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Bank structure, funding risk and the transmission of shocks across countries: concepts and measurement[1]

This article outlines a broad framework for assessing system-wide funding risks and analysing banks' role in the transmission of shocks across countries. It highlights the need to complement essential data on banks' consolidated balance sheets with information that provides a geographically disaggregated picture of those balance sheets. It then discusses how far the BIS international banking statistics, which have several though not all of the desired statistical properties, can go in providing measures of system-wide funding risk.

JEL Classification: F34, G15, G21, Y10.

The recent financial crisis has sparked broad discussions about the types of information needed for financial system surveillance at the global level.[2] Particular emphasis has been placed on measures of *system-level maturity mismatch* (hereafter, simply called "funding risk"[3]) and *leverage*, metrics that could have signalled the build-up of imbalances in specific sectors, and that could have provided some guidance on the extent of maturity transformation in the system.

This article lays out a framework for thinking about such measures, and discusses some of the related data issues. Its key premise is that the geography of banks' international activities matters, and should be taken into account in the measurement of systemic vulnerabilities. Internationally active banks are complex organisations, with local offices (branches and subsidiaries) around the world. These offices provide credit to and raise funds from affiliated and non-affiliated counterparties in the host country and elsewhere. Hence, local offices can have unique *funding structures*, and it is often on these local balance sheets (rather than at the holding company or "group" level) that

[1] The views expressed here are those of the authors and not necessarily those of the BIS.

[2] For an example, see FSB-IMF (2010) and Issing Committee (2009).

[3] The term funding risk is meant to capture the degree of *effective maturity* mismatch on a financial institution's balance sheet. This can arise from actual mismatches in the residual maturities of assets and liabilities in addition to an inability to liquidate assets quickly (liquidity risk) and/or to tap new or roll over existing sources of funding (rollover risk).

problems first develop. As a result, problems can be obscured when only the globally consolidated balance sheet, with positions netted across locations, is considered.

In measuring funding risk, ideally one would have data which provide a *geographically disaggregated picture* of banks' consolidated balance sheets. That is, data in which the *structure* of banks' global operations (for both assets and liabilities) is visible, and which contain some level of information on banks' operations in various locations, and on the interlinkages between these local offices (ie inter-office positions) and with non-affiliated entities.

No dataset exists with this level of detail, or is likely to any time soon. The purpose of this article is thus to explore the extent to which the existing BIS international banking statistics, which have some but not all of the desired properties, can help in the measurement of system-level funding risk.

To set the scene, the first section provides simple examples of banks' international lending and funding activities, and highlights the importance of taking into account bank structure when analysing how shocks are transmitted across countries. The following section discusses the implications for system-level surveillance, and shows the extent to which the geography of banks' activities is captured in the BIS banking statistics. The third section then illustrates how these data can be used in the monitoring of funding risks and of interlinkages in bank balance sheets across office locations. The final section concludes.

Why bank structure matters

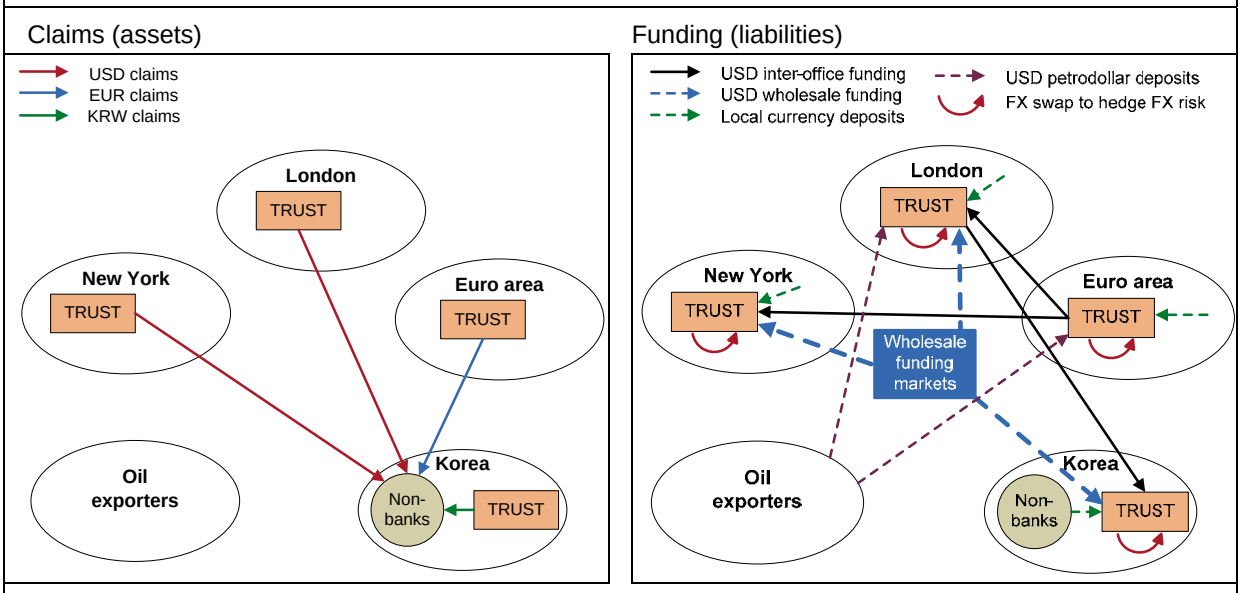
Bank structure influences the transmission of shocks

Large, international banks tend to have offices in many different countries. A key implication of this geographically diverse setup is that the cross-border interlinkages of individual office locations can determine how shocks are transmitted from one location (country) to another. In terms of funding risk, *only if* resources available at one office location can immediately be used elsewhere (ie, if banks' internal transfers of funds are perfectly frictionless) will group-level consolidated data provide an adequate picture of any vulnerabilities. And *even if* internal funds transfers are frictionless, knowledge about banks' local balance sheet positions – and how they compare across locations – can convey important information for policymakers on *where* balance sheet adjustments might actually take place in response to any adverse shocks. In turn, this can shed some light on the identity of the borrowers that might ultimately be affected.

To see why this is the case, consider how a hypothetical European bank – call it TRUST Ltd – might set up its global operations (Graph 1). At the group level, the bank is assumed to have $100 billion in exposures to non-banks in a particular economy – say Korea. Suppose that $40 billion of this is booked by TRUST Ltd's home office in the euro area, while $20 billion is booked by each of its local offices in New York, London and Korea. That is, four different offices of the same global entity lend to non-banks in Korea.

