

INTERNATIONAL MONETARY FUND

**Integrating Stability Assessments Under the Financial Sector Assessment Program into
Article IV Surveillance: Background Material**

Prepared by the Monetary and Capital Markets Department

Approved by José Viñals

August 27, 2010

Contents	Page
Glossary	2
I. Introduction	3
II. The Methodology for Identifying Jurisdictions with Systemically Important Financial Sectors	3
A. Definition of Systemic Importance	3
B. Data	4
C. Methodology	5
D. Results	12
E. Interpretations and Caveats	15
III. Frequency of Mandatory Financial Stability Assessments for Jurisdictions with Systemically Important Financial Sectors	16
A. General Considerations and Industry Practice	16
B. Lessons from the Early Warning Literature	17
References	22
Tables	
1. Composite Index Ranking: the Top 50 Jurisdictions	10
2. Cluster Analysis: the Top Three Clusters	12
3. Jurisdictions with Systemically Important Financial Sectors	13
Figures	
1. The Global Banking Network	9
2. The Position of the 25 Jurisdictions with Systemically Important Financial Sectors in the Global Banking Network	14
Appendix I: Data Sources	19

GLOSSARY

BIS	Bank of International Settlements
CAMELS	Capital adequacy, Asset quality, Management, Earnings, Liquidity, Sensitivity to market risk
CPIS	Coordinated Portfolio Investment Survey
FDI	Foreign Direct Investment
FSAP	Financial Sector Assessment Program
FSB	Financial Stability Board
IFS	International Financial Statistics
IIP	International Investment Position
OECD	Organization and for Economic Co-operation and Development
OTC	Over the counter
PPP	Purchasing power parity
SIMIs	Systemically Important Institutions, Markets, and Instruments
UNCTAD	United Nations Conference on Trade and Development
WEO	World Economic Outlook

I. INTRODUCTION

1. **This paper presents the staff analysis underpinning two central elements of the proposal to make financial stability assessments under the FSAP mandatory for members with systemically important financial sectors:**

- the definition of systemic importance used in the paper and the methodology for identifying members with systemically important financial sectors (Section II); and
- the review of the literature and industry practices that form the basis for the staff proposal to conduct these mandatory financial stability assessments at a frequency of about three years (Section III).

II. THE METHODOLOGY FOR IDENTIFYING JURISDICTIONS WITH SYSTEMICALLY IMPORTANT FINANCIAL SECTORS¹

A. Definition of Systemic Importance

2. **There is no clear, universally accepted definition of “systemic importance.”** Systemic importance is not a binary concept but can be measured along a continuum: some firms, sectors, markets, or countries can be judged to be “more” or “less” systemically important than others, using different criteria. It is a dynamic concept, changing over time as economic agents or whole sectors or countries evolve. Systemic importance is also contingent on the state of global or domestic markets, thus reflecting to a certain degree the subjective views of market participants. Against this background, distinguishing between different jurisdictions on the basis of whether or not their financial sectors are “systemically important” is not a straightforward task.

3. **Nevertheless, establishing a set of relevant and transparent criteria for identifying systemically important financial sectors is a crucial component of the proposal to integrate financial stability assessments into Article IV surveillance.** Establishing clear criteria and applying them consistently is crucial for the uniform treatment of all members in the process of establishing mandatory financial stability assessments. At the same time, given that systemic importance is a fluid concept and that financial sectors and their interlinkages evolve over time, these criteria cannot be cast in stone but would have to be reviewed periodically.

4. **A useful starting point for the analysis is the set of criteria that have been established for identifying systemically important institutions, markets, and instruments (SIMIs).** In 2009, the IMF, the Bank of International Settlements (BIS), and the

¹ Prepared by Martin Čihák, Sònia Muñoz, and Ryan Scuzzarella.

Financial Stability Board (FSB) defined criteria to identify SIMIs:² (i) *size*, i.e., the volume of financial services provided by an individual financial institution or market; (ii) *interconnectedness*, i.e., the extent of linkages with other financial institutions or markets; and (iii) *substitutability*, i.e., the extent to which other institutions or markets can provide the same services in the event of the failure of part of the system.

5. **Substitutability is hard to measure and arguably less applicable as a criterion of systemic importance for entire financial sectors.** As acknowledged in IMF/BIS/FSB (2009), it is difficult to capture the degree of uniqueness of an individual institution of a specific market in the provision of a financial service, and simple indicators such as concentration may not capture the key dimensions of lack of substitutability. Measuring substitutability in an objective way is even more challenging when referring to whole financial sectors, rather than individual institutions or markets. More importantly, for entire financial sectors, substitutability may not be a relevant concept: within a country, there is little or no substitutability between the services provided by the financial sector and those of other sectors; and the cross-border substitutability of financial sectors is already captured by the measure of interconnectedness.

6. **The criteria of size and interconnectedness, on the other hand, are intuitive and easy to apply to the analysis of entire financial sectors.** The methodology discussed below thus focuses solely on size and interconnectedness.

- Size is measured in terms of the volume of services provided by a jurisdiction's financial sector. This defines the importance of a jurisdiction's financial sector in the global financial system and in the specific jurisdiction.
- Interconnectedness is the extent of linkages of a particular financial sector with financial sectors in other jurisdictions. Interconnectedness captures the potential for systemic risk that can arise through direct and indirect interlinkages, so that an individual failure or malfunction has repercussions around the financial system, leading to a reduction in the aggregate amount of services.

