' foreign positions and cross-country financial linkages (see Box 1). The BIS consolidated banking statistics used here are not bank-level, but rather are aggregated at the level of national banking systems, i.e. the set of internationally active banks headquartered in a particular country (e.g. UK banks). The data cover banks' worldwide *consolidated* exposures to borrowers in particular countries and sectors, and can provide banks' asset and liability positions in specific currencies.

Box 1

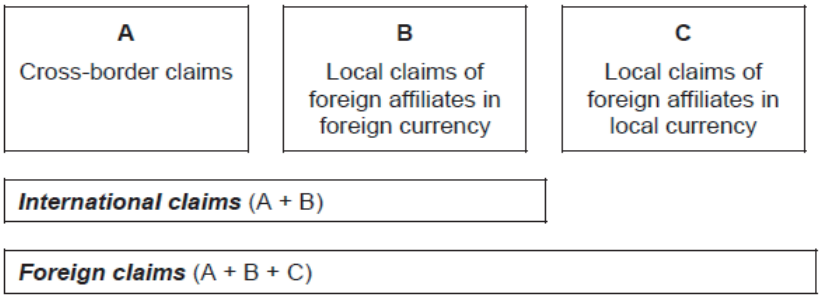
The BIS International Banking Statistics

The BIS international banking statistics (IBS) track internationally active banks' foreign positions through two main datasets: the BIS consolidated banking statistics (CBS) and the BIS locational banking statistics (LBS). Collectively, they are a key source of country-level aggregate information for analyzing financial stability. This box describes the characteristics of the IBS data that make them unique.

BIS Consolidated Banking Statistics

The CBS track banks' worldwide consolidated gross claims and other exposures to individual countries and sectors.[①] They thus provide internationally comparable base measures of national banking systems' exposures to country risk (e.g. cross-border asset exposure).[②] Reporting banks' foreign claims are composed of several pieces (see figure below). Cross-border claims (A) are claims on non-residents booked by either a bank's head office or a foreign affiliate (branch or subsidiary) in a third country. Local claims are those booked by a foreign affiliate on borrowers residing in the host country of the affiliate. Local claims can be denominated in foreign currencies (B) or in the local currency of the host country (C).

Banks report foreign claims (A+B+C) on borrowers in individual countries on both an immediate borrower (IB) basis and an ultimate risk (UR) basis. In the CBS (IB), banks' claims are allocated directly to the country where the borrower resides. In addition, banks' foreign claims are reported as international claims (A+B) and local claims in local currency (C). In contrast, in the CBS (UR), banks allocate their claims to the country where the ultimate obligor resides, defined as the country where the guarantor of a claim resides or the head office of a legally dependent branch is located. Here, banks' foreign claims are reported as cross-border claims (A) and local claims in all currencies (B+C). Also in the CBS (UR), banks separately report off-balance sheet items such as derivative contracts and contingent exposures (undisbursed credit commitments and guarantees).[③]



BIS Locational Banking Statistics

Unlike the CBS above, the LBS are residence-based data (i.e. they follow balance-of-payments accounting) and track the cross-border positions and the local positions in foreign currencies of banks located in a particular country. Banks' positions are broken down by currency, by sector (bank and non-bank), by country of residence of the counterparty, and by nationality of reporting banks. Both domestically owned and foreign-owned banking offices in the reporting countries record their positions on a gross (unconsolidated) basis, including positions vis-à-vis own affiliates in other countries.

The LBS are one of the few sources of information about the currency composition of banks' balance sheets, and so aid in tracking system-level funding risks. Because reporting jurisdictions also provide information on the nationality (i.e. the country of headquarters) of the reporting banks in their jurisdiction, the statistics can also be aggregated (across reporting locations) along the lines of consolidated national banking

systems, as in the CBS described above. These data provide a broad picture of the currency breakdown of banks' consolidated foreign assets and liabilities. When combined with the CBS data, they help to track, at the bank nationality level, cross-currency funding and investment patterns (Figure 3 in main text), which proved fragile during the crisis.

[1] See McGuire and Wooldridge (2005) for further discussion of the uses and structure of the BIS CBS.

[2] Banks net out intergroup positions and consolidate positions across offices worldwide, an advantage over residence-based data, such as the BIS locational banking statistics (LBS) and the IMF's Coordinated Portfolio Investment Survey (CPIS).

[3] Derivative 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.

Measurement of Banks' Foreign Credit Exposures

How big are banks' exposures to a particular country or a sector within a country? Which banks are most exposed? How do exposures compare to the parent bank group's consolidated capital? Answering these questions is difficult with available data. Commercially available bank-level data do not contain enough detail on foreign exposures (i.e. the borrowers' country location and/or sector). Aggregated bank data, such as the BIS international banking statistics, do track banks' exposures to countries and sectors, but lack granularity.

