CHAPTER 2

SYSTEMIC RISK AND THE REDESIGN OF FINANCIAL REGULATION

Summary

The recent financial crisis has triggered a rethinking of the supervision and regulation of systemic connectedness. While there is a clear need to take a multipronged approach to systemic risk, and a flood of regulatory reform proposals has ensued, there is considerable uncertainty about how those proposals can be practically applied. Thus, this chapter aims to contribute to the debate on systemic-risk-based regulation in two ways. First, it presents a methodology to compute and smooth a systemic-risk-based capital surcharge. Second, it formally examines whether a mandate, by itself, to explicitly oversee systemic risk, as envisioned in some recent proposals, is likely to be successful in mitigating it.

Systemic-Risk-Based Surcharges

While not necessarily endorsing the adoption of systemic-based capital surcharges, the first part of the chapter presents a methodology to calculate such surcharges. Underpinning this methodology is the notion that these surcharges should be commensurate with the large negative effects that a financial firm's distress may have on other financial firms—their systemic interconnectedness.

The chapter presents two approaches to implement this methodology:

- A ***standardized approach*** under which regulators assign systemic risk ratings to each institution and then assess a capital surcharge based on this rating.
- A ***risk-budgeting approach,*** which borrows from the risk management literature and determines capital surcharges in relation to an institution's additional contribution to systemic risk and its own probability of distress.

Regulatory Architecture

The chapter also argues that an important missing ingredient from most architecture reform proposals is the analysis of regulators' incentives—including regulatory forbearance incentives to keep institutions afloat when they should be unwound—that will likely vary across the alternative ways the regulatory functions could be allocated.

In particular, the chapter shows how adding a systemic risk monitoring mandate to the regulatory mix without a set of associated policy tools does not alter the basic regulator's incentives at the heart of some of the regulatory shortcomings leading to this crisis. In fact, in the absence of concrete methods to formally limit the ability of financial institutions to become systemically important in the first place—regardless of how regulatory functions are allocated—regulators are still likely to be more forgiving with systemically important institutions than with those that are not.

For this reason, it is necessary to consider more direct methods to address systemic risks, such as instituting systemic-risk-based capital surcharges, applying levies that are related to institutions' contribution to systemic risk, or perhaps even limiting the size of certain business activities. Which measures are finally chosen will have a significant impact on the financial sector.

A wide range of official, academic, and private sector financial reform initiatives have surfaced in response to the recent global financial crisis. These include the establishment of a specialized supervisor of systemically important firms, refinements in the lender-of-last-resort principles, new funding liquidity and leverage restrictions for banks, and capital surcharges based on an institution's likely contribution to systemic risk.

Several of these proposals suggest that regulations guiding the risk management practices of financial institutions are in need of significant improvements and, more specifically, that the focus on the stability of a financial institution in isolation needs to be reassessed. The proposals also suggest that prudential reform efforts need to be supported by an overhaul of the current structure of financial regulation.

The introduction of capital charges based on an institution's contribution to systemic risk is one regulatory proposal that has attracted attention, and the chapter illustrates how this can be done. Although the chapter does not necessarily endorse the adoption of such charges, it illustrates how they can be made operational and at the same time correct for the procyclicality of these charges, thereby countering a critique often leveled against the current set of Basel II capital charges—and one that the Basel Committee on Banking Supervision is now addressing forcefully.

The adoption of capital surcharges and related regulatory measures is likely to represent an additional burden on the financial sector at a time when capital is scarce, and should thus be implemented carefully so as to ensure the availability of adequate credit to support the recovery. Moreover, to fully assess the desirability of surcharges, their costs need to be contrasted against the benefit of lowering systemic risk and the desirability of other measures.

At the financial regulatory architecture level, one of the most prominent proposals is the creation of a systemic risk regulator that would focus on the macroprudential monitoring of the financial system as a whole. This responsibility could be carried out either by new regulators or existing regulators with a new focus. While the benefits of strengthening oversight of systemic risk are considerable, implementation of such oversight may not be straightforward, as it will require close coordination and clear delineation of responsibilities between the new and existing (or systemic and nonsystemic) supervisory bodies. This chapter therefore suggests some key principles that need to be borne in mind in implementing the oversight of systemic risk. It shows that under an expanded mandate to oversee systemic risks, regulators will tend to exercise more forbearance against systemically important institutions than nonsystemically important ones. This suggests that, regardless of how regulatory functions are arranged, regulators' toolkits will need to be augmented to mitigate systemic risks.

It is worth noting that there is no one definition of systemic risk, which this chapter defines as the large losses to other financial institutions induced by the failure of a particular institution due to its interconnectedness.[1]

Implementing Systemic-Risk-Based Capital Surcharges

Calls for more and higher-quality capital were the first natural reaction to the crisis. In time, these calls have been shaped into more concrete proposals (Box 2.1 and Table 2.1). One proposal is the introduction of systemic-risk-based capital charges. However, certain challenges will need to be confronted in order to ensure the effective operationalization of these surcharges. In particular, if one views systemic risk as the systemic linkages that are likely to arise from the complex web of contract relationships across financial institutions, then a practical way to estimate institutions' interconnectedness and their corresponding contribution to systemic risk is required. In addition, systemic-risk-based capital charges have the potential to be procyclical, as they will increase in economic downturns (when systemic risk is likely to be higher) and decrease during booms (when systemic risk

Note: The authors of this chapter are Marco A. Espinosa-Vega (team leader), Juan Solé, and Charles M. Kahn. Special thanks to Rafael Matta for outstanding research support and Jean Salvati for his help in adapting the CreditRisk+ model. Yoon Sook Kim provided data management assistance.

[1]See Chapters 2 and 3 of the April 2009 *Global Financial Stability Report* (IMF, 2009) for a more complete discussion of various definitions of systemic risk.

Table 2.1. Comparison of Some Methodologies to Compute Systemic-Risk-Based Charges

Methodology/Proposal	Authors	Data Requirements	Pros	Cons
Proposals to design capital surcharges based on inter-bank correlations of returns	Acharya (2009)	Data on banks' returns	Based on easily accessible market data.	Data may be unreliable under tail events and/or not representative of underlying fundamentals during stress periods. Charges could be procyclical. Does not take into account second-round contagion effects.
Proposals to design capital surcharges based on measures of institutions' and markets' degree of "exuberance"	Bank of England (2009)	Economic activity indicators, credit default swaps (CDS), equity prices, real estate prices	Capital surcharge displays anticyclical behavior.	May be difficult to estimate institutions' and markets' degree of exuberance on an ongoing basis. Does not take into account second-round contagion effects.
Proposals to design capital surcharges based on co-movements of banks' risks (e.g., co-value-at-risk; Adrian and Brunnermeier, 2008)	Brunnermeier and others (2009) and Chan-Lau (forthcoming)	CDS and equity data	Based on easily accessible market data.	Data may be unreliable under tail events and/or not representative of underlying fundamentals during stress periods. Charges could be procyclical. Does not take into account second-round contagion effects.
Two alternative approaches to design capital surcharges	This report and Espinosa-Vega and Solé (forthcoming)	Data on interbank exposures and balance sheet information	Gives the regulator the choice between a refined and a practical approach. Relies on data available to financial regulators. Takes into account second-round contagion effects.	Intensive data requirements (interbank exposures).
Tax based on over-the-counter (OTC) payables in derivative markets	Singh (2010)	Data on payables in OTC derivatives	Based on off-balance-sheet data. Includes netted exposures, measuring the potential systemic interconnectedness of these contracts more accurately.	Tax would only be based on banks' OTC derivative payables. Does not increase institutions' capital base. Does not take into account second-round contagion effects.

Source: IMF staff.

is likely to subside). In fact, most of the proposed approaches in Table 2.1 suffer from this issue.

This chapter contributes to the debate on the merits and feasibility of systemic-risk-based capital surcharges by presenting two approaches of a methodology to compute these charges. The methodology is not meant to be prescriptive. Instead, the goal is to contribute to the discourse on the design of prudential regulation based on each institution's contribution to systemic risk.[2] The chapter also illustrates that smoothing the charge through time could lessen the degree of procyclicality potentially associated with systemic capital charges, though it does not address the existing procyclicality of Basel II capital charges. The proposed methodology comprises the following steps:

(1) Tracking financial institutions' portfolios through the credit cycle;

(2) Estimating each institution's spillover effects following a stress event, at each point in the cycle, based on network analysis; and

(3) Computing capital surcharges as a function of an institution's systemic risk profile according to two alternative approaches: a "standardized" approach and a more refined approach that borrows from the risk management literature and that is dubbed "risk-budgeting" approach.

In addition, a smoothing technique is applied to the risk-budgeting approach to lessen its procyclical profile.

To demonstrate these ideas and provide the intuition, every step of the proposed methodology is illustrated by means of examples. The rest of this section explains in detail each of these steps as applied to a selected number of hypothetical banks.