What does this imply? With such a geographically dispersed structure, the *stability* of the credit provided by TRUST Ltd to its Korean non-bank customers

The structure of TRUST Ltd's global operations



The ovals depict countries/regions, while the boxes depict offices of TRUST Ltd in each country. Graph 1

(meaning its willingness or ability to continue to roll over said funds) is inherently tied to the funding structures in each of TRUST's subsidiaries, and these structures are likely to be different. In the example in Graph 1, the liabilities booked in the euro area (home) office could be local currency deposits which are lent cross-border to non-banks in Korea, or sent to affiliates elsewhere (black arrows, right-hand panel). At the same time, the lending from the London office could be supported by a combination of wholesale dollar borrowing, petrodollar (or Asian surplus) deposits and the proceeds from swapping inter-office funding in euros with dollars in the foreign exchange (FX) swap market. The positions booked by the New York office, in turn, could be funded with wholesale borrowing and commercial paper issuance to money market funds, and those booked in Korea could be supported by local currency deposits and inter-office transfers of funds. That is, four different liability structures support the four components on the claim side discussed above.

Netting a bank's balance sheet positions across offices ...

As a result, when viewed from outside the bank using group-level (globally consolidated) data, stresses at the office location level can be masked, possibly generating a misleading picture of the overall degree of funding risk. An example from the recent crisis helps to clarify this point. In the run-up to the crisis, offices of foreign banks (ie those headquartered outside the country) in Korea (and other emerging economies) borrowed US dollars offshore and from their affiliated offices at home, in London or in other financial centres. These dollar funds were then swapped (assuming banks hedge their exchange rate risk) into local currency and invested in local assets in the host country. Concurrently, these same banks' offices in London, New York and in the home countries were funding purchases of US dollar securities by borrowing dollars wholesale and by swapping domestic currency deposits into dollars.

... can mask funding risks at the local level

In short, in some office locations (Korea and other emerging markets), these banks were dollar providers to the FX swap market, while in others (eg home countries, London) they were US dollar borrowers. In principle, at the

group level, banks could thus be net zero in dollar FX swaps. But there would still be potentially significant dollar funding risks across the different office locations.[4] Netting across offices using group-level data effectively assumes that the resources in one office can immediately be used elsewhere (ie perfectly frictionless internal transfers of funds) – a rather strong assumption.

To see this, consider the following. At the height of the crisis (and again more recently), European banks faced problems borrowing dollars in their home and London offices. What to do? In principle, the Korean office could simply send the dollars it had obtained earlier to cover (part of) the needs of the London office. Yet, in practice, the extent to which this is possible depends on a variety of factors, including the nature of the local currency positions financed with these US dollars, and whether these (and the FX swaps used to obtain local currency) can be unwound in a timely fashion. This unwinding can be particularly difficult in an environment where many banks are trying to do the same thing or are facing problems or restrictions in the relevant location. And when more than one location is involved, adjustments made in one of these may have implications for what will happen in the others.[5]

More broadly, frictions in banks' internal funds transfers can include the following.[6] First, host countries' capital and liquidity requirements may restrict a local office's ability to make significant balance sheet adjustments to support affiliates elsewhere. Second, to the extent that funds transfers involve correspondent banks, these relationships may be disrupted in times of stress. And third, ownership structure may play a role as well. When the foreign entity is a branch, the parent may have complete control. Yet when the foreign entity is a partially owned subsidiary, with its own corporate culture and management, it is less clear how much access there is to the subsidiary's funding resources.

Implications for system-level surveillance

If the structure of banks' business activities matters, then this should be reflected in the way financial stability is monitored. In particular, the relevant data may have to be collected in ways that preserve the geographical information on funding risks (and other potential vulnerabilities). This calls for joint reporting of group-level and location-based information.

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[4] The emerging market offices face funding risk in rolling their direct US dollar offshore interbank (and possibly inter-office) borrowing. The home and London offices face funding risk in rolling their US dollar FX swap funding.

[5] In late 2008, foreign banks in Korea rushed to shed won assets. Domestic banks, in turn, faced difficulties in borrowing in the interbank market and much higher costs of obtaining short-term US dollar financing through FX swaps. See Baba and Shim (2010) and Lee (2010).

[6] See Cetorelli and Goldberg (2008) and de Haas and van Lelyveld (2010) on the role of internal transfers of funds in international shock transmission.

Data dimensions

When thinking about the data needed for financial surveillance, discussions often revolve around the creation of bank-level datasets. The idea is to generate matrices of bilateral exposures of systemically important banks (eg TRUST's exposure to other banks) and of their common exposures to particular sectors or counterparties.[7] Information like this would be based on the globally consolidated (group-level) positions of the relevant sample of individual banks. While this is important to consistently relate a bank's overall exposures to the capital base ultimately supporting them (or to the headquarters location where the key managerial decisions are being made), group-level data miss the geography of *both* the bank's balance sheet structure (ie the balance sheets by office location) and the location (country) of its counterparties.

Data on bank geography can enhance macro-monitoring

As a result, financial system surveillance efforts might be enhanced with data that provide a geographically disaggregated perspective. Specifically, better gauging funding risks and, more broadly, the role of banks in the transmission of shocks across countries calls for information on (1) the balance sheets of bank entities (ie branches and subsidiaries) in particular *locations* (countries), (2) the *interlinkages* between these entities via banks' inter-office funding, and (3) the interlinkages between these entities and *counterparties* in other countries – that is, the data on banks' *directional* asset and liability positions as depicted by the arrows in Graph 1. Of course, *entity-level* data with this amount of detail would prove difficult to collect and analyse. As discussed in the next section, the BIS banking statistics provide some information along the lines mentioned above, albeit at a higher level of aggregation.

The BIS banking statistics

The BIS international banking statistics have several, but not all, of the desired statistical properties. The underlying data can be used to construct consolidated bank balance sheets which are *aggregated*, in the sense that no data on individual banks are available. But the data are *disaggregated* in two important ways. First, for each national banking system (as defined by banks' *headquarters* location), the data provide a picture of the aggregated balance sheet of the underlying entities by office location (country level). Second, for each of these banking system-office location pairs, there is a partial breakdown of the location of the counterparties, for both assets and liabilities. Thus for, say, German banks' offices in France, the data show the total balance sheet broken into positions vis-à-vis residents of the host country (France) and cross-border positions (vis-à-vis all countries), along with further breakdowns by currency and counterparty type.

