WP/13/199

IMF Working Paper

Addressing Interconnectedness: Concepts and Prudential Tools

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INTERNATIONAL MONETARY FUND

 WP/13/199

IMF Working Paper

Monetary and Capital Markets Department

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Authorized for distribution by Michaela Erbenova

September 2013

Abstract

This paper reviews tools used to identify and measure interconnectedness and raises the awareness of policymakers as to potential cross-sectional implications of prudential tools aimed at controlling interconnectedness. The paper examines two sets of tools—developed at the IMF and externally—to identify the implications of interconnectedness in systemic risk and how these tools have been applied in IMF surveillance. The paper then proposes a preliminary framework to analyze some key internationally-agreed-upon and national prudential tools and finds that while many prudential tools are effective in reducing interconnectedness, the interaction among these tools is far less clear cut.

JEL Classification Numbers: G20, G21, G22, G23 G28, C38, C45

Keywords: Interconnectedness; network analysis; prudential tools; policymakers; systemic riskAuthor's E-Mail Address:jscarlata@imf.org

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I. Introduction[1]

The financial crisis raised awareness of the need to improve the analysis and management of the factors underlying financial contagion and risk concentration, i.e., interconnectedness. While the research surrounding the modeling of interconnectedness had been ongoing, the financial crisis saw a surge in the attention and resources it garnered. Although microprudential tools to control concentration and exposure limits had long since been an accepted supervisory tool in the banking sector, there has been no explicit international standard on concentration risk, and even large exposure limits have not been fully addressed. In recent years, international standard setters have turned their attention to developing new tools to address complex linkages. These tools have been augmented by efforts of national authorities to deal with their own domestic problems of interconnectedness. Consequently, there is now a range of regulatory instruments that confronts interconnectedness in the banking sector, OTC derivatives, insurance, and the realm of systemically important financial institutions.

Two sets of tools (developed in-house or externally) are reviewed here that have been actively used at the IMF after the global financial crisis to identify the interconnectedness dimension of systemic risk; namely network analysis, and price-based measures. Network analysis is used to identify interconnectedness risk. Price-based measures cover both direct and indirect spillover channels. These sets of tools can aid macro stress testing exercises in measuring concentration risks.

From the understanding developed in existing models, some of the key prudential tools aimed at interconnectedness are examined and the paper takes a first step at analyzing how these tools might interact with each other—either as complements or at odds—as well as their impact on dealing with contagion and risk concentration. Tools include those involving capital and liquidity requirements, as well as structural frameworks for banks' business models, the clearing of OTC derivatives, and resolution of systemically important financial institutions. The paper proposes a simple framework for reviewing the tradeoffs a policy maker should take into account when considering the potential consequences of these tools. As these tools are in a stage of infancy—many not yet implemented and some still in development—the assessments made are very much preliminary and based on qualitative assumptions, as no empirical evidence is yet available.

The paper examines models used in the analysis of systemic risk and their potential application in policy formulation by assessing the models' strengths and weaknesses, their usefulness in actual policymaking, and the complementarity or conflict amongst those prudential tools developed to contain cross sectional risk. The paper begins with a

[1] The authors are grateful to staff of MCM's Financial Supervision and Regulation Division, Marco Espinosa, Sonia Munoz and Jacek Osinski for their valuable insight and comments.

review of some of the key analytical tools used at the Fund to analyze risk and interconnectedness. It presents how they have been used—in FSAPs, spillover reports, the GFSR, and Article IV reports—as well as how they may contribute to policy-making. The paper then reviews some of the more prominent prudential tools being proposed, and then follows with an analysis of how these tools interact with each other and with their intended effects on contagion and risk concentration. The paper concludes with policy considerations and the use of this framework for future work.

II. THE ROLE OF INTERCONNECTEDNESS ANALYSIS IN ADDRESSING SYSTEMIC RISK

The importance of financial interconnectedness for financial stability has been illustrated rather dramatically during the recent global financial crisis. Indeed, there is a growing consensus that the size of an institution alone is not the only (or even the main) consideration in assessing spillover risk.[2] Identification of systemically important institutions also requires an assessment of the nature and extent of their interconnectedness. Interconnectedness arises from actual—and perceived—complex webs of contract relationships across financial institutions.

Financial interconnectedness could have opposing effects on financial stability. On the one hand, linkages may act as channels to propagate shocks to the whole system, that is, they act as "shock transmitters." On the other hand, through these linkages, shocks can be shared and absorbed by others, that is, financial linkages may act as "shock absorbers." Policymakers are, of course, most concerned with the downside of interconnectedness.

Systemic (or spillover) risk arises when the failure or weakness of one or multiple financial institutions or infrastructures disrupts financial services and imposes costs on the economy as a whole. The failure or weakness of multiple financial institutions may arise through a variety of mechanisms.[3] Direct bilateral exposures across institutions are the most direct transmission mechanisms of shocks within a financial network. However, indirect linkages may arise from exposure to common risk factors such as the adoption of similar business models, common accounting practices across financial institutions, the market perception of financial institutions' coincidence of fortunes, and other factors like fire sales and informational contagion that might be as important as direct exposures.[4]

[2] BIS, 2011; Arsov and others 2012; Cont and others 2012.

[3] According to Nier and others 2007, the failure or weakness of multiple financial institutions at the same time arises through four main mechanisms: (i) direct bilateral exposures between institutions; (ii) correlated exposures of financial institutions to a common source of risk; (iii) feedback effects from endogenous fire-sale of assets by distressed institutions; and (iv) informational contagion.

[4] Scott and the Committee on Capital Markets Regulation 2012 argue that asset and liability interconnectedness were not the main drivers of the systemic risk concerns during the recent financial crisis in the United States, but that contagion was at the front and center.

What is the optimal level of interconnectedness? Highly stylized analytical work such as that of Allen and Gale (2000) shows that complete networks of financial intermediaries (in which every intermediary is connected to the rest of the network)[i] are more stable than "incomplete" networks, where not all intermediaries are connected to the rest of the network.[5] The intuition is that in a complete network the system relies less heavily on individual nodes of the network (because there are more nodes), making it less likely that the failure of a node will cause the network to fail. However, in reality, complete networks are not observed, which complicates the assessment of the optimal level of interconnectedness. Although there has been important empirical work on the topology of banking networks, e.g., Hattori and Suda (2001), empirical work relating to the degree of interconnectedness and financial stability remains limited. As a notable exception, Čihák, Muñoz, and Scuzzarella (2011) combine data on banking crises around the world with a data set on crossborder financial linkages. They find that in banking systems that are not very connected to the global banking network, increases in interconnectedness tend to be associated with increased financial stability. Once the degree of interconnectedness reaches a certain value,[6] further increases in interconnectedness do not improve financial stability and can in fact increase fragility.[7]

Because existing models are not able to assess whether interconnectedness is excessive in practice, policy efforts to address the cross-sectional dimension of systemic risk have focused on the identification of SIFIs and the mitigation of their systemic contribution. For instance, the BCBS has developed an assessment methodology for global systemically important banks (G-SIBs) based on an indicator-based measurement approach instead of a model-based approach.[8] Current analytical tools cannot replace qualitative assessments but can contribute to meet the objectives of identification and mitigation in at least three important ways.[9] Firstly, understanding the financial network and contagion channels and

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[5] Freixas and others (2000) show the possibility for contagion in a system with money-centre banks, where the institutions on the periphery are linked to banks at the centre but not to each other, crucially depends on the precise values of the model's parameters. Battiston and others (2010) show that connectivity and stability of a network is not a simple monotonic relationship but that, beyond a point, connectivity in a network could increase instability.

[6] The authors estimate this point to be at about the 95th percentile of their distribution of countries in terms of interconnectedness, when upstream interconnectedness is 0.37. Below this threshold, upstream interconnectedness reduces the probability of a banking crisis. When upstream interconnectedness is above 0.37 (the remaining 5 percent), the relationship between interconnectedness and crisis probability is more complex: it is upward-sloping at first, only to become downward-sloping again.

[7] Nier and others (2007)

[8] Selected indicators are chosen to reflect the size of banks, their interconnectedness, the lack of readily available substitutes for the service they provide, their global (cross-jurisdictional) activity and their complexity.

[9] The indicator-based measurement approach has the advantage that it is relatively simple and it encompasses many dimensions of systemic importance that may not be fully captured by certain models.

ranking the systemic risk contribution of different institutions help regulators decide on the perimeter and intensity of financial individual and systemic oversight. Secondly, using tools like network models and market-based measures has strengthened our conventional stress test analysis. Finally, measuring the contribution to systemic risk by individual institutions provides a natural basis for applying systemic risk surcharges.

A. Analytical Tools to Assess Interconnectedness and Concentration

Two sets of tools actively used to identify systemic risk in the cross-sectional dimension are network analysis and market-based indicators. They have been developed at the IMF and externally in the wake of the current crisis and are classified according to their main data requirements, i.e., balance sheets or market data. These tools have been deployed recently in the context of Article IV consultations, FSAPs, and stability reports (Box 1).

Understanding the architecture of financial interconnectedness is a step toward both better analyzing the transmittal and spillovers of shocks and assessing how the (domestic or global) system could be made more resilient to shocks. Network[10] analysis allows for the identification of core elements of such architecture, thus providing elements for visual and analytical representation of exposures and facilitating the assessment of risk transmission (or absorption) of shocks. The analysis requires, as a starting point, the measurement of exposures among financial institutions. The kind of claims or exposures to be covered usually depends on the purpose of the analysis. Data availability is sometimes a constraint that limits the analysis (Appendix 1). Three main tools for network analysis are used within the IMF and externally: centrality analysis, cluster analysis, and balance sheet simulation methods (Table 1 and Appendix 2).

Market-based measures of systemic risk rely on asset prices (such as stocks, bonds, and derivatives) to estimate distress dependence among financial institutions. Distress dependence is based on the fact that financial institutions are linked both directly and indirectly through a variety of channels. Methodologies developed for the measurement of risk in portfolios of securities have been adapted to the measurement of systemic risk for a "portfolio" of institutions. In this context, the methodologies have been enhanced to identify common risk factors, track how distress in one institution may affect others, and measure the contributions of individual institutions to system-wide risks. A variety of market-based tools are currently used at the IMF (Table 2 and Appendix III).

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[10] A financial network is a set of bilateral claims (links) among different financial institutions (nodes).

Table 1. Tools for Network Analysis

Centrality analysis	Centrality analysis infers from the pattern of linkages among financial institutions the extent to which a node is "central" in the financial network. Several indicators of interconnectedness, or "centrality," are used to quantify the relative importance of each financial institution in a financial network.[11]
Cluster analysis	Cluster analysis separates the network into subgroups ("clusters") of nodes that have closer connections to each other than with those outside the cluster. It can help identify subgroups of nodes with close connections and "gatekeeper" institutions or systems that bridge across different clusters allowing for the contagion to spread out.
Balance sheet simulation methods	Balance-sheet simulation methods use simple balance-sheet identities to trace the effect of difficulties at an individual bank or banking sector through a combination of data and assumptions. Balance-sheet simulation methods complement the basic mechanisms of shock transmission (via lending exposures) with the mechanisms for absorption (via bank net worth). The systemic importance of an institution is quantified by assuming its hypothetical failure and simulating the imposed losses on each other institution in the network.

[11] In addition to the local measures that quantify the relative importance for each node in the network, there are global measures intended to characterize the network as a whole.

Box 1. Use of Interconnectedness Analysis by the IMF

Surveillance tools like network analysis and market-based indicators have been actively deployed in the context of IMF Article IV consultations, FSAPs, Early Warning Exercises and spillover reports to assess interconnectedness and the systemic risk contribution of individual institutions, as well as quantify contagion.

- *Centrality Analysis* - Within IMF work, centrality analysis contributed to the identification of jurisdictions with systemically important financial sectors, which were assigned mandatory financial stability assessments on a regular basis. Network analyses using institutional-level data are usually conducted by country supervisory authorities, given the confidentiality of data. As such, measures of centrality at the institutional level are usually not disclosed. Some supervisors disclose global measures intended to characterize the network as a whole.[12, 13] In the context of FSAPs, information on size and interconnectedness of individual financial institutions is used to assess systemic importance. For example, a recent FSAP to Australia called for a special risk mitigation arrangement for a set of systemically important banks (Australia FSAP 2012).

- *Cluster Analysis* - IMF analysis identified a Nordic-Baltic financial cluster. Strong connections from the Nordic economies (gatekeepers) to the Baltics implied a key role of the former in providing funds to the latter in the run up to the crisis. During the crisis, policy actions in "gatekeeper" countries — including strengthening banks—helped limit bank deleveraging and negative output effects in the regional cluster.

- *Balance Sheet Simulation Methods* –This methodology is most frequently applied to the exposures of individual banks within a particular banking system, especially by national regulatory organizations. In the context of FSAPs, some teams have worked with the local authorities to include such analysis in the assessment (e.g., India 2011, Brazil 2012). In recent years, the IMF has increasingly applied this methodology to the global banking network, taking the banking sector in a country as the unit of analysis. This analysis has been increasingly adopted in FSAPs and Spillover Reports.

- *Market-based indicators* – These indicators have been actively used for bilateral and multilateral surveillance at the IMF in recent years. In terms of bilateral surveillance, price-based measures have been used mostly as early-warning indicators or to quantify systemic risk contribution by individual institutions (Table 2). Additionally, the JPod/CoPod and Systemic CCA models provide estimates of probabilities of default and expected shortfall (or loss) during tail events, and therefore, have been used in the context of stress testing. In terms of multilateral surveillance, price-based measures have been used for the identification of regional and global systemically important financial institutions.

[12] For example, the Reserve Bank of India computes a connectivity statistic, a cluster coefficient and the average path length both for the domestic Indian interbank network and for the domestic financial network.

[13] Cihak and others. (2011) and Minoiu and Reyes (2011) compute measures of country centrality and network density (connectivity and clustering) for cross-border interbank linkages using BIS locational data. Hattori and Suda (2007) also study the characteristics of the cross-border bank network topology and find that it has become tightly connected over time.

Table 2. Main Market-Based Measures Used at the IMF

CoVaR	The CoVaR is defined as the VaR (i.e., risk indicator that measures the potential loss in value of a risky portfolio over a defined period for a given confidence interval used by financial institutions) for an institution 'i' conditional on the financial situation of another institution 'j.' The difference between the CoVaR conditional on distress of an institution 'j' and the CoVaR conditional on the "normal" state of institution 'j,' ΔCoVaR, captures the marginal contribution of institution 'j' to risk in institution 'i.'
Returns spillovers	The return spillover indicator is based on the fraction of the N-step-ahead error variance in forecasting the returns to one institution that is attributable to shocks to each other institution.
Distress spillovers	The distress spillover indicator uses market data on returns to date "extreme events," The probability of an extreme event happening for an institution is estimated conditional on extreme events happening or not for other institutions, after controlling for real and financial developments in the home country and in global markets.
JPod/CoPoD	The JPoD/CoPod methodology estimates the multivariate distribution of asset returns for all financial institutions, based on estimates of their individual probability of distress extracted from high frequency market prices. Having obtained this joint probability distribution of distress across a number of institutions, it is possible to then "slice" this multivariate distribution to estimate different measures of distress dependence including a matrix of dependence.
Systemic CCA	The systemic CCA uses option pricing theory for individual institutions and estimates a multivariate distribution to derive a market-implied measure of systemic risk based on estimates of joint expected losses. This multivariate conditional tail expectation, by applying a multivariate density, allows quantifying the contribution of each individual institution to systemic risk.