B. Data

7. **The need to apply the criteria uniformly across the entire Fund membership limits the data that can be used.** Data for the analysis are mainly drawn from the Bank of International Settlements (BIS), IMF's *World Economic Outlook* (WEO), *International Financial Statistics* (IFS), and *Coordinated Portfolio Investment Survey* (CPIS), as well as the United Nations Conference on Trade and Development (UNCTAD) dataset on foreign direct investment (FDI). The sample covers 191 jurisdictions (187 Fund members and 4

² IMF, BIS, FSB on "[Guidance to Assess the systemic Importance of Financial Institutions, Markets and Instruments: Initial Considerations](#)," October 2009.

territories that are subject to Article IV surveillance).³ The data cover the year 2008, which is the most recent period for which the relevant data cover the full sample. A description of the data is provided in Appendix I.

8. **Interconnectedness is calculated from bilateral locational banking data.** The network analysis is done using BIS bilateral data for cross-border interbank assets and liabilities at end-2008. The BIS bilateral locational banking statistics treat all countries on a residence basis,⁴ and capture the geography of banking activity in a consistent fashion. The fact that banks in all reporting countries disclose both assets and liabilities is used to alleviate the problem of data gaps for some countries.⁵ Other types of cross-border claims, such as equity, debt, and FDI, are available but were not used in the exercise because they do not necessarily reflect the interconnectedness of the financial sector.

C. Methodology

9. **The methodology for identifying systemically important financial sectors is a three-stage process.** In the first stage, separate ordinal rankings of jurisdictions are developed for size and interconnectedness. In the second stage, the rankings of size and interconnectedness are combined into a composite index of systemic importance. In the third stage, cluster analysis is used to identify groups of jurisdictions with financial sectors of a similar degree of systemic importance that provide the basis for the final list.

First stage

10. **Four indicators of financial activity are used to capture size.** There are, of course, several possible ways to define “financial activity,” but the selection is limited by the need to use data that are, to the maximum possible extent, uniform and available for the entire membership. Three of these are measures of the “absolute” size of the financial sector (in U.S. dollars or other currency units), and the fourth a measure of the “relative” size of a financial sector (in relation to the jurisdiction’s output). The first three capture the importance of a jurisdiction’s financial sector in the global financial system, and the fourth measures the relative weight of the financial sector within a given jurisdiction.⁶ These are:

³ In the subsequent text, the term “country” is often used for simplicity to denote all jurisdictions.

⁴ *Residence* depends on whether a banking entity is permanently located, physically and/or by way of law or registration, inside or outside a country’s borders. *Nationality*, on the other hand, is determined by the location of the head office, rather than the location of the banking unit.

⁵ Only positions between non-reporting banks and between nonbanks remain unobservable.

⁶ In the case of territories of Fund members that issue their own currencies, the size of the financial sector is measured in relation to the size of the economy of the territory and not of the member country of which it is part.

- ***Currency and deposits in U.S. dollar terms.*** This indicator is included as a proxy for the size of the total balance sheet of a jurisdiction’s banking sector. Unfortunately, comparable data on total banking sector assets and liabilities are not available on a sufficiently broad and comprehensive basis. Data on currency and deposits, however, are widely available. They are closely aligned with the M2 monetary aggregate, and tend to be well correlated with total banking sector assets.⁷
- ***Volume of non-banking activity in U.S. dollar terms.*** This is a collection of different measures of non-banking activity (pension fund assets, hedge fund assets, over-the-counter (OTC) derivatives markets, and insurance premiums).
- ***International investment position (IIP) in U.S. dollar terms.*** This measures the importance of the gross external position of each jurisdiction in the global financial system.
- ***Financial depth of the domestic economy,*** measured as the share of currency and deposits in the jurisdiction’s output. In contrast to the previous three, this measure of “relative” size captures financial depth in each jurisdiction, which is a crucial component of systemic importance of the financial sector for each individual economy.

11. **These size indicators are scaled by the share of the jurisdiction’s output to world output.** The systemic importance of a financial sector does not only depend on its own (relative or absolute) size but also on the size of the economy in which it operates. For example, distress in an individual financial sector can propagate to the rest of the world both directly through financial connections and indirectly through real economy linkages. The former is captured by interconnectedness, as explained below. To capture the latter, the four measures of size described above are weighted by the relative size of each jurisdiction’s total output to global economic output (measured by the ratio of domestic GDP to world GDP). Given the broad range of countries being compared, a purchasing power parity (PPP) measure of GDP is used throughout the analysis to take into account the differences in price levels across economies and better measure each jurisdiction’s contribution to world GDP.

12. **The four size indicators are then combined into a single ranking for size.** All jurisdictions are ranked in each of the four size indicators separately,⁸ and the median of the four is calculated as the basis for the single ranking for size.

⁷ Staff estimates using data for countries where both currency and deposit and total banking sector assets are available show that the correlation between these two is 99 percent.

⁸ For the volume of non-bank financial activity, given the heterogeneity of this type of information, jurisdictions are ranked separately in each of the four measures, and then for each jurisdiction the highest rank of the four is used.

13. **Interconnectedness is measured using network analysis.** The underlying idea of the analysis, based on von Peter (2007) and Kubelec and Sá (2010), is to infer from the pattern of cross-border linkages among financial sectors the extent to which a financial sector in a jurisdiction is “central” in the international banking network. The international network is a set of bilateral claims (links) of different banking systems (nodes) on each other; linkages in financial infrastructure, for example payment systems, are not considered. Data availability limits the measures of interconnectedness to the banking sector only. To ensure that the analysis focuses only on economically meaningful links, claims representing less than 0.01 percent of GDP of the source jurisdiction are not considered.