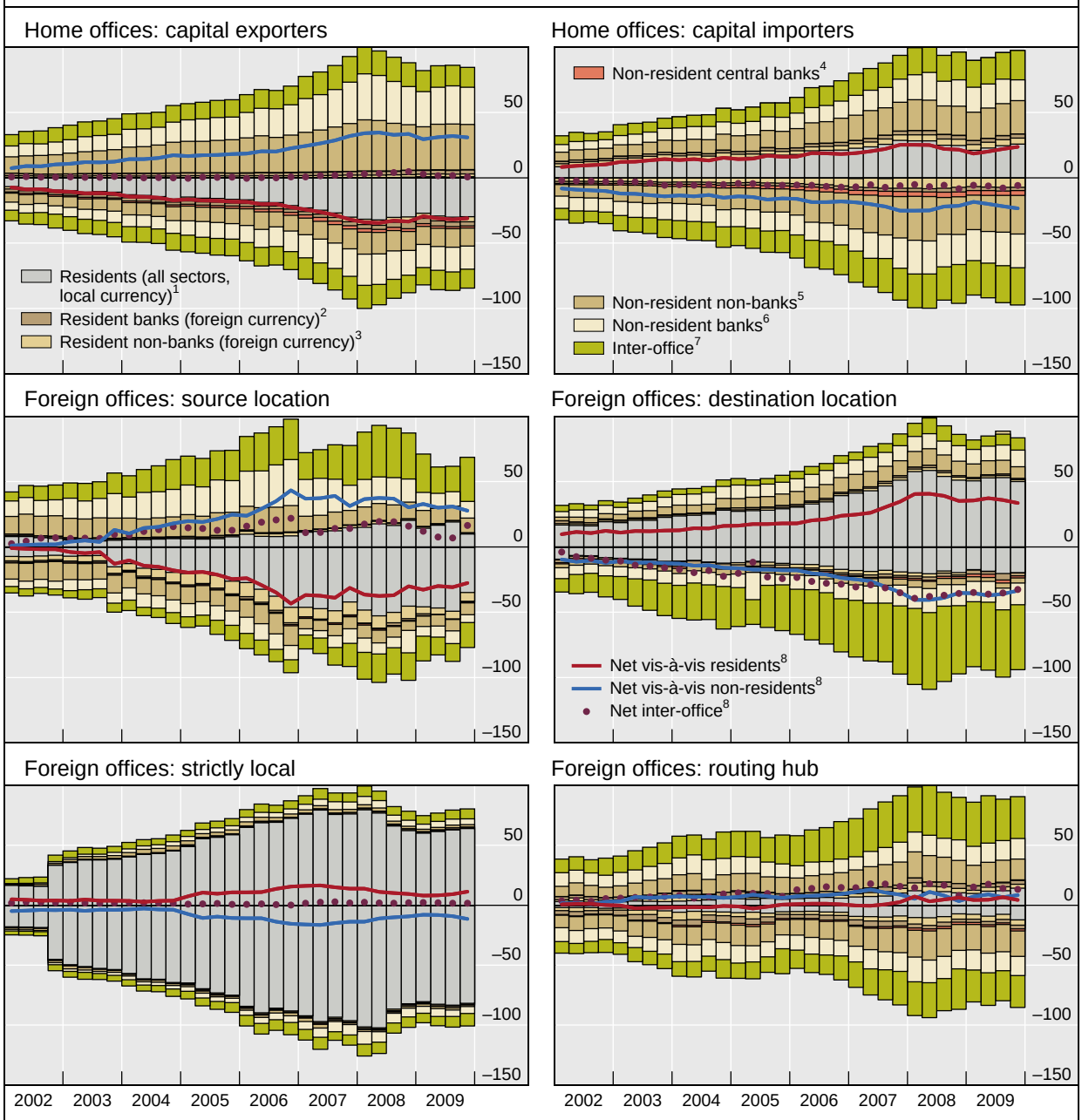
BIS data show balance sheets by office location

In short, the underlying structure of the BIS banking statistics provides some information on the currency, type and direction of banks' funding and lending activities, *both* at the level of their consolidated international balance sheets

[7] See FSB-IMF (2010), recommendation #9, for an example.

(group level) and at the office location (country) level. That said, the data have a number of gaps.

Sample balance sheets



The graph shows stylised bank balance sheets in particular office locations. The stacked bars indicate total assets (positive) and liabilities (negative), normalised to 100. The figures are created by adding together similar balance sheets for offices of different banking systems in different locations. The coloured bars indicate both a breakdown by counterparty location (resident and non-resident counterparties) and a breakdown by counterparty sector (bank, non-bank, central bank and inter-office). No counterparty sector breakdown is available for local currency positions vis-à-vis residents (grey bars). Total assets do not always equal total liabilities because of omissions and errors in the underlying data.

[1] Local currency positions vis-à-vis residents of the home or host country. [2] Local positions in non-local currencies vis-à-vis resident banks (unaffiliated) in the host country. [3] Local positions in non-local currencies vis-à-vis resident non-banks in the host country. [4] Cross-border positions in all currencies vis-à-vis official monetary authorities. [5] Cross-border positions in all currencies vis-à-vis non-banks. [6] Cross-border positions in all currencies vis-à-vis (unaffiliated) banks. [7] Cross-border positions vis-à-vis own offices located elsewhere. [8] The lines show the net (assets minus liabilities) inter-office positions and net positions vis-à-vis residents and non-residents, as a share of total assets.

Sources: BIS consolidated banking statistics (immediate borrower (IB) basis); BIS locational statistics by nationality. Graph 2

To get a sense of what these data do and do not contain, Graph 2 portrays stylised balance sheet types. They are created by aggregating (and scaling to 100) the underlying, partially confidential, data for particular banking system-office location pairs with similar characteristics. The purpose is to provide as concrete a view as possible of what the underlying BIS banking data reveal at the office location level. Across types and over time, the stacked coloured bars show banks' assets (positive) and liabilities (negative) vis-à-vis residents and non-residents of the host countries. These positions are further broken down (to the extent possible) by counterparty sector (bank, non-bank, central bank, inter-office).[8]

The top two panels depict examples of banks' *home offices*, split into whether the home offices are net exporters of capital from the home country (top left-hand panel) or net importers (top right-hand panel). The former include Japanese, German and Swiss banks' home offices, which are all headquartered in current account surplus countries. Not only do these home offices engage in direct cross-border lending to counterparties elsewhere (blue line), they are also major sources of inter-office funding for their offices abroad (positive olive bars). Since much of the assets are in foreign currencies financed with local currency deposits from home-country residents (grey bars), there are large off-balance sheet FX swap positions implicit in these offices' balance sheets, which can add rollover risk.

In contrast to these offices, the home offices depicted in the top right-hand panel (eg Spanish and Australian banks' home offices) import capital to the home country via net inter-office funding from foreign offices and direct borrowing from non-resident non-affiliated counterparties. If in foreign currency, this involves the additional step of swapping these funds *into* the home currency before lending them on to residents.