[2]See Bank of England (2009) for an insightful discussion of some of the issues involved in the operationalization of systemic capital surcharges.

Box 2.1. Proposals for Systemic Risk Prudential Regulations

This box presents a critical review of some recent proposals to reform prudential regulation so as to curb the negative effects of financial system linkages.

Proposals in the U.S. House of Representatives and Senate put forward broad criteria to identify the degree of an institution's systemic risk, including the sources and term structure of funding, the extent of leverage, relationships with other financial firms, and concentration. However, the way in which these criteria would be unified and used to identify the degree of an institution's systemic risk has not been spelled out. Furthermore, the proposals focus entirely on firm-specific data without taking account of indirect financial linkages arising from market perceptions of common risk exposures or the influence of general market conditions. It is also unclear what type of prudential measures would be put in place to limit these firms' systemic risk contributions.[1,2]

The U.K. Financial Services Authority (FSA, 2009) has put forward an idea that size, interconnectedness, and markets' perception of common exposures are recognized as key elements in determining a financial firm's degree of systemic importance. As in the United States, the FSA has not detailed the way these criteria would be used to identify the degree of an institution's systemic risk. However, U.K. proposals (FSA and the Bank of England[3]) have been forceful in calling for a *continuous approach* to identify and limit these firms' systemic risk contributions. That is, U.K. proposals call for tying the stringency of prudential requirements to the degree of financial firms' contributions to systemic risk. By contrast, an alternative *binary approach* in which regulators set static cutoff thresholds, whereby some firms would be considered of systemic importance and others would not, would leave room for regulatory arbitrage and increased moral hazard. Also, the Bank of England (2009) has provided an illustrative methodology for implementing capital surcharges that take into account each firm's marginal contribution to systemic risk.

Cross-Border Spillovers

The FSA has suggested the need to design capital surcharges for globally active financial groups as a function of their business risk profile (e.g., the extent of their trading and wholesale activities) and organizational structure (subjecting globally integrated groups to group-wide prudential surcharges). The rationale behind the idea is that penalizing integrated groups would encourage conventional commercial banking activities carried out through local subsidiaries, which are viewed as being better regulated by supervisors in the host countries. However, as with the proposals to identify financially important firms, the details are sketchy.

Liquidity Regulation

Compared to capital regulations, liquidity regulations are still in an early stage of discussion. Little work has been done on measuring a firm's contribution to systemic liquidity risk. Recently, the Basel Committee recommended a standardized approach to estimate the amount of liquid assets banks must hold, regardless of their systemic risk profile. The FSA is the first major regulator to introduce tighter liquidity standards for financial firms following the crisis. The FSA now requires banks to perform stress tests by taking account of three types of liquidity stress—idiosyncratic, market-wide, and a combination of the two—to determine the fraction of easily redeemable assets they would need to have to meet potential outflows of funds over certain periods.

Note: The author of this box is Kazuhiro Masaki.

[1]U.S. House of Representatives, *Wall Street Reform and Consumer Protection Act of 2010* (H.R.4173).

[2]U.S. Senate Committee on Banking, Housing, and Urban Affairs, *Restoring American Financial Stability Act of 2009* (see chairman's marked text, March 2010).

[3]Paul Tucker, Barclays Annual Lecture, October 2009.

Tracking Institutions' Portfolios through the Credit Cycle

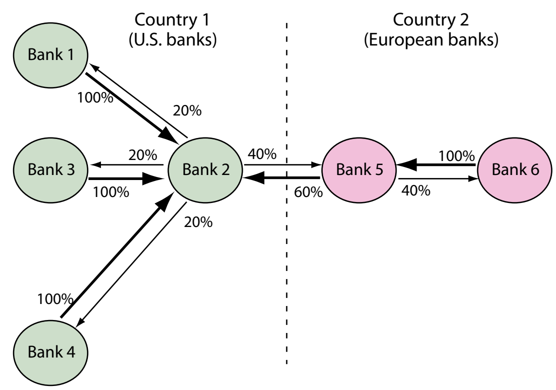
The chapter considers the portfolios of six hypothetical financial institutions, four of them mimicking important features of the U.S. banking system and two representing stylized features of European banks—in terms of the size, composition, and quality of their portfolios. More specifically, the six prototypical institutions are constructed from the end-2006 balance sheet and financial statements of a sample of representative large and internationally active U.S. and

European banks.[3] The composition of the portfolios analyzed was inspired by information on U.S. and European institutions' annual reports and the U.S. Securities and Exchange Commission's 10-K filings.

The portfolios that are analyzed comprise securities, mortgages, and interbank assets. The size of the securities and mortgage portfolios was designed to represent the weighted average of the portfolios of the selected institutions, respectively. In terms of relative size, securities portfolios for U.S. banks were designed to be close to 20 percent larger than European banks, while the mortgage portfolios for U.S. banks were designed to be, on average, around 115 percent larger. Finally, regarding the quality of the securities portfolios, the chapter follows Gordy (2000) and Peura and Jokivuolle (2004)—who exploit the results from internal Federal Reserve Board surveys of large banking organizations—and considers four possible portfolio quality classifications (high, average, low, and very low). These portfolios are far from a full characterization of the U.S. and European banking systems and are constructed simply for pedagogical purposes.

Interbank exposures are a key element to assess network spillovers. In the absence of detailed interbank exposure data, the chapter assumes the network structure depicted in Figure 2.1. This particular configuration was inspired by a seemingly similar structure reported by several authors (e.g., Boss and others, 2004; Müller, 2006; and Upper and Worms, 2004), which consists of a few large banks that are highly interconnected, and a larger number of smaller banks that are connected to the rest of the network (mostly) through one of the larger banks.[4] The network includes a different number of banks from two different jurisdictions (i.e., four U.S. institutions and two European institutions) to illustrate several cross-border systemic risk issues that need to be addressed.[5]

Figure 2.1. Network Structure of Cross-Border Interbank Exposures



Source: IMF staff calculations.

Note: Percentage number indicates interbank exposure in percent of lending bank's total interbank exposure. The origin of the arrows denotes the lending bank and the end of the arrow denotes the borrowing bank; the thickness of the arrows is proportional to the value of the bilateral exposure.

[3]December 2006 was selected to obtain balance sheets that reflect a pre-crisis period without the influence of the fallout of the crisis.

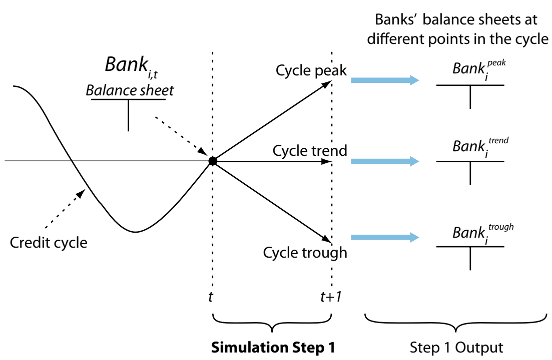
[4]Notice that Figure 2.1 depicts only the flows within the network of the representative U.S. and European institutions. In reality, these institutions have connections to other institutions outside this network, which were excluded for simplicity.

[5]Note, however, that the number of institutions chosen is for illustrative purposes and does not represent a characterization of the relative size of the U.S. and European banking systems. The chapter assumes that U.S. bank holdings of interbank assets are

In particular, the subsection on *cross-border issues* illustrates how capital surcharges calibrated from a global perspective could differ from those calibrated from an individual country perspective.

In addition to a static view of firms' portfolios, it is essential to track their evolution through the credit cycle for two key reasons: first, to assess how network spillovers—and, hence, systemic risk—evolve with economic conditions; and second, to evaluate the potential procyclicality of systemic-based capital surcharges. This step would be straightforward for those regulators with access to comprehensive historical data. However, in the absence of such data, the chapter simulates the evolution of the institutions' portfolios at different points in a stylized credit cycle and the corresponding capital adequacy requirements based on the Basel II capital adequacy requirements as shown in Figure 2.2.

Figure 2.2. Simulation Step 1: Illustration of the Evolution of Banks' Balance Sheets at Different Points in the Cycle



Source: IMF staff calculations.