To illustrate, consider assessing the potential losses a banking system *i* faces through its asset exposures to a particular sector in a particular country *j*. Banking system *i*'s foreign credit exposure to country *j* is composed of three parts: (i) direct cross-border exposures to borrowers in country *j* booked by all offices of banking system *i* located outside of country *j*, (ii) effective exposures via the local positions booked by bank *i*'s subsidiaries and branches located in country *j*, and (iii) all off-balance sheet exposures (derivatives, credit guarantees, and credit commitments) related to borrowers in country *j*. For the second of these components, note that a bank's exposure to its *subsidiaries* in country *j* is, from a strictly legal perspective, limited to the capital of the subsidiary plus any other non-equity funds provided by the parent bank. In contrast, the bank absorbs *all* losses on branch exposures most often.[11]

The BIS consolidated banking statistics (CBS) on an ultimate risk basis are of some help in this analysis, but they have their limitations. They track banking system *i*'s *foreign claims* on borrowers in country *j*, which include its worldwide consolidated direct cross-border claims on country *j* plus the positions booked by its affiliates (subsidiaries *and* branches) in country *j* vis-à-vis residents of country *j*. That is, they capture consolidated *gross* exposures to particular countries/sectors, regardless of the branch/subsidiary structure of the reporting

[11] Of course, reputational concerns play a key role as well. While parent banks have supported foreign subsidiaries beyond their legal obligation, this is not always the case. Hryckiewicz and Kowelewski (2011) document 149 episodes when subsidiaries were abandoned between 1997 and 2009. Regarding branches, some countries (e.g. the US) have explicit provisions 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 certain actions by the host government (e.g. exchange controls, expropriations). This aspect was not considered in the analysis. See Cerutti (2011) for more detail on the exposure calculations and the differences between branches and subsidiaries.

banks, and thus provide *upper-bound* measures of a banking system's exposure to country *j*. Supplementing these statistics with bank-level data yields *lower-bound* measures which take into account the legal *limited* exposure of parent banks to their subsidiaries.[12]

Figure 1 presents a comparison of foreign claims (upper bound) and the adjusted asset exposure (lower bound) measures, where values are expressed as a percentage of GDP and the bubble sizes are proportional to total domestic banking assets. As of September 2010, the adjusted lower-bound measure is, on average, about 10 percent below the upper-bound gross foreign claims measure. The two measures differ little for Swiss banks, but more for Canadian, Greek, and Spanish banks. And when off-balance sheet exposures are included in the calculations (Figure 1, right-hand panel), the adjusted lower-bound measures fall below the gross measures, especially for Belgian, Swiss, and US banks.

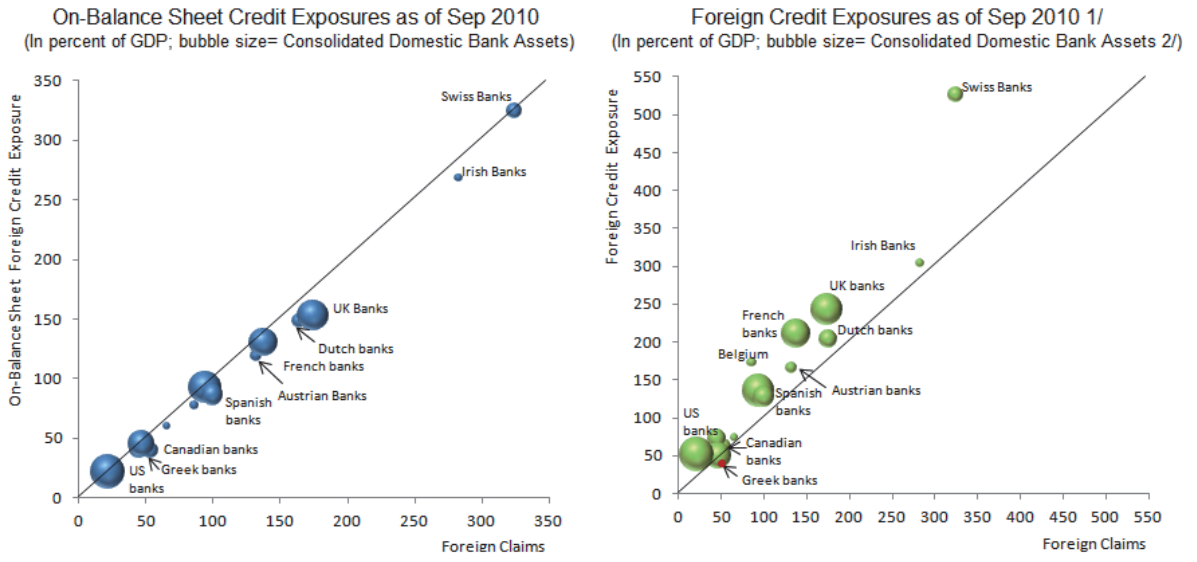
This analysis of foreign credit exposures highlights how differences in banks' organizational structures and legal status need to be taken into account in an international context, and that available data only allow calculations at the level of whole banking systems, rather than at the level of individual banks.

Measurement of Borrowers' Reliance on Foreign Bank Credit

Similar problems arise in measuring risks from the perspective of a borrower country. For example, many borrower countries experienced disruptions in international credit flows during the recent financial crisis. This is because the creditor banking systems themselves had balance sheet problems elsewhere that forced them to reduce exposures globally. As a result, they did not roll over all cross-border credit, and diverted funds raised locally by their subsidiaries in particular countries.

Figure 1

Foreign Credit Exposure Measure



Source: BIS Consolidated banking statistics, WEO, IMF and authors' estimations.
Notes: 1/The foreign credit exposure is equal to the sum of on-balance sheet foreign credit exposure and off-balance sheet liabilities (credit commitments, credit guarantees and derivatives); 2/ The consolidated domestic bank assets refers to the aggregated domestically-owned banks' consolidated assets (domestic and external) incorporated in each country.