Some offices finance local currency activity offshore …

The remaining four panels of Graph 2 show stylised pictures of banks' operations *outside* their home countries. The "destination location" type (centre right-hand panel) includes offices in host countries such as Spain and Korea. Many foreign banks' offices there have large local currency claims on residents (grey bars), and fund these positions through some combination of inter-office and offshore borrowing. In some bank/host country combinations (eg some European banks' offices in Spain), the local currency asset position and the cross-border liability positions are in the same currency (euros). In others (eg the Korea example in the previous section), the local position is funded by non-local currencies (often US dollars) offshore, again implying an FX swap hedge into the local currency.

In the "strictly local" office types (bottom left-hand panel), typified by foreign banks' offices in Mexico and Brazil, operations on the assets side look similar to the "destination" type above. But, here, the local currency assets are mainly financed locally in the local currency. Such a structure, which does not

[8] This breakdown is incomplete since no counterparty sector information is available for local positions in local currencies (the grey bars in Graph 2).

require any FX swap hedges, is arguably more insulated from shocks external to the host country.[9]

… while others tap local funds to finance lending elsewhere

By contrast, in the so-called "source location" type (eg European banks' offices in Belgium and Luxembourg), local sources of funds (ie the domestic deposit base) are tapped, in part, to finance *international* activities. This is done via inter-office transfers or direct cross-border lending to non-residents.

Finally, there is the "routing hub", where strictly local activities are overshadowed by international lending and funding, via both wholesale markets and inter-office transfers of funds. Examples include host countries such as the United Kingdom and Switzerland (eg TRUST Ltd's assumed activities in London in Graph 1). One distinguishing feature is that foreign banks' offices in these host countries have relatively small positions vis-à-vis residents (red line), and thus contribute little to the countries' domestic credit figures. At the same time, the large cross-border asset and liability positions of these banks can have a significant impact on the host countries' balance of payments figures, even if such movements have little to do with exposures of the country's residents (see box).

To sum up, the BIS banking data suggest that the activities of banks' offices in individual country locations are, to some extent, unique to that location. Activities can be very similar across banks in a particular location, while being different across locations. In turn, the types of funding risks which can arise are likely to be at least partially location-specific as well. As a result, to capture these geographical patterns, funding risks would be best measured at as disaggregated a level as possible. This issue is taken up in the next section.

Measuring system-level funding risk: how far can we go?

A prominent feature of the recent financial crisis was the dislocation in funding markets. The problem developed when a large number of institutions found themselves in need of US dollars that they had incorrectly assumed they could either borrow directly or obtain through the foreign exchange swap market. Measuring these vulnerabilities requires knowledge of banks' consolidated balance sheets (rather than the balance sheets constructed along national borders). At the same time, as argued above, further information on local funding is needed beyond the globally consolidated positions to understand interlinkages and related risks.

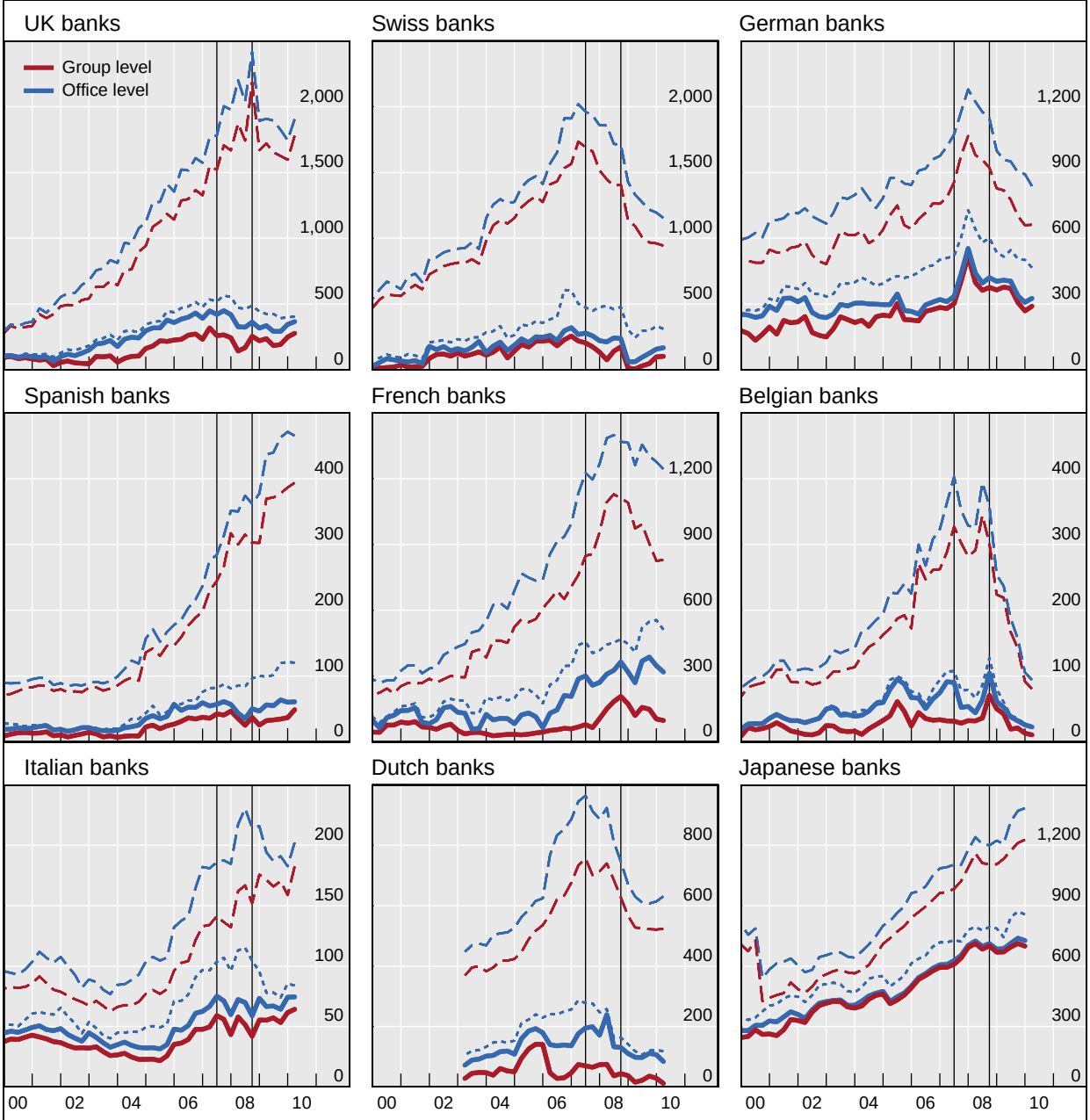
System-level funding risk should be measured …

An illustration of this argument is provided in Graph 3, which takes the analysis of funding risks to the office location level. The graph shows upper- and lower-bound measures of US dollar funding risk for nine banking systems. These measures are meant to capture the net amount of short-term dollar funding that must be rolled over, either via direct borrowing or via the FX swap

[9] On the pros and cons of a more decentralised model of international banking, in which a greater portion of lending to residents of a particular country is funded, managed and supervised by offices in the country, see CGFS (2010). Kamil and Rai (2010) present empirical evidence on the relative stability of banks' local activities in Latin America during the recent crisis.

