F.   Contagion Risks

I. Exposure Through Trade Channels [2]

Motivation

Trade vulnerability indicators are computed for each country using a two-step process. First, two measures of a given country's exposure to a downturn are constructed using data on bilateral trade flows from the IMF's Direction of Trade Statistics—one measure that captures its exposure to a downturn in countries that supply imports and another indicator that captures its exposure to a downturn in its export markets.

For example, for a particular country (j), the measure used to assess its vulnerability to a crisis in countries that country j exports to be given by:

Indicator for country j $= \dfrac{X_j}{GDP_j} \sum_i \dfrac{X_{ji}}{X_j} * P_i$

where X_j =   total exports of country j

GDP_j = GDP of country j

X_{ji} = exports from country j to country i

P_i = riskiness of country i .

Similarly, country j's vulnerability to a crisis in countries that it imports from is given by:

Indicator for country j = $\dfrac{M_j}{GDP_j} \sum_i \dfrac{M_{ji}}{M_j} * P_i$

where M_j = total imports of country j

GDP_j = GDP of country j

M_{ji} = Imports of country j from country i

P_i = riskiness of country i

- In the second step, each of these measures is multiplied by the riskiness (P_i) of import and export markets. Exposure to trade contagion is then assessed by comparing this value to the mean of the sample.

Data sources

Variables	Source
Exports	IMF's Direction of trade statistics
Imports	IMF's Direction of trade statistics
Nominal GDP	IMF's WEO

II. Cross-border Financial Sector Exposure[3]

Motivation

This tool provides a comprehensive assessment of a country's vulnerabilities arising from cross-border banking channels. The tool contributes two quantitative exercises. First, it measures risks stemming from downstream exposures (i.e., lender countries' exposures to default risk in countries that borrow from its banks) and upstream exposures (i.e., borrower countries' exposures to funding risk due to crises in its creditor countries). Second, it performs scenario analysis to capture the propagation of financial sector shocks across borders through bank losses and deleveraging.

Methodology[4]

It is possible to quantify cross-border balance sheet positions at the country-pair level using the Bank of International Settlements (BIS) bilateral banking statistics. The data reflect exposures stemming from direct cross-border lending activities, purchases of securities, and other assets of

---

[3] Contributing authors: Camelia Minoiu and Paola Ganum

[4] For further detail on methodology, see Cerutti (2015, 2013) and Cerutti et al. (2012).

internationally active banks in a number of reporting countries. BIS data also capture off balance sheet exposures owing to credit lines, guarantees, and derivatives. Some of these exposures are acquired through foreign affiliates such as branches and subsidiaries.

Downstream Exposure Analysis

Data adjustments are needed to arrive at plausible estimates of consolidated international banks' claims on residents in different countries, depending on the funding structure of their foreign affiliates. For instance, a parent bank's claims on a borrower country acquired through foreign affiliates should be limited to the capital incorporated in the affiliates plus non-equity to the affiliates (see figure). For this reason, raw BIS cross-border downstream exposures likely *overstate* true downstream exposures because they do not account for the fact that subsidiaries can partly be funded with local deposits.
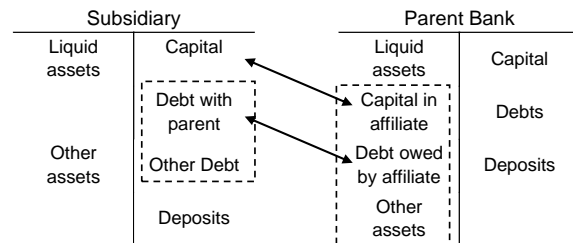
To compute a country's global downstream exposure, we add up its on and off-balance sheet exposures and account for the extent to which the subsidiaries of its internationally active banks are funded with local deposits. We define a lender country's *global downstream exposure* as:

$$\text{Downstream Exposure}_i = A_{ij} + B_{ij} + C_{ij}$$

where:

- A_{ij} captures the direct cross-border exposure of lender country i on borrower country j

- $B_{ij} = \text{local claims}_{ij} - \text{deposits}_{ij}^{subs}$ captures the exposure of lender country i on borrower country j through its foreign affiliates (e.g., subsidiaries and branches) after removing subsidiaries' deposits