Assessing Institutions' Potentially Systemic Linkages

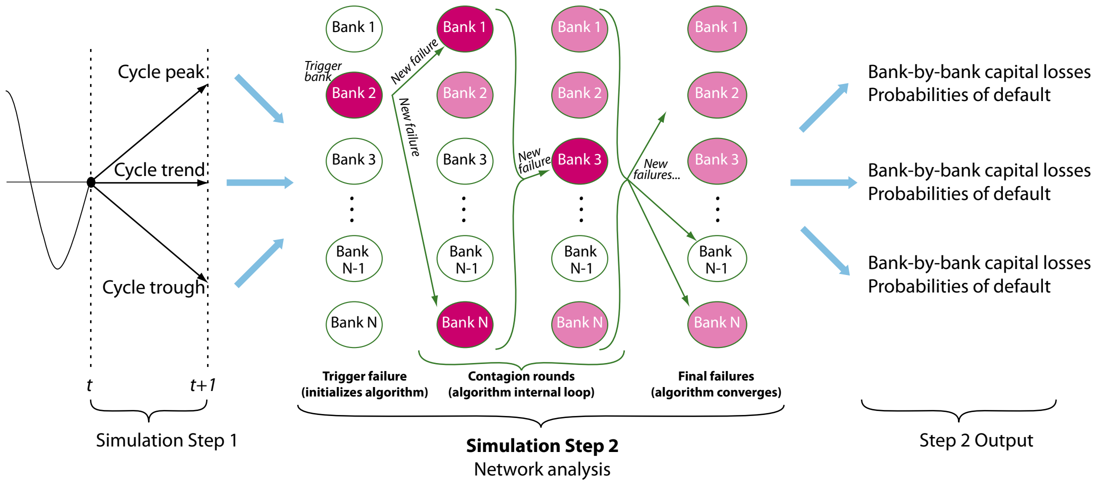
Although research on measuring institutions' systemic linkages is still in its infancy, important breakthroughs have been accomplished recently.[6] Broadly speaking, these methodologies can be divided into (1) those that rely primarily on market data (such as equity, option prices, and credit default swap spreads) and (2) those that rely on institutional data (such as balance sheets and interbank exposures data). In practice, regulators are likely to draw on a combination of those methodologies. However, for brevity, this chapter focuses on network analysis, which relies on institutional data, to assess potentially systemic linkages.[7] Although the analysis is applicable to any set

equivalent in size to 3 to 10 percent of their portfolios of securities plus mortgages, whereas European banks hold the equivalent of 15 percent of their securities plus mortgage portfolios in interbank assets. This assumption is in line with the observation that European banks tend to hold more interbank assets (as a proportion of total assets) than U.S. banks (see Upper, 2007).

[6]Recent advances can be found in BIS (2009), IMF (2009), and IMF/BIS/FSB (2009), among others. This chapter exploits the network methodology described in IMF (2009, Chapter 2); other methodologies, such as the contingent claims approach (Gray and Jobst, 2009), co-value-at-risk (Adrian and Brunnermeier, 2009), co-risk (Chan-Lau, forthcoming), and Shapely values (Tarashev, Borio, and Tsatsaronis, 2009)—or, indeed, a combination of these measures (e.g., an indicator-based approach)—could be used instead.

[7]In particular, the chapter uses a network model to track the spread of credit shocks throughout the network of banks. Thus, starting with a matrix of interbank exposures, the analysis con-

Figure 2.3. Simulation Step 2: Illustration of Contagion Effects at Different Points in the Credit Cycle



Source: IMF staff calculations.

of financial institutions, the analysis takes the evolution of banks' portfolios as inputs, and uses a network model to estimate the potential systemic distress that hypothetical institution-by-institution interbank defaults would induce at different points in the cycle (Figure 2.3). For the purpose of this exercise, institutions are defined to be in distress when their capital adequacy ratio falls below 4 percent, because many supervisors focus on this ratio as a trigger for the deployment of early intervention measures. The contagion effects, in turn, are measured in terms of system-wide *after-shock* capital losses.

Two Approaches to Compute Capital Surcharges

In addition to the information on the spillover effects, the network analysis can be used to estimate each institution's post-shock probabilities of default. This subsection illustrates how this information is used to calculate a systemic-risk-based capital surcharge according to two alternative approaches: a standardized approach and a more refined risk-budgeting approach. Importantly, both approaches move away from a *binary* characterization of systemic importance, a move advocated by, for example, the U.K. proposals (Box 2.1).

- Standardized approach: Regulators assign systemic risk ratings based on the amount of system-wide capital impairment that a hypothetical default of each institution would bring to bear on the financial system. Institutions with higher systemic risk rating are assessed higher capital surcharges.
- Risk-budgeting approach: Borrows from the risk management literature and determines capital surcharges as a function of an institution's marginal contribution to systemic risk and its own probability of distress.

As the section illustrates, the risk-budgeting approach delivers more refined estimates of the surcharges. However, given that the standardized approach starts from the same basic information as the risk-budgeting approach and both approaches deliver the same policy implications, the standardized approach may be a suitable alternative from a practical perspective. Moreover, despite its more modest modeling requirements, the standardized approach also meets the criteria being discussed. For instance, U.S. Treasury proposes that "capital requirements [for systemic institutions] should reflect the large negative externalities associated with the financial distress...of each firm" (U.S. Department of the Treasury, 2009, p. 24).

sists of simulating the default of a specific institution and tracking the domino effect to other institutions. See IMF (2009) and Espinosa-Vega and Solé (forthcoming) for a detailed explanation of the network model used for the simulations.

Example of the Standardized Approach

To illustrate how the standardized approach would work in practice, consider the case of a regulator instituting three possible systemic-risk ratings, according to the system-wide capital impairment that each institution's default would bring to bear on the others: Tier 1 (T1) for institutions deemed most systemic, Tier 2 (T2) for the second tier of systemic institutions, and nonsystemic (NS) for all other institutions.[8] Each of these rating categories would be associated with a predetermined capital surcharge—perhaps to be agreed upon in international forums. For illustrative purposes, in our example these charges are arbitrarily set to 4 percent of risk-weighted assets for T1 institutions, 2 percent for T2 institutions, and nil for nonsystemic institutions.

Table 2.2 presents the ratings assigned to each bank in our example based on the system-wide capital losses they would inflict on the financial system at different points in a stylized credit cycle. Since the goal is to lessen the probability of tail-risk scenarios, the regulator would identify the highest systemic risk rating assigned to each institution over the cycle and base the capital surcharge on that rating. For instance, Bank 6 obtains a T2 rating at the peak and trend points of the cycle, and a T1 rating in the cycle trough. In this case, Bank 6 would be assigned an overall systemic risk rating of T1, reflecting the fact that in a worst-case scenario this bank would be highly systemic. The ultimate systemic risk ratings for all banks are presented in Table 2.3.

It is important to note that the identification of an institution's systemic importance under this approach is sensitive not only to its spillovers, but also to its relative size and the stage of the credit cycle. These three factors—spillovers, size, and the stage of the business cycle—are in line with the factors that were noted in IMF/BIS/FSB (2009) as important in identifying potential systemic institutions (Box 2.2). For example, Bank 4 obtains its worst rating at the cycle peak since, during a boom, this bank's capital would grow to represent a fraction of the banking system's capital base above the threshold established to become a T2 institution (i.e., Bank 4 represents 20.3 percent of the banking system's capital versus the T2-threshold of 20 percent). Therefore, although its failure would not cause severe distress in other institutions (third column of Table 2.2), its demise would represent a significant capital loss for the sys-

Table 2.2. System-Wide Capital Impairment Induced by Each Institution at Different Points in the Credit Cycle and Associated Systemic Risk Ratings

Trigger Failure	Capital of Distressed Institutions *(in percent of system's capital)*	Number of Distressed Institutions Due to Contagion	Cyclical Rating
Simulation at Peak of Cycle			
Bank 1	14.7	0	NS
Bank 2	85.3	4	T1
Bank 3	19.7	0	NS
Bank 4	20.3	0	T2
Bank 5	28.4	1	T2
Bank 6	28.4	1	T2
Simulation at Trend of Cycle			
Bank 1	15.0	0	NS
Bank 2	85.0	4	T1
Bank 3	19.5	0	NS
Bank 4	19.9	0	T2
Bank 5	28.4	1	T2
Bank 6	28.4	1	T2
Simulation at Trough of Cycle			
Bank 1	16.4	0	NS
Bank 2	83.6	4	T1
Bank 3	18.8	0	NS
Bank 4	18.6	0	NS
Bank 5	83.6	4	T1
Bank 6	83.6	4	T1

Source: IMF staff estimates.

Note: Systemic rating scale is as follows: nonsystemic (NS) if capital of distressed institutions is below 20 percent of capital of all banks; Tier 2 (T2) if capital of distressed institutions is between 20 and 35 percent of capital of all banks; Tier 1 (T1) if capital of distressed institutions is above 35 percent of capital of all banks. An institution is considered in distress when its capital falls below 4 percent of its risk-weighted assets.

[8]In our example, the systemic rating scale is as follows: a bank is assigned the rating nonsystemic if the capital of those institutions in distress as a consequence of its default is below 20 percent of the capital of all banks (both distressed and nondistressed); the rating Tier 2 (T2) is assigned if the capital of the distressed institutions is between 20 and 35 percent of the capital of all banks; and the rating Tier 1 (T1) if the capital of the distressed institutions is above 35 percent of the capital of all banks. Notice that in this example the systemic rating scale contains only three categories, but that in practice the standardized approach certainly allows for multiple (if not a continuum of) charges. Moreover, our choice of cutoffs is arbitrary.

