Guidance to Assess the Systemic Importance of Financial Institutions, Markets and Instruments: Initial Considerations—Background Paper

Report to the G-20 Finance Ministers and Central Bank Governors

Prepared by:
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October 2009

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October 28, 2009

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GLOSSARY

ABCP	Asset-backed commercial paper
AIGFP	AIG Financial Products
BCBS	Basel Committee on Banking Supervision
BIS	Bank for International Settlements
CAR	Capital adequacy ratio
CCA	Contingent claims analysis
CDOs	Collateralized debt obligations
CDS	Credit default swap
CGFS	Committee on the Global Financial System
CLOs	Collateralized loan obligations
DNB	De Nederlandsche Bank
ECB	European Central Bank
ECOFIN	Economic and Financial Affairs Council
FDIC	Federal Deposit Insurance Corporation
FRA	Forward rate agreement
FRBNY	Federal Reserve Bank of New York
IAIS	International Association of Insurance Supervisors
IMF	International Monetary Fund
IOSCO	International Organization of Securities Commissions
iPOD	Implied probability of default
LBHI	Lehman Brothers Holding Inc.
MBBGs	Major British banking groups
OIS	Overnight index swap
OTC	Over-the-counter
RAMSI	Risk Assessment Model for Systemic Institutions
RMBS	Residential mortgage-backed securities
SIVs	Special investment vehicles
SRM	Systemic Risk Monitor

I. Summary of Responses to the Country Survey of Systemic Issues

A. Background on the Survey

1. **To inform the preparation of the paper, country authorities were surveyed on their experiences with identifying systemically important institutions, markets and instruments.** Feedback on an initial draft questionnaire, coordinated by the IMF, FSB and BIS, was sought from counterparts at several central banks (see Attachment). The finalized questionnaire was subsequently sent out to the central banks of G-20 and FSB members, plus a few other countries which are widely recognized as key home/host countries to important international banks; in all, the survey was sent to 27 central banks. The survey was also sent to the supervisory and regulatory standard setters—the Basel Committee on Banking Supervision (BCBS), the International Association of Insurance Supervisors (IAIS) and the International Organization of Securities Commissions (IOSCO)—for their information and possible responses from their respective members. The survey is provided as Appendix I.

2. **The survey comprised quantitative and qualitative components.** On the quantitative side, countries were asked to indicate if a particular sector is systemic, and whether individual institutions in that sector are systemic. They were then asked to rank the five most important factors contributing to their classification of systemic relevance, both before and after the onset of the current crisis. The qualitative aspect was made up of three parts: (i) how countries assess systemic relevance; (ii) the design of a framework to assess systemic relevance; and (iii) where relevant, how financial crises have informed approaches to identifying systemic relevance.

3. **Completed surveys were received from all the central banks to which they were sent, representing a 100 percent response rate.** In some countries, where the financial supervisory role is also performed by the central bank, responses to the survey were coordinated between the financial stability analysis and supervisory functions. In one case, the central bank had shared the survey with the supervisory agency, which prepared a separate response. Responses were also sent directly from the supervisory agencies of two countries. In all, 30 separate responses were received to date (Table 1).

4. **Countries typically provided comprehensive responses to the survey.** Most countries provided answers to both the qualitative and quantitative components; six countries preferred not to rank the factors contributing to the systemic relevance, citing the difficulty of any ex ante assessment, which is largely attributable to the state-dependent nature of systemic relevance and the lack of formal definitions of what constitutes systemic importance.

5. **This chapter is organized as follows.** Section B presents and analyzes countries' identification of the main systemically important entities in their financial systems, and the relevant systemic factors contributing to their classification. A summary of the discussion by

respondents on the identification of systemic relevance and on the design of a framework to assess systemic relevance are presented in Section C.

Table 1. Survey Respondents

	Country	Respondent
1.	Argentina	Banco Central de la República Argentina
2.	Australia	Reserve Bank of Australia
3.	Brazil	Banco Central do Brasil
4.	Canada	Bank of Canada
5.	China	People's Bank of China
6.		China Banking Regulatory Commission
7.	France	Banque de France
8.	Germany	Deutsche Bundesbank
9.	India	Reserve Bank of India
10.	Indonesia	Bank Indonesia
11.	Italy	Banca d'Italia
12.	Japan	Bank of Japan
13.	Mexico	Banco de México
14.		Comisión Nacional Bancaria y de Valores
15.	Russia	Central Bank of the Russian Federation
16.	Saudi Arabia	Saudi Arabian Monetary Agency
17.	South Africa	South Africa Reserve Bank
18.	South Korea	Bank of Korea
19.	Turkey	Central Bank of the Republic of Turkey
20.	United Kingdom	Bank of England
21.	United States	Federal Reserve
22.	Hong Kong SAR	Hong Kong Monetary Authority
23.	Netherlands	De Nederlandsche Bank
24.	Singapore	Monetary Authority of Singapore
25.	Switzerland	Swiss National bank
26.	Austria	Oesterreichische Nationalbank
27.	Hungary	Magyar Nemzeti Bank
28.	Spain	Banco de España
29.	Sweden	Riksbank
30.	Romania	Comisia de Supraveghere a Asigurărilor

B. Analysis of Quantitative Survey Data

6. **Analysis of the data obtained from the survey reveals several broad trends in countries' assessments of systemic importance:**

- ***Entities.*** All surveyed countries consider their banks to be the most systemically important among institutions. Insurance companies and pension funds are seen as the next most relevant in terms of their potential impact on financial/economic stability. The stock market, interbank money market, foreign exchange market and government debt market are perceived to have the greatest systemic impact among markets before and during the current crisis. Separately, many countries assess their payment and settlement systems as being critically important infrastructure for ensuring the smooth functioning of the financial system.

- ***Factors.*** With few exceptions, size is by far the most important factor contributing to the classification of systemic importance, both before and after the onset of the current crisis. Interconnectedness is clearly the second most important factor in the determination of the systemic importance of institutions, markets and instruments by country authorities. Following the onset of the current financial crisis, there has been some change in the importance placed by authorities on certain factors in the determination of systemic relevance.

7. **Prior to the crisis, banks were clearly the main institutions of concern for country authorities in that they were considered potentially systemic by all respondents.** Pension funds, insurance companies and state-owned/sponsored financial institutions were seen as having the greatest systemic impact after banks.

8. **Pre-crisis, the size of institutions was the main focus of country authorities in terms of their systemic impact, but other factors also figured prominently** (Figure 1):

- The general consensus was that **size** posed the biggest risk for the systemic relevance of banks; only one respondent thought that **leverage** represented the biggest risk. **Size** was also considered the most important factor influencing the systemic relevance of all other institutions. Hedge-funds were the exception, with interconnectedness, leverage and opacity/complexity seen as more important factors. Some countries viewed the role of pension funds in **fiscal policy** as a potential risk.

- **Interconnectedness** was largely ranked the second and third most important systemic risk factor for institutions. That said, views were more dispersed, with some respondents ranking **concentration risk** as the second most important factor, and **leverage** third. The **correlation of exposures** was also a popular third-ranked factor.

9. **Since the onset of the financial crisis ("post-crisis"), assessments of the factors contributing to the systemic importance of financial institutions have changed somewhat** (Figure 1):

- Fewer respondents now consider **size** to be the main risk factor; more consider factors such as **interconnectedness**, **leverage** or **maturity mismatches** to be the main risks.

- While **interconnectedness** remains the second-ranked risk factor of choice, respondents appear to be focusing more on **maturity mismatches**, **concentration risk** and **leverage** as well. The third-ranked factors are largely the same as before.

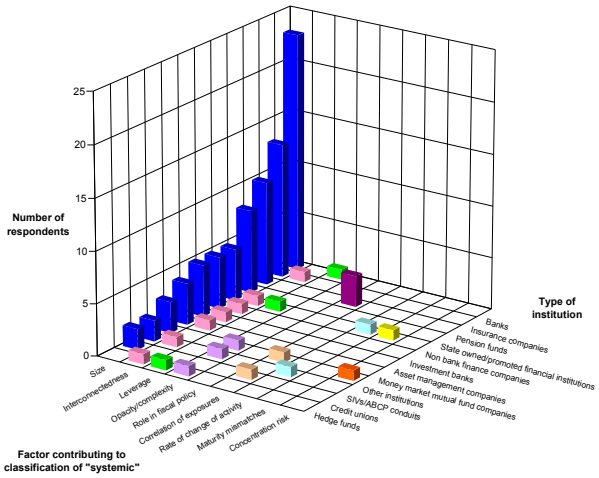
10. **Banks, insurance companies and pension funds continue to be perceived as key "systemic" institutions in many financial systems post-crisis.** More respondents now consider asset management and money market mutual fund companies to pose greater systemic threat.

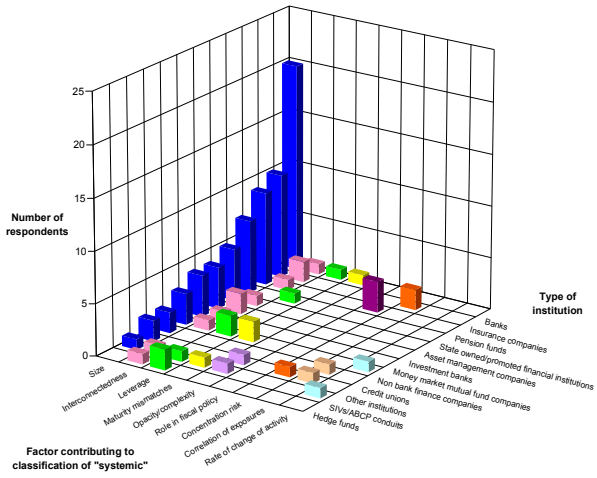
Figure 1. Factors Contributing to the Classification of Systemic Institutions

Pre-Crisis

Post-Crisis

Rank 1





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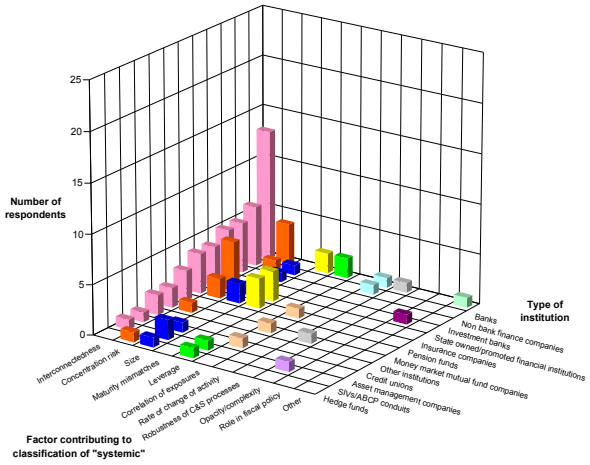
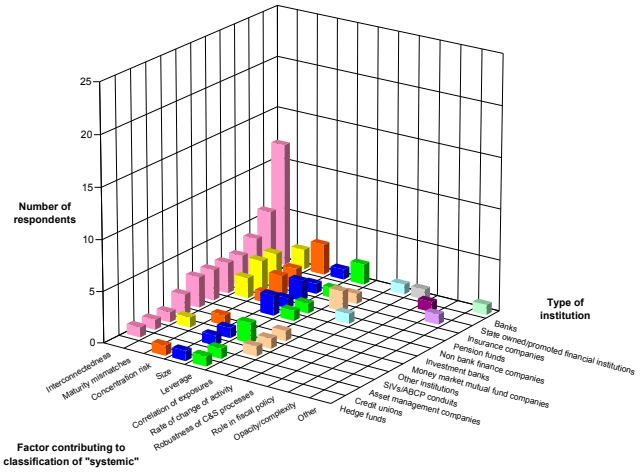
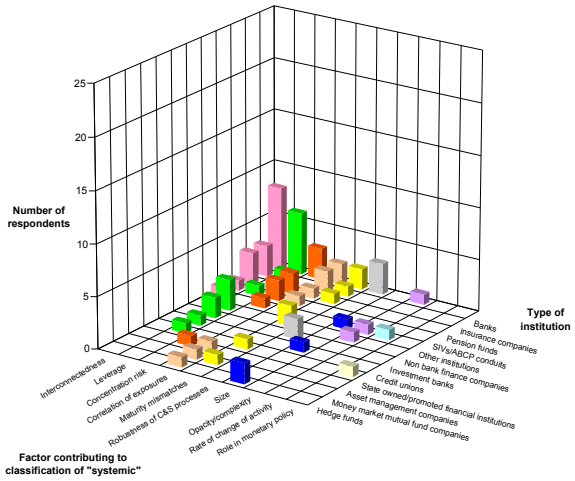
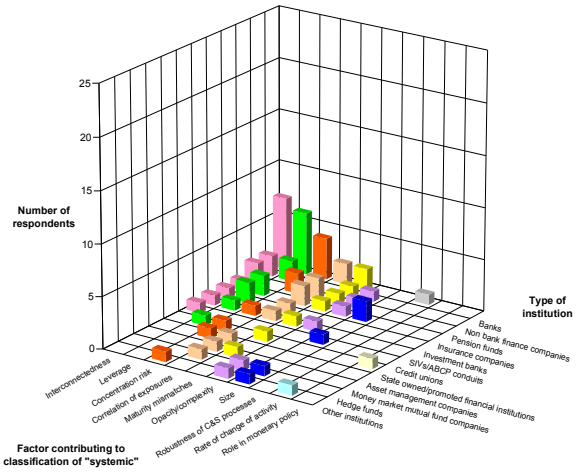




Rank 3





11. **As to markets and instruments, stock, interbank, foreign exchange and government debt markets were considered the most systemic pre-crisis** (Figure 2).