- $C_{ij} = \text{derivatives}_{ij} + \text{guarantees}_{ij} + \text{credit commitments}_{ij}$ captures off-balance sheet exposures of lender country i on borrower country j

Global downstream exposures for lender countries, coupled with estimated crisis probabilities in borrower countries (produced by VEA and VEE) and loss-given default estimates (LGD), are then used to calculate potential expected losses. The *downstream exposure indicator* (D_i) of lender country i expresses potential expected losses as a share of GDP or total banking sector assets as follows:

$$D_i = \sum_{j=1}^{N} \frac{A_{ij} + B_{ij} + C_{ij}}{Z_i} \square V_j$$

where Z_i is a scaling factor such as GDP, domestic banks' Tier I capital, or total banking sector assets in lender country i; and $V_j = \left(\text{Probability of crisis}\right)_j \times LGD_j$ is the riskiness of borrower country j times the LGD the same country.[5]

Upstream Exposure Analysis

Upstream exposures capture, from a borrower country's perspective, potential funding and rollover risks owing to cross-border debt to banks in lender countries. This measure, too, accounts for the extent to which foreign affiliates in borrower countries are funded by parent banks in creditor countries. The *global upstream exposure* of borrower country j is defined as:

$$\text{Upstream exposure}_j = \text{Cross-border claims}_{ij} + \text{Local claims}_{ij} \times \left(1 - \min\left(\frac{\text{Deposits}}{\text{Loans}_{ij}}, 1\right)\right)$$

where:

- $\text{Cross-border claims}_{ij}$ represent the direct cross-border claims of lender country i on borrower country j

- Local claims_{ij} represent the claims of foreign affiliates of parent banks from lender country i on borrower country j

- $1 - \min\left(\frac{\text{Deposits}}{\text{Loans}_{ij}}, 1\right)$ is a proxy for the proportion of foreign affiliates' loans that are not funded with local deposits. The higher is the deposit-to-loan ratio, the lower is the share of non-deposit funded local claims. As in the downstream analysis, lending by foreign affiliates that is funded by parent banks, for instance through credit lines, cannot be measured directly since available bank-level balance sheet data from Bankscope is not sufficiently detailed.[6]

---

[5] The loss given default ratio is applied to banks' non-liquid assets (defined as total assets minus liquid assets) in the calculation of lenders' exposures to their foreign affiliates.

[6] Borrower country national deposit to loan ratio is used when foreign affiliate bank-level data is unavailable to ensure the largest country coverage possible. Using instead foreign affiliates' total assets minus deposits as a measure of affiliates' loan claims funded by their parent banks, as in the calculation of downstream exposures, yields similar results, but such a calculation is more limited in terms of country coverage.

The *upstream exposure indicator* (U_j) is given by:

$$U_j = \sum_{i=1}^{N} \frac{\text{Upstream exposure}_j}{Z_j} \times \left(\text{Probability of crisis}\right)_i$$

where Z_j is a scaling factor (such as GDP or bank credit to the non-bank private and public sectors in borrower country j); and *(Probability of crisis)$_i$* is the riskiness of lender country i.

Scenario Analysis

The module allows us to gauge foreign credit availability to borrower countries based on assumptions regarding defaults in certain economic sectors of an individual lender country or group of countries. Consider, for instance, a shock to a particular sector in one or more countries that involves losses on the foreign assets of banks from a lender country. If capital buffers are not sufficiently large to meet a minimum Tier 1 capital ratio (assumed in most simulations to be at least 8 percent), and if there are no bank recapitalizations, then banks need to deleverage to restore capital.

The process of deleveraging leads global banks to shrink their loan books either directly, because they experience losses on their assets, or indirectly, because they experience a funding shock to the extent that they borrowed from deleveraging banks. If the funding shock itself triggers fire sales, banks will experience further losses, triggering additional deleveraging. The process of deleveraging leads to a reduction in foreign credit, impacting economic activity in borrower countries. The system converges to a steady state when no further deleveraging takes place (i.e. all banks meet their capital adequacy requirement).

Data sources

Most of the data used in the module represent BIS bilateral banking statistics that are consolidated on an ultimate risk basis, at the banking system level and on a quarterly basis (see McGuire and Wooldridge (2005) for details on the BIS consolidated banking statistics). These data are supplemented by BIS locational (residency-based) banking statistics also on a quarterly basis. Most data are confidential. The module makes use of macroeconomic data from the International Financial Statistics (IFS) and additional banking data collected from central banks, supervisory agencies, and Bankers Almanac, as well as bank-level balance sheet data from Bankscope, which is available on an annual basis. The table below reports the main variables and sources.