B. Use of Analytical Tools, their Complementary Nature, and Limitations

Centrality and cluster analysis allow for an initial characterization of a financial network's architecture and contribute to the identification of systems in need of heightened surveillance. Centrality and clustering are descriptive and "behavior-risk neutral," that is, they make no assumption about the underlying economic behavior that gives rise to the observed interconnections. The descriptive analysis must be complemented by delving deeper into the functional characteristics and understanding the economics underpinning each cluster.[14] Being less data-intensive than balance-sheet simulation methods,

[14] Understanding the economic characteristics of a cluster is crucial, as cluster identification is not as readily interpretable as the output of centrality measures and balance-sheet simulation models.

these tools are useful in a first stage to define the perimeter and intensity of surveillance (including stress testing).[15]

Balance-sheet simulation methods complement the analysis by incorporating not only the role of exposures across the network but also the important role of financial capital buffers. An institution highly interconnected with well capitalized institutions poses very different risks than one highly interconnected with poorly capitalized institutions. In addition, balance-sheet simulations can incorporate and track the implications of liquidity events.

While network analysis focuses on direct bilateral exposures between institutions, some price-based measures cover also indirect spillover channels. They enable the tracking of how distress in one institution may affect others. However, price measures fail to identify the specific channels or mechanisms for contagion at play, only reflecting comovements in risks as they are priced in by the markets.

Market-based methodologies can be implemented using data publicly available on a high-frequency basis, limiting the need to rely on detailed supervisory data (which is usually confidential). Market-based measures are forward-looking, reflecting investors' assessment of the financial health of a specific institution and the domestic and global developments that would affect its prospects**.** Thus, potentially, they can be used to guide policy actions to contain risk. However, when a large fraction of the financial sector is not publicly traded or stock price data are not reliable due to thin trading or reporting issues, the use of market-based measures in not an option. Additionally, the investor or market's perception of risk may not always reveal the true default probability of a bank. For instance, as experienced during the global financial crisis, markets did not price in default of major financial institutions such as the Lehman Brothers.

These measures help rank relative contributions to systemic risk, but have a short horizon for the early warning of distress.[16] Arsov and others (2012) analyze the early warning capacity of different price-based indicators. In general, methodologies relying on market data suffer from the limitation that market perceptions can vary greatly between normal and crisis times. As a result, the early warning capacity of these indicators is, at best, a few months ahead of the actual crisis events.[17]

How these tools work in conjunction also warrants further examination. Centrality and cluster analysis, balance-sheet (domino) simulations, and market-based measures could complement each other, but have mostly been used separately. For example, as mentioned earlier, centrality and cluster analysis could be deployed to help define the

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[15] IMF 2012 makes use of centrality and cluster analysis. Markose 2012, RBI 2011/10, Muller 2006 and Upper and Worms 2002 use both centrality analysis and balance-sheet simulation methods.

[16] The authors refer to these as "near coincident" indicators.

perimeter of surveillance. Then, domino analysis could be deployed to extract contagion and vulnerability indicators. Finally, and when relevant market data were available, the results of the domino analysis could be contrasted with those of the market-based analysis. The use of these methods is relatively new at the Fund and, as the synergies of these methodologies become apparent, their sequential use should become more widely spread.

Also, given the confidentiality of domestic financial network studies, almost no empirical work has been done to study the relationship between network and price-based measures. As a notable exception, Aydin and others (2011) compute both types of indicators for domestic banks in Korea, but do not show how the identified relative systemic importance of each institution compares under both methodologies.

In spite of the recent advances in measuring the cross-sectional dimension of systemic risk, several weaknesses remain. Firstly, a variety of contagion channels can lead to financial stability, but the available set of tools does a better job capturing direct than indirect channels. Network analysis focuses on direct channels. Some price-based measures capture both, but fail to identify the specific channels conducting to stress dependence between institutions. Moreover, they are based on market perceptions, which may not always reflect underlying fundamentals. Secondly, the early warning capacity of the current toolkit is not strong, possibly leaving policymakers with a limited window for action.

C. Analysis of Interconnectedness and Policymaking

The analysis described in the previous section has laid the ground for the enhancement of the standard stress-testing analysis focused on the resilience of individual financial institutions to shocks. A shortcoming of traditional approaches to stress testing is that they ignore the interdependence among shocks and among affected institutions or systems (IMF 2012). By explicitly tracking possible contagion and distress dispersion across financial institutions or sectors, these analyses provide the foundation for systemic-focused stress testing.

In some cases, the network analysis and market-based tools discussed above have been proposed as a guide to calibrate macroprudential tools to mitigate systemic risks. Measuring the contribution to systemic risk (the negative externality) of individual institutions provides a natural basis for the assessment of required levels of systemic-risk-based capital surcharges.[18] For instance, Brunnermeier and others (2009) and Chan-Lau (2010) propose capital surcharges based on contributions to systemic risk derived from

[18] Cont and others (2012) argue that targeting capital requirements to the most contagious institutions is more effective in reducing systemic risk than increasing capital ratios uniformly across all institutions. Also, capital requirements should not simply focus on the aggregate size of the balance sheet but depend on their concentration/distribution across counterparties.

CoVaR and CoRisk, respectively. Espinosa-Vega and Sole (2010) propose capital surcharges based on their balance-sheet simulation model. Markose (2012) proposes a "super-spreader" tax based on centrality analysis to raise a fund that would mitigate potential socialized losses from the failure of highly connected banks (Table 3).

Table 3. Comparison of Some Methodologies to Compute Systemic-Risk-Based Charges

Main data requirements	Examples	Pros	Cons
Market prices	Brunnermeier and others (2009) Chan-Lau (2010)	Based on publicly available, high-frequency data. Potentially captures channels other than direct exposures	Data may be unreliable under tail events and/or not representative of underlying fundamentals during stress periods
Bilateral exposures	Espinosa-Vega and Solé (2010) Markose (2012)	Data is reliable and reflects fundamentals even during stress periods	Intensive data requirements

Predicting the timing and severity of a systemic event will continue to be an uphill battle. This toolkit of methodologies provides policymakers with much needed help in this quest. While the toolkit should be considered as work in progress, any promising contribution in the detection and regulation of interconnectedness and systemic risk warrants close scrutiny.

III. Prudential Tools and Interconnectedness

A. Cross-Sectional Prudential Tools: A Recent Review

As the aforementioned methodologies for determining degrees of interconnectedness have not yet been introduced to regulatory policymaking, practical options have been the identification of SIFIs in national stress tests, with relevant bank-specific policy actions, and the broader application of prudential measures. An example of the former is the U.S. Supervisory Capital Assessment Program (SCAP) framework that is utilized with systemically important institutions and that applies existing tools and policy measures to relevant financial institutions. But in addition to the conceptual modeling approaches to identify, measure, and monitor systemic risk, systemic risk identification and monitoring should also encompass evidence and information from supervisory judgment and on-site and off-site analyses. Prudential tools complement the analytical models by identifying key variables that indicate levels of contagion and concentration, and that establish enforceable limits to control financial institutions' exposures and linkages The prudential tools examined here are some of the most clearly designed to address interconnectedness: microprudential exposure limits, capital charges—particularly for systemically important financial institutions (SIFIs), liquidity regulation and limits on liquidity mismatches, clearing of OTC derivatives on a central counterparty (CCP), structural limits on activities, resolution frameworks, and insurance.

Microprudential exposure limits

Microprudential exposure limits are normally designed as nonrisk sensitive backstops to limit concentration from a microprudential perspective, but they are also relevant from a macroprudential point of view.[19] Rules on exposure limits have long been generally accepted principles and were broadly defined internationally, but it is not until recently that the Basel Committee decided to review the framework and establish an internationally agreed-upon standard.[20] Nevertheless, almost all supervisors have set prudential limits to restrict bank exposures to single counterparties or groups of connected counterparties.[21] Normally, exposures representing ten percent or more of a bank's capital are defined as a large exposure; and twenty-five percent of a bank's capital is the limit for an individual large exposure to a private sector nonbank counterparty or a group of connected counterparties. However, deviations from these limits are frequent and exceptions abound. Exposures arising from off-balance sheet as well as on-balance sheet items and from contingent liabilities should be captured. However, further work is needed on the method for calculating exposures (e.g., taking into account risk mitigation, how to calculate limits for off-balance sheet items, etc.), restrictions on a bank's exposure to other financial institutions (FI), specific intra-group limits for G-SIFIs, and aggregate limits across all exposures to FIs. Also, supervisors are expected to review sectoral, geographical, and currency concentrations in bank portfolios in consideration of Pillar 2 capital add-ons. The relevance that these prudential requirements have in containing systemic risk deriving from interconnectedness is clear, as they represent hard limits.

Capital buffers

The capital requirements in Basel I or Basel II did not contain measures to address concentration or systemic risk. The capital framework required the same minimum capital requirement for all (internationally active) banks, regardless of their systemic importance. In terms of risk weights attached to assets, concentration risk was not incorporated. As noted, Basel II expected that concentration risk should be taken into account under the Pillar 2 framework. However, this was dealt with differently across jurisdictions, as no quantitative guidelines were provided. There was criticism of the treatment of capital requirements on instruments such as sovereign bonds, instruments with high credit ratings, and securitized products under Basel II, whose risk weights are determined by their external credit ratings. Even risk weights of traditional loans under the standardized approach of Basel II is determined by external credit ratings, and the global financial crisis showed relative lack of

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[19] An exception to nonrisk sensitive microprudential exposure limits arises in the EU, where large exposure limits, in particular, are allowed to be risk-weighted.

[20] A draft proposal by the BCB, "Supervisory framework for measuring and controlling large exposures," (March 2013) is examining new prudential measures on concentration.

[21] Foreign exchange open position limits are additional regulations on exposure.

robustness in high credit ratings for securitized products. However, there was sufficient flexibility within the Basel II rules for jurisdictions to adopt above-minimum capital ratios and/or higher risk weights for assets (for specific sectors) that would have tackled concentration or contagion risks.

Basel III minimum capital rules, in contrast, were formulated with explicit consideration for concentration and systemic risk. The agreed-upon Basel III framework explicitly states that "addressing systemic risk and interconnectedness" is one of its objectives. Some new features have been imbedded in the calculation of capital requirements themselves, such as capital incentives for using CCPs for OTC derivatives clearing, higher capital requirements for trading and derivative activities, and higher capital requirements for intrafinancial sector exposures. These new requirements are intended to reduce the level of bilateral trading (sometimes uncollateralized) among financial institutions, thereby reducing interconnectedness within the financial sector.[22]

A prominent feature of Basel III introduced to address systemic risk is the G-SIB (global systemically important banks) framework.[23] The framework requires additional loss absorbency (as common equity capital surcharge) for larger and more interconnected global banks. The Basel Committee expects that this framework will provide incentives for global banks to be smaller and less interconnected. This is not a hard limit, but part of the conservation buffer, where breaches will only trigger limitations to the allocation of profits. Surcharges are price-based measures (rather than quantity tools) that act as a levy or a Pigouvian-type tax, which is less costly (lower adjustment costs for banks) to be changed by a macroprudential authority. The ultimate aim of such capital surcharges would be to incentivize banks to hold larger capital buffers and reduce reliance on taxpayer support. There also would be national frameworks for D-SIB (domestic systemically important banks), where national supervisors might set capital surcharges for banks that are not G-SIBs, but still are systemically important for that jurisdiction.[24]

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[22] In addition, in the IRB formula, a multiplier introduced to the correlation parameter of all exposures to large financial institutions (whose total assets are larger than US$100 billion) meant also to tackle concentration risks and contagion.

[23] There are also some aspects in Basel III that address systemic risk and interconnectedness. These include capital incentives for using central counter parties for OTC derivatives, higher capital requirements for trading and derivative activities, and higher capital requirements for intrafinancial-sector exposures. These new requirements are intended to reduce the level of bilateral trading (sometimes uncollateralized) among financial institutions, thereby reducing interconnectedness within the financial sector.

[24] It is important to note that capital surcharge is only one part of the multipronged approach of SIB frameworks. The frameworks also require intensive and intrusive supervision and effective resolution mechanisms.

Liquidity regulation and limits on liquidity mismatches

Unlike the capital adequacy ratio, there was no global liquidity requirement before Basel III. While some countries used quantitative indicators to monitor bank liquidity risk, in many advanced countries those indicators were not enforced as strict rules.[25] The crisis raised the concern that the lack of liquidity requirements has contributed to some banks' high reliance on central-bank funding (as a lender of first resort) and short-term funding from other financial institutions. This, in turn, increased interconnectedness among financial institutions and concentrations in short-term wholesale funding risks in the run-up to the global financial crisis. The lack of information regarding banks' balance sheet exposures and, specifically, banks' reliance on inter-bank and other wholesale markets for liquidity contributed to the sudden dry-up in these markets after the collapse of some major financial institutions aggravated the impact of the crisis. The situation was further exacerbated by a lack of clarity about the role of central banks and governments in supporting large FIs.

Box 2. Insurance and Interconnectedness

Cross-sectional prudential rules to tackle interconnectedness and risk concentrations in the insurance sector are at a nascent stage. Prior to the crisis, many of the prudential tools tackling interconnections and risk concentrations in the insurance sector were microprudential in focus, with limits placed on single exposures and asset classes. The limits are expressed as percentages of the invested assets. Usually these limits only apply to assets allowed to set up the technical reserves and capital, insurers can hold non qualified assets beyond the limits. More advanced regimes have tended to apply the prudent man concept. Post-crisis, the FSB working through the International Association of Insurance Supervisors (IAIS) is addressing the issue of systemic risk by identifying global systemically important insurers (G-SIIs). The proposed IAIS policy measures for G-SIIs focus on systemic risk reduction plans (SRRPs), including prohibitions or strong disincentives for insurers to be G-SIIs.

In addition, capital surcharges similar to those for G-SIBs are also under discussion. The methodology is indicator-based, where the selected indicators can be grouped into five categories: size, global activity, interconnectedness, nontraditional and non-insurance activities (NTNI), and substitutability. In developing the methodology, consideration was given to the fact that the traditional insurance business model is different from banking and, in particular, that traditional business does not involve a payment system, credit intermediation, or investment banking services. However, nontraditional insurance activities and non-insurance financial activities are potential drivers of the systemic importance of insurers and thus have the greatest impact on failure. Additional prudential tools for insurers to tackle interconnectedness and risk concentration have been discussed; among them monitoring and limiting ratios on capital markets activity, of liquid to illiquid assets, and of gross negative value of derivatives liabilities with other financial sector participants.

[25] More traditional instruments have tended to be employed by emerging market and developing economies to control banking system risks. Raising reserve requirements and increasing limits to control lending in foreign currency as well as large, open foreign exchange positions and exposures are some examples.