- The **size** of these markets was the biggest consideration in classifying them as systemic. Some respondents felt that the **interconnectedness** of interbank money markets and "other" over-the-counter (OTC) markets such as interest rate and cross-currency swaps, overnight index swaps (OIS) and forward rate agreements (FRA), and interest rate and currency options were most important. Among potentially systemic instruments, the **size** of foreign exchange loans and covered bonds outstanding was ranked as the biggest risk factor.

- Perceptions became more dispersed when countries were asked to rank subsequent factors of risk for markets and instruments. **Interconnectedness** was largely seen as the second most important risk factor, while the **robustness of clearing and settlement processes** was ranked third. The **rate of change of activity** and the **correlation of exposures** were among the other choices.

12. **Assessments of the systemic importance of particular markets are little changed since the onset of the crisis** (Figure 2). At the margin, the interbank money market has now edged out the foreign exchange market as the one that is considered potentially most systemic.

- Countries' assessments of the key risk factor for determining systemic markets and instruments have become more dispersed. While **size** remains the most important, **interconnectedness** is now perceived by more respondents to be the main factor. Some others now consider **opacity/complexity**, **role in monetary policy** or **concentration risk** to be the key factor.

- Among the second-ranked factors, **interconnectedness** continues to be the most-used, but **size**, the **rate of change of activity,** and **concentration risk** have become more important considerations. The **robustness of the clearing and settlement process** remains the most-quoted third-ranked factor, followed by **interconnectedness**.

13. **Prior to the crisis, the robustness of the clearing and settlement processes was the main factor for countries which felt that the financial infrastructure was potentially systemic** (Figure 3). **Size** was considered by some to be most important, while **interconnectedness** was second-ranked by most respondents. One respondent thought that rating agencies had the potential to pose systemic risk as a result of the **opacity/complexity** of their products.

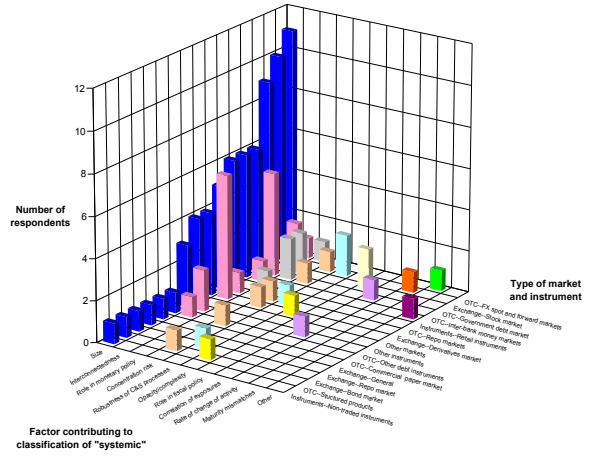
14. **There has been little change in countries' assessment of factors influencing the systemic importance of infrastructure since the onset of the crisis.** However, one more respondent now considers rating agencies as being potentially systemic.

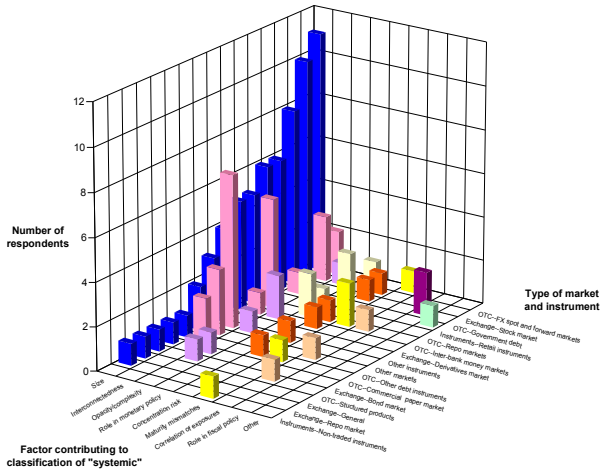
Figure 2. Factors Contributing to the Classification of Systemic Markets and Instruments

Pre-Crisis

Post-Crisis

Rank 1





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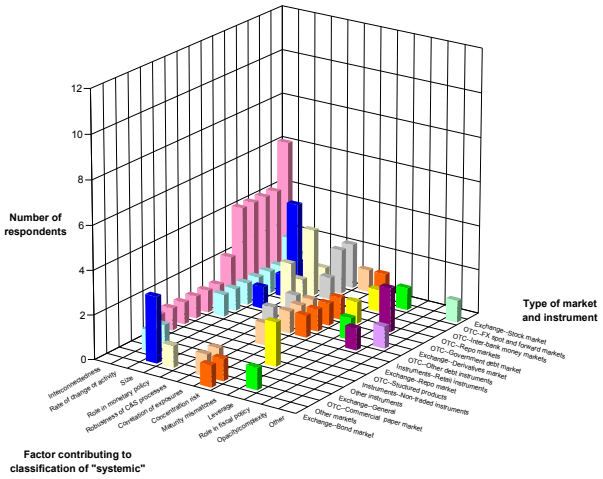

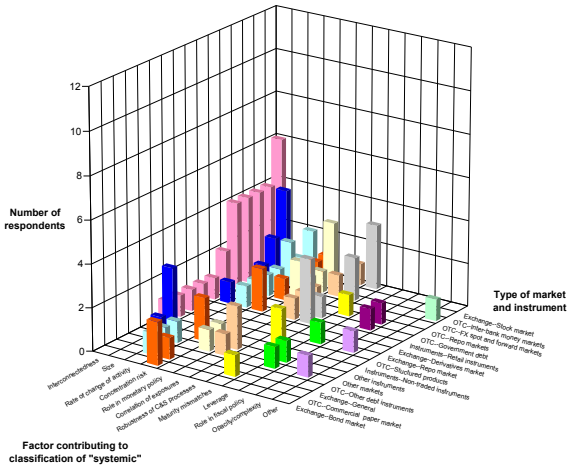

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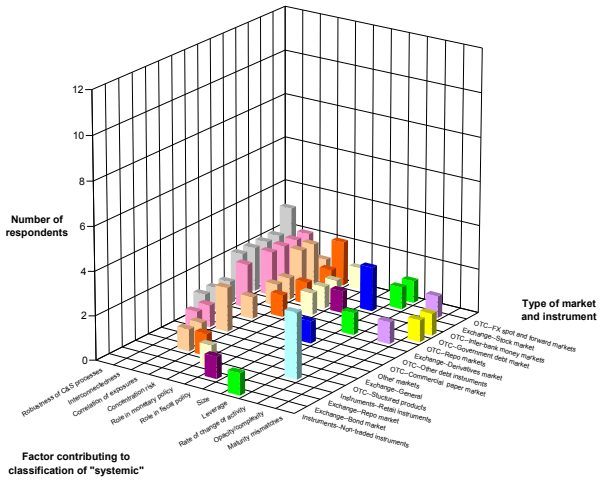


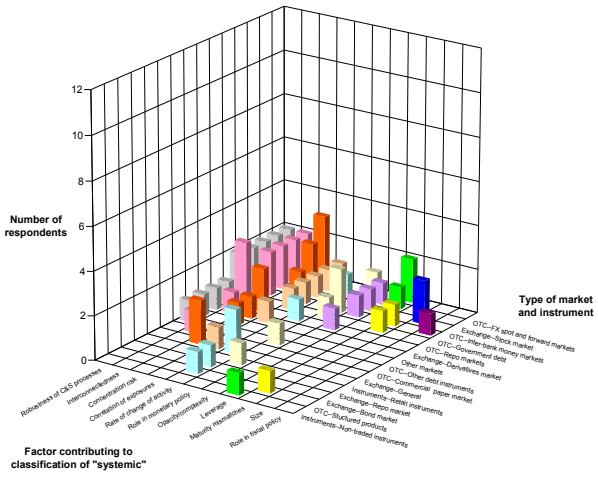
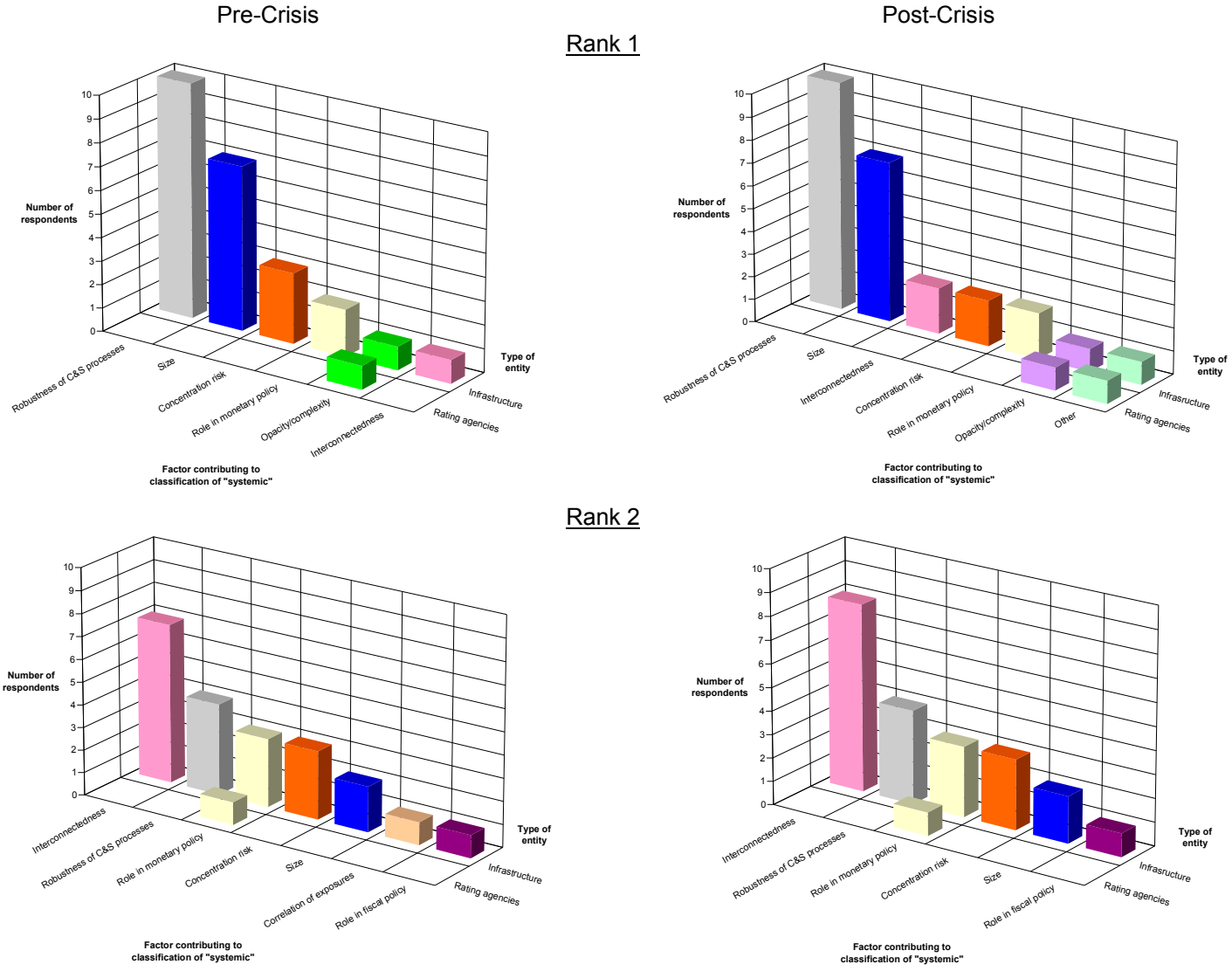


Figure 3. Factors Contributing to the Classification of Systemic Infrastructure and Rating Agencies



C. Analysis of Qualitative Survey Information

15. **The following provides a review of the Survey responses ordered by the questions in the survey:**

Part 1. Identifying systemic institutions, markets and instruments

1a. How would you define "systemic" importance for the financial sector? What factors/metrics do you use to determine what constitutes a potentially systemic market, instrument or institution ("SIMI") for your financial system? What are the key differences

between the institutions, markets or instruments that you consider systemic and those that are non-systemic?

Respondent countries typically do not have a legal or formal definition of what constitutes "systemic importance." Broadly, an institution, market or instrument is defined as systemic by authorities if its failure causes widespread distress, either as a direct impact or as a trigger for broader contagion. However, the interpretation is nuanced in that some authorities focus on the impact of potentially systemic institutions, markets or instruments on the financial system, while others consider their ultimate impact on the real economy as key.

Many of the risk metrics/factors that are presented in our questionnaire are used by country authorities in their identification of systemic importance. The issue of size is considered the biggest risk factor by most respondents. Other areas of significant concern include interconnectedness and risk concentration. Respondent countries are by far the most preoccupied with their respective banking sectors, in terms of identifying systemically important institutions. Many countries also highlight the potentially systemic nature of clearing, payment and settlements systems for their financial systems.

Numerous countries note the state dependent nature of what constitutes systemic. They argue that conditions are likely to vary over time and that systemic importance would be dependent on the shocks to the system, the structure of the system and the condition of individual markets and balance sheets at that particular point in time—during periods of extreme turbulence, more institutions, markets or instruments are likely to be systemically relevant. One respondent notes that the risk of having formal designations or definitions of what constitutes "systemic" is that changes to the systemic importance of particular entities in the financial system may be overlooked.