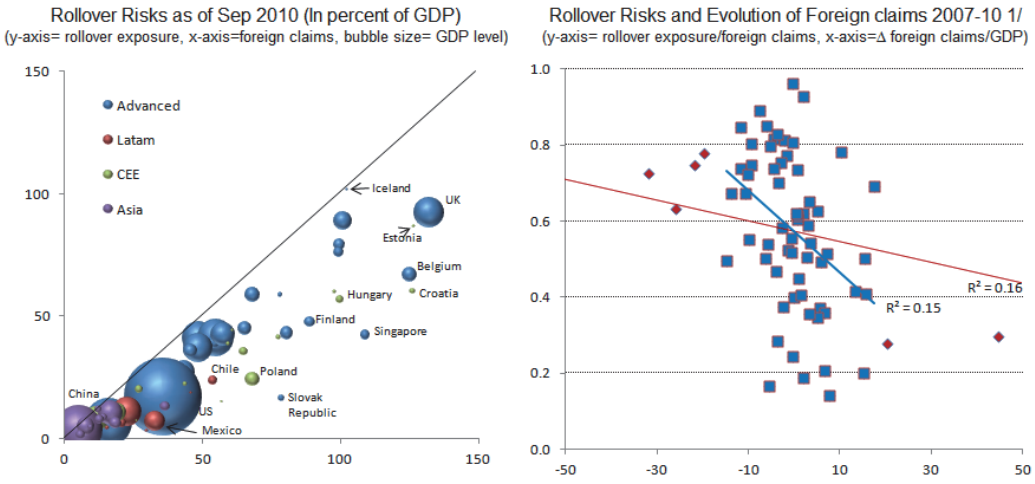
[12] Information on the branch/subsidiary structure is not included in the BIS CBS statistics. For this analysis, as detailed in the Annex, proxies are derived using bank-level data by subtracting total customer deposits in the subsidiary from total assets of the subsidiary, and then aggregating to the level of banking systems.

The BIS consolidated banking statistics are one of the few sources of information on the extent to which borrowers in a country rely on credit from a particular consolidated banking system (UK banks, Swiss banks, etc.). However, because these data were not designed with the borrower's perspective in mind, they may overestimate reliance on a particular national banking system in cases where at least part of the banking system's funding comes from sources in the borrower country. Again, combining these data with bank-level data helps to illustrate the scale of the problem. Specifically, bank-level data provide an indication of the financing that subsidiaries and branches obtain from local customer deposits, which can then be subtracted from the banking system's gross foreign claims on the country.[13]

The differences between the gross BIS foreign claims and the adjusted rollover risk figures (Figure 2, left-hand panel) tend to be large for emerging market borrowers. This is because (i) large foreign affiliates located in many of these countries account for a significant share of gross foreign claims (i.e. the share of direct cross-border lending in total foreign claims is generally low) and (ii) these affiliates are funded primarily by local deposits. For example, the adjusted measure for Latin-America (red circles) is, on average, only 40 percent of banks' foreign claims. Similarly, the exposures for emerging Asia and Europe are on average roughly half of foreign claims. By contrast, the ratio for advanced countries is 65 percent.

Figure 2

Reliance on Foreign Bank Credit



Source: BIS Consolidated banking statistics, WEO, IMF and authors' estimations.
Notes: 1/ The evolution of foreign claims between the period Dec 2007 - Sep 2010, as percentage of 2010 GDP, is corrected from structural breakes in BIS series (e.g., increase in reporting banks and misreporting) and exchange rate fluctuations.

The ratio of the adjusted measure to gross foreign claims captures the borrower country's relative dependence on local resources. Countries which depended more heavily on resources from parent banks located outside going into the crisis (i.e. a higher ratio) saw a greater contraction in their total foreign funding during the crisis (December 2007-September

[13] As detailed in the Annex, the adjusted rollover risk measure sums direct cross-border claims and affiliates' claims that are not financed by local consumer deposits, the latter proxied by the bank-level deposit to loan ratio of foreign subsidiaries and affiliates. This rollover risk measure could, in principle, also be calculated by combining the BIS locational banking statistics by nationality and consolidated statistics (immediate borrower basis). However, a complete picture is possible only for those countries which are reporters of BIS data, which excludes many emerging markets.

2010; Figure 3, right-hand panel).[14] This holds even if outliers (red squares) are eliminated. This is consistent with the notion that the global shock to wholesale funding markets, rather than deterioration in borrower-country fundamentals, played a major role in the contraction of foreign claims.

The analysis of borrower countries' dependence on credit from foreign banks requires data which preserve banks' multinational structure rather than consolidate it away. It also requires granular data on banks' internal capital markets and wholesale sources of funds (interbank repo market borrowing and other non-deposit funding, etc.), information which is generally not available at either the individual bank or banking system level.

Measurement of Cross-currency Funding and Maturity Transformation

In the run-up to the crisis, many European and other non-US banks invested heavily in US dollar-denominated assets, and increasingly relied on short-term US dollar funding in the form of direct interbank borrowing and the swapping of euros and other currencies for dollars. When concerns over exposures to toxic assets mounted, these banks found it difficult to roll over their dollar funding positions, driving up the overall costs of dollar funds. Throughout much of the crisis, but particularly following the collapse of Lehman Brothers in September 2008, the global demand for short-term dollar funding could only be met through the establishment of central bank swap lines.[15] In the wake of these experiences, central banks and other regulatory authorities have a greater interest in monitoring the international use of their currency. This requires comprehensive information about aggregate international balance sheet positions by currencies, including gross and net currency derivatives, for institutions operating both in and outside the currency issuing country.

While imprecise, BIS data help to illustrate the size of the problem since they provide some indirect information on non-US banks' dollar funding needs in the run-up to the crisis. Figure 3 shows the net US dollar asset and liability positions of major European and Japanese banks since 2000. The figure suggests a growing risk of funding problems prior to the crisis, as longer-term investments in non-banks became increasingly dependent on short-term foreign currency funding. By these estimates, large European banks depended on some USD 1 trillion in short-term funding on the eve of the crisis, much of it obtained via FX swaps.