14. **The model is based on four indicators of interconnectedness, or “centrality,” of a jurisdiction’s financial sector within the global financial network.** The network is expressed in matrix form, where A_{ij} represents the value of financial assets held by jurisdiction i in jurisdiction j . The matrix has dimension n equal to the number of countries and can be read in two directions: rows of A represent assets of jurisdiction i in jurisdiction j and columns of A represent liabilities of j in i . All diagonal elements are zero. Off-diagonal elements are zero for jurisdiction pairs that have no links (either as a creditor or as a debtor). The network is directed, hence A is not symmetric. The indicators are based on whether a link exists or not, i.e., they are based on the indicator $N_{ij} = 1$ if $A_{ij} > 0$, and 0 otherwise. The four measures of centrality, following the literature (e.g., von Peter, 2007; Kubelec and Sá 2010), are defined as follows:

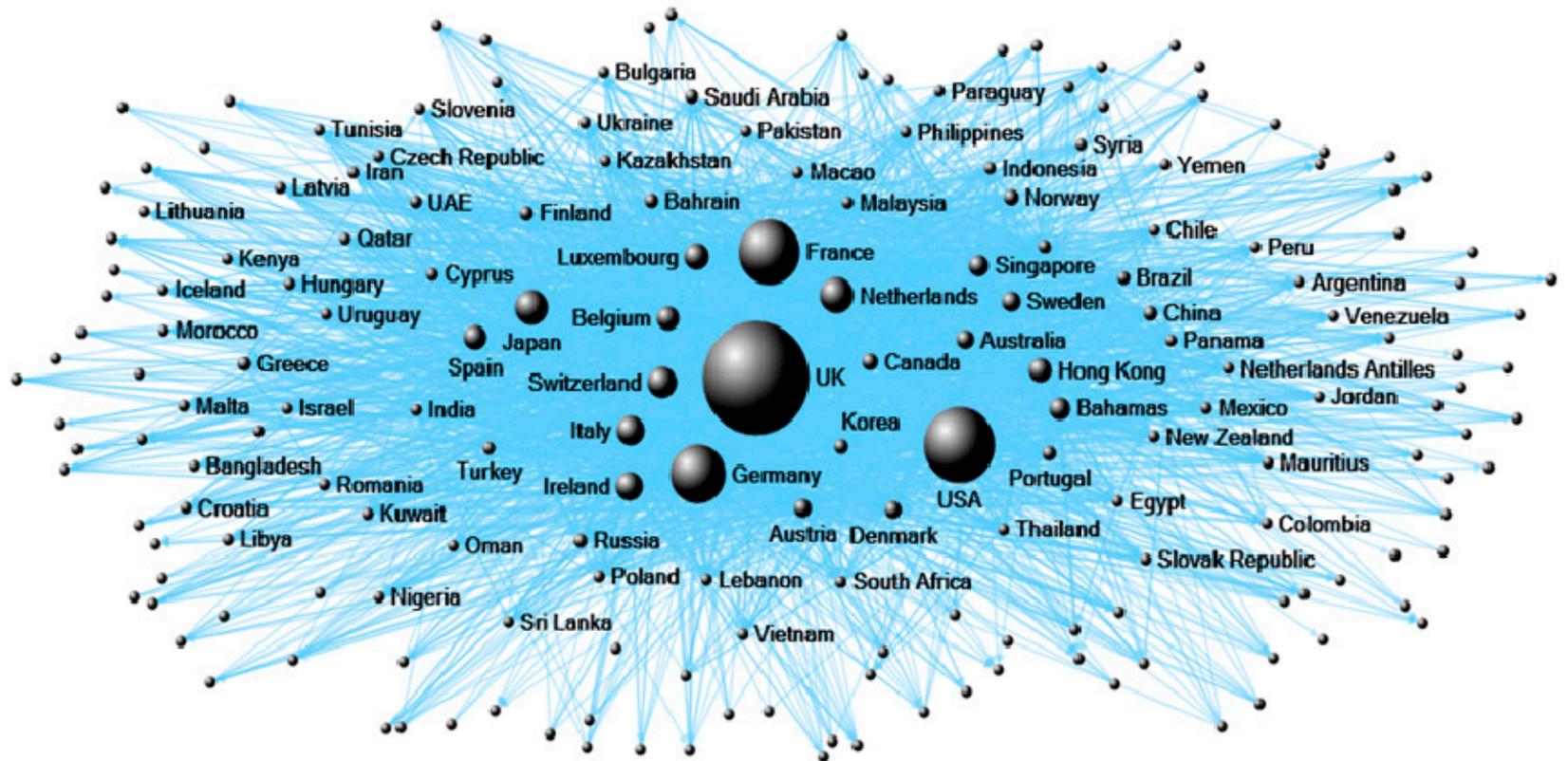
- **“In-Degree”** is the number of links that point to a node, i.e., it is given by the sum $\sum_j N_{ji}$.
- **“Closeness”** is the inverse of the average distance from node i to all other nodes. The distance between i and j , δ_{ij} , equals the length of the shortest path. The average distance from i to all other nodes is given by $\sum_j \delta_{ij} / (n-1)$. Closeness is the inverse of this measure.
- **“Betweenness”** focuses on the nodes that the shortest path goes through. Let g_{jk} denote the number of shortest paths between j and k , and $g_{jk}(i)$ denote the number of such paths that go through node i . The probability that node i is on the shortest path from j to k is given by $g_{jk}(i) / g_{jk}$. “Betweenness” of node i is the sum of these probabilities over all nodes excluding i , divided by the maximum that the sum can attain: $\left(\sum_{j \neq i} \sum_{k \neq i} g_{jk}(i) / g_{jk} \right) / ((n-1)(n-2))$.
- **“Prestige”** (or eigenvector centrality) considers the identity of the counterparties. It is a measure of the importance of a node in the network. It assigns relative scores to all