1b. Do you presently have a formal process to assess the systemic relevance of institutions, markets, or instruments? If so, please describe your institutional and governance arrangements. In particular:

- *which agencies are involved, who is ultimately responsible;*
- *what techniques and data are used in the assessment;*
- *what is the frequency of assessment;*
- *what are the results used for (e.g., financial supervision, financial surveillance)?*

Many respondent countries do not have formal processes nor agencies that are formally charged with the responsibility for leading the process of assessing SIMIs. In these cases, supervision and regulation are assigned to various agencies according to functional criterion, and emerging risks would require collaboration among the individual agencies. In a few countries, the central banks or monetary authorities have oversight of a larger part of the financial system, if not all of it. A handful of countries have each established a body (e.g., financial stability committee or council) comprising the key agencies, which have the

responsibility of determining what constitutes systemic risk using the analyses of individual agencies.

A variety of techniques are used to assess systemic relevance across countries. They range from basic "traditional" techniques for identifying risks in the banking system, to sophisticated quantitative models, to qualitative criteria which include "market intelligence". In a couple of instances, the analysis done in deciding whether to provide lender-of-last-resort support—using the guiding principle of whether failure could damage the stability of the financial system—is used as a technique to define systemic importance. Among some European countries, the European Central Bank's Systemic Impact Assessment Handbook is used as a guide for determining the issues to be covered in the assessments.

Responses on the frequency of assessments are mixed. While some authorities note that they perform assessments of what constitutes systemic importance regularly, others point out that routine assessments are not feasible. Many consider the assessments of risks to the soundness of their respective financial systems in their financial stability reports to be an important assessment tool.

In almost all cases, respondents note that the results of any assessment are used as important inputs for financial supervision and surveillance.

1c. How do you monitor institutions, markets and instruments that do not currently fall within the scope of regulation and which could potentially pose systemic risks in your country?

Many respondents are of the opinion that the key institutions, markets and instruments, which they consider potentially systemic, are already captured by their regulatory perimeter. Where important regulatory gaps are identified, regulators indicated that they will set up an appropriate framework for regulation or oversight. In some countries, those entities that are exempt from regulation—such as hedge funds and private equity firms—are not considered systemically important. In one case, guiding principles had been developed for regulated institutions that invest in those unregulated entities. While some countries can only monitor the activities of unregulated entities indirectly, others have set up both formal and informal mechanisms for monitoring.

1d. With what frequency do you produce statistics on balance sheet and flow-of-funds information on what you would consider to be systematically important financial institutions, markets and/or instruments?

Data are produced at different periodicities across countries. Balance sheet statistics on systemically important institutions are available to the authorities on a daily, monthly, quarterly or annual basis, depending on the type of data. Where respondents explicitly mention flow-of-funds data, they are being collected on a monthly or quarterly basis. Market

data tend to be of higher frequency. Where necessary, these data series are supplemented by ad hoc requests on a case-by-case basis, especially in crisis situations.

1e. Do you currently have sufficient information to allow you to identify systemic institutions, markets and instruments? Please identify any critical information gaps.

Many respondents agree that there is a reasonably large amount of information available to identify potentially systemic institutions, markets and instruments in their respective countries. Several indicate that ad hoc reporting requirements could be invoked, if necessary, in order to obtain additional information about certain entities. Some authorities are of the opinion that the availability of information on hedge fund activity could be improved. Currently, collection of hedge fund data is being done indirectly through brokers/dealers in some countries. One major financial center notes that legal authority would need to be in place if information is to be required from hedge funds.

The lack of access to timely data on inter-institutional exposures, including subsidiaries and branches, appears to represent the most common information gap in many countries. One country finds the information gap to be especially glaring between prudentially regulated institutions and those that are not prudentially regulated. Several respondents feel that existing data on cross-border exposures are insufficient for performing proper risk assessments, and that the cooperation of home supervisors would be necessary.

Information gaps also exist in markets and infrastructure. OTC market activity, especially in derivatives and structured products—and leverage through the use of these instruments—stand out as one area in which coverage is considered inadequate. Separately, a handful of countries acknowledge that information on their payment and settlement systems is inadequate, with one respondent noting that data on payment systems are being provided by market participants on a voluntary basis only.

Part 2. Questions on the design of a framework to assess systemic relevance

2a. How regularly should assessments of systemic importance be conducted (e.g., annually, every 3 years, every 5 years)? What factors should be considered when deciding on the frequency of such assessments (e.g., growth rate of institutions and markets, financial innovation)?

Most countries support having regular assessments. These would be supplemented by ongoing monitoring and ad hoc assessments during periods of financial turbulence or when there are material changes (e.g., mergers and acquisitions, financial structure, market concentration, financial sector growth and innovation, market volatility). Many respondents are of the view that annual assessments could be appropriate, taking into account, *inter alia*, cycles for onsite examinations and strategic reviews to allocate supervisory resources. A few think that in-depth assessments could be conducted at longer intervals (every 3 years),

especially where financial sector growth and innovation are slow. One country suggests supplementing less frequent detailed assessments with annual updates that are less resource intensive.

2b. Are there specific methodologies, indicators and techniques that should be recommended to assess systemic relevance?

Most respondents use a range of techniques that consider different dimensions/criteria of systemic importance. These include simple quantitative and qualitative indicators, network analysis, stress tests, scenario analysis and assessments of market developments. Reliance on a single technique risks leading to blind spots. A few countries commented that appropriate techniques would depend on the characteristics of each country's financial system.

2c. What types of data would it be important/necessary to collect in order to conduct assessments of systemic relevance, e.g., flow-of-funds data?

Consistent with the above, data needs are also vary across countries. Besides regular regulatory returns from financial institutions and transactions data from payment systems and markets, many respondents cite flow of funds, counterparty exposures and market concentration as important data to consider. Other data items that are listed include detailed information on group structures and business models, patterns of deposit flows and movements in market prices and spreads.

2d. How should countries with significant financial interlinkages collaborate on such assessments, e.g., should they conduct joint assessments of systemic importance?

Most respondents support sharing information to facilitate assessments of systemic importance. Such information includes cross-border exposure data, methodologies, etc. Many cite supervisory colleges as a possible starting point for such collaboration. Others mention cooperating under the auspices of international and regional fora. Some respondents suggest extending cooperation to joint stress testing and crisis simulation exercises. They favor developing protocols for coordinated action to deal with problem institutions and markets. A few countries are open to conducting joint assessments, but note that this would have to be considered on a case-by-case basis given the far-reaching implications for supervision and regulation, as well as access to government safety nets.

2e. What information should authorities publish on their assessments of systemic importance (e.g., objective, methodology, results)?

The consensus from the survey is that it would be useful to publish the objectives of the assessments and the methodologies used in the assessments. This would help the market to better understand the authorities' approach, and help promote the development of good

practices internationally. Most respondents do not recommend publication of the names of individual institutions or markets that are considered to be systemically important as this could increase the risks of moral hazard and of entities seeking to game the system. However, they concede that publication may be unavoidable if the assessments are used for public regulatory actions or interventions.

Part 3. Optional questions on experiences with crises

3a. If your country has faced a financial crisis in the last 30 years, please describe the role of systemic institutions, markets or instruments: (i) in triggering the crisis; and (ii) as channels of contagion.

Many countries shared their experiences with financial crises. In many cases, the crises were "traditional" in that they originated in the real economy and were then transmitted to the financial sector. While asset markets suffered significant losses, banks typically bore the brunt in such situations. In those instances, the deterioration in asset quality as a result of a sharp economic downturn affected bank solvency and was sometimes exacerbated by poor risk management and weak internal controls. One respondent noted that deficient bankruptcy legislation aggravated the banking crisis in that particular country. In some countries, quick intervention in individual bank failures prevented widespread crises.

Several respondents noted the role of foreign exchange markets in triggering a loss of confidence in the banking sector during crises. The foreign exchange market was seen as an important channel of contagion when sharp depreciations in local currencies resulted in problems at banks with large foreign currency liabilities. In some cases, these problems resulted in deposit runs. Conversely, banks were seen as an important channel of contagion in one country, contributing to the collapse of its fixed exchange rate regime.

Various institutions, markets and instruments were seen to have played important roles in either triggering crises or channeling contagion in some respondent countries. In one case, speculative plays by hedge funds, using the foreign exchange, stock and equity futures markets placed immense pressure on these markets; massive intervention by the government eventually stabilized the markets. In another country, the loss confidence in mutual funds was channeled through the government bond market to the rest of the domestic market. Separately, the failure of a medium-sized security company in one country resulted in a default in the interbank market, causing perceptions of counterparty risk to rise sharply. The rapid loss of confidence in the banking system led to bank runs.

Only a few countries assessed the current financial crisis, likely because it has yet to fully play out. The interbank money market was seen as a channel of contagion to the wide credit market. Separately, the sharp drop in asset-backed securities prices, which resulted in large losses to banks' trading books, was seen to have affected confidence in the banking

sector, resulting in widespread concerns about counterparty risk. One respondent considered "financial innovation" to be the trigger for the current crisis.

3b. How has each crisis experience influenced the ways in which systemic relevance is assessed in terms of: (i) indicators; (ii) procedures; and (iii) methodologies?

There was little discussion on how crises influenced the assessment of systemic relevance, in terms of indicators, procedures and methodologies. Instead, most respondents detailed steps that were taken to improve financial stability following crises. Specifically, they noted that crises in their countries had led to the strengthening of legal, operational, regulatory and/or supervisory frameworks, for example, through:

- The establishment of integrated regulators with strengthened mandates.
- The introduction of regulatory regimes for exposures, capital and liquidity requirements; strengthened regulation and enforcement on short selling; and the introduction of limits on the size of positions that investors are allowed to hold.
- The development of real time gross settlement systems to mitigate risks in the clearing and settlement process; the development of foreign exchange information systems to enable regular monitoring of all transactions.
- Improvements in crisis management coordination.

Some respondents improved their analytical and surveillance capabilities following crises. One respondent highlighted the development of its financial stability analysis following a banking crisis; another focused on the necessity of more comprehensive assessments of macro and micro prudential indicators; while a third introduced indicators and methods to identify institutions. One key home country to international banks revealed that it was participating in initiatives to strengthen cooperation with host counterparts. Another country indicated that it has developed a systemic assessment tool—albeit not directly a result of past crises experiences—based on recommendations by ECOFIN and the "common language" initially developed by the ECB.

Countries have also introduced new tools in the current crisis to mitigate risks in the financial system. These include facilities for the provision of liquidity; programs to support short-term funding markets and to purchase agency debt obligations and mortgage-backed securities; and temporary guarantee programs.

II. CASE STUDIES

16. **The current crisis has highlighted the closely interlinked channels of systemic risk in the global financial system.** One of the original channels of systemic risk arose from the widespread use of off-balance sheet special investment vehicles (SIVs). SIVs were typically funded by relatively short-term commercial paper sponsored by commercial and investment banks. When this market dried up, following a sharp loss in market confidence as the sub-prime crisis in the U.S. intensified and spread, institutions that had relied on wholesale funding to increase their leverage became vulnerable, potentially affecting other institutions and markets. The examples of **Northern Rock, Lehman Brothers** and **AIG** are used to illustrate key channels and impacts arising from the dislocation in the short-term funding market.

Case Study 1: Northern Rock

17. **The difficulties that beset Northern Rock in the Fall of 2007 are a prime example of how systemic risk, encompassing an institution, markets and instruments could be conditional on an evolving environment.** The Northern Rock event showed that the soundness of financial institutions in an increasingly integrated and inter-linked financial system cannot be assessed separately from developments in capital markets and innovations in financial instruments. The situation also demonstrated the critical importance for country authorities to have a credible bank resolution framework in place, and to be able to identify systemic situations early through having developed approaches for assessment.

18. **The Northern Rock crisis was sparked by problems in financial markets and instruments, and the institution itself became a potential channel of contagion.** Although Northern Rock was classified as one of the six major British banking groups (MBBGs), it was not, in and of itself, considered by most market analysts to represent a systemic institution within the U.K. banking system in the manner of, say, its Big Four counterparts. As at end-2006, its assets accounted for less than 2 percent of the U.K. banking system (Figure 5), which was one of the least concentrated in Europe (Figure 5). On the other side of the balance sheet, the total debt owed by Northern Rock amounted to about 2.5 percent of the total MBBG group alone (Figure 6), while its stock market capitalization as at end-2006 was about 0.3 percent of the total capitalization of the U.K. stock market (Figure 7).

19. **Northern Rock's operations had been simple and transparent.** It was in the business of making residential mortgage loans, and borrowed largely from wholesale markets to fund its expansion. Its funding model and rapid expansion were well-known, and the bank had been able to diversify its sources of funding and increase the maturity of its liabilities to some extent. Additionally, Northern Rock appeared to be well-capitalized, and had little exposure to unsecured consumer borrowing.

20. **However, Northern Rock's heavy reliance on funding through more volatile wholesale markets became its Achilles heel as the crisis unraveled.** Northern Rock's debt funding was one of the highest among the MBBGs (Figure 8), and while it was not unique among U.K. banks in its increasing dependence on non-retail funding, the *extent* to which it utilized this source of funding made it an unusual case (Figure 9). In addition to Northern Rock's use of off-balance sheet funding vehicles, its dependence on short-term wholesale funding meant that it was targeting similar investors for both types of funding. Consequently, Northern Rock suffered a severe liquidity shock in early-August 2007, when the spread of the U.S. subprime crisis problems to Europe caused investors in its short- and medium-term paper to stop rolling over their funding to the institution.