Basel III, in response to these experiences, introduced new global liquidity standard—the liquidity coverage ratio (LCR) and the net stable funding ratio (NSFR).[26] These two new ratios, LCR for short-term liquidity and NSFR for long-term liquidity, penalize reliance on short-term financing, particularly for financing from other financial institutions. For example, the LCR sets higher run-off rates for deposits from other financial institutions compared to corporate and retail deposits, increasing the required amount of high-quality liquid assets (HQLA), such as sovereign bonds, which a bank needs to hold if it relies on this kind of financing.[27] By increasing banks liquidity buffers and reducing maturity mismatches at individual banks, the LCR and NSFR aim to indirectly mitigate systemic liquidity and contagion risk. Moreover, the LCR and NSFR penalize banks for having sizable exposures to other financial institutions, providing an incentive to reduce funding interconnectedness as well as counterparty and exposure concentration among banks. With the new LCR published in 2013, there is some concern that the LCR benefit of reducing contagion and interconnectedness has diminished somewhat. While there may be some truth in such an argument, the new LCR with the proposed NSFR is still expected to mitigate systemic liquidity contagion as well as funding and counterparty interconnectedness.

OTC derivatives and central counterparties

Central counterparties (CCPs) are operators of multilateral systems used for clearing securities and derivatives transactions. The multilateral nature of CCPs distinguishes them from other financial institutions, including banks and securities firms.[28] The operator of a CCP interposes itself between counterparties of securities and derivatives transactions, becoming the buyer to every seller and the seller to every buyer, thus removing the counterparty credit risk of bilateral clearing.

Despite the recognized benefits of CCPs, the OTC derivatives market remained largely bilaterally cleared until the default of Lehman Brothers revealed the risks arising from the complex bilateral interconnections between OTC derivatives counterparties. These included the build-up of large counterparty exposures between particular market participants that were not appropriately risk-managed; the contagion risk arising from the

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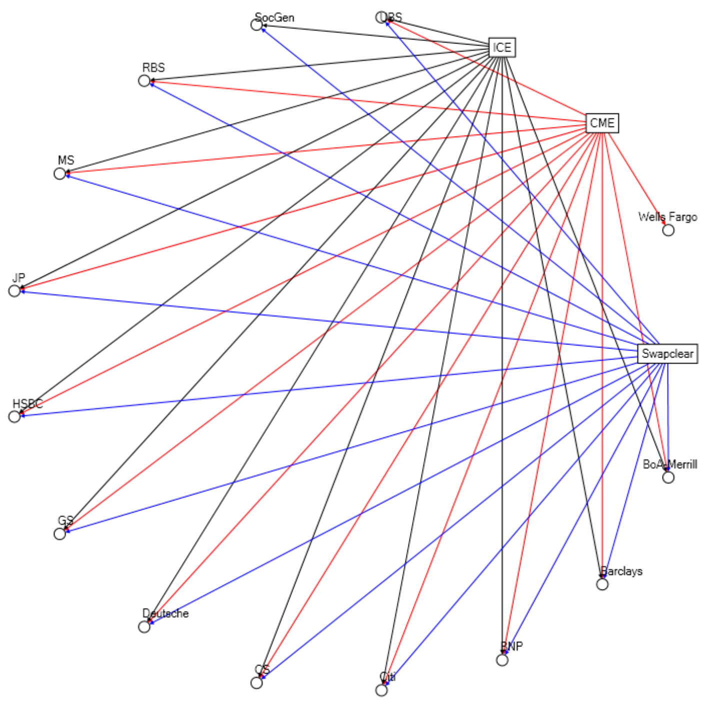
[26] LCR rules were recently finalized by the GHOS of the BCBS (January 6, 2013). The package has four elements: revisions to the definition of high quality liquid assets (HQLA) and net cash outflows; a timetable for phase-in of the standard in 2015–19; a reaffirmation of the usability of the stock of liquid assets in periods of stress, including during the transition period; and an agreement for the Basel Committee to conduct further work on the interaction between the LCR and the provision of central bank facilities. The NSFR is scheduled to be introduced in 2018; the BCBS will revisit NSFR rules before introduction.

[27] The run-off rate is a rate by which a bank must assume that the portion of its liability will outflow over the next 30 calendar days, thus increasing the bank's total net cash outflow that needs to be covered by the stock of high quality liquid assets (HQLA) held by the bank. Most deposits from financial institutions have 100 percent run-off rate, while the run-off rates for some retail deposits are as low as 3 percent.

[28] Payment and settlement systems share the multilateral nature of CCPs.

interconnectedness of OTC derivatives market participants; and the limited transparency of overall counterparty credit risk exposures, which precipitated a loss of confidence and market liquidity in time of stress.[29]

Figure 1. The G14 and the CCP Global Network



Experiences during the crisis led to the G-20 leaders' commitment to mandate the central clearing of all standardized OTC derivatives contracts in September 2009. The mandatory clearing requirement recognizes the various benefits that CCP clearing has over bilateral clearing. It reduces the contagion effect that a default of one of the counterparties may trigger by inserting the CCP as central counterparty and thus insulating counterparties from one another. CCPs mutualize the risk of counterparty failure using various risk management mechanisms, including prefunded default funds. They also manage counterparty credit risk centrally and reduce exposures through multilateral netting and collateralization of initial and potential future exposures (initial and variation margin). CCPs also increase

[29] Financial Stability Board, 2010.

transparency of the amount and distribution of risk exposures. CCPs thereby reduce the potential contagion (shock transmission) effects of the failure of a major counterparty because the impact is absorbed by the CCP and is mutualized among its clearing members who must share in any losses.[30]

CCPs limit contagion risk of derivative exposures, but simultaneously increase the concentration risk by substituting for a whole network of FIs. By enabling the clearing of standardized bilateral derivative contracts together with requiring the submission of initial and variation margins, CCPs help to reduce contagion risk through the netting of such derivative exposures and the loss absorption from access to collateral. This netting benefit is most significant with a reduced number of CCPs; in theory, with a single CCP—at the cost of highly concentrated risk. Specifically, CCPs are currently concentrated on several levels: (i) there are only three generally recognized globally systemic CCPs thus far, (ii) each CCP specializes in a particular financial product and globally dominates the clearing of the product, and (iii) there is a small group of large, globally important derivative traders who are members of all major CCPs.[31] Without an adequate regulation, supervision and resolution framework of the CCPs, concentration within the financial network could be greatly increased through CCPs.

At the moment, it is unclear how quickly the risk reducing benefits of CCP clearing can be realized. This is due to various reasons. Firstly, the legislative and regulatory framework mandating CCP clearing is still missing in many jurisdictions, and a significant proportion of trades still remain bilaterally cleared, in particular for certain asset classes.[32] Secondly, there are currently proposals for a proliferation of CCPs that might at least temporarily reduce the risk mitigating impact of CCP clearing, because the use of multiple CCPs reduces the full benefits from multilateral netting. Finally, loss sharing arrangements vary widely across CCPs at present in terms of the distribution of the burden represented by the risk buffers of the CMs and their clients.[33]

Structural limits on activities

Financial regulatory and supervisory policy may be construed as the prescription of minimum standards of business conduct and prudential risk management for financial

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[30] Some of these benefits are dependent on a market structure wherein a small number of CCPs clear the lion's share of standardized OTC derivative contracts globally. From the singular perspective of maximizing netting potential, Duffie and Zhu (2011) have made it clear that the most efficient market structure is one where a single global CCP clears all OTC derivative contracts.

[31] The three major CCPs are SwapClear, ICE, and the CME.

[32] Typically it is equity, commodity, FX and exotic (non-standard) derivatives.

[33] For more details and a call for greater disclosure by CCPs of their risk models, see Li Lin and Jay Surti (2013), *Capital Requirements for Over-the-counter Derivatives Central Counterparties*, IMF WP/13/3.

institutions (FIs). Correspondingly, prudential instruments, whether individually or taken together, can be expected to influence and impact the size and scope of FIs' businesses. As such these tools act as regulatory and supervisory constraints on the business models of financial institutions.

At a reasonably broad level, such prudential measures can take either of two forms. Indirect measures—such as the Basel capital and liquidity requirements for banks, G-SIBs surcharges—impact the cost and income of FIs from increasing the size and scope of their businesses, thereby providing them powerful incentives to cap these off at a lower level than in their absence. And direct measures—such as the historical Glass-Steagall separation of investment banking from deposits and credit in the U.S.—constrain FI size and scope by prescription.

The crisis brought about fundamental changes in the approach to, and content of, indirect measures. It highlighted that neither FIs' risk management nor market risk assessments keep pace with financial innovation. There is now considerable skepticism regarding the ability of FIs' internal risk models to attenuate—on their own and in the presence of moral hazard induced by implicit or explicit government support—the likelihood of institutional or systemic distress. Questions have also arisen regarding the ability of indirect measures to address the systemic risk implications of FIs' business practices and models. This is especially so as the maintenance of complex business models—especially the G-SIBs—may impair the ability to supervise and enforce the new and enhanced set of post-crisis rules. Similarly, until a comprehensive, cross-border bank resolution framework becomes a reality, the ability of national authorities to protect local affiliates of foreign banks and secure business continuity thereof will be a challenge.

The utility of direct measures in lowering financial system contagion, promoting continuity of vital banking functions in a crisis and making available a wider set of FI restructuring and resolution options, has become clearer. Direct restrictions on the scope of businesses conducted by G-SIFIs—and more generally—large or internationally active banks and concomitant changes in their business organization can lower complexity and more assuredly contain intra-system exposures. These measures aim to safeguard core banking business from contagion shocks that could spill over from riskier business activities and the subsequent distress that would impact the broader financial system and real economy.

Three sets of direct measures have been proposed by advanced market economies. These include a narrow banking proposal in the United States, the Volcker Rule, prohibiting deposit-funded banks from engaging in speculative trading and investments. The two European proposals (Vickers and Liikanen) have favored a subsidiarization model, wherein deposit-funded banks are ring-fenced from their investment banking affiliates and, in one case, prohibited from maintaining business relationships outside a pre-specified geographic perimeter (Table 4).[34]

Table 4. Comparison of the Structural Reform Proposals

	Liikanen group report	United Kingdom	United States
Institutional coverage 1/	All E.U. licensed banks and their subsidiaries - includes mutual and cooperative banks	Financial institutions running U.K. retail deposit and payments businesses - excludes U.K. building societies	U.S. banks and their subsidiaries globally; Non-U.S. banks' U.S. subsidiaries and branches
Size threshold for application	Trading business to exceed: (i) €100 billion in absolute value; ***or*** (ii) 15-to-25% of total assets; ***and*** (iii) EC calibrated threshold (not specified)	Assets held greater than £25 billion	None
Activities prohibited for deposit taking banks 2/	(i) Proprietary trading; (ii) Market making; (iii) Investments in hedge funds, PE funds and SIVs	(i) Proprietary trading; (ii) All wholesale and investment banking; (iii) Business with non-EEA counterparties;	(i) Proprietary trading; (ii) Investments in hedge funds, PE funds and SIVs
Permitted corporate structure	Retail bank/depository can cohabit in same financial group with trading company	Same as under E.U. proposal	Prohibited activities cannot be conducted by depository or any affiliate within BHC
Higher loss absorbency rule	Yes, via leverage ratio for trading business that exceeds size threshold	Yes, as add-on to the conservation buffer	Only for U.S. SIFIs
Depositor preference 3/	Presently not envisaged	Yes, for U.K. retail banks	Yes, under U.S. FDIA
Implemented in legislation?	No	No. Planned completion by May 2015	Yes
Implementing regulations finalized?	No	No	No
Proposed implementation schedule and status	Not available	Envisaged by 2019	Full implementation was scheduled for July 2014. May be delayed.

Notes:

1/ Similar conditions have been imposed on U.K. building societies via amendments to the Building Societies Act (e.g., they are subject to higher loss absorbency requirements.

2/ Structural reform proposals released by France on December 19, 2012 w ould leave market making inside the ring-fence and carry a size threshold for application, albeit further details are aw aited. Wholesale funding and use of derivatives to hedge business risks remains permitted for U.K. retail banks.

3/ For insured deposits in the U.K.

[34] See Pazarbasioglu and others for further discussion.

Resolution of cross-border financial institutions

As with previous tools, the crisis demonstrated the need for an effective cross-border resolution framework to minimize the costly contagion effects of the failure of a globally systemic financial institution. Endorsed by the G20, the *Key Attributes for Effective Resolution Regimes for Financial Institutions"* aims to establish a framework that sets out a series of policies that address the problem of moral hazard of SIFIs and make resolution feasible, without severe systemic distress or costly taxpayer bail-outs. The *Key Attributes* is broad in scope and encompasses any institution deemed to be of systemic importance, including not only banks, but also nonbank financial institutions and market infrastructures, such as CCPs. The *Key Attributes* involve 12 key principles considered essential to an effective resolution regime (Box 3). These principles can be grouped into three broad powers: (i) powers to intervene quickly (prior to insolvency) and assume control from existing owners and managers; (ii) powers to effect a resolution; and (iii) powers to support the resolution, for example, by suspending third party actions that could otherwise undermine it.[35] Importantly, the objectives of the *Key Attributes* extend beyond the national level to ensure the containment of cross-border contagion, whereby jurisdictions establish arrangements for mutual cooperation in resolving GSIFIs.

[35] The Key Attributes of Effective Resolution Regimes for Financial Institutions: Progress to Date and Next Steps," August 2012, IMF.

Box 3. The Key Attributes—A Summary[1]

The *Key Attributes* set out 12 features considered essential for an effective resolution regime:

- ***Scope:*** The regime should cover any financial institution that could be systemically significant.
- ***Resolution authorities*** should be independent and have clear mandates, roles, and responsibilities.
- ***Toolkit:*** Resolution authorities should have broad resolution powers, as described in part III.
- ***Set-off, netting, collateralization,and segregation of client assets:*** These should be preserved, although the authorities should also be able to suspend the operation of such rights, subject to adequate safeguards.
- ***Legal Safeguards:*** While resolution authorities may depart from the hierarchy of claims, they may have to offer compensation to creditors, and their decisions must be subject to judicial review.
- ***Funding of firms in resolution:*** Authorities should not be reliant upon public funds to resolve firms.
- ***Framework for cross-border cooperation*:** Resolution authorities should be empowered and encouraged to achieve cooperative solutions with foreign resolution authorities.

  Crisis Management Groups: Home and key host authorities should maintain CMGs that actively review and report on resolvability and on the recovery and resolution planning process for G-SIFIs.
- ***Institution-specific cross-border cooperation agreements*** should be in place among relevant authorities to manage the sharing of information and specify responsibilities in respect of all G-SIFIs.
- ***Resolvability assessments:*** Resolution authorities should regularly undertake resolvability assessments for all G-SIFIs, and should be able to require changes to business practices, structure or organization.
- ***Recovery and resolution planning:*** Jurisdictions must require planning for the recovery and resolution of firms that could be systemically significant or critical.
- ***Information sharing***: Jurisdictions should eliminate impediments to the domestic and cross-border exchange of information among authorities, both in normal times and during a crisis.