nodes in the network based on the principle that connections to high-scoring nodes contribute more to the score of the node in question than equal connections to low-scoring nodes. The “prestige” of jurisdiction i (v_i) is obtained by taking the “prestige” of its creditors, weighted by a matrix of relationships with i , i.e., $v_i = \sum_j R_{ji} v_j$. This defines a linear system $v = R'v$, where R is the matrix of relationships. The solution to this system is the eigenvector associated with the unit eigenvalue.

15. **As with the ranking for size, a single ranking for interconnectedness is calculated from these four different indicators.** Jurisdictions are ranked separately in each of these four “centrality” measures, and then a single interconnectedness rank is calculated as the median of these four rankings. It should be noted that this definition of interconnectedness takes into account whether or not a relationship (exceeding a minimum threshold of 0.01 percent of GDP of the source jurisdiction) exists between two banking sectors, but not the size of the exposure.⁹ Figure 1 presents the global banking network “map” based on this ranking. Straight lines between jurisdictions reflect the connections between their financial sectors. The interconnectedness ranking of each jurisdiction is reflected in its position in the two dimensional space: the closer to the center of the graph, the more interconnected is its banking sector. In addition, for illustrative purposes (these data are not used in the calculations), Figure 1 also shows the size of each jurisdiction’s external interbank assets and liabilities.

⁹ Incorporating the size of cross-border linkages into the network model increases considerably the complexity of the calculation, and the tools for this are still evolving in the research community. While it has not been explored here, it may be considered for future analysis.

Figure 1. The Global Banking Network



Source: Staff estimates.

Notes: Lines between jurisdictions reflect the connections between their respective banking systems. The size of the spheres represents the volume of their external interbank assets and liabilities.

Second stage

16. **In the second stage, an overall composite index of systemic importance is calculated as a combination of the size and interconnectedness rankings.** The rankings of size and interconnectedness are combined into a weighted average “baseline” index, to allow the analysis of the relative significance of size and interconnectedness in systemic importance. To derive the baseline index, the relative weights for size and interconnectedness are set at 0.7 and 0.3, respectively. As size is a more fundamental measure of systemic importance, it is given a relatively higher weight in the baseline index than interconnectedness. Table 1 presents the 50 jurisdictions ranked highest in this baseline composite ranking.

Table 1. Composite Index Ranking: the Top 50 Jurisdictions

Rank	Jurisdiction	Rank	Jurisdiction
1	United Kingdom	26	Denmark
2	Germany	27	Saudi Arabia
3	United States	28	Malaysia
4	France	29	Portugal
5	Japan	30	Greece
6	Italy	31	South Africa
7	Netherlands	32	Poland
8	Spain	33	Thailand
9	Canada	34	Finland
10	Switzerland	35	Norway
11	China	36	United Arab Emirates
12	Belgium	37	Indonesia
13	Australia	38	Chile
14	India	39	Egypt
15	Ireland	40	Israel
16	Hong Kong SAR	41	Philippines
17	Brazil	42	Argentina
18	Russian Federation	43	Czech Republic
19	Korea	44	Iran
20	Austria	45	Kuwait
21	Luxembourg	46	Ukraine
22	Sweden	47	Cyprus
23	Singapore	48	Hungary
24	Turkey	49	Venezuela
25	Mexico	50	Kazakhstan

Source: Staff estimates.

17. **A range of sensitivity tests have been used to test the robustness of the composite index.** In addition to the 0.7/0.3 baseline weight combination, alternative composite rankings are calculated for 0.5/0.5, 0.6/0.4, and 0.8/0.2 weight combinations. This also serves as preparation for the third stage of the calculations. In addition, different ways of combining the subcomponents of the size measure and the subcomponents of the interconnectedness measure (using averages instead of medians), and different types of bilateral financial assets and liabilities (such as equity, debt, and FDI) were added in another check. While these changes affect some of the individual country ratings at the margin, the country groupings are very robust to different weights.

Third stage

18. **In the final stage, cluster analysis is used to identify groups of jurisdictions with financial sectors that have comparable degrees of systemic importance.** The underlying idea is to “let the data speak for themselves” in identifying groups of financial sectors that are not only closely ranked, but whose rankings are relatively stable across different weight combinations. To capture this idea, the standard deviation of ordinal rankings across different combinations of weights is calculated for each financial sector as a proxy for the robustness of the ranking. Clusters of jurisdictions are then calculated by iteratively minimizing the within-cluster sum of squared standard deviations from cluster means over several possible clusters of jurisdictions. The top three clusters identified by the data in this way are presented in Table 2.