21. **Ultimately, the Northern Rock crisis resulted from a confluence of institution-specific characteristics and exogenous factors which evolved into a potentially systemic problem for financial stability in the United Kingdom.** Some of the more salient features of the inter-linkages include:

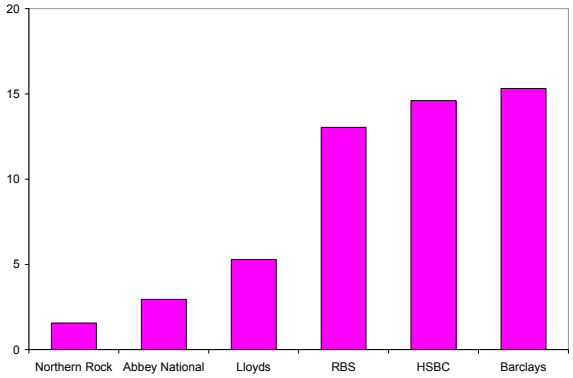
- *Rapid growth and role in the credit market.* Between 1997 and 2006, Northern Rock's consolidated balance sheet grew more than six-fold, reaching an asset value of £101 billion, to become the fifth largest mortgage lender in the United Kingdom. Its assets mainly comprised secured lending on residential properties.

- *Size of exposure to markets and instruments.* Northern Rock relied heavily on wholesale markets, namely, securitization and covered bonds, for its funding. This meant that any dislocation in these markets and loss of confidence in the instruments would effectively close its access to key financing sources. Moreover, wholesale funding is typically more difficult and costly to roll over during times of company-specific or market-wide stress.

- *Maturity mismatches.* While Northern Rock had had some success with increasing the maturity of its funding prior to the crisis, it assumed regular and continued access to sources of longer-term financing. As a result, it made mortgage loans on the assumption that it would be able to access term funding through its regular securitization activities. By September 2007, however, longer-term funding markets were effectively closed to Northern Rock.

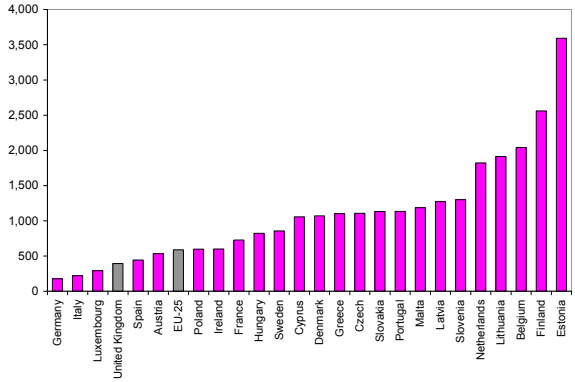
- *Correlation in asset markets.* Contagion from the U.S. subprime crisis, which eventually swept through global financial markets, first manifested in Europe through German and French financial institutions in early-August. As conditions in global credit and money markets deteriorated and severely damaged investor confidence, the market for residential mortgage-backed debt followed, resulting in severe consequences for Northern Rock's ability to obtain funding. Separately, the liquidity problems that had beset ABCP conduits, traditionally reliable investors of U.K. prime RMBS paper, exacerbated the sharp decline in demand for those instruments.

Figure 4. MBBG: Total Assets
(In percent of total banking system assets)



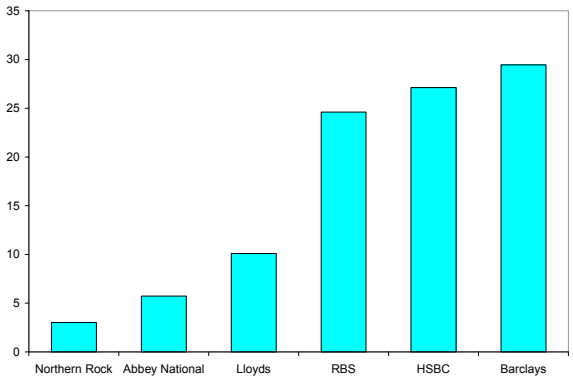
Sources: Bankscope and European Central Bank.

Figure 5. EU-25: Herfindahl Index



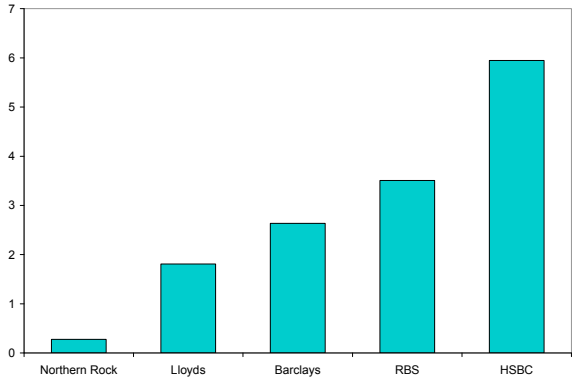
Source: European Central Bank.

Figure 6. MBBG: Total Liabilities
(In percent of total MBBG liabilities)



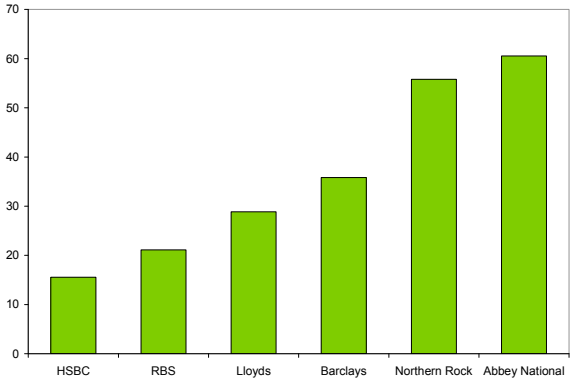
Sources: Bankscope and European Central Bank.

Figure 7. MBBG: Market Capitalization
(In percent of total U.K. stock market capitalization)



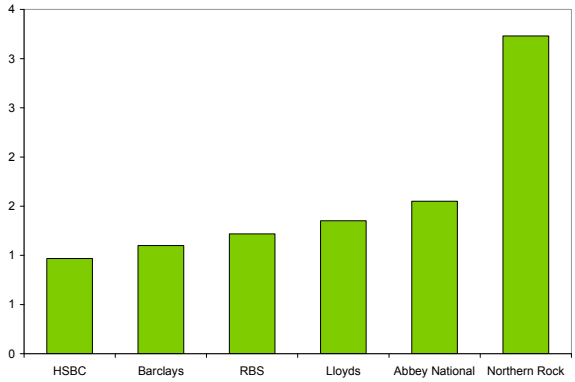
Source: Bankscope.

Figure 8. MBBG: Debt-to-Equity Ratio



Source: Bankscope.

Figure 9. MBBG: Loan-to-Deposit Ratio



Source: Bankscope.

- *Concentration in a key funding market.* While Northern Rock had largely depended on the securitization market, the converse was also true: the U.K. securitization market was highly concentrated on Northern Rock's securities, which accounted for over 17 percent of RMBS issuances by U.K.-based issuers in the first-half of 2007 alone. Thus, the troubles at Northern Rock highlighted similar problems at other banks which relied heavily on wholesale funding at a time when those markets were already under significant stress. In other words, the high-profile crisis at Northern Rock, a major player in the securitization market, caused problems for other banks with similar funding structures, in this instance, by inference.

Case Study 2: Lehman Brothers

22. **Lehman Brothers Holding Company (LBHI) was the fourth largest US-based stand-alone investment bank in the US.** On September 15, 2008 it filed for bankruptcy protection.

23. **Proximate causes of the bankruptcy**: Lehman's perceived creditworthiness had worsened steadily through 2008, which was straining its ability to operate given its large derivatives business and substantial balance sheet which was largely funded in the repo market and its large derivatives business which required a strong credit rating to operate. After a brief reprieve in March after the Bear Stearns take-over arranged by the Fed, Lehman's CDS spread began widening again and reached 350 basis points by the end of August; about 200 basis points wider than at the beginning of the year. The firm was losing business and derivatives counterparties were demanding higher collateral postings. Finally, after the firm reported a larger than expected loss for the third quarter on September 9, a ratings downgrade seemed imminent and its CDS spread spiked to above 500 basis points in couple of days. Over the next few days it was unable to find a strategic partner and its clearing bank, JPMorgan, cut its credit line. With the Fed unwilling to provide financing, Lehman filed for bankruptcy on September 15, despite being well-capitalized on under regulatory capital requirements.

24. **Ultimate cause of the failure**: Lehman suffered a bank run of sorts—except it wasn't a flight by retail depositors but rather the institutional lenders which provided its collateralized overnight financing. Market participants differ on whether Lehman was insolvent or whether it faced a liquidity crisis, but the size of losses on the senior debt (currently trading at 15 cents on the dollar) suggest that insolvency cannot be ruled out. Repo financiers pulled overnight credit lines for two main reasons:

- *Uncertainty about the value of assets*: Given the deteriorating conditions in the real estate markets, investors became concerned about the quality of marks on its large holdings of residential and commercial mortgage backed loans/securities. Indeed,

while the companies' book value of common equity at the end of the second quarter was still a healthy $29 billion[1], the market value plunged below $4 billion after the release of 3rd quarter earnings as investors expressed skepticism about its value as a going concern. [Note that its holdings were financed in the repo and CP markets and so their market values were critical in assuring counterparties.]

- *The lack of a coherent recapitalization plan*: After the demise of Bear Stearns, it was commonly felt that Lehman needed an aggressive recapitalization plan. The company did raise equity after the second quarter but it surprised the market with bigger than expected write-downs in both the second and third quarters and none of the planned strategic capital infusions came through.

25. **Why did it prove systemic?**

- *Large*: Lehman Brothers was the fourth largest stand-alone investment bank in the United Sates. Its consolidated net balance sheet of $340 billion (relative to total assets of $600 billion) at the end of 2008 Q2 compared with the total balance sheet of U.S. registered security broker dealers of about $3 trillion. It was one of the five largest fixed-income operations in the United States and was one of the largest originators of private label mortgage-backed securities, both residential as well as commercial.

- *Leveraged*: Lehman's net and gross leverage (assets divided by common equity) at the end of 2008 Q2 were about 13 and 24 times, respectively. While this was in the range for a typical broker dealer, Lehman's precarious capital position was further compounded by the small size of capital cushion to absorb losses from holdings of credit-sensitive assets. In particular, at the end of the second quarter, the combined holdings of level 3 assets and level 2 mortgage-backed securities was about three times common equity. This meant that a 25 percent reduction in value of these hard-to-hedge and value assets would have wiped out the equity.

[1] The book value at the end of the third quarter is not available since the company filed for bankruptcy before its filing.

- *Maturity mismatched*: About 62 percent of total liabilities were short term (largely accounted for by repo financing, customer cash in prime brokerage accounts and debt rolling over within a year) while the average asset maturity was much longer. Unlike a typical commercial bank, where short-term financing is heavily in the form of FDIC guaranteed retail deposits which are "sticky," some 110 different counterparties provided $247 billion in repo financing to Lehman, and 6 counterparties provided more than $10 billion each, all of whom could quickly withdraw if they detected trouble. The underlying assets would then need to be sold in illiquid markets at distress prices.

- *Interconnectedness*

  - *Derivatives exposure*: As of the end of the 2008 Q2, Lehman had net unrealized gains of about $46 billion and net unrealized losses of $26 billion on its derivatives positions.[2] This meant that Lehman's collapse exposed Lehman's counterparties to losses on open derivatives positions that were not collateralized.

  - *Prime broker*: Lehman was a major prime broker providing clearing and financing facilities to clients (typically hedge funds). As part of the financing agreement, the securities pledged as collateral could be sold or rehypothecated up to a certain percentage at Lehman's discretion, and often were. With Lehman's collapse, a number of clients could not access their securities which adversely affected their ability to manage their portfolios during the high volatility period that followed. Prompted by Lehman's collapse, securities investors in the United Kingdom withdrew or tightened up permission for lending and rehypothecation, resulting in a drastic deleveraging of broker-dealer and securities lender balance sheets.

  - *The effect on money market mutual funds*: Lehman debt was held by other financial intermediaries and by some money market mutual funds. While these funds do not have to mark-to-market their securities portfolio (allowing them to maintain their NAV at close to 1), a bankruptcy event requires recognizing a loss on the portfolio. As the NAV of the Prime Reserve Fund, one of the well established money market funds, fell below 1, it caused a general run on the more than $3.5 trillion in money market accounts severely straining the commercial paper and repo markets which rely on them.

[2] These were net of cash collateral postings though the number would be smaller if security collateral postings are considered.

- *Common holdings of risky assets:* In common with several large investment banks, Lehman held substantial positions in real estate loans and securities as well as leveraged corporate loans. As it was forced to deleverage through 2008 because of capital adequacy concerns, it contributed to the depression in the prices of these securities exacerbating market losses for other firms.

Case Study 3: AIG

26. **The AIG crisis was systemic in nature because of the firm's size, complexity and interconnectedness.** By 2007, AIG—a global financial conglomerate and the largest U.S. insurer—had evolved to become a complex and leveraged institution that was not only involved in insurance but provided financial services in the areas of asset management, capital markets including its participation in many facets of the U.S. mortgage market.[3] Many of the largest derivatives market-makers had large counterparty exposures to AIG. The extraordinary scope and scale of AIG's business activities confirms its status as a systemically important institution.

27. **Leverage from derivatives and common risk exposure to the U.S. housing market through its various financial activities were key vulnerabilities of AIG.** The AIG crisis was largely rooted in taking a one-sided bet on the housing market. AIG's insurance companies grew to become a large investor in the U.S. subprime mortgage market. AIG also leveraged on its AAA credit rating to backstop a financial trading business focused on derivatives. In particular, AIG sold large amounts of unhedged credit default swap protection, notably on super senior tranches of CDOs with concentrated exposure to the housing market. AIG had also sold CDS protection on CDOs and CLOs backed by corporate exposures. AIG had also invested much of the cash collateral from its securities lending program in sub-prime mortgage backed securities.