With these data, however, only broad tendencies can be identified since there are no actual data on residual maturities or the use of FX swap markets. Instead, information on the counterparty type (bank, non-bank, central bank) is used to proxy for the (unavailable) residual maturities, and interbank (blue line in right-hand panel) and net foreign exchange swap positions (bars in right-hand panel) are assumed to have a shorter average maturity than positions vis-à-vis non-banks (green line in right-hand panel).

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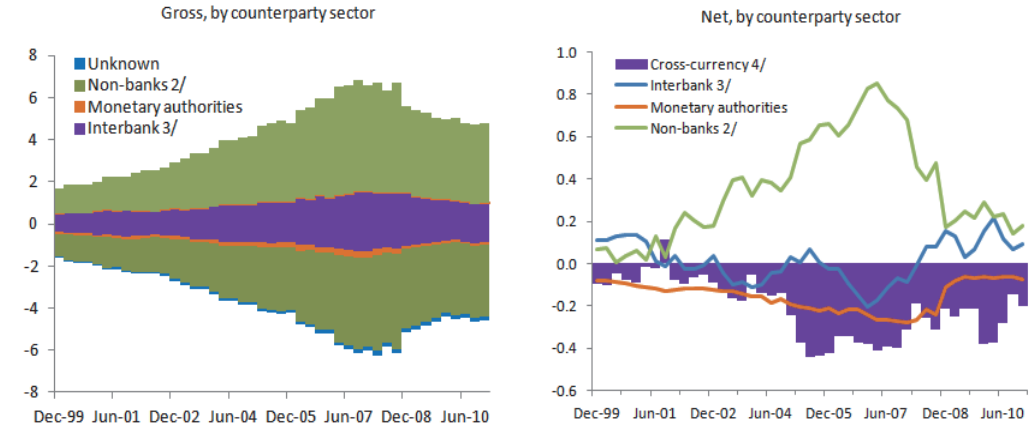
[14] The change in foreign claims is calculated after correcting the data for breaks in series, an expansion in the population of reporting banks, and movements in exchange rates. The BIS reports 41 series breaks during the 2007-09 period in the BIS consolidated banking statistics, many of which are large (e.g. the Italian 2007Q1 USD 622 billion and the US 2009Q1 USD 1,334 billion breaks in series due to the coverage expansion).

[15] Estimates (McGuire and von Peter (2009)) suggest that the wholesale US dollar funding needs of many European banks during the crisis greatly exceeded the dollar lending capacity of their home central banks.

Figure 3

On-Balance Sheet USD Positions at Long-USD European Banks[1/]

(In USD trillions)



Sources: BIS Locational banking statistics by nationality; BIS consolidated banking statistics (immediate borrower basis); and authors' calculations.

Notes: 1/ Estimates are constructed by aggregating the worldwide on-balance sheet cross-border and local positions reported by internationally active banks headquartered in Germany, the Netherlands, Switzerland and the United Kingdom; 2/ International positions vis-à-vis non-banks plus local positions vis-à-vis US residents (all sectors) booked by banks' offices in the United States. No sectoral breakdown is available for these positions; 3/ Estimated net interbank lending to other (unaffiliated) banks; and 4/ Implied cross-currency funding (ie FX swaps), which equates US dollar assets and liabilities.

Modeling Systemic Risks for International Banks

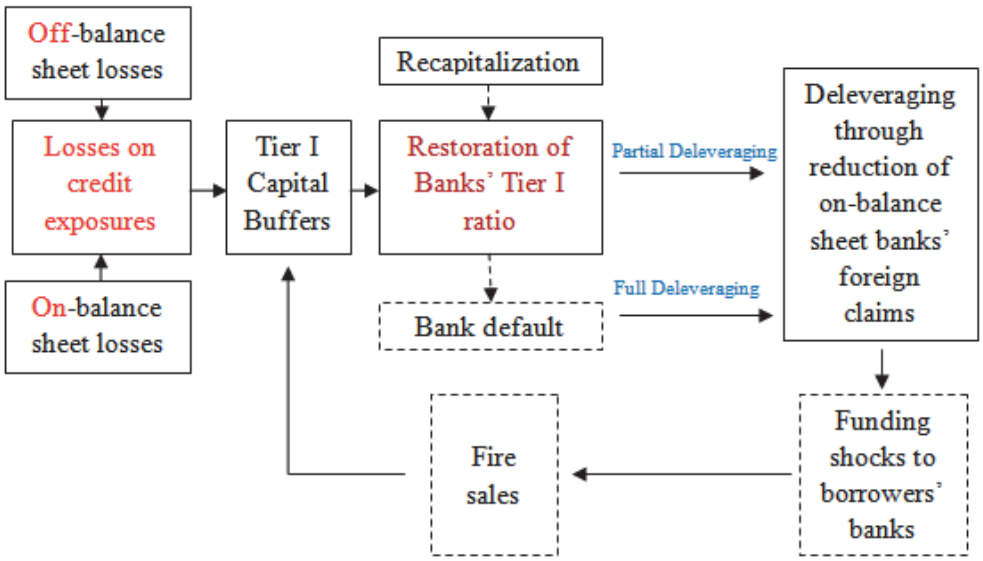
Systemic events typically involve a combination of self-reinforcing asset and funding shocks which then spill over to banks in other countries. While the origins of shocks are often difficult to identify (and model) a priori, assessing the size and direction of the subsequent spillovers can be easier. One approach is that of the IMF cross-border bank contagion scenario module used for surveillance, spillover analyses, and early warning exercises.[16] The scenario starts from asset credit exposures, differentiating between potential losses on cross-border claims, affiliates' claims, and off-balance sheet exposures. It then captures the propagation of shocks across borders through bank losses, funding shocks and deleveraging. Again, however, it suffers from the weaknesses of existing data.