Indicators of US dollar funding risk, by national banking system[1]

In trillions of US dollars



The two vertical lines are placed on end-Q2 2007 and end-Q3 2008.

[1] The graph indicates two sets of measures of US dollar funding risk, constructed as described in footnote 10. The group-level estimates (red lines) are constructed by aggregating banks' global balance sheets into a consolidated whole, and then calculating funding risk on this aggregated balance sheet. The office-level estimates (blue lines) are constructed by calculating funding risk at the office location level, and then aggregating the series up across office locations for each banking system. By construction, the office-level estimates should at least be as large as the corresponding group level.

Sources: BIS locational banking statistics by nationality; BIS consolidated banking statistics (IB basis); BIS calculations. Graph 3

Country-to-country banking interlinkages

To illustrate the importance of *both* group- and office-level balance sheet data in the analysis of interlinkages, it is instructive to see the results that can be obtained from analysing only *one* of these data dimensions. In the main text, the discussion starts at the consolidated level to then show why office location can be important. This box uses the BIS locational banking statistics *by residency*, perhaps the most familiar of the four international banking datasets maintained by the BIS, to look at interlinkages at the country level. These statistics include the size, currency, counterparty type and, critically, the counterparty location of claims and liabilities of banks in one country to borrowers located in another country. They do not contain information on the *nationality* of the reporting banks in each location. Thus, the data provide a particular picture of *geographical* (ie country-to-country) *interlinkages* and the flow of funds between them, but are less well suited for more structural balance sheet analysis.

A broad-level illustration of these geographical interlinkages between banks' local operations is presented in Graph A, where the nodes depict countries or regions where banks are *located*. In the top panels, the size of the nodes is proportional to the share (in the global total) of cross-border bank assets and liabilities booked by banks located in that country node. The thickness of the lines, in turn, is a measure of the amount of finance (size of the linkage) across nodes, shown separately for US dollar- and euro-denominated positions.[1] The lower panels show the cumulative net *flow* of capital (in all currencies) which was transacted across bank balance sheets in the seven years before the start of the crisis and the three years since. The estimated net capital flows, depicted by the thickness and direction of the arrows, take into account changes on the assets *and* liabilities side of the balance sheets of all reporting banks located in *both* countries in each bilateral pair.[2]

At least two key points emerge from Graph A. First, capital flows saw a phenomenal reversal in the wake of the recent crisis (lower panels), in particular out of the United States. Up to mid-2007, banks facilitated international capital flows out of Japan and the euro area as well as from Asian financial centres and oil-exporting countries. Banks routed these funds via offices in the United Kingdom and in Caribbean financial centres, ultimately transferring them to borrowers in the United States and in emerging markets. After the start of the crisis, the direction of many of the bilateral flows reversed, in part generated by capital movements back to the United Kingdom, and in part reflecting asset writedowns.

Second, and more important, cross-border banking is very concentrated in a few locations (top panels). That is, a large chunk of the world's cross-border banking business is booked (or has a counterparty) in the United Kingdom and a few other key banking centres. As McCauley et al (2010) discuss, however, the activity on the ground in these locations can be largely driven by the activity of *foreign* banks (ie affiliates of foreign-headquartered institutions). Thus, these location-level linkages say little about the actual consolidated exposures of residents of a given country or of the banks that are headquartered there.

In short, Graph A, and similar more detailed analyses with these data, can be used to illustrate *what happened* to the financial linkages between countries before and after the crisis: cross-border financial flows to borrowers in the United States and many emerging market countries surged, and then reversed direction. Yet it offers little information on *why* this happened, since the strictly residency-based perspective effectively aggregates the balance sheets of entities from different banking groups in a particular location, thus precluding any serious analysis of balance sheet stresses. Uncovering these stresses requires a deeper, more structurally based view of banks' balance sheets – one that combines the location-based information in Graph A with headquarters-based consolidated reporting, as discussed in the main text.

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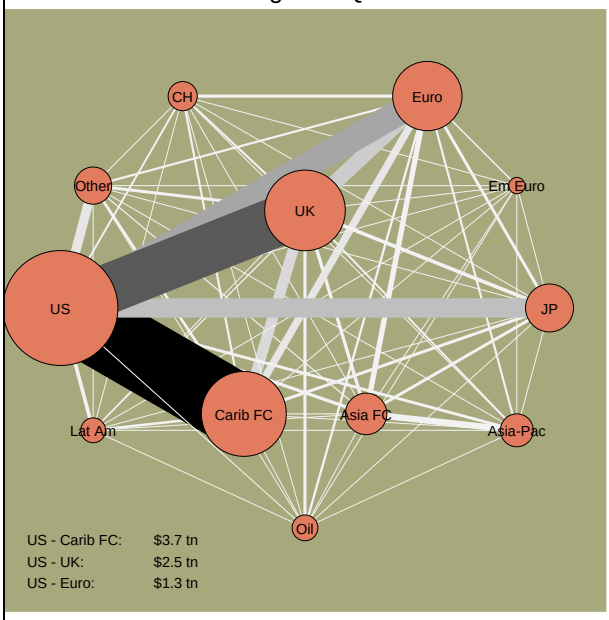
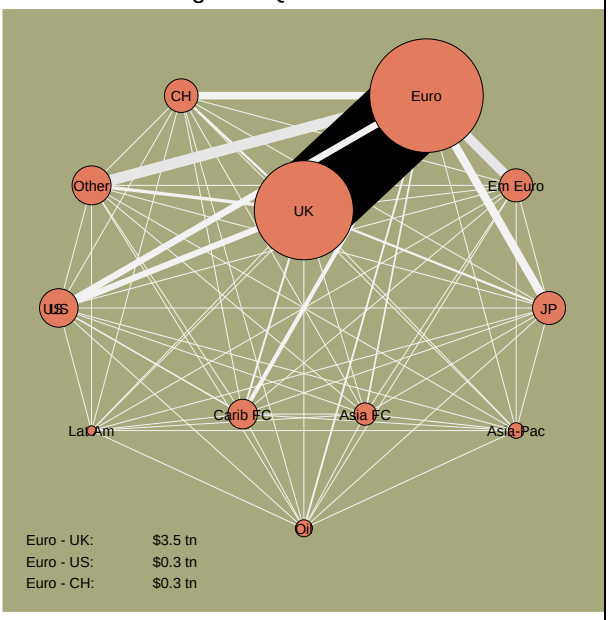
[1] See footnote 1 in Graph A for a definition of the term linkage. There is nothing special about this choice of definition, other than that it nicely summarises the relative strength of the overall banking connection across countries. Similar charts based only on assets or liabilities, or only on interbank positions, are also possible. [2] A fundamental problem in the flow calculation is that banks increasingly rely on *debt securities* liabilities and, unlike with deposits, they often do not know the identity and location of the holder, since the securities are bought and sold in secondary markets. *Bilateral* net flow figures are thus biased. The calculations in the bottom panels of Graph A attempt to correct for this by backing out the counterparty location using debt securities *claims* on the assets side of the balance sheet, and allocating the remainder of the liabilities to counterparty countries using weights based on observable liabilities. See McGuire and Tarashev (2007) for more details.