Table 2.3. Capital Surcharges Based on the Standardized Approach

	Systemic-Risk Rating	Systemic-Risk Capital Surcharge
		(Percent of risk weighted assets)
Bank 1	NS	0.0
Bank 2	T1	4.0
Bank 3	NS	0.0
Bank 4	T2	2.0
Bank 5	T1	4.0
Bank 6	T1	4.0

Source: IMF staff estimates.
Note: T1 indicates institutions that are deemed to be highly systemic (Tier 1); T2 indicates institutions that are deemed to be relatively systemic (Tier 2); NS indicates institutions that are deemed nonsystemic.

tem as a whole.[9] Note also that Bank 2, at the center of the network, contributes the most to the loss of capital in the banking system (some 80 plus percent), showing the importance of spillovers.

By assigning and fixing the highest systemic-risk rating and corresponding surcharge through the cycle, the regulator removes the procyclicality of these charges. There are, of course, alternative ways of implementing a standardized approach. For example, the regulator could decide to impose a surcharge as a function of the frequency with which an institution is classified as Tier 1. This suggests potential advantages of implementing a more refined approach.

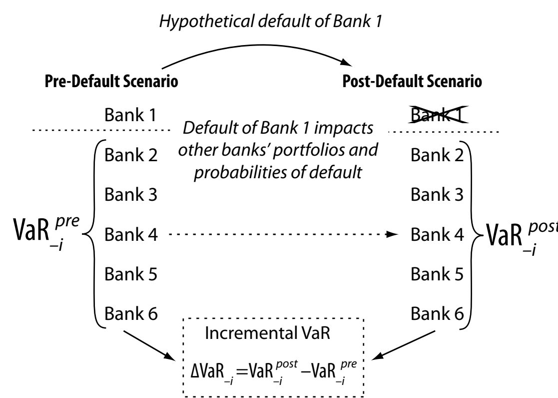
Example of the Risk-Budgeting Approach

The risk-budgeting approach is based on the estimates of an institution's marginal contribution to systemic risk. More specifically, under this approach, an institution's capital surcharge is determined as a function of its probability of default and its incremental credit value-at-risk (VaR)—defined as the increase in the system's VaR (i.e., the monetary losses that would be incurred in the system) brought about by the institution's default on its interbank exposures (Figure 2.4).[10]

[9]Bank 4 does not induce severe distress in other institutions because the relative size of its only connection to the network (i.e., through Bank 2) is not large enough to bring down Bank 2.

[10]VaR "summarizes the worst loss over a target horizon that will not be exceeded with a given level of confidence" (Jorion, 2007, p. 17). See also Chapter 7 of Jorion (2007) for a general introduction to incremental VaR, and Garman (1996, 1997) and Mina (2002) for examples of applications to asset management.

Figure 2.4. An Illustration of the Computation of Incremental Value-at-Risk for Bank 1



Source: IMF staff calculations.
Note: To estimate the systemic risk externalities induced by institution *i*'s default to the rest of the institutions in the sample, the chapter estimates the subsample's *pre-* and *post-* institution *i*'s default value-at-risk (VaR).

Box 2.2. Assessing the Systemic Importance of Financial Institutions, Markets, and Instruments

This box summarizes the high-level guidelines developed by the International Monetary Fund (IMF), Financial Stability Board (FSB), and Bank for International Settlements (BIS) for identifying systemically important institutions, markets, and instruments developed in response to a request from the leaders of the G-20.

At the London Summit on April 2, 2009, the G-20 leaders issued a "Declaration on Strengthening the Financial System" and called on the IMF, FSB, and BIS to develop guidelines on how national authorities can assess the systemic importance of financial institutions, markets, and instruments. The guidelines focused on institutions' activities, regardless of their legal charter. The main objective is to ensure that systemically important institutions, markets, and instruments are subject to an appropriate degree of oversight and regulation, reducing the scope for regulatory arbitrage. The guidelines were welcomed by the G-20 finance ministers and central bank governors at their November 2009 meeting. The report's main conclusions can be summarized as follows:

- *The concept of what constitutes systemic relevance.* Systemic risk is intimately related to financial stability and would be defined as a risk of disruption to financial services that (1) is caused by an impairment of all or parts of the financial system and (2) has the potential to have a serious adverse effect on economic activity. Assessments will need to depend on evolving economic and financial conditions, and would involve a high degree of judgment.
- *The criteria for determining systemic importance.* The report proposed criteria that include (1) the volume of financial services provided by the individual component of the financial system; (2) elements that are critical to the working of the financial system because there are no close substitutes; and (3) interlinkages between the elements where individual failure has repercussions by propagating stress. Potential vulnerabilities, including the degree of complexity of financial institutions, leverage, and maturity mismatches, should also be taken into account, as well as the capacity of the financial system to handle failures should they occur. Certain criteria will be both qualitative and quantitative. The assessment of the systemic importance of markets presents more conceptual challenges than that of institutions, but the criteria of size, substitutability, and interconnectedness remain relevant.
- *A toolbox of measures and techniques to operationalize the assessment of systemic risk.* These would range from fairly simple measures and indicators of size, substitutability, and interconnectedness to more sophisticated tools that measure interconnectedness through network analysis and co-movement in the performance of different components, as well as stress testing to take account of state dependency. Implementation will depend on data availability; improvements in data gathering are recommended to allow for effective assessments.
- *International guidelines for assessing systemic relevance, the form they might take, and their possible uses.* The objective is to establish a reasonable minimum framework that is sufficiently flexible to cater to a broad range of countries and circumstances, and that would reflect a set of good practices. Key elements would include the need to establish a framework for system-wide assessments, the use of appropriate information and methodologies, communication of assessment results depending on the purpose of the assessments, and cross-border cooperation in the assessments.

The guidelines would have a number of potential uses, including helping calibrate regulations to take account of systemic risks, to define the perimeter of regulation, and in the design of crisis management policies.

Note: The authors of this box are Barry Johnston and Li Lian Ong.

As illustrated in Márquez Diez-Canedo (2005), the use of credit VaR is helpful in determining an institution's regulatory capital requirements. The chapter further exploits this concept to estimate capital surcharges based on each institutions' marginal impact on the banking system's credit VaR. Besides its intuitive appeal, an additional advantage of this approach is that its

Chan-Lau (forthcoming), also proposes using an incremental VaR to calculate capital surcharges.

basic data requirements are similar to those under the Basel II internal-ratings-based approach. Furthermore, the modeling requirements are also based on standard techniques in the risk management literature.

For instance, to compute the system's VaR, the chapter relies on a simplified version of the Credit-Risk+ model presented by Avesani and others (2006) that estimates the aggregate probability distribution of the system's losses based on individual banks' probabilities of default, assets, and losses-given-default (see Box 2.3 for details).[11] Since this chapter is interested in measuring each institution's *externalities*, the incremental VaR *excludes* the specific institution for which the capital surcharge is being computed. Note that, even though it is excluded, the hypothetical failure of a specific institution will affect the other institutions by increasing their direct losses from the defaulting institution and by increasing their probability of default. Both of these effects are captured by the incremental VaR computation.

Recognizing that each institution's systemic risk contribution would materialize only with some likelihood, proper design of capital surcharges would need to adjust each institution's contribution to systemic risk by its own probability of default. The chapter estimates this probability of default based on an adaptation of a distance-to-default model that builds on Merton (1974).

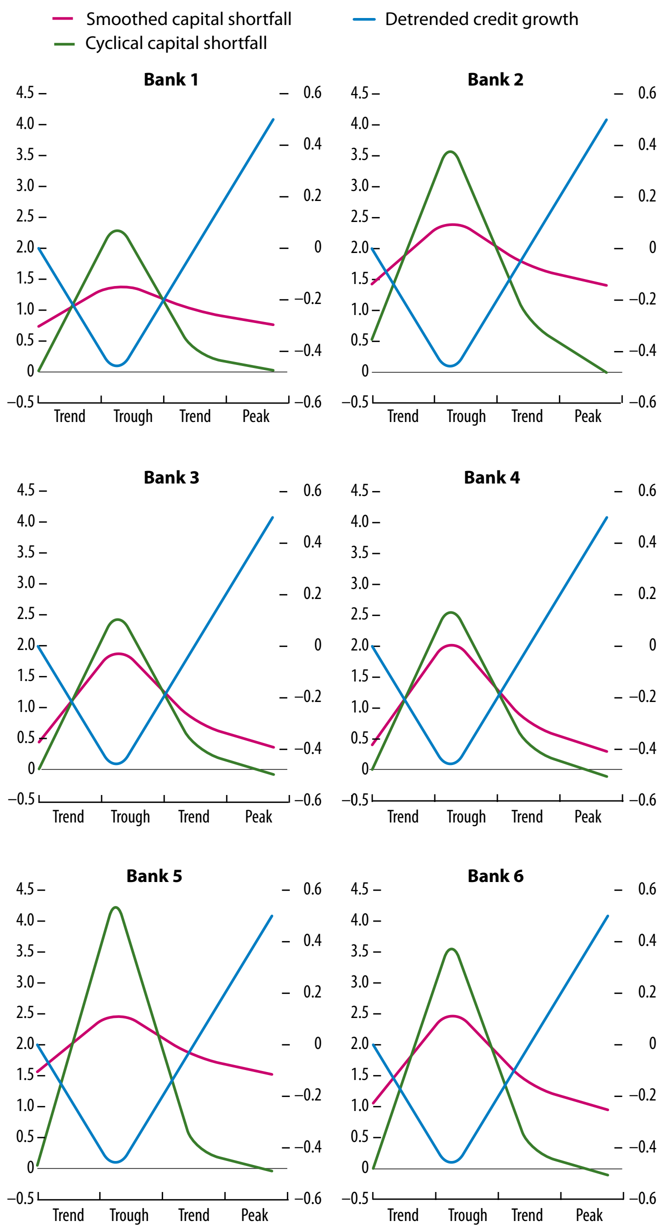
The capital surcharges obtained under the risk-budgeting approach for the data at hand are listed in Table 2.4. It is important to note that these surcharges would lessen the impact of systemic linkages by increasing banks' capital buffers by an average of 25 percent during economic downturns (see the bottom of the second column in Table 2.4).[12]