[1] "The Key Attributes of Effective Resolution Regimes for Financial Institutions: Progress to Date and Next Steps," August 2012, IMF.

B. Cross-sectional Prudential tools: Assessment of Interactions and Impact

A simple qualitative framework for cross-sectional analysis

The paper develops a qualitative matrix that serves as a first step in developing a framework for policymakers to reflect on the potential interactions of prudential tools. This simple framework is based on several basic parameters—the number of concurrent tools, the timing of implementation, the number of successive stages of impact, the cross-sectional dimension of interaction, and the type of institution. The nature of tools analyzed here is bilateral, for the most part, evaluating the interaction of two tools at a time. Further, it is assumed that the tools are implemented simultaneously and not sequentially. While the case of whether one tool is initiated before another may have significant implications for their subsequent interface and is worthy of subsequent research, the analysis here attempts to be more singular in approach. The framework largely assesses the first round effects of the interaction, that is, the more immediate impact of each tool on the other. Introducing subsequent second and third round effects would introduce not only more ambiguity as to the interactions, but would also add complexity by drawing in multiple dimensions into the analysis, i.e., the second round effect might now involve four tools interacting instead of two, questions as to sequential timing of interaction or spread out the impact over time, and spillovers that in turn impact the choice of such tools. The focus here remains on the cross-sectional nature of the interface, as the introduction of a time dimension adds substantial complexity.[36] Lastly, the analysis is targeted, for the most part, at the banking sector. The analysis does not base assessments on the cost implications of these instruments as the focus here is on the objective of an instrument with respect to interconnectedness. However, each of these parameters adds more depth to the analysis and their incorporation into subsequent frameworks would introduce a more multi-dimensional aspect for policymakers.

In turning to the matrix framework, complementarity and impact assessments in this section are broad based and qualitative in nature, as many of these tools are only in their nascent stages—some not yet implemented and others still being finalized in regulation—and thus difficult to fully assess the materiality and persistence of the effects of regulatory reforms.[37] Table 5 below summarizes the main conclusions of this section. First, it presents the evaluation of the interaction between the selected prudential instruments and reaches an overall view of the complementarity (or conflict) of each measure in the context of a general macroprudential approach to deal with the cross-sectional dimension of systemic risk. Then, the table presents a preliminary assessment on how these measures may impact concentration and contagion to reach an indication of their ability to reduce the risks related to

[36] The time dimension of macroprudential tools is examined separately in, "SDN Cost-benefits analysis of macroprudential policies."

[37] For example, it is difficult to distinguish the effects of the reforms from the outcome of crisis related actions and the current cyclical downturn.

interconnectedness (the spillover consequences for other institutions in the network). Finally, an overall assessment of the selected measures to address interconnectedness is provided.

Table 5. Interaction of Prudential Tools to Deal with Bank Interconnectedness: Concentration Risk and Contagion[1]

<table>
<tr><td colspan="2">TOOLS [2,3]</td><td>Microprudential Exposure limits</td><td>Capital buffers (SIFIs)</td><td>Limits on liq. mismatches (LCR,NFSR)</td><td>Limits on activities (V-V-L)</td><td>Resolution frameworks</td><td>CCP clearing requirements</td></tr>
<tr><td colspan="2">Microprudential Exposure limits</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Capital buffers (SIFIs)</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Limits on liquidity mismatches</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Limits on activities (structural)</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Resolution frameworks</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">CCP clearing requirements</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Overall Complementarity</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Impact on Concentration</td><td>↓↓</td><td>↓</td><td>↓↑</td><td>↓↓</td><td>↓</td><td>↑</td></tr>
<tr><td colspan="2">Impact on Contagion</td><td>↓↓</td><td>↓</td><td>↓</td><td>↓↓</td><td>↓</td><td>↓</td></tr>
<tr><td colspan="2">Overall reduction in interconnectedness</td><td>HIGH</td><td>LOW</td><td>MEDIUM</td><td>HIGH</td><td>MEDIUM</td><td>LOW</td></tr>
<tr><td rowspan="2">Complexity of implementation</td><td>Regulators</td><td>LOW</td><td>MEDIUM</td><td>HIGH</td><td>HIGH</td><td>HIGH</td><td>MEDIUM</td></tr>
<tr><td>Banks</td><td>MEDIUM</td><td>LOW</td><td>HIGH</td><td>HIGH</td><td>HIGH</td><td>LOW</td></tr>
</table>

[1] The matrix is characterized by several parameters: tools are analyzed bilaterally; involve simultaneous implementation of the tools; focus on the more immediate first round effects; and does not involve a time series dimension. Further, the matrix pertains to banks, acknowledging that there may subsequent implications in the non-bank or non-regulated sectors

[2] Fully Complementary: tool is mutually reinforcing the intended objective of another tool (dark blue); Partially complementary: tool may have a partially offsetting impact on the intended effects of another tool (light blue); Partially conflicting: the tool has conflicting impact with the intent of another tool but are not major (light red); Not related or not contradictory (white).

[3] Arrows indicate an increase (↑) or decrease (↓) in resulting impact.

Microprudential exposure limits

Microprudential exposure limits are, on the whole, partial complements with the other prudential instruments considered in this paper. Microprudential exposure limits may interact with capital buffers SIB in several ways. On one hand, the larger capital buffer of a G-SIB will increase its capital base, and enable a bank's absolute exposure to a counterparty to increase (although its exposure does not increase in relative terms). On the other hand, the increased capital charge may cause a bank to reduce its concentration in riskier assets, thus overall, have a partially conflicting effect. As regards the interaction with liquidity ratios, there should be reinforcing characteristics between the objectives of the microprudential instruments for exposure limits to a single counterparty and the liquidity ratios, such as the LCR, that limit concentration in particular instruments, such as wholesale funding, and promote more liquid instruments. However, if a bank builds up required amounts of level 2 liquid assets to meet liquidity ratios (e.g., corporate debt subject to haircuts), it could subsequently increase the bank's exposure to the same issuer(s), and thus run up against the microprudential limits on a bank's exposure to counterparties. That said, the indirect limit on wholesale funding may also reduce interbank activity and thereby reducing interconnectedness. Thus, contagion is considered partially complementary while from the concentration angle, it is partially conflicting. Exposure limits reinforce the purpose of the regulations that similarly place limits on banks activities.[38] Likewise, they partially complement the purposes of the resolution frameworks, since having exposure limits in place should make the resolution process easier. Finally, microprudential exposure limits, such as banks' limits on counterparty exposures, may conflict with the purpose of trading through central clearing systems.[39] The requirement to trade standardized contracts on a CCP concentrates the exposure of a financial institution to a single counterparty—the CCP—and potentially approach limits on single counterparty exposures. However, unlike an individual counterparty, CCPs have significant safeguards in place to address risk exposures for both members and the CCP as a whole, such as capital, collateral

Microprudential exposure limits reduce network complexity, concentration and connectivity resulting in a less contagious financial network for financial institutions. FIs can have common exposures that arise both directly and indirectly. FIs may be directly exposed through financial contracts between systemic institutions, or to one sector or instrument (e.g., housing, real estate, sovereign bonds). FIs maybe also exposed indirectly through financial activities with counterparties who themselves are directly exposed to the same underlying risks. Further, current microprudential regimes do not impose limits on sectors, instruments or sovereign exposures and ignoring quite often indirect exposures. For other such exposures, management falls within Pillar II of Basel.

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[38] There is a risk, however, is that these limits on activities could transfer to the non-regulated sector and thereby increase interconnectedness outside of the regulated banks.

[39] The paper assumes that CCPs are following the CPSS-IOSCO Principles for Financial Market Infrastructures.

Capital buffers

In general, capital buffers for systemically important banks partially complement other cross-sectional macroprudential tools. Although SIFI capital surcharges do not interact with liquidity requirements, and central counterparties, they have a minor conflict with microprudential exposure limits as explained above. But they strongly complement the intent of regulations on limits on banks' activities, as both measures aim to limit the interconnectedness and riskiness of SIBs either via internalizing the costs of their systemic importance via capital charges or via their business models. Capital surcharges on SIBs should not interact with resolution framework as the capital surcharge is a going concern surcharge within a capital conservation buffer. If the bank is to be resolved, the surcharge will have been long since absorbed. The surcharge does not affect resolution, which is why the G-SIB package of measures includes a resolution framework. Capital is a first line of defense so that resolution is not triggered.

Capital surcharges related to a bank's systemic importance utilize a financial penalty to lead banks to cost in the systemic growth of a SIFI, but it not clear it provides enough disincentive. One response to the too-big-to-fail problem is to levy higher capital surcharges that can be graduated to increase with the systemic importance of the FI. SIFI surcharges can be viewed as a kind of Pigouvian tax to tackle the externality of systemic risk. Additional capital buffers such as the proposed Basel Committee's G-SIB or D-SIB charges, or the IAIS's charges on systemically important insurers, are intended to create incentives for SIFIs and the financial network as a whole to become less concentrated and less contagious. However it is worth bearing in mind that banks the G-SIB surcharge may be viewed as an inevitable cost of undertaking business and will be deemed acceptable to the G-SIBs if the fees and incomes they get from being interconnected more than compensate for this charge.

Furthermore, there is a concern that the new framework may contribute to accelerating concentration and interconnectedness in ways beyond those identified in Table 5.

- The strengthened capital and liquidity requirements would provide an incentive for banks to increasingly allocate more of their funds into low risk-weighted and high-quality liquid assets, notably sovereign bonds. This applies not only to capital buffers but also for liquidity buffers and CCPs. This would give rise to concentration risk in banks' assets and interconnectedness between banks and sovereigns with the potential risks of an adverse sovereign-banking loop arising in distressed conditions. However, the capital framework has been complemented with a non-risk sensitive leverage ratio to prevent excess leverage resulting from the holdings of low risk weighted assets.

- It is also possible that higher requirements could reduce the number of global players in financial markets that could meet both higher capital requirements and liquidity requirements, e.g., only the largest banks may have the deepest pockets for HQLA, or mergers and acquisitions in order to compete globally, increasing concentration risk and interconnectedness among global financial institutions.

Liquidity regulation and limits on liquidity mismatches

Overall, liquidity regulations strongly complement other prudential tools to limit the effects of interconnectedness. Despite their neutrality toward capital surcharges to SIBs, limits on liquidity mismatches strongly complement regulations that limit banks' activities—by constraining the reliance on short-term funding and thus reducing rollover risk and access to short–term funding that could lead to asset fire sales as banks act to obtain liquidity. As a result, liquidity regulations make banks' balance sheets more stable, facilitating the resolution process.[40] It is not deemed that limits on liquidity mismatches interact in one way or another with the requirement to use CCPs as a macroprudential response to interconnectedness as the objectives of these measures are not conflicting. However, both banks' liquidity requirements and CCPs require HQLA for either collateral or LCR, thus introducing competing demand for and increasing cost of HQLA, although both are intending to make the system safer.

Liquidity regulations, as with capital buffers, reduce systemic contagion, although the impact on industry concentration is less clear-cut. Reducing liquidity mismatches through limits (LCR, NSFR) may mean there are more sizable liquidity buffers (high quality assets) for FIs to absorb losses and mitigate liquidity runs. That said, the impact of limiting liquidity mismatches has an uncertain impact on financial network concentration. A more challenging liquidity standard requiring high-quality liquidity assets, (particularly for Level 1 assets) may favor larger systemic SIFIs who through their market making positions have access to a wider variety of such assets at reasonable costs. Smaller SIFIs may find it difficult and costly to acquire such liquid assets resulting in their exit (through consolidation or failure) with the overall concentration of the financial increased in this case. Nevertheless, limits on liquidity mismatches help to make transparent a bank's positions and exposures enabling easier comparisons across the financial network and incentivizing reduction in the size of such mismatches and consequent network concentrations.

Structural limits on activities

Structural limits on activities generally complement other prudential tools to limit the effects of interconnectedness (concentration and contagion). Structural limits on activities should reinforce the purposes of microprudential exposure limits, capital surcharges for SIFIs, and limits on liquidity mismatches.[41] They also complement the purpose of regulations

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[40] It should be noted that in the process of ring fencing of proprietary trading, the investment bank portion of the institution will need to increase its holding of liquid assets, which could be costly.

[41] However, under the Volcker Rule, there are concerns that market liquidity may decline, thereby reducing the supply of high quality liquid assets and the ability of banks to meet Basel III liquidity requirements.

aimed to facilitate banks' resolution processes, as both measures—resolution and structural limits—are intended on achieving simpler institutions with easier resolvability.[42] Structural limits on activities, however, are considered neutral with respect to the use of CCPs as they tend not to be affected by the institutional requirements set forth for the traders/clearing members.

The various direct measures (Volker, Vickers and Liikanen) that restrict the size and scope and complexity of bank's business models should reduce cross-sectional dimension of systemic risk across the banking system, but not necessarily across the financial system. Direct structural measures have the potential to significantly reduce the complexity, risk concentrations and interconnections across the banking system. However, such direct regulations creates the potential for the transfer of complex risks and increased interconnections within the lightly regulated shadow banking and financial system as a whole due to regulatory arbitrage and increased cost of credit and capital within the banking system due to such direct measures. Recent evidence from the FSB/BIS suggests that both the banking and shadow banking system have grown over the very period that regulation has been proposed, it maybe that in this regard the shifts of risks between banking and the shadow banking system occurs more abruptly after implementation of regulation and macroprudential tools.[43]

Resolution of cross-border and systemic financial institutions

An effective resolution framework complements the intent and purpose of other instruments to tackle interconnectedness. The existence of a sound resolution framework helps fulfill the purposes of microfinancial exposure limits, and limits on banks activities. It also strongly complements the limits on liquidity mismatches, making resolution simple. The only area where the resolution process could enter into conflict with other macroprudential measures is in the case of CCPs. On one hand, the resolution framework should establish how financial institutions would be wound down, and make it easier to deal with CCP exposures. Moreover, a CCP's net exposure across counterparties should make the bank/clearing member's counterparty exposures easier to resolve because they are subject to multilateral netting and thus reduce counterparty exposures. However, if the execution of the resolution framework is weak or legal framework is not well defined such as priorities of precedent in the resolution process (e.g., CCPs before all other creditors) then both CCPs and resolution mechanisms could conflict in tackling the interconnectedness dimension of

[42] The imposition of structural limits could impact resolution through other channels, such as the absence of bail-ins in the retail portion of the bank, increase difficulty of moving funds across the larger bank holding company in times of distress and potential runs on the retail side of the bank because of concerns about the health of the investment bank component.. See Pazarbasioglu and others. for further discussion.

[43] Ibid.

systemic risk.

Resolution plans are intended to help to transfer first-loss away from taxpayers to the owners of SIFIs, helping to contain their impact on network concentration and contagion. Resolution frameworks/plans, and by definition the elements attached to it—living wills, bail-ins, group-wide exposure and derivatives netting—help to increase the feasibility of resolving complex FIs and thereby reducing costly contagion effects. In a well structured resolution framework that includes, for instance statutory bail in features, as debt and equity holders would suffer first-loss, investors would push for more rigorous risk assessment and mitigation to ensure resolvability. For regulators, resolution and recovery plans and an effective resolution regime aim to transfer first loss of a SIFI failure away from taxpayers to the owners of a SIFI, reducing overall systemic risk and improving financial stability. Network concentration and contagion in these circumstances would be reduced as the size and number of interconnections would be reduced by the resolution framework and all its tools. Moreover, resolution would also seek to ensure the continuance of critical (payment and settlement) functions.