Linkages in the international banking system

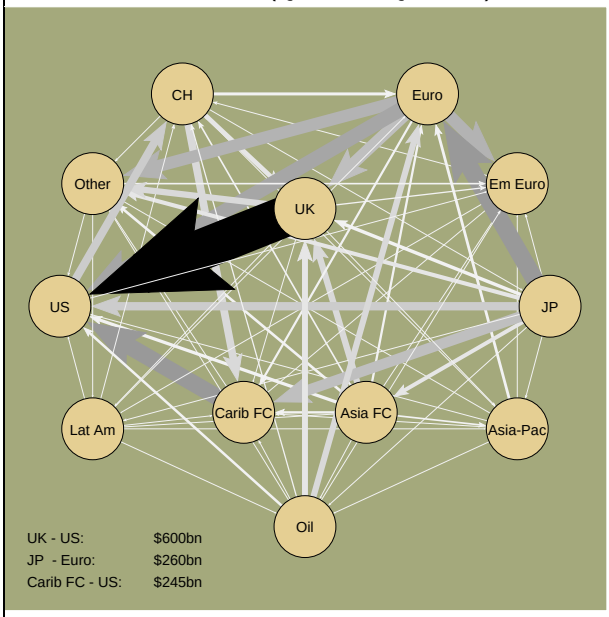
US dollar stocks linkages at Q1 2010[1]



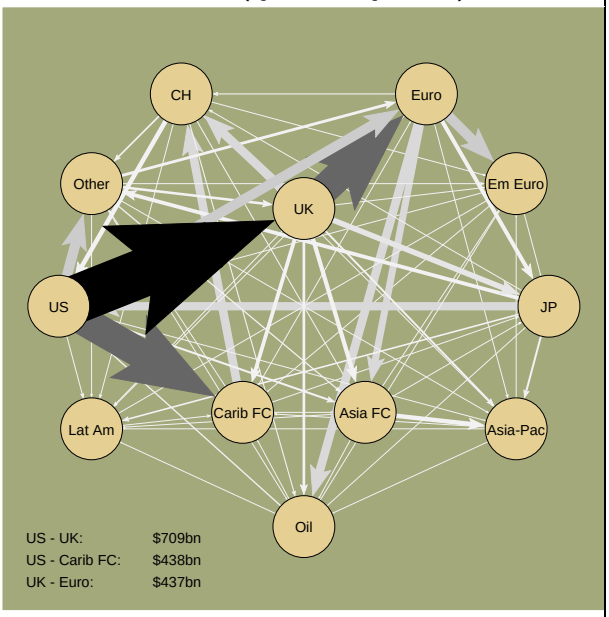
Euro stocks linkages at Q1 2010[1]



Cumulative net flows (Q1 2000–Q2 2007)[2]



Cumulative net flows (Q3 2007–Q1 2010)[2]



Asia FC = Asian financial centres (Hong Kong SAR, Macao and Singapore); Asia-Pac = China, Chinese Taipei, India, Indonesia, Korea, Malaysia, Pakistan, the Philippines and Thailand; Carib FC = Caribbean financial centres (Aruba, the Bahamas, Bermuda, the Cayman Islands, the Netherlands Antilles and Panama); CH = Switzerland; Em Euro = emerging Europe (Bulgaria, Croatia, Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia, Turkey and Ukraine); Euro = euro area member states excluding Slovakia, Slovenia, Cyprus and Malta; JP = Japan; Lat Am = Argentina, Brazil, Chile, Colombia, Mexico, Peru and Venezuela; Oil = OPEC member states (excluding Indonesia) plus Russia; Other = Australia, Canada, Denmark, New Zealand, Norway and Sweden; UK = United Kingdom; US = United States.

[1] The size of each circle is proportional to the stock of cross-border claims and liabilities of reporting banks located in the particular geographical region. Some regions include non-reporting countries. The thickness of a line between regions A and B is proportional to the sum of claims of banks in A on all residents of B, liabilities of banks in A to non-banks in B, claims of banks in B on all residents of A and liabilities of banks in B to non-banks in A. [2] Exchange rate adjusted flows, expressed at constant end-Q1 2010 exchange rates. The thickness of an arrow is proportional to the amount of net bank flows between regions, and is comparable across panels. An arrow points from A to B if net flows in this direction are positive, calculated as changes in net interbank claims (assets minus liabilities) of banks in A on banks in B, plus net claims of banks in A on non-banks in B, minus net claims of banks in B on non-banks in A. (This last component is missed if B is not a reporting country.) See "Tracking international bank flows", *BIS Quarterly Review*, December 2006.

Sources: BIS locational banking statistics by residence; authors' calculations. Graph A

market.[10] The calculation is performed twice. In the first instance, *group-level* estimates are generated by first consolidating the banking system's global balance sheet across office locations and then calculating the funding risk measures on the basis of these total positions (solid and dashed red lines). In the second, *office-level* estimates are generated by calculating the measures separately for each office location and then adding them up across locations for each banking system (solid and dashed blue lines). To this second set of estimates is added a mid-measure (dotted blue lines), which adds net inter-office US dollar funding to the lower-bound, office-level estimate. This helps to establish a banking system's reliance on this type of funding and thus to gauge the scope for spillovers across locations arising from these funds.

These measures are rough, with very wide ranges between bounds, limiting their effectiveness in policy analysis. In part, this is because actual information on the residual maturity of banks' US dollar positions is unavailable.[11] Even so, the indicators do seem to confirm that funding risks are actually larger than consolidated data would make them appear – a result of the netting of interbank and FX swap positions in the group-level estimates. Effects like this can be rather large, as suggested by the differences in the lower-bound indicators for French, Dutch and Belgian banks. Moreover, analysis of the underlying office location-level funding risk measures (not shown) indicates that a significant portion (as high as 80%) of the total dollar funding risk is attributable to a given banking system's *foreign offices*, about which home country regulators may have only limited information.