In general, however these surcharges would be procyclical: they would increase during economic downturns and decrease during expansions, as shown in Figure 2.5 where the blue line represents the credit

[11]CreditRisk+ is a methodology developed by Credit Suisse for calculating the distribution of possible credit losses from a portfolio (www.credit-suisse.com/investment_banking/research/en/credit_risk.jsp).

[12]While this increase appears significant, note that the Swiss authorities have increased the capital adequacy target ratio for UBS and Credit Suisse to be in a range between 50 and 100 percent above the minimum Basel II requirement, thus raising the total required capital to between 12 and 16 percent of risk-weighted assets by 2013.

Figure 2.5. Simulation of Systemic Risk Capital Surcharges
(Capital shortfall in percent of risk-weighted assets)



Source: IMF staff calculations.
Note: The capital shortfall is defined as the difference between the minimal Basel capital requirements *plus* the systemic-risk surcharge *minus* the actual total capital of each institution, in percent of risk-weighted assets.

Box 2.3. Computing an Aggregate Loss Distribution

The box illustrates the technicalities regarding how to compute the aggregate loss distribution and the value-at-risk for a portfolio of assets subject to credit risk, under specific default distribution assumptions for its individual components.

To illustrate the basic notions of how the credit risk of a portfolio of assets is evaluated, we start with a statistical distribution representing how frequently a loss of one asset might occur and how the assets in the portfolio affect losses associated with the portfolio as a whole. For instance, when individual defaults are subject to mutually independent Bernoulli distributions, a common representation of loss possibilities, the aggregate loss distribution can be computed by "convolution" (or combination) of the individual loss distributions. Consider a portfolio with two assets, each with a Bernoulli loss distribution: Asset 1 with default probability P1, and associated loss-given-default (LGD) L1; and Asset 2 with default probability P2 and LGD L2. Assume that L2 < L1. The table below shows that if the assets are independent:

Asset 1	Asset 2	Aggregate Loss	Probability
Default	Default	L1 + L2	P1 x P2
Default	No Default	L1	P1 x (1–P2)
No Default	Default	L2	(1–P1) x P2
No Default	No Default	0	(1–P1) x (1–P2)
			Total: 1

The last two columns of the table describe the aggregate loss distribution.

Note: The author of this box is Jean Salvati.

In this simple example with only two assets, the loss distribution is easily computed by enumerating all the possible combinations of individual losses. As the number of assets increases, this method becomes impractical. To see this, consider that the total number of combinations for 30 assets is over 1 billion. In order to handle larger portfolios, a more efficient algorithm is needed.

In mathematical terms, the vector [(1–P1) x (1–P2), (1–P1) x P2, P1 x (1–P2), P1 x P2] is the *convolution* of the vectors [(1–P1), P1] and [(1–P2), P2]. Based on the convolution theorem, the Fourier transform can be used to efficiently compute convolutions. Computing the aggregate loss distribution by convolution of the individual loss distributions is an efficient algorithm that can be applied to a large number of assets, thus its usefulness for the chapter (see Avesani and others, 2006, for details).

Once the loss distribution is known, various statistics and risk measures can be computed. One of the most important risk measures is the value-at-risk (VaR), which is the worst loss associated with a given confidence level over a target horizon. Let L represent the aggregate loss across the portfolio, and let $VaR(x)$ represent the VaR at the x-percentile level. The probability that the loss will not exceed $VaR(x)$ is:

$$P[L \leq VaR(x)] = x\%$$

The VaR can be computed in a simple way, by sorting the possible values for the aggregate loss, and by computing cumulative probabilities. In the example above, the probability that the loss will exceed L1 is P1 x P2. Therefore, L1 is the VaR at the (1–P1 x P2) level. When the VaR level is not equal to one of the cumula-

Table 2.4. Systemic-Risk-Based Capital Surcharges through the Cycle

(In percent of initial risk-weighted assets)

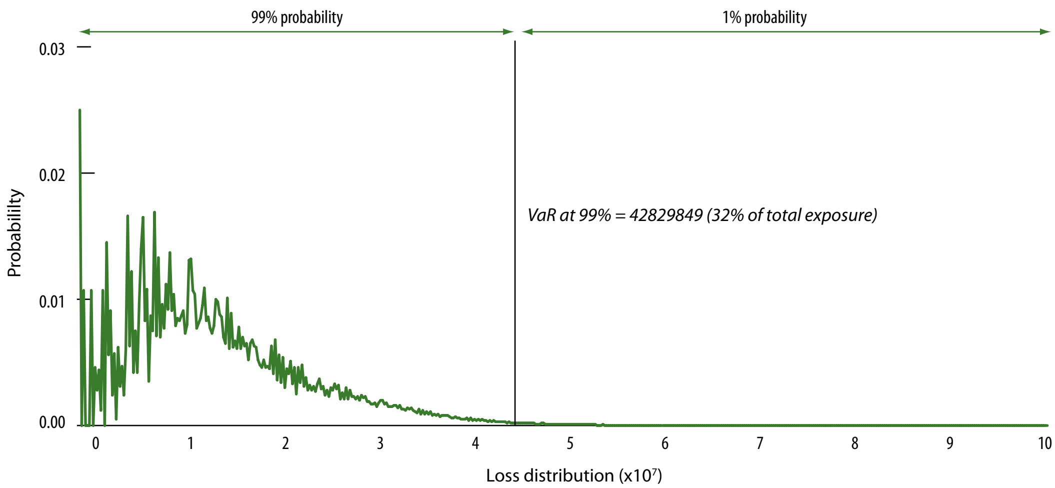
Institution	Credit Cycle Trough	Credit Cycle Trend	Credit Cycle Peak	Through-the-Cycle Smoothing
Bank 1	1.73	0.02	0.00	0.74
Bank 2	2.67	0.53	0.02	1.43
Bank 3	1.02	0.01	0.00	0.44
Bank 4	0.95	0.01	0.00	0.41
Bank 5	3.39	0.05	0.00	1.56
Bank 6	2.17	0.00	0.00	1.06
Average	1.99	0.10	0.00	0.94
Average/Initial capital	24.87	1.28	0.03	11.73

Source: IMF staff estimates.

cycle and the green line the amount of capital requirements coming from the model. For instance, the *average* systemic-risk surcharge *across* institutions fluctuates between zero and 2 percent of risk-weighted assets over the credit cycle (Table 2.4). Therefore, the chapter now explores an alternative smoothing technique consisting of averaging the methodology's inputs (i.e., probabilities of default and loss-given-default amounts) through the cycle, and then computing the capital surcharges.[13]

[13]Regarding ways to counteract the procyclical effects of risk-based capital charges, see also Gordy and Howells (2006) or

Loss Distribution and Value-at-Risk (VaR) for a Sample Portfolio of 25 Assets



Source: Avesani and others (2006)

tive probabilities, the VaR is computed by interpolating the loss distribution.

The figure displays the aggregate loss distribution and VaR for a sample portfolio of 25 assets. The x-axis represents all the possible values for the aggregate loss. The y-axis measures the associated probabilities. The VaR at the 99 percentile level is the 99th percentile of the loss distribution. It is expressed in absolute terms, and as a percentage of the aggregate exposure (the sum of losses given default for all 25 assets in the portfolio).

The model assumes that default probabilities are nonrandom. More sophisticated models recognize that default probabilities are not known with certainty, and treat them as random variables. This is the case, for example, of the CreditRisk+ model developed by Credit Suisse, a simplified version of which is used in this chapter to examine the defaults of the various portfolios of banks as in Figure 2.4. CreditRisk+ relies on very specific assumptions. In particular, it assumes that default probabilities are driven by Gamma-distributed random factors. It also uses the fact that, for small enough default probabilities, a Poisson distribution is a good approximation for a Bernoulli distribution. These assumptions make it possible to compute a fast and accurate analytical approximation for the loss distribution when default probabilities are random.