19. **The final list contains the jurisdictions that have both the highest and the most robust rankings of systemic importance.** The criteria for choosing which cluster(s) will be included in the final list of jurisdictions with systemically important financial sectors are (i) the order of the ranking (clusters ranked lower cannot be included if clusters ranked above them are excluded); (ii) the robustness of the ranking (clusters of jurisdictions whose ranking is more robust to changes in weight combinations are presumed to be more systemically important than those whose ranking is more sensitive); and (iii) the degree of coverage of the global financial system by the jurisdictions in the cluster(s) (clusters that represent a higher share of the global financial system are presumed to be more systemically important than those that represent a lower share). These criteria ensure that the jurisdictions on the final list are *both* the highest ranked according to the “baseline” composite index *and* have the most robust rankings across different weighting schemes *and* represent a substantial share of the global financial system. This methodology eschews as much as possible a priori judgments on the size and makeup of the list (it is not possible to determine ex ante the number of jurisdictions to be included or “cherry pick” individual jurisdictions), and allows the data to indicate its final composition.

Table 2. Cluster Analysis: the Top Three Clusters

Cluster 1	Cluster 2	Cluster 3
United Kingdom	China	Denmark
Germany	Belgium	Saudi Arabia
United States	Australia	Malaysia
France	India	Portugal
Japan	Ireland	Greece
Italy	Hong Kong SAR	South Africa
Netherlands	Brazil	Poland
Spain	Russian Federation	Thailand
Canada	Korea	Finland
Switzerland	Austria	Norway
	Luxembourg	United Arab Emirates
	Sweden	Indonesia
	Singapore	Chile
	Turkey	Egypt
	Mexico	Israel
		Philippines

Source: Staff estimates.

D. Results

20. **On the basis of this methodology, the final list of jurisdictions with systemically important financial sectors includes the 25 jurisdictions in the first two clusters** (Table 3). These clusters were chosen because the ranking of these jurisdictions is not only the highest in the entire sample, but also very robust to different weight specifications. For a wide range of different weight combinations, the composition of this group remains unchanged (although the ordering of countries within the group may vary slightly). Only Mexico appears to be a borderline case, dropping out of its cluster for some of the weight combinations. These jurisdictions also ensure a broad coverage of the global financial system, comprising about 90 percent of global international investment and global currency and deposits and almost 80 percent of global PPP GDP. As Figure 2 shows, they also occupy a central position in the global banking network. As such, the financial sectors of these jurisdictions are of such systemic importance as to merit more in-depth monitoring of their financial sector policies through the conduct of periodic financial stability assessments in the context of Article IV. The first cluster alone, in contrast, represents less than 70 percent of the global financial system and less than half of global output. The third cluster (16 additional jurisdictions) is also relatively stable for different weight combinations, but only accounts for a very small share (less than 5 percent) of the global financial system.

Table 3. Jurisdictions with Systemically Important Financial Sectors

Country	Overall Rank ¹	Size Rank	Interconnectedness Rank
United Kingdom	1	3	1
Germany	2	4	2
United States	3	1	10
France	4	6	3
Japan	5	2	14
Italy	6	8	8
Netherlands	7	9	6
Spain	8	7	11
Canada	9	9	14
Switzerland	10	15	4
China	11	4	34
Belgium	12	19	5
Australia	13	14	17
India	14	11	29
Ireland	15	20	9
Hong Kong SAR ²	16	17	18
Brazil	17	12	32
Russian Federation	18	13	31
Korea	19	18	22
Austria	20	22	13
Luxembourg	21	26	7
Sweden	22	23	16
Singapore	23	26	12
Turkey	24	21	25
Mexico	25	16	49

Source: Staff estimates.

¹ Weighted average of the size and interconnectedness rankings using a 0.7/0.3 weight breakdown, respectively.

² Stability assessments for Hong Kong Special Administrative Region will form part of Article IV consultations with the People's Republic of China.

Figure 2. The Position of the 25 Jurisdictions with Systemically Important Financial Sectors in the Global Banking Network



Source: Staff estimates.

Notes: Lines between jurisdictions reflect the connections between their respective banking systems. For simplicity, only the connections between each of the 25 jurisdictions and the rest of the global network are shown.

E. Interpretations and Caveats

21. **It is important to bear in mind the limitations of this definition of systemic importance:**

- **It is not a proxy for a jurisdiction's systemic importance writ large.** The analytical approach used in this paper is focused on the financial sector. It does not purport to measure all aspects of a jurisdiction's relative importance in the world economy, such as the size of the domestic market, growth potential, trade linkages, etc. As a result, some large, systemically important economies may be ranked lower than smaller countries that have relatively big and/or highly interconnected financial sectors.
- **It does not capture market perceptions.** This approach is entirely data-based. Market perception of a financial sector's systemic importance, though a key component of systemic risk, can be volatile; is influenced by economic and political factors that go beyond the size and interconnectedness of the particular financial sector; and is hard to measure objectively. It is therefore not incorporated into this approach.
- **The extent of vulnerabilities is also not considered.** The methodology is focused on systemic importance as measured by size and interconnectedness, not vulnerabilities. This is because the benefits of regular financial stability assessments would be maximized—both for the individual members and for the global financial system—if these assessments are focused on the countries with the most systemically important financial sectors, not on the most vulnerable. To be sure, members faced with macrofinancial vulnerabilities, regardless of their size or interconnections, would also benefit from an in-depth look at their financial sectors and may need additional Fund support. But there are other instruments, including Article IV surveillance, voluntary FSAPs, and technical assistance, which would continue to provide this analysis.
- **Like all quantitative analyses, it is limited by the quality of data.** In particular, it may not reflect accurately the importance of non-bank and unregulated segments of the financial sector, given the difficulties countries often experience in collecting such data, nor can it fully take into account differences in the quality of data collection and reporting across countries.