The scenario analysis allows for shocks to affect assets and funding through several rounds (Figure 4). The first round considers losses on assets that deplete bank capital partially or fully. It relies on assumptions about the percentage loss on particular types of assets (e.g. claims on the public sector, banking sector, and non-bank private sector of an individual country or group of countries). Losses can also occur through off-balance sheet exposures. In the second round, if losses are large, banks are assumed to restore their capital adequacy to at least a certain threshold (here, the Basel III Tier I capital asset ratio) through deleveraging (i.e. sale of assets and refusal to roll over existing loans). In the third round, banks are assumed to reduce their lending to other banks (funding shocks), potentially triggering fire sales, further deleveraging, and additional losses at other banks. Final convergence is achieved when no further deleveraging occurs. The possibility of (public) recapitalization allows one to simulate how policy could mitigate the deleveraging process and reduce systemic risks.

[16] See Tressel (2010) for the methodological framework and IMF (2011b) for some recent modifications.

Figure 4

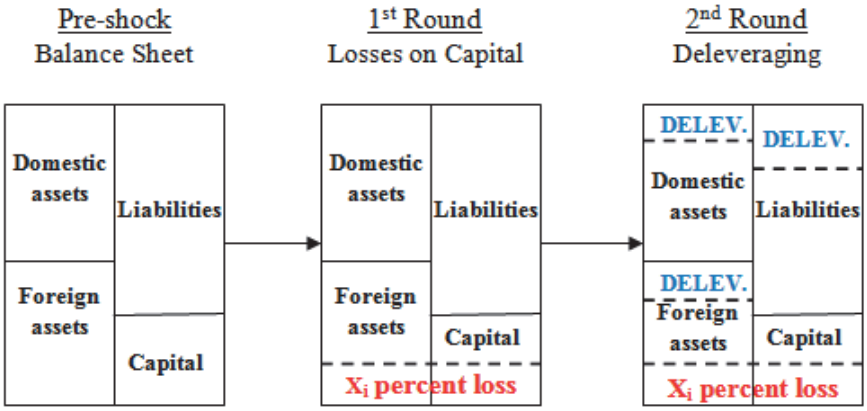
Shock Propagation across Borders through Bank Losses and Deleveraging



Contagion across borders and through common lender effects can now be analyzed. Consider a common shock, due to a crisis in a particular sector(s) in one or more countries, that involves losses of X_i percent on the foreign assets of banks from country *i* (illustrated in Figure 5). If capital buffers are not large enough, and/or without bank recapitalization, deleveraging will need to occur to restore capital (e.g. to a Tier I capital ratio of 6 percent).[17]

Figure 5

Effect of Foreign Credit Losses on the Balance Sheet of Country *i* Banks



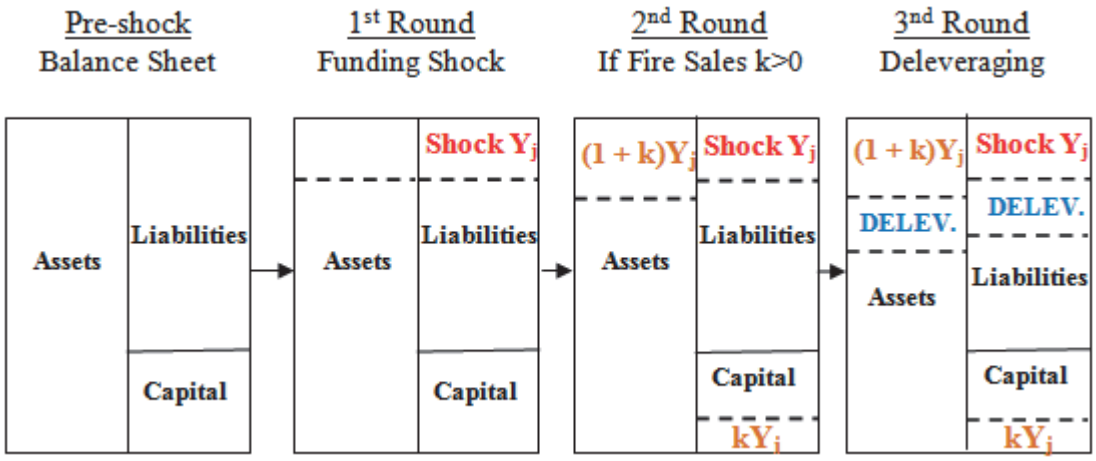
The process of deleveraging then means a global reduction in loans of all banks affected either directly or indirectly, impacting financing and economic activity in various countries. For banks in borrower country *j*, the funding shock (Y_j) equals the deleveraging across all its

[17] Figure 5 implicitly assumes that deleveraging occurs proportionally across domestic and foreign assets. In practice, when deleveraging, banks often liquidate more risky assets first. This can be captured by assuming that banks disproportionately liquidate claims on more vulnerable countries or sell all types of foreign assets first.

creditor countries (Figure 6). If the funding shocks trigger fire sales, banks could experience further losses, triggering additional deleveraging if capital buffers are not large enough and/or in the absence of bank recapitalization. The system converges to a steady state when no further deleveraging takes place (i.e. banks meet their capital adequacy requirements).