OTC derivatives and CCPs

In terms of complementarity, CCP clearing requirement shows, in general, weaker interactions vis-à-vis other macroprudential tools. Along the previous explanations of this section, microprudential exposure limits, capital buffers (SIFIs), limits on liquidity mismatches, and limits on activities have, in general, very limited interaction with the CCP clearing requirement, while with respect to exposure limits the interactions can be conflicting. Resolution frameworks could potentially interact positively or negatively, depending on the sound design of the resolution framework vis-à-vis exposures to CCPs.

IV. POLICY CONSIDERATIONS AND NEXT STEPS

The analysis conducted here emphasizes the importance for policy makers to consider the nature and significance of the cross-sectional dimension of systemic risk in their jurisdictions and take actions accordingly. There are a few important considerations worth bearing in mind with regard to the significance of cross-sectional dimensions of systemic risk. First, the identification and measurement of risks stemming from the analytical models would introduce a significant tool into the prudential arsenal and deserve investigation as to how they could be supportive in the regulatory framework. Second, the application of the above prudential tools can result in increased costs, for which the qualitative framework here does not attempt to correct. Lastly, the framework has focused almost entirely on interactions and impacts with regard to the banking system, and it would be expected that such interactions will extend to the wider financial system. While it is premature to fully operationalize hard guidance across different national jurisdictions on the set of cross-sectional prudential tools to be utilized, the analysis indicates some preliminary considerations.

A clear conclusion from the analysis was the complexity of the interaction of the various prudential tools and their impact on interconnectedness. From the point of view of their singular effect, contagion and concentration are expected to diminish as desired with the various instruments, with the exception of the CCP clearing requirement, which has a more conflicting impact on interconnectedness. In terms of their overall reduction in interconnectedness—considering both contagion effects and risk concentration—the traditional microprudential exposure limits, resolution framework and limits on activities are among the most robust. Regardless, these are each measures advisable in addressing interconnectedness.

However, when examined in terms of bilateral complementarity, simple conclusions are less clear cut. Liquidity limits, structural measures and resolution frameworks seem, overall, mostly complementary, while mandatory clearing of OTC derivatives on CCPs has a much more neutral relationship with other tools. However, the traditional microprudential exposure limits introduced some of the most difficulty in the analyses, raising questions not only on how they might interact with other prudential measures but also awareness of gaps that need to be addressed, particularly in the areas of exposure to sovereigns, product risk and CCPs. Overall, the analysis reveals the need for a strong precautionary warning in predicting the impact of the simultaneous implementation of multiple tools. Even for a qualitative analysis at such a basic level, the potential for nuanced interactions and interplay render cautious conclusions.

Going forward

The difficulty in analyzing the interactions of microprudential exposure limits elicits the need for more work on the management of large exposures to domestic sovereigns, on concentration risk management beyond name risk and exposures to CCPs, each of which presents complexities outside the more traditional counterparty limits in the past.[44] Many countries currently apply an exposure waiver or discount the consideration of domestic sovereign exposures with regard to large exposure limits. However, in tail risk conditions high concentration exposure to a good (low probability of default) counterparty, such as the recent experience with sovereign, debt could also turn problematic.[45] More examination is also needed on the management of concentration risk beyond name risk. While Basel II guidance is such that this risk is dealt with in Pillar II, with options including

[44] The Basel Committee on Banking Supervision is now considering such measures, and has issued the consultative document, “Supervisory framework for measuring and controlling large exposures,” (March 2013).

[45] In normal conditions, capital accounts for unexpected losses calibrated within a given safety margin but would not fully account for tails risks.

additional capital buffers, more specific limits should be considered. For example, if a bank has a substantial concentration in a product, market segment, or economic sector the supervisor should require on a bank by bank basis to have some safeguard against the concentration risk. This can be in the form of specific restrictions and limits on these exposures, or additional capital buffers. Conducting stress-testing for concentration risk to measure the magnitude and calculate the appropriate amount of buffer may be necessary. Likewise, standardized derivatives are now being mandated to clear on CCPs—with the accompanying benefit of multilateral netting to reduce contagion—but would increase a financial institutions' exposure to a single counterparty. Exposure to a CCP, which is subject to significant safeguards for credit and operations risk, should be subject to separate exposure limits that account for the uniqueness of this type of counterparty.

While new Basel liquidity ratios are designed for banks to increase their holding of more liquid assets, and thereby reduce holdings of less stable funding sources, an area for consideration is to link these ratios to the financial institution's interconnectedness.[46] Korea has recently designed a bank levy to increase borrowing costs, to dampen banks and companies' demand for external debt (wholesale funding).[47] And this is intended to ultimately reduce external debt at the national level. The bank levy (2-20bp currently, rising to 50bp) is imposed on bank's non-deposit foreign currency liabilities, increasing banks' funding costs. The banks are likely to cover only a part of the additional costs, while the rest will be passed through to companies' borrowing interests. As a result, companies will not only cut the ratio of foreign currency borrowing but rely more on long-term funding, which is subject to a lower levy rate. As well, the banks will find more incentive to increase the ratio of relatively low-cost and stable deposits. In all, the bank levy is likely to reduce the overall demand for wholesale funding and enhance the country's resilience against pro-cyclicality. According to preliminary empirical assessment, the overall impact of the Korean macro-prudential measures appears to be positive, but a longer-term view of the bank levy itself is still needed with regards to use by other countries especially EM countries.[48]

The matrix developed in Table 5 provides policymakers with a preliminary qualitative framework to assess possible interactions of various prudential tools that tackle interconnectedness (i.e., concentration risks and contagion). This is important given these tools are not always complementary. The two-dimensional matrix enables us only to consider interactions between prudential tools as a bilateral relation – namely only interactions for two tools at a time. Extending this framework to look at simultaneously the interaction between

[46] The Basel Committee on Banking Supervision.

[47] The Bank of Korea, "Macro-prudential Stability Levy in Korea"(2012), Korean version.

[48] Shin and Bruno (2012) find that the sensitivity of Korea-bound capital flows to global conditions decreased in the period following the imposition of macro-prudential policies, relative to a comparison group of countries.

more than two prudential tools is challenging but is necessary to obtain a more comprehensive picture of potential interactions.

Another area where this analysis can be taken forward is to look at how prudential-tool interactions might evolve over time. This raises the prospects of spillovers of such interactions in terms of additional (2^{nd} and 3^{rd} order) impacts rather than immediate (1^{st} order) impacts. Similarly, moving from simultaneous implementation to varying the timing (e.g., sequentially used tools) would add additional insight. Indeed this extension, though adding complexity and ambiguity to multiple interactions, may give some idea about the mix of prudential tools that could be applied in the short-term relative to medium and longer-term prudential policy mixes to tackle the cross-sectional dimension of systemic risk.

Lastly, a dimension that expands the analysis considerably is incorporating the potential impact and interactions with the nonbank and shadow banking sectors (SBS). The likelihood of various regulatory measures influencing risk and portfolio adjustments across financial sectors, movements of traditional banking activities into the SBS, or opportunities for regulatory arbitrage—across both regulated as well as non-regulated sectors—are each areas for potential analysis in the framework. All these factors add complex dimensions to efforts to accurately predict the ultimate consequences of these prudential instruments.

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Appendix I. Data Requirements for Network Analysis

A crucial first step in network analysis is to define the data on which the analysis will be based. Depending on the purpose of the analysis, the researcher faces two important choices regarding (a) the perimeter of the financial network to be analyzed, and (b) the set of bilateral claims to be considered. In practice, information on bilateral exposures is scarce and often partial or of limited quality. Therefore, data availability usually constrains the analysis. This box reviews the perimeter and exposures included in a number of domestic financial network analyses for selected countries.[49]

The financial network empirical literature centers almost exclusively on the interbank market. For the purposes of systemic risk monitoring, one should define a financial firm broadly to include all institutions which perform critical functions in financial markets, including credit intermediation, maturity transformation, the provision of savings vehicles, risk management and savings payments, and the support of primary and secondary funding markets. Focusing on specific financial sectors may disregard potentially important sources of systemic risk. For example, Money Market Mutual Funds (MMMFs) in the U.S. are an important source of liability interconnectedness risk since they invest heavily in the short-term liabilities of banks. Contagious runs on MMMFs can therefore result in the withdrawal of a major source of liquidity from the banking sector. However, data on bilateral exposures covering institutions in multiple financial sectors is rarely available. Some studies characterize the aggregate exposures across different sectors of the financial system.

The set of bilateral claims that defines the financial network is constrained by data availability. Supervisors in several countries require banks to report their bilateral exposures. In some cases, those reports are fairly complete and allow for a representative analysis. In the majority of cases, however, those reports are subject to some sort of censoring, such as: (a) excluding certain types of exposures (typically off-balance sheet), (b) being subject to relatively large reporting thresholds or covering only the largest exposures, and (c) being available for only large institutions and on a low frequency basis (to avoid imposing burdensome reporting costs). Additional sources of data on bilateral exposures are Payment Systems and Credit Registries. There is hardly any work that has quantified the consequences of censoring. Table 1 reviews the types of exposures included in a variety of domestic interbank network studies depending on data availability. In other cases, balance sheet data for each bank reports only aggregate interbank exposures so additional assumptions (e.g.,

[49] See Cerutti and others (2011) for a review of the data challenges in measuring systemic risk in global banking.

maximum entropy) are required to estimate the bilateral exposures.[50][1] As a drawback, these estimates usually fail to reproduce some properties of real world interbank markets.

[50] See, for example, Degryse and Nguyen (2007) for Belgium, Elsinger and others (2006) for Austria, Elsinger and others (2006) for the U.K., Gauthier and others (2010) for Canada, Sheldon and Maurer (1998) for Switzerland, and Upper and Worms (2004) for Germany.

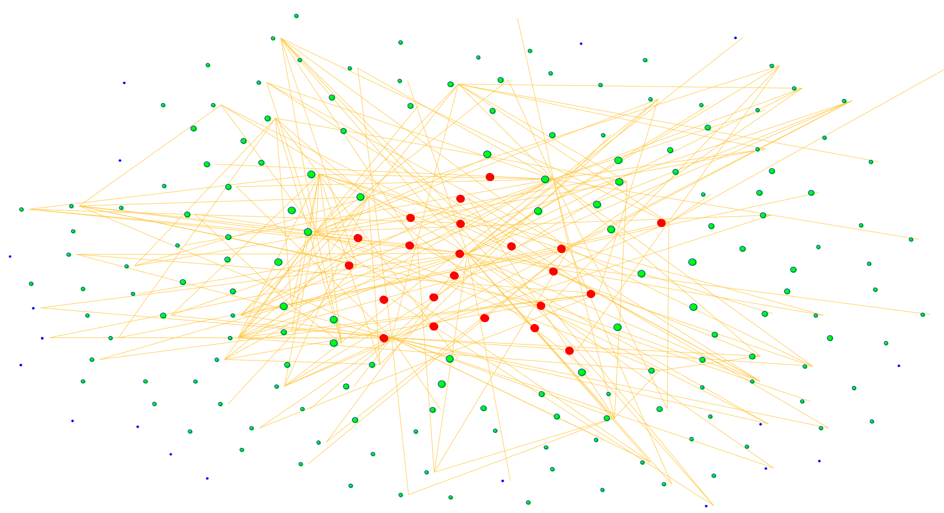
Table 1. Data used in Selected Countries' Network Analyses

Country	Reference	Data Source	Perimeter	Exposures
Sweden	Blavarg and Nimander, 2002	Bank reporting	Interbank network (4 largest banks)	Banks report 15 largest exposures with full principal credit risk Focus on exposures containing full principal credit risk _ uncollateralized lending _ holdings of securities issued by counterparties _ credit element of OTC derivative exposures (gross and net exposures) _ FX settlement exposures as they do not incorporate PVP or DVP mechanisms Excludes exchange-traded derivatives and payment and settlement systems with PVP and DVP mechanisms.
Korea	Aydin and others, 2011	Bank reporting	Interbank network (18 banks)	Interbank Assets: bank bonds receivable, loans, call loans, bonds purchased under repurchase agreements, accounts receivable, derivative assets. Interbank liabilities: deposits, CD, bank bonds payable, borrowings, call money, bonds sold under repurchase agreements, accounts payable and derivative liabilities. Excludes off-balance sheet bilateral exposures.
Mexico	Martínez-Jaramillo and others, 2010	Bank reporting	Interbank network	Focus on largest exposures _ uncollateralized interbank lending _ securitites held issued by other banks _ credit component of derivative transactions and credit lines as part of the interbank market
India	RBI, 2011	Bank reporting	Interbank network (75 banks)	Focus on bilateral fund based and non-fund based exposures. Excludes transactions where settlement takes place through a central counterparty.
Italy	Mistrulli, 2007	Bank reporting	Interbank network	All interbank exposures excepts shares (CDs, current accounts, repos, other loans, subordinated and unsubordinated loans).
Netherlands	van Lelyveld and Liedrop, 2006	Bank reporting	Interbank network	Focus on interbank deposits. For all banks, consider deposits larger than 3 percent of actual own funds. Top 10 banks with respect to interbank assets were asked to fill in a more complete survey.
Switzerland	Müller, 2006	Bank reporting	Interbank network (300 banks)	Focus on 10 largest interbank assets and liabilities (including off-balance sheet). For repos, only unsecured portion is taken into account).
Hungary	Lubloy, 2005	Bank reporting	Interbank network	Uncollateralized interbank loans and deposits denominated in local currency between domestic banks.
U.S.	Furfine, 2003	Payment system	Interbank network (719 banks)	Focus on overnight bilateral credit exposures arising from federal funds transactions (uncollateralized lending) estimated from data on large scale payment system (FedWire).
Denmark	Amundsen and Arnt, 2005	Payment system	Interbank network (117 banks)	Focus on overnight bilateral credit exposures arising from domestic overnight loans (uncollateralized) estimated from data on real time gross settlement payment system (Kronos).
Germany	Memmel and Stein, 2008	Credit registry	Interbank network	All internbank loans when the indebtedness of the borrower exceeds €1.5mn. Includes traditional loans, off balance-sheet positions and exposures from derivative positions. Excludes position of trading book.

Appendix II. Network Analysis Tools
Centrality Analysis[51]

The underlying idea of centrality is to infer from the pattern of linkages among financial institutions the extent to which a node is "central" in the financial network. Financial networks usually display a high density of interactions (Figure 2). However, the distribution of links between nodes does not seem be uniform across the entire network. In particular, there seem to be a very dense set of relationships occurring at the center of the network, which peter-out as we travel toward the periphery. Understanding which nodes belong at the core of the graph and which are peripheral is an important tool.