III. FREQUENCY OF MANDATORY FINANCIAL STABILITY ASSESSMENTS FOR JURISDICTIONS WITH SYSTEMICALLY IMPORTANT FINANCIAL SECTORS¹⁰

22. **The appropriate frequency of mandatory financial stability assessments has to be based on a balance of different considerations.** Financial stability assessments should in principle take place as frequently as needed to provide timely input to surveillance and minimize the probability of vulnerabilities or threats to financial stability growing undetected. At the same time, these considerations need to be weighed against resource costs, both for the country and for the Fund.

23. **A review of the relevant literature and practice in the financial industry suggests three years as a reasonable target for the frequency of stability assessments.** Economic and financial theory and empirical literature do not provide unambiguous answers. Nevertheless, on the basis of a review of several strands of literature and industry practice, it appears that about three years is a reasonable frequency for regular in-depth macro-level assessments of financial stability. Not only would this provide an appropriate window for the detection of the vulnerabilities that are the main focus of FSAP stability assessments, but also a reasonable timeframe for the authorities to take appropriate action in response to these vulnerabilities.

A. General Considerations and Industry Practice

24. **The frequency of stability assessments in the financial industry differs substantially depending on the purpose and scope of such assessments.** Portfolio managers often have a short time horizon (e.g., quarterly or less for the most active trading institutions), while banks typically focus on a one-year horizon for their own credit risk and capital needs assessment (Castren, *et al.*, 2009). The scope, technical complexity, and resource intensity of the assessment also affects its frequency: product-based market risk assessments using Value-at-Risk models are fairly straightforward and often updated on a daily basis, while risk assessments of structured products or enterprise-wise risk assessments are technically much more complex, require more time and resources, and are done less frequently.¹¹

¹⁰ Prepared by Nicolas Blancher and Hiroko Oura.

¹¹ An industry survey by Deloitte (2009), covering various types of financial institutions from around the world, documents the wide variety of practices. Risk management practice is still fragmented within institutions: more than 40 percent of institutions are still lacking an integrated risk management system for a whole enterprise. As for stress testing, the same survey reports that roughly 80 percent of the institutions employed stress tests for their banking and trading books, although a smaller amount (58 percent) reported performing stress tests of their structured products (or securitization and related transaction) exposures. Among institutions that conducted stress tests of their structured product exposures, only 17 percent conducted them daily, while 68 percent conducted these tests quarterly or less often.

25. **Sector- or macro-level assessments of the type conducted by supervisory institutions cover broader, systemic sources of vulnerabilities and are performed much less frequently than in the financial industry.** Macro-level risk assessments have broad coverage, including the interactions between the financial sector and the other sectors of the domestic economy or even across borders, and are generally highly resource intensive. System-wide stress testing exercises often require resources and input from both supervisors and participating financial institutions, sometimes over several iterations. Supervisory authorities that conduct system-wide stress testing exercises typically do so on an annual or even lower frequency.

26. **The vulnerabilities assessed in the context of FSAP stability assessments are primarily of a macro-financial nature, which typically build up over multi-year periods.** FSAP assessments focus on the buildup of systemic risks with potential macroeconomic implications, such as the deterioration of asset quality, the accumulation of leverage, the formation of asset bubbles, and the buildup of concentrated exposures. Such risks may reflect macroeconomic imbalances, persistent shifts in capital allocation and flows across asset classes, countries, and markets, or other business cycle factors. Since the average business cycle is about five years (National Bureau of Economic Research, 2010), macro-financial stability analysis conducted at this, or somewhat higher frequency (say, every in three to five years) should in principle be able to detect a major buildup of vulnerabilities.

27. **The frequency of macro-financial risk assessments may need to be higher when the system is undergoing structural change or innovation.** Even though stability assessments focused on detecting macro-financial vulnerabilities can be effective at a relatively low frequency, the literature on financial crisis suggests that vulnerabilities can build up faster at times of financial innovation or structural change. Over the last several centuries, major financial crises have taken place years or even decades apart (Reinhart and Rogoff, 2008). Even during the Bretton Woods period, there was no major banking crisis—despite the occurrence of some currency crises. Some authors attribute this to the currency peg system, as well as to extremely tight financial sector regulation around the world as a consequence of the Great Depression (Allen and Gale, 2000; Ishii and Habermeier, 2002; Ranciere *et al.*, 2005). However, Bordo, *et al.* (2001) noted that the frequency of crises has increased in recent decades, especially since the 1980s. This pattern suggests a more rapid accumulation of vulnerabilities during periods of structural change, financial innovation, and deregulation, as during the last decade. Other things being equal, this would militate in favor of more frequent vulnerability assessments under these circumstances.

B. Lessons from the Early Warning Literature

28. **The early warning literature suggests that an assessment window of three years or less might be needed for a financial stability exercise to identify vulnerabilities with reasonable accuracy and allow the authorities to take policy action.** The models underpinning the frequency of supervisory examinations of financial institutions, as well as

early warning models of financial distress, can provide some potentially useful lessons on the appropriate frequency of macro-financial surveillance under FSAPs.

29. The early warning models for individual institutions used by supervisors seem to have been reasonably successful with identifying vulnerable institutions typically one and a half to three years.