Figure 6

Effect of a Funding Shock on Balance Sheet of Borrower Country *j* Banks



While the model is quite rich, the lack of detailed and consistent input data limits its use. Ideally, comprehensive scenario analyses of this sort would be conducted using *bank-level* data which also track *bilateral* linkages in the interbank market. Currently, BIS consolidated banking data are used to model the losses due to direct exposures of banking systems to the public sector, banking sector and/or non-bank private sector, and indirect exposures via off-balance sheet contingent positions, to borrowers in an individual country or group of countries.[18] Bank-level data (aggregated) provide the estimates of these banking systems' positions vis-à-vis borrowers in the home country and of their Tier I capital needed in the analysis, neither of which is available in the BIS data.[19] While the BIS data track many of the international dimensions of interest, the costly implicit assumption, of course, is that an entire banking system can be treated as a single bank.[20] Thus, problems which arise within a group

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[18] In the IMF model, scenarios are calculated for those countries for which consolidated BIS banking statistics on an ultimate risk basis are currently available (Austria, Belgium, Canada, France, Germany, Greece, Ireland, Italy, Japan, the Netherlands, Portugal, Spain, Sweden, Switzerland, the UK and the US). The deleveraging impact is, however, estimated for almost all 180 countries, except for the potential additional impact triggered by funding shocks, which are only calculated for the domestic consolidated banking sector of BIS reporting countries.

[19] Comprehensive international data on banks' consolidated balance sheets which follow the BIS CBS aggregation structure but include banks' domestic positions (i.e. positions vis-à-vis residents of the home country) are not yet available. Only the ECB Banking Supervision Committee, which reports a national balance sheet for the aggregated domestically owned consolidated banks in each EU state, provides national aggregates similar to the BIS CBS for some concepts, such as Tier I capital and capital ratios, and total bank assets. In other cases, it is necessary to sum individual domestically owned consolidated banks' balance sheets, or alternatively, depending on the number of foreign subsidiaries, subtract from national aggregates foreign-owned subsidiaries' balance sheets.

[20] There are some additional data limitations: (i) the counterparty-sector breakdown is available only for total foreign claims, but not separately for the components of foreign claims (i.e. cross-border claims and local claims); (ii) maturity breakdowns are available only for international claims (immediate borrower basis), which

of banks of a particular nationality cannot be uncovered, limiting the effectiveness of the analysis in policy discussions.

III. What Additional Data Are Needed?

Institutional and regulatory differences across countries can greatly affect the scale of shocks and the direction of their propagation across borders. These differences also make it difficult to construct analytical indicators that track the buildup of vulnerabilities at the system level. And the lack of internationally comparable data for the largest global institutions complicates things further. Drawing on the lessons of the recent crisis, this section reviews gaps in the currently available data, outlines the G20 data initiative to close these gaps, and makes suggestions on areas which should be given high priority.

Analyzing systemic risks in international banking (e.g. common exposures across institutions, cross-currency funding patterns and maturity transformation, and the volatility of cross-border capital flows) requires *joint* analyses of data covering *many* financial institutions. Common exposures to a particular asset class or funding source are easily masked in aggregate data. To detect these types of vulnerabilities requires data at the *individual bank level* which is collected in a consistent and comparable format across banks, so that subsequent aggregation is possible.

Bank-level data obtained by national supervisors contain some of the needed information. But the experience during the crisis showed that, in many jurisdictions, supervisors lacked critical pieces of information, specifically data on how international banks are connected to each other. During periods of market turmoil, real-time information on how the failure (or not) of a particular institution might impact other institutions is crucial for policy decisions, but was lacking in the days leading up to the collapse of Lehman Brothers. Thus, for crisis management purposes, there is a need for more information on bank-level *bilateral* linkages.

The bank-level data that are collected by supervisors are not widely shared, generally not even across supervisory jurisdictions, and only broad aggregates (if anything) are publicly disclosed.[21] No single supervisor therefore has a detailed overview of the global system. And without such a view, system-level vulnerabilities can go undetected. It was difficult (even late in the crisis), for example, to gauge the size of European banks' global exposures to US dollar CDOs, and there was virtually no system-level information on the scale of these banks' reliance on short-term dollar funding (e.g. money market funds), which dried up suddenly amidst the turmoil. Detecting these types of stresses early on requires detailed breakdowns of banks' assets and liabilities (i.e. by currency, instrument, residual maturity, and, if possible, counterparty type and country), and their joint analysis across many banks.

Bank-level data available outside the supervisory community are generally not detailed enough. Commercial databases compile information from banks' annual reports, but have considerable data lags and gaps. Information on the counterparty sector and country are generally missing, and coverage of branches is particularly poor. In many countries, standard balance sheet data (e.g. capital asset ratios) are not even publicly disclosed (or are disclosed

include both cross-border claims (in all currencies) and locally extended claims in foreign currencies; and (iii) the interaction between funding and deleveraging risks is restricted to those countries that report BIS data on an ultimate risk basis (for several important markets, e.g. China, Brazil, Korea, such data are not available).

[21] Access to supervisory data is limited outside the home country. In some cases Memorandums of Understanding allow specific data to be exchanged between two countries. Also, in some cases, data are made available to teams conducting the joint IMF-World Bank Financial Sector Assessment Program (FSAP).

without much detail). Banks generally also do not report information on the currency of their positions or their exposures to particular counterparty types. Moreover, many banks disclose only their globally consolidated financial statements, which aggregate their positions across all their subsidiaries and branches (at home or abroad), and thus the information on the geographic structure of banks' operations is not preserved. As a result, much of the information about the funding and asset structures of banks' operations (branches and subsidiaries) is lost, limiting the usefulness of these data for global risk analysis.