Figure 2. Dense Interconnected Network



Several indicators of interconnectedness, or "centrality," are used to quantify the relative importance of each financial institution in a financial network.[52] The most

[51] See IMF (2012) and Cihak and others (2011).

[52] In addition to the local measures that quantify the relative importance for each node in the network, there are global measures intended to characterize the network as a whole.

common measures of "centrality" usually take into account whether a relationship between two nodes exists or not, but not the size of each node nor of the exposure between them.[53]

- Degree centrality: quantifies the number of connections any given node has to all others in the network. Degree centrality of a node can be computed respectively as the sum of: incoming links (in degree); outgoing links (out degree); or all links (degree).

- Closeness centrality: measures the mean or shortest path in terms of the number of paths, between one node and all others.

- Random walk betweenness centrality: quantifies the importance of each node in relaying flows amongst all others. This can be approximated by the expected number of times that a random walk between any starting and ending node will pass through an intermediate set of nodes averaged over all starting and ending vertices.

- Eigenvector centrality: defines both the number and the quality of the connections any given node has within the network. It assigns relative scores to all financial institutions in the network based on the principle that connections to high-scoring financial institutions contribute more to the score of the financial institution in question..

Sometimes, different indicators of interconnectedness are combined into a single ranking of interconnectedness.[54] A percentile rule is usually followed to distinguish the core from the periphery based on the computed ranking. According to country studies,[55] domestic interbank networks tend to exhibit a tiered structure. A tiered structure is one where different institutions have different degrees or levels connectivity with others in the network. The bulk of the activity takes place between the financial institutions in the core. These institutions are closely connected with each other. The institutions in periphery, on the other hand, are connected with the institutions in the core but have limited exposures to other institutions in the periphery.

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[53] Incorporating the size of bilateral linkages in the network model is less prevalent as it increases considerably the complexity of the calculation, and the tools for this are still evolving in the research community. See Cihak and others (2011) for an example.

[54] Alternatively, just one indicator may be chosen, usually the one related to eigenvector centrality.

[55] See Upper and Worms (2004), Craig and von Peter (2009), and Reserve Bank of India (2012).

Cluster analysis[56]

Cluster analysis condenses the mass of bilateral linkages into subgroups of nodes—whether in the core or in the periphery—among which connections are particularly strong. Most cluster identification methods rely on partitioning algorithms which define separable non-overlapping, non-nested sub-groupings. Such algorithms are subject to some constraints on the number, size, or shape of the clusters to be identified. For example, such methods necessitate defining ex-ante the number of clusters into which the network should be partitioned, so the choice of the number of clusters has a non-trivial effect on the results. Also, because each node can only belong to a single cluster, these methods ignore the implications of overlapping or nested subgroups of institutions. This dilutes the potential for richer understanding of the particular nodes that facilitate such overlaps, and therefore the set for interactions across nodes.

Work at the IMF has emphasized the importance of methods that allow for identification of an unknown number of potentially overlapping clusters with varied membership size. The architecture that emerges from a recently developed cluster identification algorithm is described in stylized form in Figure 3.[57] The system comprises a number of overlapping clusters of institutions. Connections among institutions within the cluster are stronger than with those outside. Some institutions are situated in the intersection of a large number of clusters. These institutions are "central" and, as such, form the core. But beyond the global core, there are institutions through which clusters are connected either to the core or to other clusters. Owing to their capacity to act as transmitters (and potentially amplifiers or mitigators) of shocks, nodes comprising the cluster overlap regions are "gatekeepers." Countries can be gatekeepers to multiple clusters. Groups of countries can also serve as gatekeepers; for example, countries in the core can individually and as a group serve as gatekeepers to different parts of the system.

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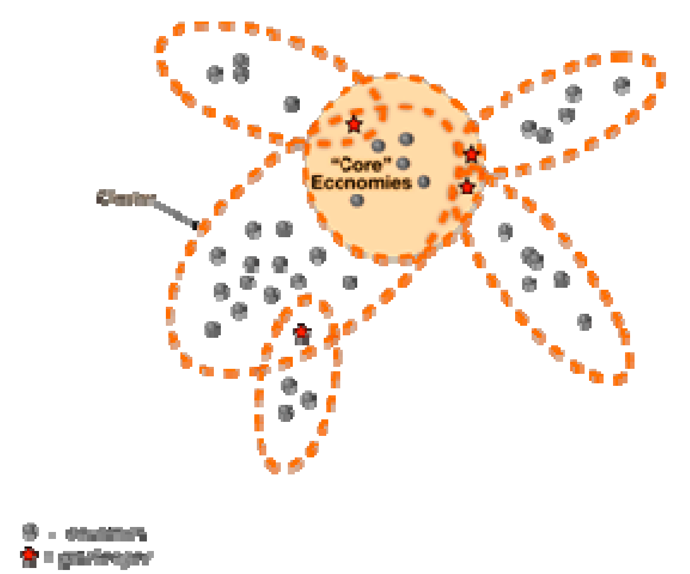
[56] See IMF (2012).

[57] The algorithm is called "Clique Percolation Method" and is described in IMF (2012).

Figure 3. Cluster Identification: A Stylized Depiction



Balance Sheet Simulation Methods[58]

Balance sheet simulation methods allow analyzing and quantifying contagion and amplification mechanisms of financial shocks in financial networks. These methods use simple balance sheet identities to trace the effect of difficulties at an individual bank or banking sector through a combination of data and assumptions. Initial losses associated with the failure of a financial institution can potentially lead to the weakening and, sometimes, failure of additional nodes with further knock-on effects. The IMF’s introductory stress testing kit by Cihak (2007) includes a simple feature analyzing how a failure of a bank may affect other banks directly if it defaults on its borrowers. The “pure” interbank contagion exercise does not take into account the different likelihood of failures in different banks. The “macro” interbank contagion exercise analyzes situations when all banks are weakened at the same time by a common external (typically macroeconomic) shock, which affects each bank differently depending on its exposures to the various risk factors, and makes some of the banks (perhaps more than one) fail. Although asset exposures have historically been the focus of balance sheet interconnectedness analyses (a credit shock), recent research by Espinosa-Vega and Solé (2010) and Tressel (2010) also emphasizes the risks arising from liabilities.[59]

[58] See Espinosa-Vega and Sole (2010) and Tressel (2010).

[59] Cerutti and others (2010) present a stylized analysis of the effects of ring-fencing (i.e., different restrictions on cross-border transfers of excess profits and/or capital between a parent bank and its subsidiaries located in different jurisdictions) on cross-border banks.

This methodology incorporates not only the role of exposures across the network but also the role of financial buffers. On the one hand, linkages may act as channels to propagate shocks to the whole system, that is, they act as "shock transmitters." On the other hand, through these linkages, shocks can be shared and absorbed by others, that is, financial linkages may act as "shock absorbers." The network analysis tools described in the previous sections (i.e. centrality and cluster analysis) determine, solely from the pattern of financial linkages, the potential importance and role of a financial institution in amplifying or dampening shocks. Balance sheet simulation methods complement the basic mechanisms of shock transmission (via lending exposures) with the mechanisms for absorption (via banks' net worth).

The systemic importance of an institution is quantified by assuming its hypothetical failure and simulating the imposed losses on each other institution in the network. Espinosa-Vega and Solé (2010) propose two main criteria to classify potentially systemic financial sectors (or institutions): the number of failures in the network following a credit shock; and the capital losses (impairment) in the network of financial institutions following this credit shock. The measures are computed following domino effects unleashed by the hypothetical default of a banking system on its interbank obligations—a credit shock. In addition to the credit shock, Espinosa-Vega and Solé look at a funding shock, where the failure to roll over short-term funding in the interbank market, results in fire sales with associated knock-on effects. Additionally, Tressel (2010) includes a deleveraging channel, whereby, following a negative asset shock, institutions adjust the size of their balance sheet to maintain a target minimum capital-to-asset ratio.

Table 1. Network analysis in IMF Surveillance

Bilateral Surveillance							
Country	**Year**	**Document**	**Methodology**	**Unit of analysis**	**Data**	**Goal**	**Policy recommendation**
Australia	2012	FSAP	Simulation method (funding shock)	Cross-country	BIS	Identify key potential sources of risk	
			Interconnectedness Assessment	Domestic banks	RBA	Determine systemic importance	Call for special risk mitigation arrangements
Spain	2012	FSAP	Simulation method (credit and credit+funding shock)	Cross-country	BIS	Identify key potential sources of risk	
India	2012	FSAP (RBI calculations)	Interconnectedness Assessment (Centrality analysis)	Domestic banks and domestic financial sectors	RBI	Network descriptive analysis	
			Simulation method (credit shock)	Domestic banks and domestic financial sectors	RBI	Assess and quantify contagion effects	
France	2012	FSAP	Simulation method (credit and credit+funding shock)	Cross-country	BIS	Identify key potential sources of risk	
Brazil	2012	FSAP	Simulation method (credit and credit+funding shock)	Domestic banks	BCB	Assess and quantify contagion effects	
Japan	2012	FSAP	Simulation method (credit and credit+funding shock)	Cross-country	BIS	Identify key potential sources of risk	
	2011	Spillover Report	Simulation method (credit and credit+funding shock)	Cross-country	BIS	Identify key potential sources of risk and potential contagion destinations	
			Interconnectedness Assessment	Cross-Country	BIS	Identify key potential sources of risk	
Chile	2011	FSAP	Interconnectedness Assessment	Domestic financial sectors	BCCh	Network descriptive analysis	
United Kingdom	2011	Spillover Report	Interconnectedness Assessment (includes upstream vulnerabilty)	Cross-Country	BIS	Identify key potential sources of risk	
Korea	2011	Article IV	Simulation method (credit and credit+funding shock)	Domestic banks	BOK	Assess and quantify contagion effects	
Paraguay	2011	FSAP	Interconnectedness Assessment	Cross-country	BIS	Assess banking system's ilnkages with the rest of the world to assess cross-border supervision	
			Interconnectedness Assessment	Domestic banks and cooperatives	BCP	Network descriptive analysis	
Luxembourg	2011	FSAP	Simulation method (credit and credit+funding shock)	Cross-country	BIS	Assess and quantify contagion effects	
Finland	2010	FSAP	Interconnectedness Assessment	Domestic banks	FIN-FSA	Network descriptive analysis	
			Simulation method	Domestic banks	FIN-FSA	Assess and quantify contagion effects	

BIS: Bank for International Settlements; RBA: Reserve Bank of Australia; RBI: Reserve Bank of India; BCCh: Banco Central de Chile; BCB: Banco Central do Brazil; BOK: Bank of Korea; BCP: Banco Central de Paraguay; BIN-FSA: Finland Financial Supervisory Authority.

Table 1. Network analysis in IMF Surveillance

Country	Year	Document	Methodology	Unit of analysis	Data	Goal	Policy recommendation
Bilateral Surveillance							
Australia	2012	FSAP	Simulation method (funding shock)	Cross-country	BIS	Identify key potential sources of risk	
			Interconnectedness Assessment	Domestic banks	RBA	Determine systemic importance	Call for special risk mitigation arrangements
Spain	2012	FSAP	Simulation method (credit and credit+funding shock)	Cross-country	BIS	Identify key potential sources of risk	
India	2012	FSAP (RBI calculations)	Interconnectedness Assessment (Centrality analysis)	Domestic banks and domestic financial sectors	RBI	Network descriptive analysis	
			Simulation method (credit shock)	Domestic banks and domestic financial sectors	RBI	Assess and quantify contagion effects	
France	2012	FSAP	Simulation method (credit and credit+funding shock)	Cross-country	BIS	Identify key potential sources of risk	
			Simulation method (credit and credit+funding shock)	Domestic and foreign banks	BdF	Identify key potential sources of risk	
	2012	Article IV	Simulation method (credit shock)	Cross-country	BIS	Assess and quantify contagion effects	
Brazil	2012	FSAP	Simulation method (credit and credit+funding shock)	Domestic banks	BCB	Assess and quantify contagion effects	
Japan	2012	FSAP	Simulation method (credit and credit+funding shock)	Cross-country	BIS	Identify key potential sources of risk	
	2011	Spillover Report	Simulation method (credit and credit+funding shock)	Cross-country	BIS	Identify key potential sources of risk and potential contagion destinations	
			Interconnectedness Assessment	Cross-Country	BIS	Identify key potential sources of risk	
Chile	2011	FSAP	Interconnectedness Assessment	Domestic financial sectors	BCCh	Network descriptive analysis	
United Kingdom	2011	Spillover Report	Interconnectedness Assessment (includes upstream vulnerability)	Cross-Country	BIS	Identify key potential sources of risk	
Korea	2011	Article IV	Simulation method (credit and credit+funding shock)	Domestic banks	BOK	Assess and quantify contagion effects	
Paraguay	2011	FSAP	Interconnectedness Assessment	Cross-country	BIS	Assess banking system's linkages with the rest of the world to assess cross-border supervision	
			Interconnectedness Assessment	Domestic banks and cooperatives	BCP	Network descriptive analysis	
Luxembourg	2011	FSAP	Simulation method (credit and credit+funding shock)	Cross-country	BIS	Assess and quantify contagion effects	
Finland	2010	FSAP	Interconnectedness Assessment	Domestic banks	FIN-FSA	Network descriptive analysis	
			Simulation method	Domestic banks	FIN-FSA	Assess and quantify contagion effects	

BIS: Bank for International Settlements; RBA: Reserve Bank of Australia; RBI: Reserve Bank of India; BdF: Banque de France; BCCh: Banco Central de Chile; BCB: Banco Central do Brazil; BOK: Bank of Korea; BCP: Banco Central de Paraguay; BIN-FSA: Finland Financial Supervisory Authority.

Table 1. Network analysis in IMF Surveillance (Cont.)

Multilateral Surveillance[1]							
Authors	**Year**	**Document**	**Methodology**	**Unit of analysis**	**Data**	**Goal**	**Policy recommendation**
IMF	2012	Board paper	Centrality and cluster analysis	Cross-country	BIS	Characterize cross-border financial architecture	
Cihak and others	2011	WP	Centrality Analysis	Cross-country	BIS	Study the relationship between financial stability and interconnectedness	
Minoiu and Reyes	2011	WP	Centrality Analysis	Cross-country	BIS	Study the evolution of interconnectedness over the period 1978-2009	
IMF	2010	Board paper	Centrality analysis	Cross-country	BIS	Identify systemically important financial sectors	Establish high-frequency mandatory FSAPs for systemically important financial sectors
Espinosa-Vega and Sole	2010	WP	Simulation method	Cross-country	BIS	Identify systemically important financial sectors	
Tressel	2010	WP	Simulation method	Cross-country	BIS	Identify systemically important financial sectors	

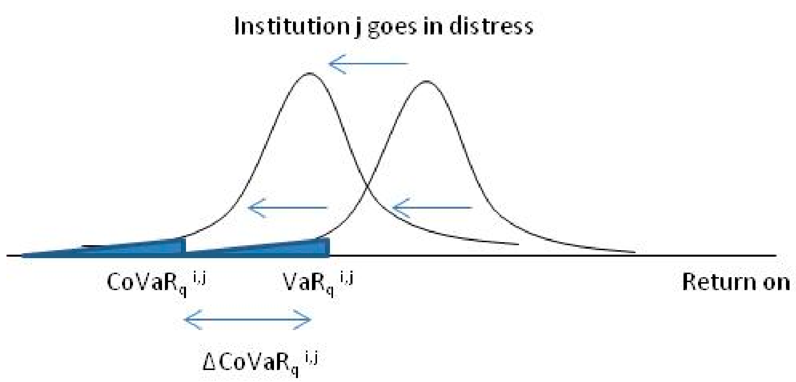
BIS: Bank for International Settlements; RBA: Reserve Bank of Australia; RBI: Reserve Bank of India; BCCh: Banco Central de Chile; BCB: Banco Central do Brazil; BOK: Bank of Korea; BCP: Banco Central de Paraguay; BIN-FSA: Finland Financial Supervisory Authority.