- Thomson (1991) assessed models of bank failures based on CAMELS variables and found that the majority of these variables are significantly related to the probability of failure as much as four years in advance of failure. However, Cole and Gunther (1998) and Hirtle and Lopez (1999) showed that CAMEL ratings cease to provide useful information about the condition of a bank more than one and a half to three years ahead, especially for the weaker institutions.
- In the mid 1990s, the Federal Reserve Board started using an early warning model to predict bank financial stress during the subsequent two years, and the Office of Currency Comptroller currently uses a model designed to predict the potential impact of different macroeconomic scenarios on banks' return on assets over the next three years (Jagtiani, 2003).
- In 2000, the BIS took stock of existing early warning models, including the ones above, and concluded that time horizons used by supervisory authorities in these statistical models were typically in the range of a few months to three years (Sahajwala and Van den Bergh, 2000).
- More recently, it has been shown that incorporating market prices in early warning models can be useful in forecasting bank distress. In particular, Gropp (2004) shows that distance-to-default indicators help predict bank failures up to one and a half years in advance, a result confirmed by Chan-Lau, Jobert and Kong (2004) in the context of banks in emerging markets.

30. The early warning literature on systemic crises suggests a time horizon as long as five years. The early warning model of financial crises used in the Fund's vulnerability exercises (IMF, 2007), in particular, builds on and expands preceding early warning models (including Kaminsky, Lizondo, and Reinhart, 1998; Kaminsky and Reinhart, 1999; and Demirguc-Kunt and Detragiache, 1998). The dependent variable is the financial crisis indicator, and the explanatory variables are divided into medium-term variables (defined over the previous five years and including house prices, stock prices, private credit growth), and near-term variables (defined over the preceding one year and including macro variables, bank and corporate sector indicators, household liability and house/stock price acceleration). This setup suggests that a five-year window is an acceptable upper bound for the optimal time horizon for macro-financial vulnerability identification. Compared to micro-level early warnings models, however, the predictive power of systemic crisis models is much weaker.

APPENDIX I: DATA SOURCES

Gross external position

The gross external position is represented by the stocks of external financial assets and liabilities in each country, that is, the international investment position (IIP).¹ Gross IIP is approximated by adding foreign direct investment, external loans and deposits, foreign exchange reserves, portfolio investment, and financial derivatives.

- **Foreign direct investment** is direct investment in the reporting economy plus direct investment abroad (stocks at end-2008). Data are reported in U.S. dollars. Source: UNCTAD, Foreign Direct Investment Database Online. <http://stats.unctad.org/fdi/>.
- **External loans and deposits** are derived from BIS locational banking statistics and are calculated as the sum of loans and deposits of reporting banks to all sectors vis-à-vis individual countries (amounts outstanding at end-2008).² Data are reported in U.S. dollars. Source: Bank for International Settlements, *Quarterly Review*, Table 7A. <http://www.bis.org/statistics/bankstats.htm>.
- **Foreign exchange reserves** are official foreign exchange assets at end-2008. These comprise currency and deposits, securities (including debt and equity securities), financial derivatives, and other claims (loans and other financial instruments) usable in the event of balance of payments needs. Data are reported in U.S. dollars. Source: International Monetary Fund, *International Financial Statistics*.
- **Portfolio investment** is the sum of total portfolio investment assets and liabilities³ at end-2008. Data are reported in U.S. dollars. Source: IMF, *Coordinated Portfolio Investment Survey*, Tables 12 and 13. <http://www.imf.org/external/np/sta/pi/datarsl.htm>.
- **Financial derivatives** cover financial instruments that are linked to other specific financial instruments, indicators, or commodities and can, in their own right, be traded in financial markets. Financial derivative assets and liabilities are added to calculate each jurisdiction's gross position at end-2008. Data are reported in U.S. dollars. Source: IMF, *IFS*.

¹ The IIP used in the paper is an approximation for this exercise and does not correspond exactly to what is published in the IMF's *International Financial Statistics*.

² The locational banking statistics report both international claims and liabilities of banks resident in 42 countries. Data for nonreporting countries are extrapolated by reversing the direction of the reported positions. This is an approximation and could vary from reported figures.

³ Liabilities show, from the perspective of the economy issuing the securities, the value of securities held by nonresidents as derived from information reported by the holders of securities (creditor information). Derived liabilities are only generated when the sum of reported holdings of securities issued by a given country is at least U.S. dollar 10 million.

Financial sector activity

This measure is used to approximate the size of the financial sector in a jurisdiction. It is comprised of transferable deposits, currency outside depository corporations, and other deposits (i.e., currency and deposits) as published in the *IFS* at end-2008. Where these data are unavailable, missing values are substituted with 2008 broad money figures from the *World Economic Outlook (WEO)*. (Eleven missing values were taken from the *WEO*, while figures for Iceland and Marshall Islands were taken from Article IV Staff Reports.) *IFS* figures have been converted to U.S. dollars using end-2008 exchange rates from *IFS*. *WEO* figures are reported in U.S. dollars. Sources: IMF, *IFS* and *WEO*.