... starting at the office location level

This suggests that the full extent of system-wide bank funding risk may be impossible to measure without geographically disaggregated data. Such data, in turn, may be difficult for any one supervisory authority to construct: (1) home country authorities may not have ongoing access to detailed supervisory data on their banks' foreign offices, and (2) host country supervisors will tend to see only the positions of local branches and subsidiaries in their respective jurisdictions. That is, the assessment of total bank funding risk – and, by implication, the possible demands for central bank liquidity if and when banks

[10] Specifically, it is assumed that banks' claims on non-banks (ie their retail and wholesale lending, and holdings of securities) approximate their "desired" US dollar-denominated investment portfolio. These exposures are of varying maturities but, on average, are likely to be longer-term than the funding that supports them. If *liabilities* to non-banks are all assumed to be long-term, then the lower-bound estimate of these banks' overall US dollar funding gap is net interbank borrowing (if positive) plus net borrowing from the FX swap market, which is backed out from the balance sheet identity. To this, any net US dollar borrowing from official monetary authorities is added. The upper-bound estimate results from adding liabilities to non-banks to the lower-bound measure, under the assumption that these are short-term. See McGuire and von Peter (2009) and Fender and McGuire (2010) for more details. For measures of funding risk based on input-output analysis methods, see Lee (2010).

[11] Because of missing pieces of information on residual maturity, instrument type and, to a lesser extent, counterparty type in the BIS banking statistics, approximations have to be made to gauge funding risk. For example, the argument implicit in the previous footnote is that "maturity" can be inferred from information on counterparty types, which itself is not very detailed (bank, non-bank, official monetary authority, inter-office). As regards instruments, the nature of funds provided (eg commercial paper, retail or corporate deposits, long-term bond issuance) is unknown. The same applies on the assets side, where securities holdings, loans to non-bank corporates and loans to non-bank financials cannot be distinguished.

in particular locations find themselves without access to sufficient (foreign currency) funds – may require information along the lines of the office-level data used to calculate the measures in Graph 3.[12]

Geographical shocks

The analysis outlined in the previous section relies on consolidated (by banking system) but geographically disaggregated (by office location) data with a number of key breakdowns of assets and liabilities. But even this level of detail cannot capture all types of funding risks that policymakers might be interested in. In particular, these data miss exposures to *geographical (or geopolitical) shocks* from any concentrations of funding obtained from residents of individual countries – a form of country risk.[13]

Understanding how shocks to particular funding sources …

Consider some concrete examples. Many banks, in particular those located in London and the United States, receive an estimated 5–7% (at end-2009) of their dollar funding from residents of oil-exporting states (primarily the Middle East). These same banks also rely on deposits of foreign exchange reserves by central banks in reserve-accumulating countries. Even more significant, banks' liabilities structures are intimately tied, in complex ways, to offshore financial centres: they book a significant amount of their total liabilities (roughly 15% at end-2009) in their offices *in* offshore financial centres, and their offices elsewhere report that roughly 14% of their cross-border liabilities have counterparties located in these jurisdictions.

Were any one of these sources of funding to be disrupted in some way, or migrate into a different currency, which banks would be most affected? And how would this affect these banks' lending to borrowers elsewhere? Answering these questions requires an understanding of how funding shocks are transmitted internationally – the task of fully uncovering the relationships depicted in Graph 1. This, in turn, would involve stress tests tracing an assumed initial shock through banks' disaggregated balance sheets, an analysis that would rely on a large number of behavioural assumptions. And when individual global banks consist of, literally, hundreds of separate entities across the globe, the consistent collection and compilation of the necessary data is likely to be impossible.

… might affect borrowers elsewhere …

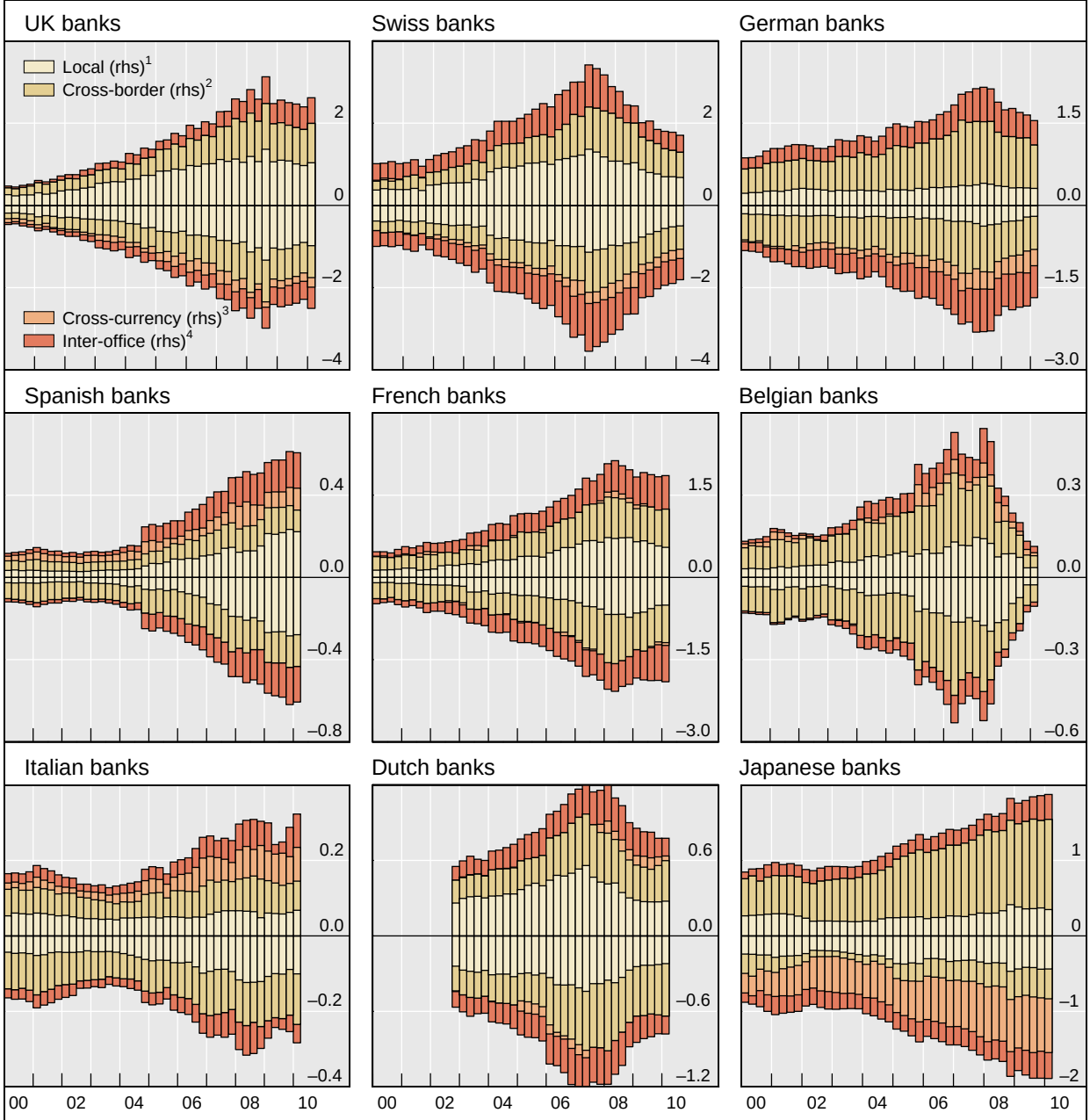
That said, even being able to determine the initial stress points in the event of a shock would help inform markets and policymakers. For example, suppose that German banks, across their worldwide operations, lend roughly equal