[1] Additionally, the IMF Research Department has developed a *bank contagion module* tool (simulation method) to analyze spillover effects from internationally interconnected banking systems. The module contributes to the IMF-FSB Early Warning Exercise.

Appendix III. Price-Based Measures

CoVaR/CoRisk. The most common measure of risk used by financial institutions, the value at risk (VaR), focuses on the risk of an individual institution in isolation. It measures the potential loss in value of a risky portfolio over a defined period for a given confidence interval. The CoVaR is defined as the VaR for an institution i conditional on the financial situation of another institution j.[60] The difference between the CoVaR conditional on distress of an institution j and the CoVaR conditional on the "normal" state of institution j, ΔCoVaR, captures the marginal contribution of institution j to risk in institution i (Figure 4). The measures can also be computed to assess the distress dependence between the market and particular institution (yielding the *contribution* to systemic risk and *exposure* to systemic risk for each institution). The CoVaR uses market data (e.g., equity prices, CDs spreads, or market value of assets) to assess the contribution of an individual financial institution to systemic risk and is therefore available on a high frequency basis. The CoVaR measure is usually estimated using quantile regressions[61], which makes it possible to evaluate the response of the dependent variable within particular segments of the conditional distribution. The time variation in the CoVaR can be estimated conditional on a vector of lagged state variables that affect the joint distribution of returns between institutions.

Figure 4. CoVaR and ΔCoVaR



Returns spillovers. The spillover measure suggested by Diebold and Yilmaz (2009) is a time-varying indicator of outward returns spillovers of institutions – the contribution of one institution to systemic risk. The indicator uses market data on returns (CDS spreads or equity prices) to estimate average (not "extreme") contributions. Vector Autoregressions are used to

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[60] Chan-Lau and others (2011) developed an analogous measure, the CoRisk model, which estimates the co-movements of financial institutions risk factors taking into account their non-linear relationship, based on CDS spreads.

[61] CoVaRs may potentially be computed in various ways.

derive the spillover index. Specifically, Variance Decomposition[62] allows assessing the fraction of the 10-step-ahead error variance in forecasting the returns to one institution that is attributable to shocks to each other institution. The spillover contribution index for institution i is given by its outward spillovers (computed adding, for each institution other than i, the share of its variance that is attributable to institution i) divided by the sum of outward spillovers for all institutions.

Distress spillovers. The distress spillover measure by Chan-Lau and others (2012) is an indicator of outward spillovers of institutions during extreme times – the potential contribution of one institution to systemic risk during crisis. The indicator uses market data on returns (based on CDS spreads, equity prices or market value of assets) to identify "extreme events" by looking at the 1st or 5th percentile of the joint distribution of returns. The probability of an extreme event happening for an institution is estimated conditional on extreme events happening or not for other institutions, after controlling for real and financial developments in the home country and in global markets. To calculate a the systemic importance of each institution in terms of "spilling over" to others, the authors take the number of significant spillover coefficients as a fraction of the number of significant spillover coefficients for all institutions. Alternatively, an index could be constructed based on the marginal effects derived from the regressions, in which case the intensity of spillovers would be taken into account.

JPoD, CoPoD. Segoviano and Goodhart (2009) propose a methodology to estimate the multivariate distribution of asset returns for all financial institutions, based on estimates of their individual probability of distress extracted from high frequency market prices (CDS spreads, equity prices or out of the money option prices).[63] This multivariate density can capture linear (correlation) and non linear interdependence among all institutions and changes over the economic cycle. Having obtained this joint probability distribution of distress across a number of institutions, it is possible to then "slice" this multivariate distribution to estimate sets of pair-wise conditional probabilities of distress -CoPoD- (i.e. the probability that a financial institution experiences distress conditional on another institution being in distress). Alternatively, other measures can be computed like the joint probability of distress for multiple institutions –JPoD-, the expected number of banks becoming distressed even that at least one bank has become distressed -BIS-, or the probability that at least one bank becomes distressed given that a particular bank has become distressed.

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[62] Variance Decomposition requires identifying assumptions. Results based on traditional Cholesky-factor identification may be sensitive to ordering. Diebold and Yilmaz find that aggregate spillover index is generally robust to the Cholesky ordering but directional connectedness, however, is found more sensitive to ordering.

[63] The approach consists on a non-parametric methodology (CIMDO methodology) that obtains the banking system multivariate density using as input empirical measurements of probability of distress for individual institutions.

Systemic CCA. Gray and Jobst' (2010) Systemic Contingent Claim Analysis quantifies the system-wide financial risk and government contingent liabilities by combining individual risk adjusted balance sheets of financial institutions and the dependence between them. The methodology consists of two estimation steps. The first step uses CCA[64] to estimate market implied potential losses for each sample financial institution. The second step uses Extreme Value Theory to model the joint market implied losses of multiple institutions as a portfolio of individual losses with time-varying and non-linear dependence among institutions, and estimates system-wide losses. The approach quantifies the contribution of specific institutions to the dynamic of systemic risk. It also shows how this risk affects the government's contingent claims over time. In this sense, it gives a magnitude of expected losses in a forward-looking manner taking into account time-varying interdependence of financial firms.

[64] The CCA is a generalization of option pricing theory pioneered by Black and Scholes (1973) and Merton (1973). It is based on three principles: (1) the values of liabilities are derived from assets; (2) assets follow a stochastic process; and (3) liabilities have different priorities (senior and junior claims). Equity can be modeled as an implicit call option, while risky debt can be modeled as the default-free value of debt less an implicit put option that captures expected losses.

Table 1. Priced-based measures in IMF Surveillance

Bilateral Surveillance					
Country	**Year**	**Document**	**Methodology**	**Unit of Analysis**	**Goal**
Chile	2009	Article IV	CoVaR/CoRisk	Domestic and foreign banks	Measure risk codependence
France	2010	Article IV	CoVaR/CoRisk	Domestic and foreign banks	Measure risk codependence
United Arab Emirates	2012	Article IV	CoVaR/CoRisk Segoviano-Goodhart	Domestic banks Domestic and foreign banking system Domestic banks	Measure risk codependence Measure risk codependence BSI, Jpod.
Qatar	2012	Article IV	CoVaR/CoRisk Segoviano-Goodhart	Domestic banks Domestic banks	Measure risk codependence BSI, S.C.
Korea	2011	Article IV	CoVaR/CoRisk Segoviano-Goodhart	Domestic banks Domestic banks	Measure risk codependence BSI, Jpod, CoPod.
Finland	2010	FSAP	Segoviano-Goodhart	Domestic and foreign banks	Measure risk codependence BSI, Jpod, CoPod.
Singapore	2008	Article IV	Segoviano-Goodhart	Domestic banks Domestic and regional banks	Jpod, CoPod. Jpod, CoPod.
United Kingdom	2011	FSAP	Segoviano-Goodhart Systemic CCA	Domestic and foreign banks Domestic banks	Jpod, CoPod. Stress testing.
United States	2010	FSAP	Segoviano-Goodhart Systemic CCA	Domestic and foreign banks Domestic banks	Jpod, CoPod. Stress testing
Sweden	2011	FSAP	Systemic CCA	Domestic banks	Stress testing
Spain	2012	FSAP	Systemic CCA	Domestic banks	Stress testing
Germany	2011	FSAP	Systemic CCA	Domestic banks	Stress testing
United Kingdom	2006	Article IV	Distress spillovers	Domestic and foreign banks	Analyze contagion risk
Ireland	2006	FSAP	Distress spillovers	Domestic and foreign banks	Analyze contagion risk
Multilateral Surveillance[1]					
Authors	**Year**	**Document**	**Methodology**	**Unit of Analysis**	**Goal**
Lopez-Espinosa and others	2012	WP	CoVaR	Large international banks	Identify main factors behind systemic risk.
Ilyina and Mitra	2012	Spillover Report	CoVaR Returns Spillovers Distress Spillovers	European SIBs and Global SIBs	Analyze spillover potential.
Arsov and others	2012	WP	CoVaR Jpod Systemic CCA Returns Spillovers Distress Spillovers	Large financial institutions in the U.S. and Euro area	Assess performance of measures as early warning indicators. Estimate potential for spillover of risk.

BSI: Bank Stability Index; Jpod: Joint Probability of Default; S.C.: Spillover Coefficient; CoPoD: Coinditional Probabilities of Default.

[1] Additionally, price-based measures are used in the context of the IMF-FSB Early Warning Exercise.

Appendix IV. Table 1. Status of Macroprudential Initiatives for Interconnectedness, by Selected Economies