Nonbanking financial markets

This measure takes into account the following nonbanking financial markets:

- **Pension fund assets** are total assets of autonomous pension funds, both occupational and personal, at end-2008. Data are reported as a percentage of GDP and are converted using PPP GDP as reported in the *WEO* (for eight countries, GDP was taken from UN data, <http://data.un.org/>). Sources: IMF, *WEO* and Organization for Economic Co-operation and Development (OECD), *Global Pension Statistics*. <http://stats.oecd.org/>
- **OTC derivatives turnover** is calculated as the sum of average daily turnover in April 2007 of over-the-counter foreign exchange derivatives (comprising outright forwards, foreign exchange swaps, currency swaps, options and other products) and single currency interest rate derivatives (comprising forward rate agreements, swaps, options, and other products). Data are in U.S. dollars. Source: BIS, *Triennial Central Bank Survey of Foreign Exchange and Derivatives Market Activity in 2007*. <http://www.bis.org/publ/rpfx07t.htm>
- **Insurance premiums** are total insurance premium volumes in 2008. Data are reported in U.S. dollars. Source: Swiss Re, *sigma*, No 3/2009, Table III. <http://www.swissre.com/sigma/>
- **Hedge funds by legal domicile** and **hedge funds by manager location** are amounts outstanding of capital managed by hedge funds at end-2008. Source: BIS calculations based on data from Hedge Fund Research.

Gross Domestic Product

- **Purchasing power parity (PPP)** valuation of GDP at end-2008 is used. Data are reported in U.S. dollars. Source: International Monetary Fund, *World Economic Outlook*.

Interconnectedness Measure

The network analysis is done using bilateral data for banking sector external interbank assets and liabilities at end-2008. Data are in U.S. dollars. Data for non-reporting jurisdictions are derived from reporting country data. Source: Bilateral locational banking statistics by BIS.

REFERENCES

- Allen, F. and D. Gale, 2001, *Comparing Financial Systems*, MIT Press.
- BIS, 2010, *Research on global financial stability: the use of BIS international financial statistics*, CGFS Papers no. 40, June.
- Bordo, M., B. Eichengreen, D. Klingebiel and M. Martinez-Peria, 2001, *Is the crisis problem growing more severe?* Economic Policy, vol. 16 issue 32.
- Castren, Fitzpatrick and Sydow, 2009, *Assessing portfolio credit risk changes in a sample of EU large and complex banking groups in reaction to macroeconomic shocks*, ECB Working Paper, no. 1002.
- Chan-Lau, J. , A. Jobert and J. Kong, 2004, *An option-based approach to bank vulnerabilities in emerging markets*, IMF working paper, WP/04/33.
- Cole, A. and J. Gunther, 1998, *Predicting bank failures: a comparison of on-and off-site monitoring systems*, Journal of Financial Services Research vol. 13, no. 2.
- Deloitte, 2009, *Global Risk Management Survey: Sixth Edition*.
- Demirguc-Kunt, A. and E. Detragiache, 1998, "The determinants of banking crises in developing and developed countries," *IMF Staff Papers*, Vol. 45, No. 1.
- Edison, H., 2002, "Do indicators of financial crises work? An evaluation of an early warning system," *International Journal of Finance and Economics*, vol.8, issue 1.
- Estrella, A., S. Park and S. Peristiani, 2000, *Capital ratios as predictors of bank failure*, Economic policy review, Federal Reserve Bank of New York Economic Policy Review, vol. 6, no.2.
- FSB, 2010, "Application of the criteria for prioritizing jurisdictions for further evaluation," Note by the Secretariat for the FSB Plenary meeting, January.
- Gropp, R., J. Vesala, and G. Vulpes, 2004, *Market indicators, bank fragility, and indirect market discipline*, Federal Reserve Bank of New York Economic Policy Review, vol. 10, no. 2.
- Hirtle, B. and J. Lopez, 1999, *Supervisory Information and the Frequency of Bank Examinations*, Federal Reserve Bank of New York Economic Policy Review, vol. 5 no. 1.

IMF, 2010, “Financial Sector Surveillance and the Mandate of the Fund”, March.

IMF/ BIS/ FSB, 2009, “Guidance to Assess the Systemic Importance of Financial Institutions, Markets and Instruments: Initial Considerations”, October.

Ishii, S. and K. Habermeier eds, 2002, *Capital Account Liberalization and Financial Sector Stability*, IMF Occasional Paper 211.

Jagtiani, J., J. Kolari, C. Lemieux and H. Shin, 2003, *Early Warning Models for Bank Supervision: Simpler Could Be Better*, Economic Perspectives, vol. 27.

Kaminsky, G., S. Lizondo and C. Reinhart, 1998, *Leading indicators of currency crises*, IMF Staff Papers, 45.

Kaminsky, G. and C. Reinhart, 1999, *The twin crisis: The causes of banking and balance of payments problems*, American Economic Review 89 (3).

Kubelec and Sá, 2010, “The Geographical Composition of National External Balance Sheets: 1980-2005,” Bank of England Working Paper No. 384, March.

Laeven, L. and F. Valencia, 2008, *Systemic Banking Crises: A New Database*, IMF Working Paper 08/224.

NBER, *Business Cycle Expansions and Contractions* (<http://www.nber.org/cycles.html>)

Ranciere, R., A. Tornell and F. Westermann, 2005, *Systemic Crises and Growth*, CESifo Working Paper Series No. 1451

Reinhart, C. and K. Rogoff, 2008, *This time is different: A panoramic view of eight centuries of financial crises*, NBER Working Paper 13882.

Rose, A. and M. Spiegel, 2009, *Cross-country causes and consequences of the 2008 crisis: Early Warning*, NBER Working Paper no. 15357.

Sahajwala and Van den Bergh, 2000, *Supervisory risk assessment and early warning systems*, BIS, BCBS Working Paper.

Thomson, J., 1991, “Predicting bank failures in the 1980s,” *Federal Reserve Board of Cleveland Economic Review*, Vol. 27, No.1.

Von Peter, 2007, “International Banking Centres: A Network Analysis,” BIS Quarterly Review, December.