It is shown that after smoothing, systemic-risk capital surcharges would remain constant through the cycle; at about 1 percent of risk-weighted assets, on average (more exactly, the through-the-cycle average charge across all banks equals 0.94 percent in Table 2.4). The remaining procyclicality (as indicated by the magenta line) in Figure 2.5 mostly derives from the use of Basel II requirements, which continue to be procyclical.

Cross-Border Issues

As mentioned earlier, the universe of banks under consideration comprises two countries, and the simulations so far have assumed that (1) the capital surcharges are estimated across countries; (2) regulators have access to the relevant cross-border data; and (3) these surcharges can be enforced seamlessly across countries. However, in practice, it is likely that most national supervisors would regulate systemic risk exclusively within their own borders and based mostly on domestically available data.

Repullo, Saurina, and Trucharte (2009).

Table 2.5. Systemic-Risk-Based Cyclically Smoothed Capital Surcharges Across Countries

(In percent of initial risk-weighted assets)

Country	Institution	Global Charges	Country 1 Charges	Country 2 Charges
Country 1 Banks	Bank 1	0.74	0.97	n.a.
	Bank 2	1.43	1.11	n.a.
	Bank 3	0.44	0.54	n.a.
	Bank 4	0.41	0.50	n.a.
Country 2 Banks	Bank 5	1.56	n.a.	0.58
	Bank 6	1.06	n.a.	0.34

Source: IMF staff estimates.

Table 2.6. Sample Systemic Risk Report

Institution	Systemic Risk Rating[1]	Own Capital to System's Capital *(In percent)*[2]	Systemic Risk Capital Surcharge to Risk-Weighted Assets
Bank 1	NS	14.5	0.74
Bank 2	T1	16.9	1.43
Bank 3	NS	19.8	0.44
Bank 4	T2	20.4	0.41
Bank 5	T1	13.0	1.56
Bank 6	T1	15.4	1.06

Source: IMF staff estimates.

[1]T1 indicates institutions that are deemed to be highly systemic (Tier 1); T2 indicates institutions that are deemed to be relatively systemic (Tier 2); NS indicates institutions that are deemed nonsystemic.

[2]Denotes the capital of each bank as a percentage of the total capital of all banks in the network.

To illustrate the difference in calculating the surcharges from both global and country perspectives, the chapter computed systemic-risk-based capital surcharges for each of the two countries *in isolation*. That is, a new set of surcharges was computed under the risk-budgeting approach, assuming that each of the two local supervisors lacks information on financial linkages outside its borders. Under these circumstances, the capital charges differ from the ones obtained taking into account the full network of interbank linkages (Table 2.5). In particular, for banks in Country 2, the difference is almost 1 percent of institutions' risk-weighted assets (equivalent to 12 percent of institutions' total capital).[14] It is important to note that these results hinge on the specific assumption of the network structure. In this example, there are only two European banks, thus from a domestic perspective, their stylized spillovers and surcharges are smaller. However, from a global perspective, these European banks affect U.S. banks through Bank 2, thus compounding the spillover effects, hence leading to a higher surcharge, on average, for European banks. This fact illustrates the importance of cross-border, information-sharing agreements on financial linkages. Furthermore, it bears emphasizing that the estimated capital surcharges should not be misconstrued as specific recommendations on the optimal size of capital surcharges for U.S. or European banks.

In reality, since most large and complex financial institutions have a global presence, it is necessary to track potential cross-border domino effects in order to measure and regulate their contribution to systemic risk. In practice, this may be hard for local supervisors to do in isolation due to limitations imposed by the lack of effective data-sharing agreements, as well as cross-border confidentiality concerns across national supervisors.

Communication

To facilitate communication across financial stability regulators, the chapter proposes assembling confidential systemic risk reports on a regular basis. Such reports would be an effective and parsimonious way to track institutions deemed systemically important and their relative ranking (as proposed by Brunnermeier and others, 2009, among others). Table 2.6 presents a sample systemic risk report that gathers most of the key information produced by our methodology.

Reforming Financial Regulatory Architecture Taking into Account Systemic Connectedness

The previous section presented developmental approaches to operationalize cycle-neutral, systemic-risk-based capital charges. However, like any regulation, to be effective, it needs to be properly enforced and monitored by regulators. This is particularly important given that weak regulation has been identified as a key culprit in this financial crisis, which is why there have been a number of regulatory architecture reform proposals (Box 2.4).

[14]Incidentally, notice that the difference between the global and local charges is greater for banks in Country 2 than for banks in Country 1. This is because, in our example, when charges are computed based only on local interconnections, more information is lost in Country 2 than in Country 1 (see Figure 2.1).

Box 2.4. Regulatory Architecture Proposals

This box reviews key aspects of recent proposals to redesign the regulatory architecture to aid in the early detection of systemic risk.

Systemic Risk Regulators: Responsibilities and Powers

Most recent proposals would benefit from a better demarcation of powers and responsibilities across "macro and micro" regulators. Recent proposals by the U.S. House of Representatives, U.S. Senate, United Kingdom, and European Union call for the creation of respective councils, each comprising existing supervisory authorities and national central banks within their country (area).[1] These councils would be charged with monitoring the buildup of domestic financial systemic risk on a regular basis with no, or a small, permanent secretariat. Member agencies of the council, including central banks, are expected to provide analytical support. The councils would have the authority to demand, at any time, the information about any financial firm deemed necessary for the fulfillment of their mandate. The systemic risk regulators would also have the authority to make recommendations at the macroprudential level to relevant regulatory bodies. However, supervision of individual institutions is left with existing microprudential regulators.

Note: The author of this box is Kazuhiro Masaki.

[1]U.S. House of Representatives, *Wall Street Reform and Consumer Protection Act of 2009* (H.R.4173); *Restoring American Financial Stability Act of 2010* (U.S. Senate Committee on Banking, Housing, and Urban Affairs; see chairman's marked text, March 2010); U.K., *Financial Services Bill* (introduced in the House of Commons, November 19, 2009); European Union, proposals for regulation of the European Parliament and of the Council on Community macroprudential oversight of the financial system and establishing a European Systemic Risk Board, Commission of the European Communities, September 23, 2009.

Systemic Risk Regulatory Proposals

	United States			
	House of Representatives	Senate	United Kingdom	European Union
Systemic risk regulator	Financial Services Oversight Council (FSOC)	Financial Stability Oversight Council	Council for Financial Stability	European Systemic Risk Board (ESRB)
Institutional arrangements	A council of Treasury secretary (chair) and heads of federal regulators; resources provided mainly by Treasury	A council of Treasury Secretary (chair) and heads of federal regulators and an independent member	A council of heads of Treasury (chair), Financial Services Authority, and Bank of England	A council of central banks and regulators; secretariat provided by European Central Bank
Powers				
Assessment of systemic risk	Yes	Yes	Yes	Yes
Making recommendations	Yes	Yes	n.a.	Yes
Identification of systemic firms	Yes	Yes	n.a.	n.a.
Rule making	No	No	No	No
Central bank in microprudence	Fed supervises all systemic firms regardless of their legal structure	Fed supervisory authority narrowed	No change	No change
Restrictions to lender of last resort	Determination by FSOC and consent by Treasury secretary required for section 13 (3)	Liquidity assistance under section 13 (3) limited to market-wide systems or utilities	No	No
Enhanced resolution mechanism	Systemic Dissolution Fund is to be established for systemic firms	Orderly Resolution Fund is to be established for systemic firms	Special Resolution Regime for major banks has been established	No

Sources: U.S. House of Representatives, *Wall Street Reform and Consumer Protection Act of 2009* (H.R.4173); U.S. Senate Committee on Banking, Housing, and Urban Affairs, Restoring American Financial Stability Act of 2010 (see chairman's marked text, March 2010); U.K., *Banking Act of 2009*, *Financial Services Bill* (introduced in the House of Commons on November 19, 2009); and European Union, proposals for regulation of the European Parliament and of the Council on Community macroprudential oversight of the financial system and establishing a European Systemic Risk Board.

Box 2.4 *(concluded)*

Involvement of Central Banks in Microprudential Supervision

Because microprudential supervision would remain largely intact under most proposals going forward, it is unlikely that there will be major changes in the supervision of individual institutions by central banks (although the current level of involvement of central banks varies significantly across the jurisdiction). The only exception would be the U.S. Senate proposal under which the Federal Reserve's supervisory authority would be narrowed to bank holding companies with assets of over $50 billion.