	Brazil	Canada	China	European Union	Hong Kong	India	Japan	Russia	Singapore	South Africa	Switzerland	United Kingdom	United States
Microprudential Exposure Limits	BCBS BCP advice currently states that ten percent or more of a bank's capital is defined as large exposure. Twenty-five percent of a bank's capital is the limit for an individual large expsoure to a private sector non-bank counterparty or group of connected counterparties. Minor deviations from these limits may be acceptable, especially if explicitly temporary or related to very small or specialised banks. In Brazil (2008) rules set a maximum exposure limit to a single counterparty at 25% of a bank's regulatory capital. A single counterparty is defined as a customer or a group of customers that represent a single economic interest. Loans to the public sector (at all levels) are also limited at 45% of a bank's regulatory capital.	BCBS BCP advice currently states that ten percent or more of a bank's capital is defined as large exposure. Twenty-five percent of a bank's capital is the limit for an individual large expsoure to a private sector non-bank counterparty or group of connected counterparties. Minor deviations from these limits may be acceptable, especially if explicitly temporary or related to very small or specialised banks. In Canada OSFI advice is aligned with BCPs.	BCBS BCP advice currently states that ten percent or more of a bank's capital is defined as large exposure. Twenty-five percent of a bank's capital is the limit for an individual large expsoure to a private sector non-bank counterparty or group of connected counterparties. Minor deviations from these limits may be acceptable, especially if explicitly temporary or related to very small or specialised banks. China is largely compliant with BCP on large exposures and exposures to related parties as of April 2012.	BCBS BCP advice currently states that ten percent or more of a bank's capital is defined as large exposure. Twenty-five percent of a bank's capital is the limit for an individual large expsoure to a private sector non-bank counterparty or group of connected counterparties. Minor deviations from these limits may be acceptable, especially if explicitly temporary or related to very small or specialised banks. For the European Union (2006) as regards the quantitative limits, there is set of limits compliant with relevant Directive of the European Union, particularly with Directive 2006/48/EC, Articles 106 - 122. Main stipulated concentration limits for banking book are as follows: -	BCBS BCP advice currently states that ten percent or more of a bank's capital is defined as large exposure. Twenty-five percent of a bank's capital is the limit for an individual large expsoure to a private sector non-bank counterparty or group of connected counterparties. Minor deviations from these limits may be acceptable, especially if explicitly temporary or related to very small or specialised banks. Concentration limits The Monetary Authority (MA) requires all locally incorporated authorized institutions (AIs) to comply with statutory limits stipulated in Part XV of the Banking Ordinance (BO) for controlling their large exposures and risk concentrations. The main limits are:	BCBS BCP advice currently states that ten percent or more of a bank's capital is defined as large exposure. Twenty-five percent of a bank's capital is the limit for an individual large expsoure to a private sector non-bank counterparty or group of connected counterparties. Minor deviations from these limits may be acceptable, especially if explicitly temporary or related to very small or specialised banks. India has the following exposure limits and norms (full details are available from RBI website) The exposure ceilings for a single borrower and group of borrowers are 15% and 40%, respectively, of the bank's capital funds (Tier I and Tier II).	BCBS BCP advice currently states that ten percent or more of a bank's capital is defined as large exposure. Twenty-five percent of a bank's capital is the limit for an individual large expsoure to a private sector non-bank counterparty or group of connected counterparties. Minor deviations from these limits may be acceptable, especially if explicitly temporary or related to very small or specialised banks. The Japan 2012 FSAP recommended large exposure rules to be revised and strengthened so that all exposures from ana individual client or group or connected clients are taken into account, limits are set as a percentage of tier 1 or core tier 1 capital, and all banks properly manage risk concentrations with respect to different regions	BCBS BCP advice currently states that ten percent or more of a bank's capital is defined as large exposure. Twenty-five percent of a bank's capital is the limit for an individual large expsoure to a private sector non-bank counterparty or group of connected counterparties. Minor deviations from these limits may be acceptable, especially if explicitly temporary or related to very small or specialised banks. According to the Law on the Central Bank of Russian Federation (Article 62) the Bank of Russia establishes the following concentration limits (ratios). - N6: Aggregate size of loans to one borrower and/or a group of connected borrowers is limited to 25% of bank's capital;	BCBS BCP advice currently states that ten percent or more of a bank's capital is defined as large exposure. Twenty-five percent of a bank's capital is the limit for an individual large expsoure to a private sector non-bank counterparty or group of connected counterparties. Minor deviations from these limits may be acceptable, especially if explicitly temporary or related to very small or specialised banks. In singapore the following statutory limits were applied (1) Single counterparty limits where: (a) aggregate exposure to a single counterparty group cannot exceed 25% of its capital funds; and	BCBS BCP advice currently states that ten percent or more of a bank's capital is defined as large exposure. Twenty-five percent of a bank's capital is the limit for an individual large expsoure to a private sector non-bank counterparty or group of connected counterparties. Minor deviations from these limits may be acceptable, especially if explicitly temporary or related to very small or specialised banks. In South Africa In terms of section 73 of the Banks Act a bank or a bank controlling company shall not make investments with or grant loans or advances or other credit to any person to an aggregate amount exceeding 10 per cent of its net qualifying capital and reserves without having obtained the	BCBS BCP advice currently states that ten percent or more of a bank's capital is defined as large exposure. Twenty-five percent of a bank's capital is the limit for an individual large expsoure to a private sector non-bank counterparty or group of connected counterparties. Minor deviations from these limits may be acceptable, especially if explicitly temporary or related to very small or specialised banks. In Switzerland risk concentrations and large exposure limits are aligned with latets BCP advice and EU driectives.	BCBS BCP advice currently states that ten percent or more of a bank's capital is defined as large exposure. Twenty-five percent of a bank's capital is the limit for an individual large expsoure to a private sector non-bank counterparty or group of connected counterparties. Minor deviations from these limits may be acceptable, especially if explicitly temporary or related to very small or specialised banks. UK large exposures and risk concentrations are fully outlined in FSA BIPRU handbook, broadly in line with latest BCPs in this area - waivers are allowed for sovereign debt holdings. UK was compliant on large exposure limits with BCPs but largely compliant on exposures to related parties, as of July 2011.	BCBS BCP advice currently states that ten percent or more of a bank's capital is defined as large exposure. Twenty-five percent of a bank's capital is the limit for an individual large expsoure to a private sector non-bank counterparty or group of connected counterparties. Minor deviations from these limits may be acceptable, especially if explicitly temporary or related to very small or specialised banks. The US is compliant with BCP on large exposure limits and exposures to related parties, as of May 2010.
Microprudential Exposure Limits	There is also an aggregate limit: the sum of exposures representing 10% or more of the regulatory capital is limited to 600% of the regulatory capital. Name concentration risk includes exposures in banking and trading book. As of July 2012 Brazil in compliant with BCP on large exposure limits and exposure to related parties.			10% of capital to single obligor or group of connected persons at most; the sum of such large individual exposures should not exceed 800% of the capital; 20% of capital within the group to which bank belongs to at most; 25% of capital outside the group to which bank belongs to at most. Most of Europe is compliant or largely compliant with BCPs on large exposures and exposures to related parties as of mid-2012.	an AI's financial exposure to a person or a group of related persons should not exceed 25% of its capital base (section 81); • an AI's unsecured exposure to its connected parties (section 83) should be within the following limits: — each individual : HK$1m; — aggregate of individual exposures : 5% of the AI's capital base; — aggregate of all unsecured connected exposures (including exposures to individuals and companies) : 10% of the AI's capital base; • an AI's holding of share capital of a company or companies in aggregate should not exceed 25% of its capital base (section 87); and • an AI's holding of interest in land in or outside Hong Kong should not exceed 25% of its capital base (section 88).	(ii) These limits can be exceeded by 5% and 10% of capital funds in the case of single borrower and a group of borrowers, respectively, if the borrower is engaged in infrastructure activities. This has been done to increase the flow of credit to infrastructure sector as part of the overall strategy of Government regarding India's economic development. (iii) With the approval of the Board of directors, in exceptional cases, the banks can assume a further exposure of up to 5% of capital funds to a single borrower or a group of borrowers.	and industries.	N7: Aggregate large credit exposures is limited to 800% of bank's capital. An exposure to one borrower (a group of connected borrowers) which exceeds 5% of a bank's capital is treated as large credit exposure.	(b) aggregate of all exposures exceeding 10% of eligible total capital to any single counterparty group cannot exceed 50% of its total exposures. These limits apply at both the solo and the group level. A list of exempted exposures is set out in Appendix 1 of MAS Notice 639 and include: • exposures to central governments, central banks, and public sector entities, that are AAA-rated; • short-term exposures to banks; and • exposures to counterparties arising from the clearing or settlement of transactions, granting intra-day facilities or entering into overnight repurchase or reverse repurchase transactions.	permission of its board of directors, or a board appointed committee for this purpose (the Registrar needs to approve the composition of the board appointed committee). The aggregate amount of investments, loans, advances or other credit to a private sector non-bank person is limited to 800 per cent of the net qualifying capital and reserves.			
Microprudential Exposure Limits					Section 90 further limits an AI's aggregate exposures under sections 83, 87 and 88 to within 80% of its capital base. The MA generally applies the above-mentioned limits to AIs on both a solo basis and a consolidated basis (i.e. including an AI's subsidiaries). Exemptions are allowed (See HKMA website) • financial exposure to other AIs or overseas incorporated banks (which are not AIs but are regarded by the MA as being adequately supervised); • financial exposure to the extent to which it is secured by cash deposit, guarantee or undertaking, securities or letter of comfort accepted by the MA; • financial exposure arising from some trade financing transactions; • financial exposure acquired under underwriting or sub	(iv) The exposure for this purpose gas been defined comprehensively and includes both on-balance sheet and off-balance sheet exposures. The exposure also includes investments and derivative products. For derivative products, the exposure amount is required to be computed as per the "current exposure method". (v) Apart from limiting the exposures to an individual or a Group of borrowers, as indicated above, banks have been advised that they may also consider fixing internal limits for aggregate commitments to specific sectors, e.g. textiles, jute, tea, etc., so that the exposures are evenly spread over various sectors.		When calculating the above mentioned ratios (N6 and N7) claims to the borrower (net of provisions) are risk-weighted with coefficients used for determining the capital adequacy ratio. These limits are applied both on a solo and on a group-wide consolidated basis.	(2) Equity investment limit where an exposure to any equity investment in a single company cannot exceed 2% of the capital funds of a bank. (3) Limit on holdings of immovable property where exposure to immovable property in aggregate cannot exceed 20% of the capital funds of a bank. (4) Immovable property sector limit where property sector exposure cannot exceed 35% of total eligible assets of a bank.	Written approval needs to be obtained from the Registrar of Banks for all exposures to a private sector non-bank persons in excess of 25 per cent of net qualifying capital and reserves. In addition to the above applying to private sector non-bank persons exempt exposures include the following: (a) exposures to, or guaranteed by, the Government of the Republic of South Africa or the South African Reserve Bank; (b) exposures to, or guaranteed by, the public sector; (c) exposures secured by cash deposited with either the reporting bank or banks within the same group as the reporting bank,			
Microprudential Exposure Limits					• financial exposure acquired under underwriting or sub-underwriting contracts (the exemption will only last for a period not exceeding 7 working days or such further period approved by the MA); and • financial exposure to a multilateral development bank, the HKSAR Government or other government acceptable to the MA, or such other government-related body or public sector entity in Hong Kong as specified in the BO (subject to conditions where applicable). Exemption from the limits in sections 87 and 88 is also available in some circumstances, such as where the share capital or interest in land is held as collateral for facilities granted or acquired (during debt recovery) by an AI. In the latter case, such share capital or interest in land	These limits could be fixed by the banks having regard to the performance of different sectors and the risks perceived. The limits so fixed may be reviewed periodically and revised, as necessary.		Calculation methods of required ratios for banking (consolidated) groups including specific methods for non-credit institutions – members of groups are established (defined) by the Bank of Russia. Russia as of November 2011 was materially non-compliant with regard to exposures to related parties as part of the BCPs.		(the above exempt exposures are, however, still under discussion. As of December 2010 South Africa was found to be materially non-compliant for exposures to related parties, but compliant with respect to large exposure limits of the BCPs.			

	Brazil	Canada	China	European Union	Hong Kong	India	Japan	Russia	Singapore	South Africa	Switzerland	United Kingdom	United States
Tightening of OTC derivatives regulation Mandatory clearing of standardized trades by CCPs	Mandatory clearing applies only to exchange traded derivatives. A working group was set up to evaluate which OTC derivatives could be cleared by CCPs and draft new regulation.	Legislation is in place in provinces where the majority of OTC derivatives are booked, but further work is required to harmonize across provinces. Provincial legislation expected by end 2012.	Legislation not yet proposed. PBOC are taking measures to encourage Shanghai Clearing House to establish detailed schemes for central clearing of OTC derivatives. Interest rate swaps central clearing operation scheme is under discussion.	EMIR adopted by the Council and Parliament in July 2012. Regulatory technical standards came into force in March 2013.	Legislative drafting has started, with the aim to have legislation approved by end 2012.	Legislation not yet proposed. CCIL to transition soon to guaranteed settlement of interest rate swaps; no immediate timeframe for guarantee settlement of CDS.	Legislation adopted via reform to the Financial Instruments and Exchange Act (FIEA) in May 2010. Initially the obligation will apply only to yen interest rate swaps and CDS. A cabinet ordinance to be implemented by November 2012 includes a requirement for central clearance of "trades that are significant in volume and would reduce settlement risk in the domestic markets."	Legislation relating to clearing services and legislation relating to tax code create the legal basis for promulgation of regulation dealing with central clearing of standardized OTC derivatives. They have both been adopted. Pending regulations that implement new requirements.	Public consultation issue on February 2012. Legislation to be introduced by end 2012.	Financial Markets Bill submitted to the National Treasury.	A working group was set up in 2011. Draft legislation scheduled for consultation in the second half on 2012.	Responsibility for supervision of CCPs has now passed to Bank of England from the now defunct FSA. Bank of England requires CCPs to hold cash, potentially supplemented with other highly liquid collateral, to meet the minimum regulatory liquidity needs set out in the revised CPSS/IOSCO Principles for Financial Market Infrastructures and reflected in the EU regulation on OTC derivatives, central counterparties and trade repositories (EU/648/2012) "EMIR", which will apply to CCPs as they are authorized under EMIR. The main UK CCPs have right of re-use to cash margins provided by members, giving them access to an extensive pool of liquidity that is not available to CCPs that do not have such rights of reuse.	Legislation adopted (Dodd-Frank in 2010). SEC and CFTC are finalizing regulations.
Recovery and resolution plans	N.A.	While no Canadian banks have been identified as G-SIFIs, draft recovery and resolution plans are being developed for largest banks, due to be completed in 2012.	D-SIBs required to develop recovery and resolution plans. An RRP for Bank of China (G-SIFI) is being developed.	High-level Expert Group on possible reforms to the structure of the EU banking sector set up on February 22, 2012.	N.A.	N.A.	N.A.	Recovery plans to be developed for D-SIBs H2 2012, and resolution plans H1 2013.	N.A.	Plans to produce RRP for D-SIBs to be put in place during 2012.	SIBs are required to produce RRPs.	The Financial Services Act adopted (2010) requires banks to produce RRPs. All banks and systemic investment firms are required to complete RRPs by June 2012. Most UK banks have completed first drafts of their RRPs which will be continuously updated.	Under the Dodd-Frank , bank holding companies with total consolidated assets of $50 billion or more and non-bank financial companies designated by the Financial Stability Oversight Council for supervision by the Fed must submit resolution plans annually to the FDIC and the Federal Reserve.
Structural changes to banks and limitations on bank activities	N.A.	N.A.	N.A.	Proposals in Europe are mainly in the discussion stage especially with regard to the Liikanen, French and German proposals.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	The extra capital requirements of Swiss G-SIFIs (the "Swiss finish") which go beyond Basel III (and need to be in place by 2019).	Vickers commission structural changes in UK banking. White Paper to implement Vickers published in June 2012. Latest version incorporating the Vicker's proposals are contained in the Banking Reform Bill due to become law in 2014.The Bill also includes provisions to enforce full separation by the PRA.	Volcker rule to limit proprietary trading in banks and investment in private equity.
Changes in crisis resolution regimes	Preparing draft legislation to address gaps in powers v-a-v the FSB's Key Attributes (KA).	The KA are being reviewed to determine legislative or regulatory changes which may be required to comply with the KA.	Plans to introduce deposit insurance are being accelerated.	The EC issued a draft directive June 2012 which would closely align national resolution regimes in the EU with the KA. The final resolution directive is planned to be implemented by 2014. The draft directive on Deposit Guarantee Schemes is still under discussion but is hoped to be agreed simulataneously with the Recovery and Resolution Directive.	Review of legislative and regulatory changes required to implement outstanding aspects of the KA is underway.	N.A.	N.A.	Review of legislative and regulatory changes required to implement outstanding aspects of the KA is underway.	Resolution regime was enhanced in 2007, and extended to insurers in 2011. Plans to further enhance regime to address some outstanding aspects of KA over the next two years.	N.A.	The resolution regime was strengthened prior to and since the crisis (Banking Act was amended in Sept. 2011) and has most of the tools in the KA .	A temporary resolution regime was introduced in 2008, and replaced with a permanent special resolution regime in 2009. This has many of the powers contained in the KA and applies not only to banks. UK proposals will also be updated in line with the EU bank Recovery and Resolution Directive.	The resolution regime was extensively revised under Dodd Frank, including by extending to non-banks and BHC's.

Sources: Basel Committee on Banking Supervision, European Union, Financial Stability Board, G20, Independent Commission on Banking, International Association of Insurance Supervisors, International Organization of Securities Commissions, and PriceWaterhouse Coopers.

[1] This table relies on the sources above and reflects the most recent information available; the most recent information may be subject to delays in publication. Entries with N.A. indicate the information is either non-available or non-applicable.

[2] Basel III liquidity framework is not finalized in detail. The entries, therefore, seek to reflect the existence of any quantitative liquidity requirements in the selected countries, and implementation of the 2008 "Principles for Sound Liquidity Risk Management and Supervision."

	Brazil	Canada	China	European Union	Hong Kong	India	Japan	Russia	Singapore	South Africa	Switzerland	United Kingdom	United States
Microprudential Exposure Limits					AI. In the latter case, such share capital or interest in land acquired should be disposed of within 18 months (or such further period approved by the MA) after the acquisition. Prudential limits Apart from the statutory limits, the HKMA may set prudential limits on an AI's exposures to particular counterparties, groups of counterparty, economic or geographical sectors if the AI is, in the HKMA's opinion, exposed to a significant level of concentration risk that may affect its financial stability. These limits will be determined on a case-by-case basis, having regard to the AI's individual circumstances. In addition, AIs are expected to set an internal "clustering" limit to control the aggregate of their non-exempt large exposures (i.e. exposures equal to or								
Microprudential Exposure Limits					equal to or exceeding 10% of an AI's capital base). Such limit should be approved by the Board of Directors and agreed with the HKMA. An industry benchmark of 200% of capital base is provided to AIs as reference for setting their clustering limit. The above provisions are contained in the HKMA's supervisory guideline CR-G-8 "Large Exposures and Risk Concentrations."								
G-SIFI buffer	N.A.	N.A.	Basel III regulation finalized and released in June 2012, will be implemented from Jan 1 2013 to 2018. Domestic systemically important banks (D-SIBs) additional capital requirements are 1%. If the D- SIB is a G-SIB, the additional capital requirement for this bank cannot be lower than the Basel minimum level.	Countries will not be limited in their capacity to require more capital than the Basel III minimum especially with regard to the systemic buffer under published CRDIV. The systemic risk buffers can apply to all banks in the system.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	Legislation adopted September 2011, draft regulation published December 2011. On top of the CET1, SIBs must have a capital conservation buffer of 8.5% (5.5% conservation buffer and additional 3% of "recovery CoCos") and a systemic surcharge of up to 6% (depending on market share and balance sheet size), bringing total capital requirements to 19%.	Draft legislation requiring above Basel III capital, composed of common equity and will be brought in line with published CRDIV.	G-SIBs not yet covered as Basel has not finalized its framework. There are references to systemic institutions under the rule making under Dodd Frank (s165 and 166) as issued in December 2011
Quantitative liquidity requirements[2]	Liquidity requirements are currently used for supervisory monitoring only. They will be formally introduced in national legislation according to the Basel III schedule.	Quantitative metric for monitoring.	Draft for consultation.	Not implemented. CRDIV will consider final BCBS proposals on NSFR and liquidity rules.	N.A.	N.A.	Basel III schedule.	Since 2004, reviewed 2011.	Not required.	Basel III timetable.	For G-SIBs only.	Implemented 2010. UK rules will be further amended in light of BCBS final proposals and their incoporation into CRDIV.	N.A.