As our earlier examples illustrate, global systemic risk analysis with currently available data rests on a myriad of tenable assumptions and yields very imprecise results. In this context, the IMF and the FSB have jointly issued a report to the G20 finance ministers and central bank governors with 20 recommendations on reducing financial data gaps (see Box 2). Recommendations 8 and 9 in this report require the creation of a common reporting template for globally systemically important financial institutions (G-SIFIs). An international working

Box 2

G20 Data Gaps Initiative

The Financial Crisis and Information Gaps, the joint IMF-FSB report to the G20, has made 20 recommendations on reducing financial data gaps. The recommendations that are most related to the topics covered in this paper are:

- Development of measures of system-wide, macro-prudential risk, such as aggregate leverage and maturity mismatches (R. 4)
- Development of a common data template for systemically important global financial institutions for the purpose of better understanding the exposures of these institutions to different financial sectors and national markets (R. 8 and 9)
- Enhancement of BIS consolidated banking statistics, including the separate identification of non-bank financial institutions in the sectoral breakdown, and the tracking of funding patterns of international financial systems (R. 11)
- Development of a standardized template covering the international exposure of large non-bank financial institutions (R. 14)

Efforts to fulfill these recommendations are underway. An international working group has created a draft template for the collection of bank-level data which, if adopted, would provide information on banks' exposures and funding positions with breakdowns by counterparty country and sector, instrument, currency, and remaining maturity. In addition, the collection of information on banks' intragroup positions and the number of branches and subsidiaries is also under consideration.

The other recommendations focus on improvements in country aggregate financial soundness indicators and implementation of standard measures that can provide information on tail risks, concentrations, variation in distributions, and the volatility of indicators over time (R. 2 and 3), improved understanding of risk transfers from credit default swaps (R. 5), improved securities data through better disclosure requirements for complex structured products and new common templates (R. 6 and 7), increased frequency and participation in the coordinated portfolio investment survey (R. 10 and 11) and international investment position survey (R. 12), monitoring and measuring nonfinancial corporations' cross-border exposures (R. 13), promotion of compilation of sectoral accounts (R. 15), compiling distributional information (such as ranges and quartile information) alongside aggregate figures (R.16), standardized presentation of government finance statistics (R. 17 and 18), improved public sector debt data (R. 18), completion of a real estate prices handbook (R. 19), and enhancement of principal global indicators (R. 20).

group has already produced a set of draft data templates designed to capture detailed information about banks' asset and funding positions, and on the linkages between banks and other individual institutions. The group also outlined a framework for the collection and storage of highly confidential bank-level data, and a framework governing the access to and use of the data (see IMF-FSB (2011)). These proposals are still subject to a consultation process with the FSB, which is expected to make decisions in 2012.

If these initiatives go forward, the resulting data would, for the first time, permit joint analyses of the global positions of many banks from different jurisdictions, thus substantially improving the ability to detect vulnerabilities in common exposures or concentrated funding positions and to assess the vulnerabilities in the global system. Moreover, when crises do occur, supervisors and macro-prudential authorities would have some information to assess the potential for spillovers from the failure of a particular institution to other institutions, national markets, and sectors, and evaluate the impact of various regulatory responses (e.g. whether ring fencing restrictions in one or a group of countries would trigger spillovers to other countries and banking groups). The envisioned data would also facilitate more realistic modeling of how asset and funding exposures endogenously interact during periods of stress.

In parallel with these efforts, enhancements to the aggregate BIS international banking statistics, which cover a much wider universe of banks, are underway.[22] In broad terms, these enhancements aim to: (i) provide more information on the currency of banks' positions; (ii) provide more information on banks' counterparties, specifically on their location and sector; and (iii) extend coverage to banks' entire balance sheets, not just their foreign positions (see BIS (2011)). In addition, coverage will be broadened so as to capture all banks' financial assets and liabilities. That is, banks will start to report also their local currency positions vis-à-vis residents of the host country. This will make it easier to assess system-level funding risks across a much wider range of currencies. It will also allow the scale of banks' international activities to be compared with their total balance sheets.

Importantly, the enhanced BIS banking data will reveal more information about banks' operational structures.[23] That is, it is currently not possible to simultaneously know a bank's location, its nationality, and the location of its counterparties (e.g. aggregate liabilities to Middle Eastern oil exporters booked in the UK offices of Swiss-headquartered banks). Starting in late 2012, information on the country location of banks' counterparties should be available separately for banks of a particular nationality in each reporting jurisdiction. This will facilitate more detailed analysis of how shocks in a banking system might affect borrowers elsewhere (see Fender and McGuire (2010)).

In addition to official authorities, market participants too need better information if they are to appropriately monitor and price systemic risks. Public dissemination of raw data when possible—and consistent aggregates of the data by market, sector, and country when absolutely not—has the potential to help market participants discipline themselves. The release of bank-level sovereign exposure data in the framework of the European stress tests has shown that public dissemination of bank-level data is feasible even during periods of financial distress.

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[22] See BIS (2011), Cecchetti et al. (2010) and Fender and McGuire (2010) for a discussion of how well-designed aggregate statistics can enhance the monitoring of systemic risks, and for a more detailed discussion of the structure of banks' international operations as revealed in the BIS banking statistics.

[23] The FSB-IMF initiative described above focuses on bank-level worldwide *consolidated* data, and thus will not contain information on the positions of the individual banks' entities.