28. **The trigger for the unraveling of the risks at AIG was the losses in its exposures to the U.S. housing market and resulting liquidity pressures.** These losses resulted in a reduction of its capital reserves. In addition, AIG had to post collateral for its outstanding CDS contracts, whose value was tied to the housing market. Such balance sheet pressure prompted rating agencies such as Standard & Poor's and Moody's Investors Service to downgrade AIG from the double-A to the single-A level on September 15, 2008. The rating downgrades triggered additional collateral calls AIG's CDS portfolio.[4] This was compounded by demand for cash by counterparties that has participated in AIG's securities lending program. AIG urgently needed liquidity to avert bankruptcy.

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[3] Total on-balance sheet assets was over $1 trillion and derivatives book notional was over $2 trillion at end-2007.

[4] AIG's credit default book grew from about $100 billion in 2002 to more than $500 billion in 2008.

29. **With the full support fo the U.S. Treasury, the Federal Reserve Bank of New York (FRBNY) provided an emergency $85 billion credit facility to AIG.** The U.S. government determined that AIG's failure would have posed unacceptable risks to the financial system, especially given the heightened uncertainty in markets at the time. Such a failure could have potentially led to systemic risk materializing throughout the global financial system.

30. **AIG's failure could have had a wider adverse effect throughout financial markets with significant impact on the economy.** The principle channels of systemic risk were (i) the potential impact on insurance policyholders, who would have faced considerable uncertainty about the status fo their claims if AIG had declared bankruptcy; (ii) the potential impact on state and local government entities that had lent more than $10 billion to AIG; (iii) the potential impact on workers whose defined contribution pension plans had purchased $40 billion of insurance from AIG against the risk that their stable value funds would decline in value; (iv) the potential impact on global banks and investment banks, whose combined exposures on loans, lines of credit and derivatives (including CDS and similar insurance contracts) exceeded $50 billion; (v) the potential impact on money market mutual funds and others that held AIG's roughly $20 billion of commercial paper; and (vi) the indirect spillovers that could have resulted from runs on insurance companies worldwide (with roughly half of AIG's insurance business conducted outside the United States), runs on defined contribution pension funds, runs on money market mutual funds, and runs on large global financial institutions. All of these consequences could have materialized in a period of severe financial crisis, following the bankruptcy of Lehman Brothers only one day before.

31. **The magnitude of AIG's direct interconnectedness with key financial market participants can be measured by payments that AIG made to its counterparties subsequent to September 16, 2009.** AIG posted $22.4 billion in collateral to its credit derivatives counterparties to collateralize changes in the market-to-market value of CDS that AIGFP had written (in addition to collateral already posted by AIG prior to the authorities' assistance). AIG counterparties also received $27.1 billion in cash payments from Maiden Lane III in exchange for the purchase of multi-sector CDOs underlying certain CDSs and early termination of these CDSs. Under its securities lending agreements, AIG paid $43.7 billion in cash to its counterparties in exchange for the return of securities lent by AIG.

32. **Beyond the effects from direct exposures, there were major concerns about the likely indirect effects of a failure of AIG.** Lehman Brothers had filed for bankruptcy the day before AIG's rescue, prompting a run on money market funds and severe stress in the commercial paper market. A failure of AIG in these circumstances would have exacerbated the problems in the money market, thereby intensifying a crisis that was already severe. Further disruption to the credit market could have imposed unnecessary costs on the real sector.

III. Analytical Techniques

33. **This section reviews several methodologies that can be used to identify systemic institutions.** Specifically, the section describes: the network approach, which can be deployed to track the reverberation of a financial institution's credit event or liquidity squeeze throughout the financial system on the basis of direct linkages; methodologies that exploit market data to assess systemic linkages among financial institutions under extreme tail events such as the univariate Co-Risk analysis or the multivariate distress dependence matrix, which examines pairs of institutions' probabilities of distress, taking into account a set of other institutions; and a "bottom-up" univariate contingent claims approach which explicitly links the value of equity, assets and debt in an integrated fashion.

A. Network Analysis

Network Simulations of Credit and Liquidity Events

34. **In order to assess the systemic importance of a financial institution, it is not enough to assess the initial impact a financial institution could have on other financial institutions in the face of credit and liquidity shocks.** It is crucial to also track second round effects. For example, it could be that institutions' troubles have limited first round effects on a subset of the network of institutions. However, in subsequent rounds of contagion, these cumulative effects could lead to significant capital impairment and/or failures of other institutions in the network. It is also important to analyze financial instruments which represent contingent extended links between institutions that can increase the range of contagion such as credit default swaps.

35. **Based on bilateral exposures, network analysis can track potential contagion paths and associated network-wide capital losses and failures** triggered by an institutions' credit and liquidity events after all rounds of contagion have been accounted for. The largest banks and non-bank financial intermediaries (regulated and unregulated such as hedge funds) are, of course, prime candidates for inclusion in such an analysis. However, size need not be the only criterion in identifying the relevant set of financial institutions. Institutions that are major counterparties to a large set of institutions such as AIG, are also key candidates to include in such an exercise.

36. **To assess the potential systemic implications of network exposures, the point of departure is data on bilateral credit exposures** between N institutions, such as the diagrammatic representation of interbank exposures in Figure 10. Methods for constructing the matrix of exposures from various data sources are reviewed in Upper (2007). The choice of distributional assumptions for filling in missing data will generally affect the results.

37. **Once the matrix of financial linkages is in place, how would network analysis help identify systemic importance?** There are two broad approaches: one measures how

institutions are connected, the other simulates contagious failures. For the first approach, network analysis provides various statistics that measure the interconnectedness or centrality of individual entities in the network.[5] Some of these centrality measures focus on the presence of links, direct or indirect, between all pairs of institutions. Others also bring the size of exposures and the identity of counterparties into the picture. For this class of measures, the formulae in a common notation can be found in von Peter (2007). These measures capture various functions that financial institutions perform, and thus provide information that is correlated with, but distinct from, the balance sheet size of institutions. In this first approach, a financial institution with elevated centrality scores can be considered systemic.

38. **The second approach gauges an institution's systemic importance directly by calculating the effects of its failure on other entities in the network.** This approach derives from the stress testing exercises performed on a number of banking systems (see below), and requires balance sheet data in addition to network linkages. To track the effect of a credit shock, analysts simulate individual or multiple defaults in the interbank market and then track the domino effects triggered by these events. Among the methodologies for simulating successive rounds of contagion, the clearing vector algorithm has become standard; it was developed by Eisenberg and Noe (2001) and extended by Elsinger, Lehar and Summer (2006). In this second approach, a financial institution would be deemed systemic if it induced capital losses above a threshold pre-specified by the policy maker.

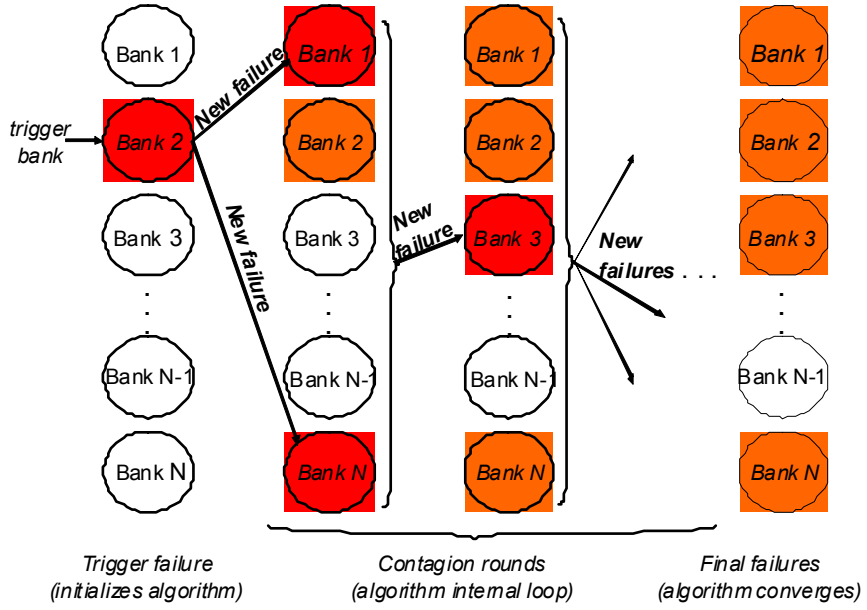
39. **These simulations measure how insolvencies propagate through the network.** To capture *liquidity* problems requires some extensions, such as fire sales (Cifuentes, Ferrucci and Shin 2005), credit lines (Müller, 2006), banks' wholesale funding costs (Aikman et al 2009), or the inability to roll over funding previously granted by defaulted institutions (Chan-Lau, Espinosa, Giesecke and Solé, 2009a). The extent to which a bank is able to replace an unforeseen drop in interbank funding will depend on liquidity conditions in the interbank, money and capital markets. Funding operations in these markets are typically undertaken under abundant liquidity conditions. Under normal conditions, financial institutions tend to have reasonable estimates of how much of their interbank and money market financing they can roll over. However, under liquidity stressed conditions, rolling over may get complicated. Network analysis is useful in tracking the potential domino implications of situations where financial institutions are able to replace only a fraction of this funding and they are forced to trade part of their assets at a discount (i.e., their market value is less than their book value) to re-establish its balance sheet identity. During the present crisis, for instance, complexity and opacity in interbank activities made banks

[5] This branch of network literature borrows from mathematical sociology (e.g., Wasserman and Faust 1994). The larger part of the network literature is concerned with measures that summarize the overall structure of a network, see Newman et al (2006).

reluctant to support troubled counterparties or institutions *perceived* to be going through similar events, even if they were not.

40. **A key advantage of network analysis is that it allows the identification of potential systemically important institutions in an objective manner.** A practical limitation is the difficulty of obtaining comprehensive information at an institutional level to assemble the matrix of bilateral exposures (see below). Moreover, the simulation methodologies involve many assumptions, some of which might bias the results (Upper 2007); for instance, the existing literature does not model endogenous responses of institutions to shocks. How often should this exercise be conducted? Because exposures may change rapidly, ideally, the analysis should be conducted at frequent intervals.

Figure 10. Network Analysis: A Diagrammatic Representation of Systemic Interbank Exposures[6]



Source: IMF. See Márquez and Martínez (2009) for similar diagrammatic network illustrations.

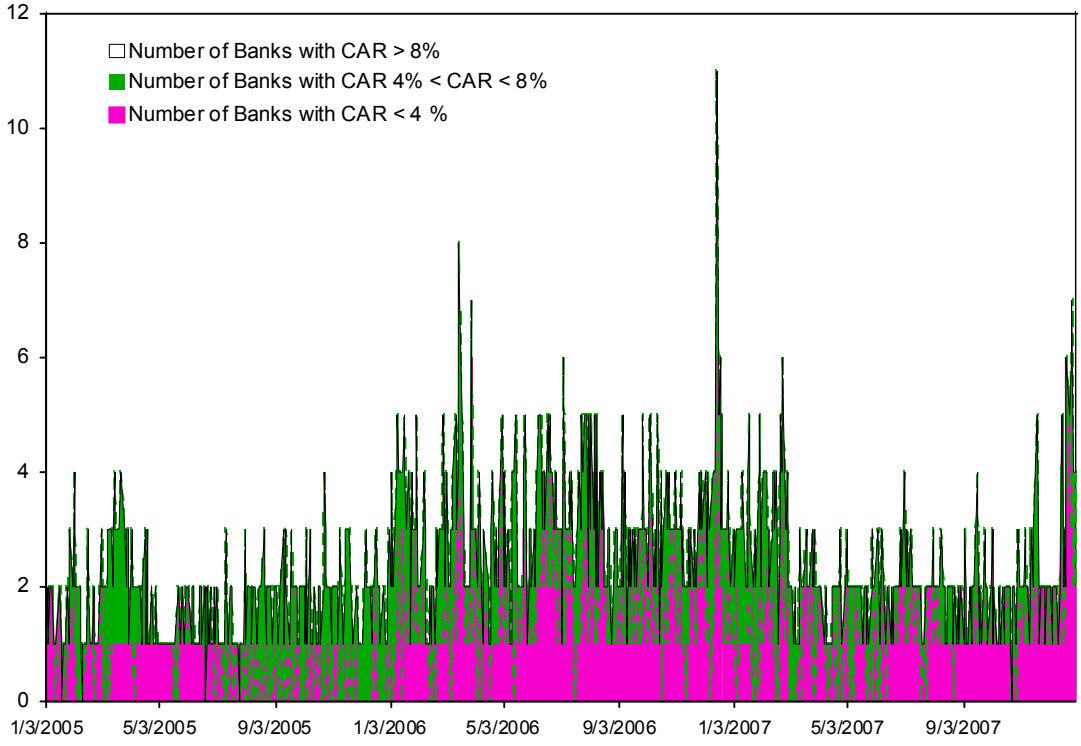
Network Analysis: Some Applications

41. **Numerous central banks conduct network analysis on a regular basis with a view to identifying institutions whose failure could have systemic implications.** They include the National Bank of Belgium, Bank of México, Swiss National Bank, Deutsche

[6] The material in this section draws from Chan-Lau, Espinosa, Giesecke and Solé (2009).