Restrictions on Lender-of-Last-Resort Authority of Central Banks

Under the U.S. proposals, there would be some restrictions on the Federal Reserve's authority to extend emergency lending to nondeposit-taking institutions (revisions to section 13(3) of the Federal Reserve Act), in an attempt to limit the Fed's lender-of-last-resort authority, and thereby lessening its ability to lend to institutions that may already be insolvent. Under the House of Representatives' bill, the Fed would need the approval of the systemic risk regulator (Financial Stability Oversight Council) and the treasury secretary (after certification by the president) to act as a lender of last resort. In addition, the loans would be scrutinized by both houses of Congress after they were extended and could be "disapproved" by a joint resolution.

Enhanced Resolution Framework

Although a positive first step, recent proposals to overhaul the resolution framework of systemically important institutions remain vague. U.S. proposals call for strengthening resolution mechanisms for systemically important institutions, including by identifying them (although no concrete proposal has been advanced) and creating a dedicated fund to be financed by those institutions, with the financing provided in direct relation to their contribution toward systemic risks. In the United Kingdom, a permanent resolution framework for banks (Special Resolution Regime) has been introduced by the Banking Act of 2009, granting the authorities the necessary "flexibility" to deal with any financial institution in distress.

One of the most prominent proposals at the financial regulatory architecture level is the creation of systemic risk regulators to monitor the financial system as a whole. This responsibility could be carried out either by new or existing regulators with a new focus. For instance, the U.S. Senate has put forward a proposal for the creation of an independent and separately staffed agency to regulate systemic risk (the Agency for Financial Stability) and the consolidation of existing microprudential regulators under a single agency (the Financial Institutions Regulatory Administration). Pan-European initiatives are also advancing. The European Systemic Risk Board is expected to be launched soon. At the same time, the European Central Bank is expected to retain its cross-border financial stability watch mandate for euro area countries. Similarly, in the United Kingdom, a white paper calls for the granting of legal powers to the Financial Services Authority to pursue financial stability objectives—also a Bank of England mandate.

While the focus on systemic-risk oversight is a welcome development, there are significant uncertainties about the specific implementation and boundaries of responsibilities across new and existing supervisory bodies. These uncertainties, which are likely to create difficulties in coordinating financial regulatory functions across systemic and nonsystemic regulators, give rise to a number of questions requiring careful consideration. For example:

- Would regulation of systemically important institutions improve if, in addition to their current responsibilities, each of the existing regulators were charged with "monitoring" the buildup of potential

systemic linkages, while distinguishing between systemic and nonsystemic institutions?
- Would regulation of systemically important institutions improve if, as some recent proposals call for, financial regulatory functions were consolidated?
- Is there a need for more direct preemptive actions to prevent institutions from becoming systemic in the first place?

Because it is unfeasible to analyze every proposed distribution of regulatory functions stemming from an added systemic oversight mandate, this chapter focuses on the following plausible interpretations of alternative reform proposals (see Box 2.4):[15]
- An agency providing a lender-of-last-resort facility and also charged with systemic risk monitoring (a plausible interpretation of U.K. and U.S. proposals);
- An agency with early intervention powers (e.g., prompt corrective actions or structured early intervention and resolution), and also charged with deposit insurance and systemic risk monitoring (a plausible interpretation of a U.S. Senate proposal); and
- A "unified" arrangement, consisting of a single regulator, charged with the provision of lender-of-last-resort and early intervention powers for both systemic and nonsystemic institutions (a plausible interpretation of a U.S. Senate proposal).

Framework for Analyzing Financial Regulation Reform Proposals

This chapter suggests the need for a framework that (1) explicitly considers alternative allocations of regulatory functions; (2) takes into account regulators' incentives to accomplish their mandates (including forbearance); and (3) explicitly considers key sources of financial intermediaries' distress, while accounting for systemic linkages. The significance of this admittedly stylized framework is not that it provides a complete representation of the complex decision-making process of regulators and their interactions, but that it imposes discipline and transparency on the analysis of key drivers behind these decisions and interactions.

Regulatory Forbearance Incentives

Regulators and policymakers often encounter this dilemma: under what conditions would it make sense to show forbearance? That is, when would it be appropriate for a regulatory agency to overlook the need to enforce supervisory actions, such as the enforcement of prompt corrective actions or other early intervention actions, or withhold liquidity support when the expected value of a financial institution is below that of liquidation?

Recent research suggests that regulatory forbearance may be socially desirable when the economy experiences "aggregate" shocks (Kocherlakota and Shim, 2007). Because of the government's taxing powers and deep pockets, it can serve as an economy-wide insurer against shocks that no private insurance arrangement could credibly cover. Given the cost of economy-wide disruptions, it can make sense for a regulator to step in and rescue a troubled financial system as a whole. Nonetheless, this research suggests that in the absence of aggregate shocks, forbearance would be socially inefficient or "excessive."[16]

Forbearance by regulators also needs to be considered from a political-economy perspective. Regulators, like other economic agents, have objectives, which are not always aligned with economic efficiency goals. They may have a bias toward excessive forbearance because a bank failure is politically expensive. That is, they see the closing of an institution as negatively affecting their reputation: the higher the financial loss associated with a failure, the higher the reputational cost. The tendency to forbear is offset by other costs to the regulator, particularly if the regulator is assigned responsibility for the solvency of the public deposit insurance

[15]For a comprehensive taxonomy on current financial regulatory arrangements and issues, see also Nier (2009).

[16]Empirical evidence reveals that regulators worldwide are often too lenient, granting wiggle room to financial institutions to continue operating, hoping they will get back on their feet, even when their liquidation value is higher than the expected value of allowing the institution to continue to operate. Indeed, several analysts (e.g., Acharya, Richardson, and Roubini, 2009) have argued that, leading up to and during the current crisis, some of the largest global financial institutions benefited from regulatory forbearance.

fund or for the losses borne as a result of unpaid debts to a lender of last resort.

Distress and Systemic Linkages of Financial Intermediaries

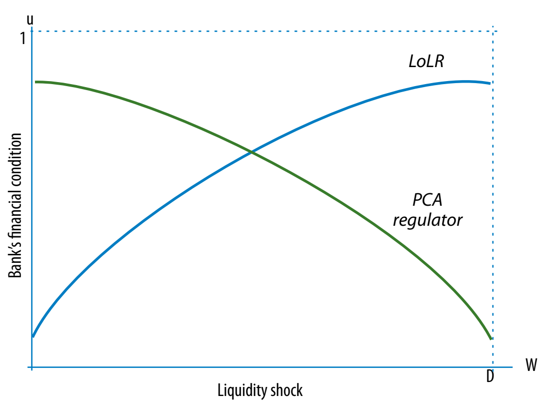
In the framework underlying the analysis in this section, financial institutions hold illiquid assets funded by (implicitly or explicitly) insured short-term funding such as deposits (for more details see Annex 2.1 and Espinosa-Vega and others, forthcoming). Financial institutions face two potential types of shocks: liquidity shocks (represented by unexpected withdrawals by depositors) and solvency shocks (represented by a decrease in the value of their assets).

The framework features a tension encountered in practice: because of the protection provided by limited liability and insured deposits, the bank management does not have an incentive to close down voluntarily even when the institution is insolvent. This is what economists refer to as an *economically inefficient* outcome. To lessen this problem, an insolvent institution can be liquidated directly by a regulator with early intervention powers (prompt corrective actions). Alternatively, a bank can be forced to close by the refusal of a lender of last resort to supply the liquidity needed in the face of a liquidity shock. Finally, the framework explicitly incorporates the possibility of some institutions' chances of survival being negatively affected by the failure of other important players.

The above discussion has provided the basis for outlining answers to the three questions posed at the beginning of this section. As a way of preview, the analysis formalized two notions:

- First, even under an expanded mandate to explicitly oversee systemic interconnectedness, both the unified and single regulators would be more lenient with systemically important institutions than non-systemically important ones.
- Second, at least for "moderate" liquidity events, a unified regulator could lessen excessive forbearance relative to a multiregulator setting, because a unified configuration would allow the conflicting incentives faced by the regulator to be internalized by one regulator. However, consolidation of standard regulatory functions alone will not lessen systemic risk.

Figure 2.6. Regulatory Forbearance under a Multiple Regulator Configuration



Source: Espinosa-Vega and others (forthcoming).
Note: Horizontal axis depicts unanticipated liquidity shocks to a representative financial institution. Vertical axis represents a financial institution's financial condition denoted by *u*. The higher the *u*, the higher "the bar" imposed by a regulator to support an institution (the lower the degree of excessive forbearance). LoLR = lender of last resort; PCA = prompt corrective actions.