Even with improved aggregate banking statistics and better bank-level data, other dimensions of systemic risk will likely remain inadequately covered. While better coverage of banks is a top priority, non-banks, including pension funds, insurance companies, and large multinational corporations, can also be systemically important. This suggests, going forward, including not only such non-bank institutions in the counterparty sector breakdown of banks' exposures, but also bringing large non-bank firms under the data gathering umbrella.

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Annex – Methodology Underlying the Foreign Credit Exposure and Rollover Risk Analysis[24]

1. Improving the Measurement of Foreign Credit Exposures

Bank-level balance sheet data are not often used in cross-country studies due to the difficulty of mapping major international banks' group structure across countries and compiling their balance sheet data. Organizing the bank data involves mapping both the parent banks and their network of subsidiaries, which is an extensive task.

More formally, a creditor country's *foreign credit exposure* would be equal to:

$A_{ij} + B_{ij} + C_{ij} + D_{ij}$, where

$A_{ij} = Cross\ border\ claims_{ij}$ captures the direct cross-border exposure from creditor banks in 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 in particular are often not reported in many countries); and

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

The *foreign credit exposure* (FCE_i) measures those exposures as a percentage of GDP or total banking sector assets in country *i* as follows:

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

where Z_i is a scaling factor (GDP or total banking sector assets in country *i*).

2. Improving the Measurement of Foreign Rollover Risks

The foreign rollover risk analysis focuses on a borrower country's rollover risk to crises in its creditor foreign banking systems. For each borrower country, it summarizes the potential rollover risks of direct cross-border lending from banks in creditor countries, as well as the lending by foreign affiliates funded by their creditor countries' parent banks.

Therefore, a borrower country *j*'s *foreign rollover risk (Rollover Risk)* can be captured by:

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

[24] See Cerutti (2011) for more details about the foreign credit exposure and rollover risk analyses, including information about necessary corrections for breaks in series and exchange rate movements.

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 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. The amount of lending by affiliates funded by their parent banks cannot be directly measured since the available bank-level balance sheet data from Bankscope are not detailed enough to identify all parent banks' non-equity claims. Therefore, the *foreign rollover risk* measure could also overestimate the effective rollover risks.[25]

3. Modeling International Banks' Assets and Liabilities Together

The scenario analysis of the contagion of a crisis across borders and through common lender effects is based on considering a stylized bank balance sheet given by:

$$Assets = Capital + Other\_Liabilities$$

where $Assets = Foreign\_Assets + Domestic\_Assets$. To quantify the effect of a shock on assets, we assume that, when facing a loss of LLR percent on, for example, its foreign assets, a bank combines asset sales DEL and recapitalization $RECAP$ to maintain a sound capital (e.g. Tier I) to asset ratio of CAR. For a given loss on its asset portfolio, and leaving aside risk weight considerations, the set of possible combinations of deleveraging (asset sales) and recapitalization is given by:

$$Capital - LLR \cdot Foreign\_Assets + RECAP = CAR \cdot (Assets - LLR \cdot Foreign\_Assets - DEL)$$

Hence, in the absence of a recapitalization of the banking sector, the extent of deleveraging by the financial institutions of a creditor country is given by:[26]

$$DEL = Assets - LLR \cdot Foreign\_Assets - \frac{1}{CAR} \cdot (Tier\ I\ Capital - LLR \cdot Foreign\_Assets)$$

The process of deleveraging results in a global reduction of cross-border claims by all international banks affected by the shock, either directly or indirectly. For each recipient country, the extent of capital outflows is the aggregation of the deleveraging process by all creditor countries.

Additional rounds of deleveraging may take place if shocks are large enough to cause international bank insolvencies, and if fire sales of assets occur, triggering further losses. The system converges to an equilibrium when no further deleveraging takes place.

(1) *Insolvency of upstream countries' banks:* Following a given shock in a market j , the banking system of country i becomes insolvent (e.g. losses exceed capital) and defaults on

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[25] In the cases where affiliates' bank-level data are not available, the borrower country national deposit to loan ratio is used in order to have larger country coverage. Using affiliates' total assets minus deposits, as in the case of the foreign default exposure to subsidiaries, as the proxy of the amount of lending by affiliates funded by their parent banks produce similar results but lower country coverage.

[26] Financial institutions are assumed to be able to sell their assets at book value. Fire sales at below book value may amplify deleveraging.

a proportion of its liabilities to the banks of other countries. This may occur if the initial shock is large enough.

(2) *Funding shock:* Following a given shock, the banks of country i reduce their lending to the banks of country j, which therefore face a *funding shock* Y_{ij}. If assets are sold at book value, no further deleveraging occurs; if, however, assets are sold at fire sale, the loss ($\kappa \cdot Y_{ij}$) is absorbed by the bank capital, which may result in further deleveraging DEL'_j according to:

$$Capital - \kappa \cdot Y = CAR \cdot \left(Assets - (1+\kappa) \cdot Y - DEL'_j \right)$$

The scenario analysis simulations assume that deleveraging occurs whenever the capital to asset ratio falls below a given threshold, implying that deleveraging is possible even if banks' equity is not entirely wiped out by the shock. The deleveraging is assumed to be proportional, such that the deleveraging of country i in country j is given by:

$$DEL_{ij} = X_i \cdot \left(A_{ij} + B_{ij} + C_{ij} \right)$$

where X_i is the loan loss ratio and $A_{ij} + B_{ij} + C_{ij}$ is the amount of cross-border and affiliates' related foreign credit exposures of country i's banks on country j.