[12] Note that similar arguments apply to measures of banks' (on-balance sheet) leverage. As a result, information on bank capital and total assets, as already reported for the BIS consolidated banking statistics by some countries, could be combined with similar data at the office location level to construct indicators of system-wide leverage corresponding to the funding gaps depicted in Graph 3.

[13] The BIS consolidated banking statistics provide measures of country risk (assets side) for consolidated banking systems. However, given the consolidated reporting basis, they provide no information on international positions at the office location level. Moreover, these statistics provide no information on international *liabilities*. For an analysis of the transmission of shocks using these statistics see, for example, Cetorelli and Goldberg (2010). Espinosa-Vega and Sole (2010) present an analysis of interbank contagion based on the same data.

Reporting banks' US dollar foreign positions, by type

In trillions of US dollars



[1] Local positions are those booked by a bank office in a given home country vis-à-vis residents of that home country. [2] Cross-border positions are those booked by a bank office in a given jurisdiction vis-à-vis residents of other jurisdictions. [3] Cross-currency funding position implied by the balance sheet identity. [4] Cross-border positions vis-à-vis offices within the same banking group. Inter-office assets and liabilities are not always equal because of omissions and errors in the underlying data.

Sources: BIS consolidated banking statistics (ultimate risk and IB basis); BIS locational banking statistics by residency. Graph 4

amounts to residents in Brazil and Korea. If oil prices were to drop by 50%, in which of these countries would non-banks be more likely to see a reduction in credit from German (and other) banks? A first-pass estimate would simply be to look across German banks' office locations to see which one(s) booked the exposures to Brazilian and Korean non-banks, and then examine the extent to which each of these is effectively funded by petrodollars. This requires joint

reporting of bank nationality, bank location and counterparty location – data that are not currently available in sufficient detail.[14]

... is hampered by incomplete data

To get a sense of how significant this lack of geographical transparency of the location of counterparties is, consider Graph 4. It shows the US dollar book for the same set of banking systems that was presented in Graph 3.[15] Here, gross stocks of assets and liabilities are plotted by adding up the US dollar positions booked by offices in each host country, broken down in terms of the location of the counterparty. *Local positions* (light tan bars) have a counterparty resident in the host country – a known location. *Cross-border positions*, those with a counterparty outside the host country, are further broken down into inter-office positions (shaded pink bars) and those vis-à-vis non-affiliated entities (dark tan bars).[16] The location of the counterparty, essential for any indicator of geographical funding risk, is unknown for *both* of these components of cross-border positions. As a result, much more is known about the funding sources of banks with decentralised operations (eg Spanish banks), which have a large share of locally booked and funded positions, than of those banks (eg German or Swiss banks) that rely on a more centralised lending and funding model (McCauley et al (2010)).

Conclusion

This article sketches a broad framework for the assessment of system-wide bank funding risks and the transmission of shocks across countries. A key point stressed throughout the discussion is that analysing these issues requires data on banks' consolidated balance sheets that are complemented with a *geographically disaggregated dimension* of those balance sheets – one in which the *structure* of banks' global operations (on both the assets and liabilities side of the balance sheet) is visible.

While no dataset currently delivers all the detail necessary to establish such a fully geographically disaggregated view, the BIS international banking statistics turn out to have several of the desired properties. In particular, the

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[14] In the context of the BIS locational banking statistics, each reporting central bank collects cross-border asset and liability positions from resident banks, broken down by currency, counterparty sector and location (country) of counterparty. It reports to the BIS these aggregates (across bank nationalities in that location) with a complete counterparty location breakdown in the *locational banking statistics by residency* (see box). The central banks then mask the counterparty location breakdown, provide totals for cross-border positions broken down by the *nationality* of the underlying reporting entity, and report these in the *locational banking statistics by nationality* (the only source of information on the currency composition of banks' *international liabilities* on a consolidated basis). Thus, in principle, joint data on bank nationality, bank location and counterparty location are already collected from the underlying population of banks, and exist in the central banks which report to the BIS.

[15] Similar decompositions of banks' euro and Japanese yen books are also possible with the BIS banking statistics.

[16] To these three is added either a long (positive) or short (negative) implied *cross-currency* funding position (light pink bars), which depicts net borrowing of dollars from (if negative), or net provision of dollars to (if positive), the FX swap market. This estimate simply equates total observed dollar assets with observed dollar liabilities, under the assumption that the banking system has no open currency positions on its balance sheet.

underlying structure of the BIS data allows for the monitoring of consolidated banking systems' international funding and lending activities, both at the group level and by office location.

Would better data (eg enhanced counterparty breakdowns, residual maturity buckets, counterparty locations) have helped to spot the build-up of unchecked and (what turned out to be) excessive maturity transformation on bank balance sheets in the run-up to the crisis? It is difficult to say. The most honest answer is perhaps that the extent of system-wide maturity transformation in 2006, had it been possible to measure, would have simply been attributed, by supervisors and market participants alike, to better financial technology. Still, if properly constructed, data of the type described above could, in the future, be used in a two-step approach to monitoring the system-level funding risk that contributed to the recent crisis. That is, with more geographical detail on counterparties, any imbalances showing up in the aggregate data (ie banking system-office location pairs) will yield the critical pieces of information – *nationality* of entity, *location* of entity and *risk type* – to inform targeted assessments of any vulnerabilities on the basis of more granular (supervisory or other) data at the firm or market level.[17]

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[17] See Cecchetti et al (2010); Eichner et al (2010) make a similar point.

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