Bundesbank, De Nederlandsche Bank, Oesterreichische Nationalbank and Bank of England. These exercises have developed into various directions. The Bank of England's Risk Assessment Model for Systemic Institutions (RAMSI) lets macroeconomic variables drive bank balance sheets to provide a quantitative framework for macro-credit risk (Aikman et al 2009). The Austrian Systemic Risk Monitor (SRM) embeds the financial network in an integrated quantitative risk management framework to assess systemic risk at quarterly frequency (Boss et al 2006). The Banco de México conducts its analysis at much higher frequency, using daily interbank exposures on loans, deposits, securities, derivatives and FX operations to construct an interbank exposure matrix to carry out contagion exercises computing the effect of spillovers on the capital adequacy ratios (CAR) of the rest of the banks (Figure 11). Thus, Banco de México is able to assess which institutions would see their CAR levels fall below specific thresholds as a result of systemic events. De Nederlandsche Bank (DNB) has developed cross institution contagion models for both the banking and the insurance sectors. The latter allows for simulating the effects of insurer and reinsurer defaults on other institutions in the sector. Finally, stress tests on international banking data have been performed at the BIS (McGuire and Tarashev 2007a) and at the IMF (Chan-Lau et al 2009).

Figure 11. Capital Adequacy Ratios after Hypothetical Credit Shocks
(Number of banks)



Source: Banco de Mexico
Note: These are hypothetical daily CARS resulting from a worst-case credit event scenario after all aftershocks are taken into account. The chart above shows the number of banks up to 12 banks, but the full sample comprises 41 banks.

Data Gaps: A Key Difficulty in the Application of Network Methodologies

42. **The effectiveness of network analysis is a function of the quality of the institutions' exposures data, both across institutions and products, which is constrained by well-recognized data gaps,** including:

- Bilateral exposures are often confidential or not collected) The counterparties holding traded liabilities, for instance, are difficult to identify (McGuire and Tarashev 2007b).

- Off-balance sheet exposures between institutions are elusive, especially when traded over-the-counter, requiring enhancements of credit risk transfer statistics (CGFS 2009).

- Cross-border linkages are difficult to collect on a consistent basis. The BIS international banking statistics, for instance, exclude linkages between non-bank intermediaries, and between non-reporting countries. For analyzing issues of risk and funding structures, more statistics on assets and liabilities on a consolidated basis have to be collected (McGuire and von Peter 2009).

- Each of these categories faces its own challenges regarding the timeliness, frequency and consistency in information disclosures.

- The need for higher reporting frequency of large-exposures data.

- The need to track credit risk transfers such as CDSs.

- Difficulties in identifying the exact counterparty to a cross-border bank exposure.

To close these gaps, regulators should have access to off-balance sheet information on banks and non-banks financial institution or group of institutions.

Going Forward

43. **The usefulness of network methodologies in identifying systemically important institutions is complicated by the difficulties in securing information on cross-institution exposures especially across borders,** due in part to confidentiality agreements; the difficulties in securing information on off-balance sheet exposures and opacity in assessing counterparty risks. Globalization means that enhancing the usefulness of network analysis requires of strong information-sharing agreements on cross-market and cross-border linkages. Going forward, new information-sharing agreements on off-balance sheet and cross-border claims and liabilities, of both regulated and unregulated products and institutions, will be a key priority, to facilitate this type of analysis.

B. Portfolio Models of Risk Based on Market Data

44. **Notwithstanding the usefulness of network analysis to assess potentially systemic financial linkages, it is useful to supplement it with alternative methodologies.** This is important because in addition to network interconnections, there are direct and indirect linkages arising from the exposure to common risks factors, such as the adoption of similar business models (e.g., similar risk management systems, or portfolio holdings), common accounting practices across financial institutions, the markets' perception of financial institutions' fragilities, and so on.

45. **One method to extract this information consists of tracking the market's perception of how the default risk of one institution affects other institutions' default risk.** An important appeal of this type of methodologies is their reliance on high frequency, publicly available data. Several methodologies have been proposed to measure the market's perception of an increase in a given financial institution's overall risk conditioned on the fact that another institution is under stress.[7] These measures can be derived from a univariate perspective (one institution at the time), or in multivariate fashion (the effect of one institution to others in the financial system). They can be evaluated from a "bottom-up" approach (such that the overall fragility of the financial system reflects the summation of the individual fragilities of financial institutions), or based on a reduced form "top-down" approach (by examining the fragility of the overall financial system). They can also be extended to include the potential state-contingent nature of financial institutions, as some may only become systemically important under certain circumstances. Finally, some techniques try to account for the potential explosive nature of contagious linkages that signal a regime shift (or a change in the probability density function of the generating data process) and become active only during contagious events.[8]

Univariate Measures of Credit Risk among Financial Institutions

46. **"Bottom-up" univariate approaches of financial stability build up from individual financial institutions.** They implicitly assume that "the sum of the parts is equal to the total", which in the case of contagion and systemic events would be clearly violated. However, these measures are fairly straight forward, widely used, and relatively simple, and have proven useful for predicting bank failures.[9] These measures include accounting models based on balance sheet data, which are widely used to assess the "fundamental" characteristics of financial institutions. As noted, they have certain advantages and distinct

[7] The measures discussed below are presented in the Spring IMF Global Financial Stability Report (2009), chapters 2 and 3.

[8] See, for example, Dungey, Fry, González-Hermosillo and Martin (2005, and forthcoming).

[9] See Chan-Lau, Jobert and Kong (2004), Gropp, Vesala and Vulpes (2006), and Chan-Lau and Sy (2007).

disadvantages particularly during periods of stress as they tend to be static and backward looking. Other techniques in this category include the Merton contingent claims approach (CCA) and Moody's KMV.[10] The CCA relies on a risk-adjusted balance sheet framework where equity and debt derive their value from the (uncertain) value of assets, which may decline and cause default. The CCA has the advantage that default probabilities can be measured probabilistically from balance sheet data. But it has the disadvantage that the default barrier, which is the trigger of default that is related to the ratio of short-term to long-term debt, is assumed exogenously. The constant volatility assumption in CCA is relaxed in the extension of Moody's KMV models where volatility becomes time-varying.

47. **Some models address the weakness in the CCA and Moody's KMV models that the default barrier (the value below which the firm is expected to default) is exogenously determined.** In particular, the option-Implied Probability of Default (option-iPoD) model relaxes the pre-specified default barrier assumption of the CCA and Moody's KMV models and instead it estimates it endogenously within the model. However, the shortcoming of the option-iPoD approach is that it requires equity options to be quoted at a variety of strike prices and it assumes that these markets are sufficiently liquid. In principle, a similar approach can also be extended to the market information derived from credit default swaps which also require that these markets are liquid in the country in question. One the key shortcomings of using credit default swaps is that the recovery rate is uncertain.

Multivariate Measures of Dependencies among Financial Institutions

48. **A few cutting-edge techniques examine the multivariate effects from common distress in the system that result from "top-down" reduced form models calibrated based on market data.** These models account for higher moments that account for non-linear dependencies (not only linear dependencies, or correlation) and allow for the remote probability that very large (joint) negative realizations (or "tail events") can be transmitted throughout the system. One approach is to examine the multivariate density function from different angles to capture pair wise distress dependences among different financial institutions (the distress dependence matrix), the probability that all financial institutions fall into distress given than any one financial institution becomes distressed (the joint probability of distress), or the probability that all financial institutions in the system fall into distress given that a specific financial institution becomes distressed (cascade effects). This approach has been applied to credit default swaps, but it is flexible enough to be applied to other type of market data.[11] Another approach is to examine higher moments based on equity put options to recover the multivariate dependencies among financial institutions and generate

[10] See Gray and Malone (2008).

[11] See Segoviano and Goodhart (2009).

measures of systemic risk.[12] Finally, quantile regressions are useful for assessing the risks posed by the default of individual institutions on other financial institutions after correcting for aggregate macroeconomic and financial factors.[13]

49. **One important caveat in analyzing market data for systemically important financial institutions is the role of guarantees and other government supporting measures that may bias the information content of data,** as the risk of financial institutions is transferred (potentially temporarily) to the sovereign. Thus, for example, credit default swap spreads my decline for systemically important financial institutions that receive government support, only to be reflected in higher credit default swap spreads for the sovereign.[14]

State-Contingent Nature of Systemically Important Financial Institutions

50. **Also important in identifying systemic events are the underlying "market conditions" that can lead financial institutions to become systemically important only under certain circumstances.** One way to address this potential catalyst is through stress tests where the effects from hypothetical market shocks can be assessed. Unfortunately, there is typically not enough substantive information to evaluate all the contingent claims (such as derivatives and other off-balance sheet positions) of financial institutions for the purposes of the stress tests. Furthermore, the fact that there are still no clearing houses for most OTC products means that there is usually no data on bilateral net off-balance sheet exposures. Finally, while market conditions can affect financial institutions, the latter can also in turn affect the former. Often this feedback loop can occur through complex relationships that involve credit availability and macroeconomic variables. Stress models are usually only able to capture the first loop. To address these shortcomings, regime switching models can be used to measure changes in market conditions that can be characterized by low, medium and high volatility periods. These techniques can be applied to bank stability indicators or global market variables.[15]

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[12] See Gray and Jobst (forthcoming).

[13] See Adrian and Brunnermeier (2009), and Chan-Lau, Espinosa, Giesecke, and Solé (2009b). For policy applications, see Chan-Lau (2009) and Espinosa-Vega, Solé, Syed and Chan-Lau (forthcoming).

[14] See Gray (forthcoming).

[15] See González-Hermosillo and Hesse (forthcoming).

IV. REFERENCE MATERIAL

Acharya, Viral and Matthew Richardson, editors, 2009, *Restoring Financial Stability: How to Repair a Failed System* (Hoboken, New Jersey: John Wiley & Sons).

Acharya, Viral, 2009, "A Theory of Systemic Risk and Design of Prudential Bank Regulation," in *Restoring Financial Stability: How to Repair a Failed System* (Hoboken, New Jersey: John Wiley & Sons).

Acharya,Viral, Lasse Pedersen, Thomas Philippon and Matthew Richardson, 2009, "Regulating Systemic Risk," in *Restoring Financial Stability: How to Repair a Failed System* (Hoboken, New Jersey: John Wiley & Sons).

Acharya, Viral and Tonju Yorulmazer, 2008, "Information Contagion and Bank Herding," *Journal of Money, Credit and Banking,* 40(10).

Adrian, Tobias and Markus Brunnermeier, 2008, "CoVar," Staff Report No. 348 (New York: Federal Reserve Bank).

Aikman, David, Piergiorgio Alessandri, Bruno Eklund, Prasanna Gai, Sujit Kapadia, Elizabeth Martin, Nada Mora, Gabriel Sterne and Matthew Willison, 2009, "Funding Liquidity Risk in a Quantitative Model of Systemic Stability," Bank of England Working Paper 372.

Allen, Franklin and Ana Babus, 2008, "Networks in Finance: Network-based Strategies and Competencies, Chapter 21," Working Paper No. 08-07 (Philadelphia: Wharton School).

Allen, Franklin and Douglas Gale, 2000. Financial Contagion," *Journal of Political Economy*, Vol 108, No. 1, pp-1-33.

Athanasopoulou, Marialena, Miguel Segoviano and Alexander Tieman, forthcoming, "Banks' Probability of Default: Which Methodology, When, and Why?" IMF Working Paper (Washington: International Monetary Fund).

Baba, Naohiko, Frank Packer and Teppei Nagano, 2008, "The Spillover of Money Market Turbulence to FX Swap and Cross-Currency Swap Markets," *BIS Quarterly Review*, pp.73–86.

Baek, Ehung G. and William A. Brock, 1992, "A General Test for Nonlinear Granger Causality: Bivariate Model," Working Paper, Iowa State University and University of Wisconsin, Madison.

Bergo, Jarle, 2002, "Using Financial Soundness Indicators to Assess Financial Stability," Deputy Central Bank Governor of Norges Bank, at an IMF Conference, September 17, 2002.

Bernanke, Ben and Mark Gertler, 1989. "Agency Costs, Net Worth and Business Fluctuations," *American Economic Review*, Vol 79, No. 99,14-31.

Black, Fischer and Myron Scholes, 1973, "The Pricing of Options and Corporate Liabilities," *Journal of Political Economy*, Vol. 81, No. 3, pp. 637–59.

Borio, Claudio and Matthias Drehman, 2008, "Towards an Operational Framework for Financial Stability "Fuzzy" Measurement and Its Consequences", 12th Annual Conference of the Banco Central de Chile, Financial Stability, Monetary Policy and Central Banking, Santiago, 6–7 November.

Boss, Michael, Gerald Krenn, Claus Puhr, and Martin Summer, 2006, "Systemic Risk Monitor: A Model for Systemic Risk Analysis and Stress Testing of Banking Systems," *Oesterreichische Nationalbank Financial Stability Report* 11.

Breuer, Peter, 2000. "Measuring Off-Balance Sheet Leverage," IMF Working Paper 00/202 (Washington: International Monetary Fund).

Brunnermeier, Markus and Lasse H. Pedersen, forthcoming, "Market Liquidity and Funding Liquidity," *Review of Financial Studies*.

Brunnermeier, Markus, Andrew Crocket, Charles Goodhard, Avinash Persaud and Hyun Shin, 2009. "The Fundamental Principles of Financial Regulation," *Geneva Reports on the World Economy,* 11, CEPR.

Buchen, Peter W. and Michael Kelly, 1996, "The Maximum Entropy Distribution of an Asset Inferred from Option Prices," *Journal of Financial and Quantitative Analysis*, Vol. 31, pp. 143-59.

Capiello, Lorenzo, Robert F. Engle and Kevin Sheppard, 2006, "Asymmetric Dynamics in the Correlations of Global Equity and Bond Returns," *Journal of Financial Econometrics*, Vol. 4, No. 4, pp. 537–72.

Capuano Christian, 2008. "The o*ption*-iPoD. The The Probability of Default Implied by Option Prices Based on Entropy," IMF Working Paper 08/194 (Washington: International Monetary Fund).