The analysis is carried out for 28 BIS "reporting" countries, which report bilateral positions for their internationally active banks, vis-à-vis more than 200 countries. In the scenario analysis, losses can be simulated on the balance sheets of economies from the reporting sample.

Variable	Unit of observation	Source
Consolidated foreign claims of reporting banking systems	Country	BIS
Consolidated cross border claims of reporting banking systems	Country	BIS
Consolidated foreign affiliate claims of reporting banking systems	Country	BIS
Derivatives, guarantees and credit commitments of consolidated banking system for domestically-owned banks	Country	BIS
Tier 1 capital of consolidated banking system for domestically-owned banks	Country	ECB Banking Supervision Committee
Assets of consolidated banking system for domestically-owned banks	Country	ECB Banking Supervision Committee
Deposits of consolidated banking system	Country	IFS
Credit to consolidated banking system	Country	IFS
GDP	Country	WEO
Loss given default ratios (LGD)	Country	World Bank Doing Business
Crisis probabilities	Country	IMF Vulnerability Assesment Exercises (SPR, RES)
Bank-level Tier 1 capital	Bank	Bankscope
Bank-level assets	Bank	Bankscope
Bank-level Total Customer Deposits	Bank	Bankscope
Bank-level Net Loans	Bank	Bankscope

References

Cerutti, E., 2015, "Drivers of cross border banking exposures during the crisis," *Journal of Banking and Finance*, Vol. 55, pp. 340–357.

Cerutti, E., 2013, "Bank's foreign credit exposures and borrowers' rollover risks: Measurement, evolution, and determinants," IMF Working Paper No. 13/9 (Washington, DC: International Monetary Fund).

Cerutti, E., Claessens, S. and P. McGuire, 2012, "Systemic risks in global banking: What available data can tell us and what more data are needed?", NBER Working Paper No. 18531 (Cambridge, MA: National Bureau of Economic Research).

III. Financial Sector exposure to vulnerable EMs[7]

Motivation

The main objective of this tool is to capture advanced economies' (AE) exposure to emerging markets (EMs) through the bank balance sheet channel. Crisis in EMs could reduce quality or trigger default on their banks' external liabilities to AE banks. Hence, an exposure indicator to EMs through banks' balance sheet channel is developed as follows.

---

[7] Contributing authors: Camelia Minoiu and Paola Ganum

Variable	Unit of observation	Source
Consolidated foreign claims of reporting banking systems	Country	BIS
Consolidated cross border claims of reporting banking systems	Country	BIS
Consolidated foreign affiliate claims of reporting banking systems	Country	BIS
Derivatives, guarantees and credit commitments of consolidated banking system for domestically-owned banks	Country	BIS
Tier 1 capital of consolidated banking system for domestically-owned banks	Country	ECB Banking Supervision Committee
Assets of consolidated banking system for domestically-owned banks	Country	ECB Banking Supervision Committee
Deposits of consolidated banking system	Country	IFS
Credit to consolidated banking system	Country	IFS
GDP	Country	WEO
Loss given default ratios (LGD)	Country	World Bank Doing Business
Crisis probabilities	Country	IMF Vulnerability Assesment Exercises (SPR, RES)
Bank-level Tier 1 capital	Bank	Bankscope
Bank-level assets	Bank	Bankscope
Bank-level Total Customer Deposits	Bank	Bankscope
Bank-level Net Loans	Bank	Bankscope

Methodology

Bilateral exposure between AM and EM banking system is based on bilateral claims reported in the BIS consolidated database. It is then weighted by EMs' riskiness, Final exposure to all the EMs is the sum of all the risk-weighted bilateral exposure of individual AM-EM pair.

Data sources

The consolidated Banking Statistics of the Bank for International Settlements and the IMF International Financial Statistics for country aggregate data. The BIS data is at a quarterly frequency.

References

McGuire, P. and P. Wooldridge, 2005, "The BIS consolidated banking statistics: Structure, uses, and recent enhancements," *BIS Quarterly Review*, September, pp. 73–86.