Carmassi, Jacopo and Richard Herring, 2009, "The Corporate Structure of International Financial Conglomerates," in Berger, Allen, Phillip Molyneux, and John Wilson, *The Oxford Handbook of Banking*, Oxford University Press, Chapter 8.

Čihák, Martin and Klaus Schaeck, 2007, "How Well Do Aggregate Bank Ratios Identify Banking Problems?" IMF Working Paper 07/275 (Washington: International Monetary Fund).

Chan-Lau, Jorge A., 2009, "The Global Financial Turmoil and its Impact on Chilean Banks," mimeo (Washington: International Monetary Fund).

Chan-Lau, Jorge A., Marco Espinosa-Vega, Kay Giesecke and Juan Solé, 2009a forthcoming, "Network Analysis as a Tool to Assess Cross Border Financial Linkages," IMF Working Paper (Washington: International Monetary Fund).

Chan-Lau, Jorge A., Marco Espinosa-Vega, Kay Giesecke and Juan Solé, 2009b forthcoming, "Co-Risk Measures to Assess Financial Systemic Linkages," IMF Working Paper (Washington: International Monetary Fund).

Chan-Lau, Jorge A., Arnaud Jobert and Janet Qingying Kong, 2004, "An Option-Based Approach to Bank Vulnerabilities in Emerging Markets," *IMF Working Paper* 04/33 (Washington: International Monetary Fund).

Chan-Lau, Jorge A. and Amadou Sy, 2007, "Distance-to-Default in Banking: A Bridge To Far?" *Journal of Banking Regulation*, Vol. 9, pp. 14-4.

Cifuentes, Rodrigo, Gianluigi Ferrucci, and Hyun Song Shin, 2005, "Liquidity Risk and Contagion," Journal of the European Economic Association, Vol. 3, Nos. 2–3, pp. 556–66.

Coles, Stuart G., Janet Heffernan and Jonathan. A. Tawn, 1999, "Dependence Measures for Extreme Value Analyses," *Extremes*, Vol. 2, pp. 339–65.

Committee on Payment and Settlement Systems, 2001, "Core Principles for Systemically Important Payment Systems," (Basel: Bank of International Settlements).

Committee on the Global Financial System, 2009, "Credit Risk Transfer Statistics," CGFS Publications No 35.

Cont, Rama, Amal Moussa, Andreea Minca and Edson Basto, 2009. "Too Interconnected to Fail: Contagion and Systemic Risk in Financial Networks". Lecture presented at the IMF, May 2009.

Counterparty Risk Management Policy Group (CRMPG) II, 2005, "Toward Greater Financial Stability: A Private Sector Perspective". July 27. Available via the Internet: www.crmpolicygroup.org

Counterparty Risk Management Policy Group (CRMPG) III, 2008, "Containing Systemic Risk: the Road to Reform. August 6. Available via the Internet: www.crmpolicygroup.org

Cover, Thomas M. and Joy A. Thomas, 2006, *Elements of Information Theory*, 2nd Edition, Wiley, New York.

Davis, Philip and Dilruba Karim, 2008, "Could Early Warning Systems Have Helped to Predict the Sub-Prime Crisis?" *National Institute of Economic Review*.

Demirguc-Kunt, Asli and Enrica Detragiache, 1998, "The Determinants of Banking Crises in Developing and Developed Countries," *IMF Staff Papers* 45, No. 1, pp. 81–109.

———, 1999, "Monitoring Banking Sector Fragility: A Multivariate Logit Approach," IMF Working Paper 99/147 (Washington: International Monetary Fund).

———, 2005, "Cross-Country Empirical Studies of Systemic Bank Distress: A Survey," IMF Working Paper 05/96 (Washington: International Monetary Fund).

Deutsche Bank, 2008, "Monitoring Banking Sector Risk," Deutsche Bank Research, October 28, 2008; www.dbresearch.com.

Dornbush, Rudiger, Yun Chul Park and Stijn Claessens, 2000, "Contagion: Understanding How It Spreads," *The World Bank Research Observer*, 15(2), 177–97.

Dungey, Mardi, Renee Fry, Brenda González-Hermosillo and Vance Martin, 2005, "Empirical Modeling of Contagion: A Review of Methodologies," *Quantitative Finance*, 5, 9–24.

———, 2006, "Contagion in International Bond Markets during the Russian and LTCM Crises," *Journal of Financial Stability*, Vol. 2, 1–27.

———, 2007, "Unanticipated Shocks and Systemic Influences: The Impact of Contagion in Global Equity Markets in 1998," *North American Journal of Finance and Economics*, 18, 155–174.

———, forthcoming, "Are Financial Crises Alike? "From the 1998 Russian/LTCM Crisis to the 2007 Subprime Debacle and Liquidity Crisis," IMF Working Paper (Washington: International Monetary Fund).

Eisenberg, Larry, and Thomas Noe, 2001, "Systemic Risk in Financial Systems," *Management Science*, Vol 47, No. 2, pp. 236–49.

Elsinger, Helmut, Alfred Lehar, Martin Summer, 2006, "Risk Assessment for Banking Systems," Management Science, Vol. 52, No. 9, pp. 1301–14.

Embrechts, Paul, Filip Lindskog and Alexander McNeil, 2001, "Modeling Dependence with Copulas and Applications to Risk Management," Preprint, ETH Zurich.

Engle, Robert, 2002, "Dynamic Conditional Correlation: A Simple Class of Multivariate Generalized Autoregressive Conditional Heteroskedasticity Models", *Journal of Business & Economic Statistics*, Vol. 20, pp. 339–50.

Espinosa-Vega, Marco, Juan Solé, Murtaza Syed and Jorge A. Chan-Lau, forthcoming, "Japan's Global Financial Interdependencies: An Assessment of Potential Spillovers and Systemic Linkages," IMF Working Paper (Washington: International Monetary Fund).

European Central Bank, 2006, "Special Feature on Identifying Large and Complex Banking Groups for Financial Stability Assessment". *Financial Stability Review*, December (Frankfurt: European Central Bank).

———, 2008, "Special Feature on Recent Policy Initiatives to Strengthen the Resilience of the Financial System" *Financial Stability Review*, December 2008, (Frankfurt: European Central Bank).

European Community (2008). "Memorandum of Understanding on Cooperation between the Financial Supervisory Authorities, Central Banks and Finance Ministries on the European Union on Cross-Border Financial Stability" (Brussels: European Community).

Federal Reserve Bank of Dallas, 2008, *Economic Letter*, "Fed Intervention: Managing Moral Hazard in Financial Crises," Vol. 3, No. 10, October.

Forbes, Kristin J. and Roberto Rigobon, 2002, "No Contagion, Only Interdependence: Measuring Stock Market Co-movements," *Journal of Finance*, 57(5), 2223–61.

Frank, Nathaniel and Heiko Hesse, forthcoming, "Financial Spillovers to Emerging Markets during the Global Financial Crisis," IMF Working Paper (Washington: International Monetary Fund).

Frank, Nathaniel, Brenda Gonzalez-Hermosillo and Heiko Hesse, 2008, "Transmission of Liquidity Shocks: Evidence from the 2007 Subprime Crisis," IMF Working Paper 08/200 (Washington: International Monetary Fund).

Furfine, Craig, 1999. "Interbank Exposures: Quantifying the Risk of Contagion," BIS Working Papers, No 70 (Basel, June).

FSA, 2009, The Turner Review. A Regulatory Response to the Global Banking Crisis, March. Available via the Internet: http://www.fsa.gov.uk/pages/Library/Corporate/turner/index.shtml

G-20 Working Group 1, 2009, *Enhancing Sound Regulation and Strengthening Transparency*, Final Report, March. Available via the Internet http://www.g20.org/366.aspx.

Global Financial Stability Report, 2009, "Assessing Global Financial Risks," April (Washington: International Monetary Fund). Available via the Internet http://www.imf.org/external/pubs/ft/gfsr/2009/01/index.htm.

González-Hermosillo, Brenda, 1999, "Determinants of Ex-Ante Banking System Distress: A Macro-Micro Empirical Exploration," IMF Working Paper 99/33 (Washington: International Monetary Fund).

———, 2008, "The Role of International Investors' Risk Appetite in Global Financial Crises: 1998-2007," IMF Working Paper 08/85 (Washington: International Monetary Fund).

——— and Heiko Hesse, forthcoming, "Global Market Conditions and Systemic Risk," IMF Working Paper (Washington: International Monetary Fund).

Gorton, Gary, 2008, "The Panic of 2007," Prepared for the Federal Reserve Bank of Kansas City, Jackson Hole Conference, August.

Gray, Dale F. and S. Malone, 2008, *Macrofinancial Risk Analysis*, by Dale F. Gray and Samuel Malone, John Wiley & Sons.

Gray, Dale F. and Andreas A. Jobst, 2009a forthcoming, "Systemic Contingent Claims Analysis—Estimating Potential Losses and Implicit Government Guarantees to Banks," IMF Working Paper (Washington: International Monetary Fund).

———, 2009b forthcoming, "Tail Dependence Measures of Systemic Risk Using Equity Options Data—Implications for Financial Stability," IMF Working Paper (Washington: International Monetary Fund).

———, 2009c, "Higher Moments and Multivariate Dependence of Implied Volatilities from Equity Options as Measures of Systemic Risk," Global Financial Stability Report, Chapter 3, April (Washington: International Monetary Fund), pp. 128-131.

Group of Ten, 2001, *Consolidation in the Financial Sector* (Basel: Bank for International Settlements).

Hamilton, James D. and Raul Susmel, 1994, "Autoregressive Conditional Heteroskedasticity and Changes in Regime," *Journal of Econometrics,* Vol. 64 (September-October), pp. 307–33.

Hardy, Daniel C. and Ceyla Pazarbasiouglu, 1999, "Determinants and Leading Indicators of Banking Crises: Further Evidence," *IMF Staff Papers* 46 (3), 247–258.

Hesse, Heiko and Miguel Segoviano, forthcoming, "Distress Dependence, Tail Risk and Regime Changes," IMF Working Paper (Washington: International Monetary Fund).

Hiemstra, Craig and Jonathan D. Jones, 1994, "Testing for Linear and Nonlinear Granger Causality in the Stock Price-Volume Relation," *Journal of Finance*, Vol. 49, No. 5, pp. 1639–64.

Huang, Xin, Hao Zhou and Haibin Zhu, 2008, "A Framework for Assessing the Systemic Risk of Major Financial Institutions," BIS Working Papers, No 281.

Hull, John C., Izzy Nelken and Alan White, 2004, Merton's Model, Credit Risk and Volatility Skews, *Journal of Credit Risk*, Vol. 1, No. 1, pp. 3–28.

Hutchinson, Michael M., 2002, "European Banking Distress and EMU: Institutional and Macroeconomic Risks," *Scandinavian Journal of Economics,* Vol. 104, No. 3, pp. 365–89.

Hutchinson, Michael M. and Kathleen McDill, 1999, "Are All Banking Crises Alike? The Japanese Experience in International Comparison," *Journal of the Japanese and International Economies,* Vol. 13, pp. 155–80.

Illing, Mark and Ying Liu, 2006, "Measuring Financial Stress in a Developed Country: An Application to Canada," *Journal of Financial Stability*, pp. 243–65.

International Monetary Fund, 2006, *Financial Soundness Indicators : Compilation Guide.* (Washington: International Monetary Fund).

Jobst, Andreas A., 2007a, "Operational Risk—The Sting is Still in the Tail But the Poison Depends on the Dose," *Journal of Operational Risk*, Vol. 2, No. 2 (Summer), pp.1–56. Also published as IMF Working Paper No.07/239 (October).

———, 2007b, "Consistent Quantitative Operational Risk Measurement and Regulation: Challenges of Model Specification, Data Collection and Loss Reporting," in E. L. Davis (ed.) *Operational Risk 2.0*. Risk Books, Incisive Media Ltd., London, 1–50.

Kaminsky, Graciela L. and Carmen M. Reinhart, 1999, "The Twin Crises: The Causes of Banking and Balance of Payments Problems," *American Economic Review* 89 (3), 473–500.

Kim, Oliver and Robert E. Verrecchia, 1997, "Pre-Announcement and Event-period Private Information," *Journal of Accounting and Economics*, Vol. 24, 395–419.

Kullback, Solomon, 1959, *Information Theory and Statistics* (New York: John Wiley).

——— and R. A. Leibler, 1951, "On Information and Sufficiency," *The Annals of Mathematical Statistics*, Vol. 22, pp. 79-86.

Lando, David, 2004, *Credit Risk Modeling*, Princeton University Press, Princeton New Jersey.

Lo, Andrew, 2009, "Hedge Funds, Systemic Risk, and the Financial Crisis of 2007–2008," Written testimony to the U.S. House of Representatives Committee on Oversight and Government Reform, November 13, 2008.

Longin, Francois M., 2000, "From Value at Risk to Stress Testing: the Extreme Value Approach," *Journal of Banking and Finance*, Vol. 24, 1097–1130.

Márquez-Diez-Canedo, Javier and Serafín Martínez-Jaramillo, 2009, "Systemic Risk: Stress Testing the Banking System," *International Journal of Intelligent Systems in Accounting, Finance and Management*, vol. 16:1, 2009.

Marsh, Ian, Ibrahim Stevens and Christian Hawkesby, 2003, "Large Complex Financial Institutions: Common Influence on Asset Price Behavior?" *Bank of England Financial Stability Review*: December.

Masson, Paul, 1999, "Contagion: Monsoonal Effects, Spillovers, and Jumps Between Multiple Equilibria" in Agenor, P.R., Miller, M. Vines, D. and Weber, A. (eds.), *The Asian Financial Crisis: Causes, Contagion and Consequences*. Cambridge University Press, Cambridge.

McGuire, Patrick, and Nikola Tarashev, 2007a, "Global Monitoring with the BIS International Banking Statistics," CGFS Publications No 29.

McGuire, Patrick, and Nikola Tarashev, 2007b, "International Banking with the Euro," *BIS Quarterly Review*, December 2007.

McGuire, Patrick, and Goetz von Peter, 2009, "The U.S. Dollar Shortage in Global Banking and the International Policy Response," BIS Working Papers, No. 291.

Merton, Robert C., 1974, "On the Pricing of Corporate Debt: The Risk Structure of Interest Rates," *Journal of Finance*, Vol. 29, pp. 449-70.

Merton, Robert C., 1995. "A Functional Perspective of Financial Intermediation," *Financial Management*, Summer, pp. 23-41.

Müller, Jeannette (2006), "Interbank Credit Lines as a Channel of Contagion," *Journal of Financial Services Research*, Vol. 29, pp. 37–60.

Newman, Mark, Albert-László Barabási, and DuncanWatts eds., 2006, *The Structure and Dynamics of Networks* (Princeton and Oxford: Princeton University Press).

Nier, Erland, 2009, "Financial Stability Framework and the Role of Central Banks: Lessons from the Crisis," IMF Working Paper 09/70 (Washington: International Monetary Fund).

Pedersen, Lasse and Nouriel Roubini, 2009, "A Proposal to Prevent Wholesale Financial Failure," *Financial Times*, January 29.

Poghosyan Tigran and Martin Čihák, 2009, "Distress in European Banks: An Analysis Based on a New Data Set," IMF Working Paper 09/09 (Washington: International Monetary Fund).

Poghosyan, Tigran and Martin Čihák, 2009, "Distress in European Banks: An Analysis Based on a New Data Set," IMF Working Paper 09/09 (Washington: International Monetary Fund).

Poon, Ser-Huang, Michael Rockinger and Jonathan Tawn, 2003, "Extreme Value Dependence in Financial Markets: Diagnostics, Models, and Financial Implications," *The Review of Financial Studies*, Vol. 17, No. 2, 581–610.

Preuss, Lucien G., 1980, "A Class of Statistics Based on the Information Concept," *Communications in Statistics, Theory and Methods*, Vol. A9, No. 15, pp. 1563–86.

Rojas-Suarez, Liliana, 2001, "Rating Banks in Emerging Markets: What Credit Agencies Should Learn from Financial Indicators," Institute for International Economics Working Paper, 01-6, May.

Segoviano, Miguel, 2006, "The Consistent Information Multivariate Density Optimizing Methodology," Financial Markets Group, London School of Economics, Discussion Paper 557.

———, forthcoming, "The CIMDO-Copula. Robust Estimation of Default Dependence under Data Restrictions," IMF Working Paper (Washington: International Monetary Fund).

——— and Charles Goodhart, 2009, "Banking Stability Measures," IMF Working Paper 09/04 (Washington: International Monetary Fund).

Sorge, Marco, 2004, "Stress-Testing Financial Systems: An Overview of Current Methodologies," BIS Working Papers, No. 165, December 2004.

Stephenson, Alex G., 2003, "Simulating Multivariate Extreme Value Distributions of Logistic Type," *Extremes*, Vol. 6, No. 1, 49–60.

Sundararajan, V., Charles Enoch, Armida San Jose, Paul Hilbers, Russell Krueger, Marina Moretti and Graham Slack, 2002, "Financial Soundness Indicators: Analytical Aspects and Country Practices," Occasional Paper, 212, International Monetary Fund.

Theil, Henri, 1969, "On the Use of Information Theory Concepts in the Analysis of Financial Statements," *Management Science*, Vol. 15, No. 9, pp. 459–80.

The High-Level Group on Financial Supervision in the EU, 2009. The de Larosiere Group Report. Brussels. February. Available via the Internet at http://europa-eu-un.org/articles/en/article_8514_en.htm.

Upper, Christian, 2007, "Using Counterfactual Simulations to Assess the Danger of Contagion in Interbank Markets", BIS Working Papers, No. 234.

von Peter, Goetz, 2007, "International Banking Centres: A Network Perspective," *BIS Quarterly Review*, December 2007.

Wasserman, Stanley and Katherine Faust (1994), *Social Network Analysis: Methods and Applications*, Cambridge University Press.

Wells, Simon, 2002, "UK Interbank Exposures: Systemic Risk Implications," *Bank of England Financial Stability Review*, December, pp.15–82.

Appendix I

COUNTRY SURVEY OF SYSTEMIC ISSUES

In response to the global financial crisis, work is underway with a view to ensuring that all systemically important institutions, markets, and instruments are appropriately overseen. The G-20 has requested that the IMF and FSB produce guidelines for national authorities to assess whether a financial institution, market or an instrument is systemically important. As an input to this exercise, Section A of the questionnaire seeks background information on how your country assesses systemic relevance. Please note that the questionnaire does not ask for individual systemic institutions to be named. Section B inquires about some aspects of the design of a possible framework to assess systemic relevance. Section C, which is optional, seeks additional background information on how financial crises have informed the approach to identifying systemic relevance.

1. Identifying systemic institutions, markets and instruments

a. How would you define "systemic" importance for the financial sector? What factors/metrics do you use to determine what constitutes a potentially systemic market, instrument or institution for your financial system? What are the key differences between the institutions, markets or instruments that you consider systemic and those that are non-systemic?

Please complete the accompanying Excel table identifying the main systemic institutions, markets, and instruments and relevant systemic factors. (Please see the example in Attachment I; the items listed in the table are not intended to be exhaustive, rather, they represent some possible examples only.)

b. Do you presently have a formal process to assess the systemic relevance of institutions, markets or instruments? If so, please describe your institutional and governance arrangements. In particular:

- which agencies are involved, who is ultimately responsible;
- what techniques and data are used in the assessment;
- what is the frequency of assessment;
- what are the results used for (e.g., financial supervision, financial surveillance)?

c. How do you monitor institutions, markets and instruments that do not currently fall within the scope of regulation and which could potentially pose systemic risks in your country? (Please see bullets in no. 2 above.)

d. With what frequency do you produce statistics on balance sheet and flow-of-funds information on what you would consider to be systematically important financial institutions, markets and/or instruments?

e. Do you currently have sufficient information to allow you to identify systemic institutions, markets and instruments? Please identify any critical information gaps.

2. **Questions on the design of a framework to assess systemic relevance**

a. How regularly should assessments of systemic importance be conducted (e.g., annually, every 3 years, every 5 years)? What factors should be considered when deciding on the frequency of such assessments (e.g., growth rate of institutions and markets, financial innovation)?

b. Are there specific methodologies, indicators and techniques that should be recommended to assess systemic relevance?

c. What types of data would it be important/necessary to collect in order to conduct assessments of systemic relevance, e.g., flow-of-funds data?

d. How should countries with significant financial interlinkages collaborate on such assessments, e.g., should they conduct joint assessments of systemic importance?

e. What information should authorities publish on their assessments of systemic importance (e.g., objective, methodology, results)?

3. **Optional questions on experiences with crises**

a. If your country has faced a financial crisis in the last 30 years, please describe the role of systemic institutions, markets or instruments: (i) in triggering the crisis; and (ii) as channels of contagion.

Attachment II provides an illustrative description as an example. If there have been more than one crisis, please describe each one separately.

b. How has each crisis experience influenced the ways in which systemic relevance is assessed in terms of: (i) indicators; (ii) procedures; and (iii) methodologies?

Please provide:

(i) References to publications and/or websites by your authorities, where relevant, in responding to the questions in this survey.
(ii) The contact details of a member of your staff whom we could contact for any clarification on the survey responses.

Attachment I

Example Table. Systemic Institutions, Markets and Instruments and Associated "Systemic" Factor(s)

Category	Sector			Factors Contributing to Your Classification of "Systemic" (Please list up to 5 factors from the list below, in order of importance)*									
	Example	Is this sector systemic? (Yes/No)	Are there individual institutions in this sector which are systemic? (Yes/ No)	What was your assessment prior to the crisis?					How would you modify your assessment in light of the crisis?				
Institutions	Banks	Yes	Yes	1	2	…	…	…	1	3	2	5	…
	Investment banks	…	…	…	…	…	…	…	…	…	…	…	…
	Pension funds	No	Yes	1	4	…	…	…	4	5	1	…	…
	Insurance companies	…	…	…	…	…	…	…	…	…	…	…	…
	Asset management companies (debt or equity)	…	…	…	…	…	…	…	…	…	…	…	…
	Money market mutual fund companies			…	…	…	…	…	…	…	…	…	…
	Non bank finance companies	…	…	…	…	…	…	…	…	…	…	…	…
	Hedge funds	…	…	…	…	…	…	…	…	…	…	…	…
	Credit unions	…	…	…	…	…	…	…	…	…	…	…	…
	Private equity firms	…	…	…	…	…	…	…	…	…	…	…	…
	SIVs/ABCP conduits	…	…	…	…	…	…	…	…	…	…	…	…
	State owned/promoted financial institutions (e.g. GSEs)	…	…	…	…	…	…	…	…	…	…	…	…
	Agents (e.g investment advisors)	…	…	…	…	…	…	…	…	…	…	…	…
	Other--please list invidually	…	…	…	…	…	…	…	…	…	…	…	…
Markets	Centralized exchanges												
	--Stock markets	Yes	Yes	1	…	…	…	…	7	1	…	…	…
	--Derivatives exchanges (e.g. CME, CBOT)	…	…	…	…	…	…	…	…	…	…	…	…
	OTC markets												
	--Government debt	…	…	…	…	…	…	…	…	…	…	…	…
	--Other debt instruments (e.g. corporate debt, securitized products)	…	…	…	…	…	…	…	…	…	…	…	…
	--FX spot and forward markets	…	…	…	…	…	…	…	…	…	…	…	…
	--Commercial paper market	…	…	…	…	…	…	…	…	…	…	…	…
	--Repo markets	…	…	…	…	…	…	…	…	…	…	…	…
	--Inter-bank money markets	…	…	…	…	…	…	…	…	…	…	…	…
	--Stuctured products (e.g. strcutured equity derivatives)	…	…	…	…	…	…	…	…	…	…	…	…
	Other--please list individually	…	…	…	…	…	…	…	…	…	…	…	…
Instruments	Retail instruments (e.g. credit cards)	…	…	…	…	…	…	…	…	…	…	…	…
	Non-traded instruments (e.g. inter-company loans)	…	…	…	…	…	…	…	…	…	…	…	…
	Other--please lsit individually	…	…	…	…	…	…	…	…	…	…	…	…
Other													
Infrastructure	e.g., Payment and settlements system, custodial banks, central clearing parties, netting capabilities	…	…	…	…	…	…	…	…	…	…	…	…
Rating agencies	…	…	…	…	…	…	…	…	…	…	…	…	…
Other--please list individually	…	…	…	…	…	…	…	…	…	…	…	…	…

* Factors contributing to "systemic" classification
1 Size 2 Interconnectedness 3 Leverage 4 Maturity mismatches 5 Opacity/complexity 6 Correlation of exposures 7 Concentration risk 8 Rate of change of activity 9 Robustness of clearing and settlement processes 10 Role in monetary policy
11 Role in fiscal policy 12 Other--please list individually

Attachment II

Example—Elements of a Financial Crisis

The financial crisis in the United States began in the fall of 2007, triggered by the deteriorating performance of securities/loans backed by mortgages. The increasing weakness affected many different markets, ultimately leading to the need for significant Fed/Treasury intervention. Some important channels of contagion were observed:

- Banks had created off-balance sheet vehicles (SIVs, ABCP conduits) which ran significant maturity mismatches and had liquidity backstop facilities from the promoting banks. As investors grew concerned about the performance of the assets held by these vehicles, they became increasingly reluctant to roll over their funding (CP, medium-term notes), thereby invoking these liquidity guarantees.

- The threat of invoking these liquidity backstops as well as general creditworthiness concerns led to pressures in bank funding markets, with the spread between 3-month LIBOR and central bank repo rates ballooning from 5–15 basis points 70–100 basis points. In addition to general funding concerns, there was also concern about the availability of U.S. dollar funding as most of these assets were dollar-denominated.

- Segments of the CDS market exacerbated the potential risks from the deteriorating performance of securities. Certain insurance companies (AIG, municipal bond insurers) had used regulatory loopholes to diversify aggressively into the business of writing protection on mortgage-backed securities. As the value of these securities fell, these insurers were downgraded; liquidity problems surfaced as they had to post collateral with their counterparties. This adversely affected the performance of the municipal market (in the case of the bond insurers), and it could have potentially led to the failure of AIG's counterparties had the Fed not intervened.

- Banks were an important channel of contagion. Commercial banks' effective leverage was higher than reported given their off-balance sheet vehicles (discussed above), while the riskiness of their loan books were increased through the issuance of exotic mortgage loans (e.g., negative amortization). Banks' holding of mortgage-backed securities in their trading books made them highly vulnerable to disruptions in liquidity and to mark-to-market pricing as securities dropped in value.

- Investment banks (IBs) dramatically increased the size of and risks to their balance sheets, but remained more lightly regulated than commercial banks. Their positions were largely financed through short-term repo markets and led to the failure/take-over of Lehman, Bear Stearns and Merrill Lynch when the values of these securities fell sharply and financing disappeared. Given the size of these institutions and their interconnectedness through derivatives markets, their failure posed systematic risk.