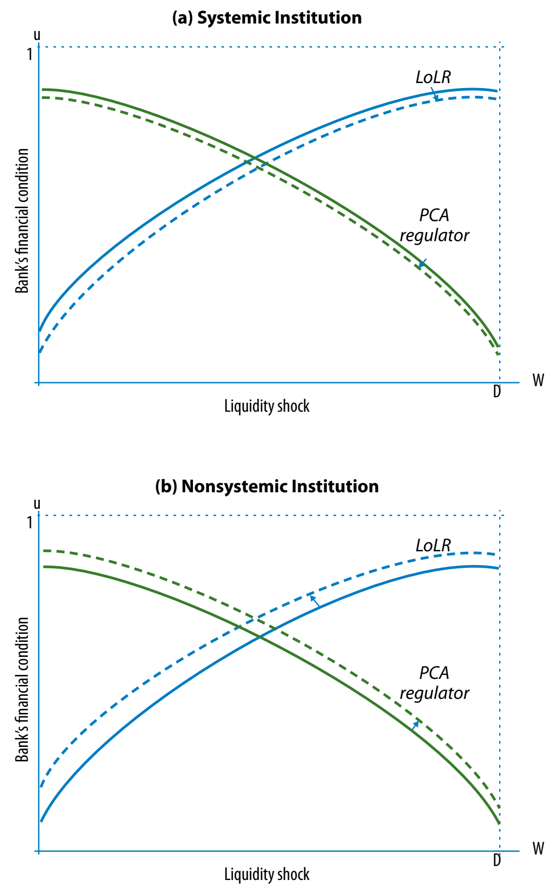
Why a Mandate to Monitor Systemic Linkages May Not Be Enough

Espinosa-Vega and others (forthcoming) show that for a lender of last resort, the size of the loan necessary to support a cash-strapped bank will determine the degree of forbearance: large infusions of liquidity will require concomitantly greater likelihood of success and therefore the lender of last resort will be less forbearing the larger the required liquidity infusion. This insight is illustrated in Figure 2.6. The horizontal axis depicts unanticipated liquidity shocks to a representative financial institution. The vertical axis represents a financial institution's financial condition, which can be summarized by the institution's expected solvency (denoted by *u*). The higher the *u*, the higher the bar imposed by a regulator to support an institution. The fact that the higher the required lender of last resort's liquidity injection, the less forbearing the lender of last resort is explains why the lender of last resort line in Figure 2.6 is upward sloping.

Consider now a separate regulator responsible for prompt corrective actions that also take into account the political costs of losses by the deposit insurance system. This regulator is more likely to engage in forbearance the greater the liquidity assistance supplied by the lender of last resort. This is because lender-of-last-resort liquidity support is outside the responsibility of the prompt corrective actions regulator. The higher the liquidity assistance, the lower the potential need for deposit insurance outlays, thus the lower the prompt corrective actions regulators' potential costs. This increases the temptation for an independent agency in charge of prompt corrective actions and deposit insurance administration to engage in forbearance as liquidity shortfalls increase—which explains why the prompt corrective actions line in Figure 2.6 is downward sloping.

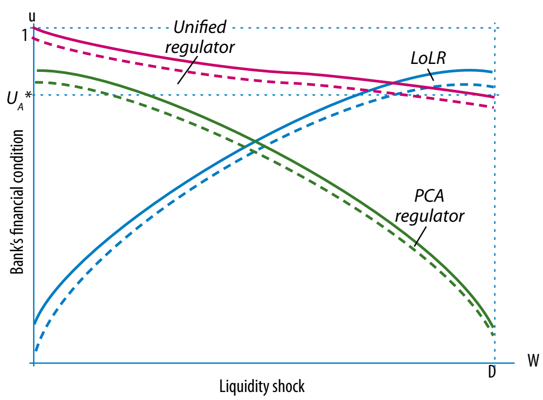
The failure of a systemically important institution increases the likelihood of failures among nonsystemic institutions. These increased costs mean that any regulator will be more lenient with a systemically important institution, as illustrated by the downward shift in lines in Figure 2.7a. On the other hand, since distress in the systemic institution negatively affects the chances of survival of the nonsystemic institution, in order to be rescued, the regulator will have to be convinced that the overall chances of survival of the

Figure 2.7. Regulatory Forbearance under a Multiple Regulator Configuration with Systemic Oversight Mandate



Note: Horizontal axis depicts unanticipated liquidity shocks to a representative financial institution. Vertical axis represents a financial institution's financial condition denoted by *u*. The higher the *u*, the higher "the bar" imposed by a regulator to support an institution (the lower the degree of excessive forbearance). The figure illustrates a higher degree of forbearance for systemically important institutions (panel a) compared to nonsystemic institutions (panel b). Solid lines denote regulators that do not distinguish institutions according to their degree of systemic risk and the dotted lines denote responses when systemic institutions are considered. LoLR = lender of last resort; PCA = prompt corrective actions.

Figure 2.8. Regulatory Forbearance under Multiple and Unified Regulator Configurations with Oversight Mandate over Systemic Institutions



Note: Horizontal axis depicts unanticipated liquidity shocks to a representative financial institution. Vertical axis represents a financial institution's financial condition denoted by *u*. The higher the *u*, the higher "the bar" imposed by a regulator to support an institution (the lower the degree of excessive forbearance). The figure illustrates a higher degree of forbearance for systemically important institutions. Solid lines denote regulators that do not distinguish institutions according to their degree of systemic risk and the dotted lines denote responses when systemic institutions are considered. LoLR = lender of last resort; PCA = prompt corrective actions.

nonsystemic institution are actually higher than would be the case if the systemic institution had not run into trouble. In other words, the regulator will become stricter with nonsystemic institutions, as illustrated by the upward shift in lines in Figure 2.7b.

Is Unified Regulation, by Itself, the Answer?

The analysis by Espinosa-Vega and others (forthcoming) also shows that a unified regulator exhibits a lower degree of excessive forbearance than a multiple regulator setting, at least for "moderate" liquidity shocks. To understand the logic, note that a unified regulator would solve the problem of a lender of last resort and a prompt corrective action regulator simultaneously and therefore would internalize the excessive forbearance incentives faced by multiple regulators, thus leading to the lowest degree of excessive forbearance. This is illustrated in Figure 2.8 by the magenta line with the highest bar imposed by the unified regulator. Note, however, that even under unified regulation, the regulator will be softer on potentially systemic institutions, as illustrated by the magenta dotted line. Consolidating standard regulatory functions without additional tools to preclude institutions from posing systemic risk will not eliminate regulators' incentives to be lenient with systemically important institutions.

It is also important to note that this analysis is silent about where to locate the unified regulator. Some proposals call for consolidating systemic regulation under the central bank. However, Espinosa-Vega and others (forthcoming) abstract from examining the interaction of monetary policy and these regulatory functions. The incentives of a central bank to forbear (perhaps by keeping interest rates lower than a purely inflation or growth objective would imply) are not treated in the model. Hence, they refrain from assessing the merits of this proposal.

Preventing Institutions from Posing Systemic Risk

As has been discussed, an expanded mandate to explicitly oversee systemic risk will not necessarily, by itself, lessen this risk. Therefore, it may be necessary to consider other, more direct preemptive measures. These measures could include (1) putting caps on leverage; (2) lessening potentially systemic linkages through, for example, systemic-based capital surcharges (as suggested in some reform proposals) or by assessing

Box 2.5. Contingent Capital—Part of the Solution to Systemic Risk?

This box reviews the concept of contingent capital as part of current regulatory efforts aimed at lowering systemic risk in the financial sector.[1] *In general, contingent capital represents a countercyclical measure that allows issuers to secure additional capital from investors when a certain predetermined stress situation arises.*

Current proposals focus on *convertible hybrid securities*[2] consisting of long-dated subordinated debt instruments that win their badge as contingent capital by automatically converting into equity when certain predefined trigger conditions are met, such as bank-specific threats, systemic risk, or both (see table). Such mandatory conversion represents a new and possible more robust form of hybrid securities, which were commonplace before their issuance stalled in 2007 when investors started questioning their ability to offset writedowns.

By issuing mandatory convertibles, banks hedge themselves against the possibility of capital shortfall and avoid costly funding in times of stress. These securities carry an obligation to pay interest and resemble debt in normal times until trigger conditions force conversion into common stock to augment their capital buffer. Besides increasing the issuer's resilience to distress, mandatory convertibles should help curb excessive risk-taking by managers to the extent that equity would be diluted upon conversion. On November 20, 2009, the U.K. bank Lloyds TSB premiered the concept of contingent capital by exchanging contingent convertible securities for existing impaired bonds in an operation worth £7.5 billion.

Note: The authors of this box are Wouter Elsenburg and Andy Jobst.

[1]For instance, both the U.S. House of Representatives' *Financial Stability Improvement Act of 2009* and the U.S. Senate's *Restoring American Financial Stability Act of 2009* make specific reference to the possibility of contingent capital. Moreover, the recent consultation paper on bank capital released by the Basel Committee on Banking Supervision (2010) highlights the role of convertible hybrid securities in the buildup of "countercyclical capital buffers."

[2]In general, the term "hybrid securities" does not only refer to cumulative or noncumulative, long-dated subordinated debt with an interest deferral mechanism, but also includes some conventional funding instruments with the capacity to absorb losses, such as preferred equity.

The effectiveness of contingent capital depends critically on the determination of both the trigger condition(s) and the conversion rate from debt to equity. The table provides some of the possibilities.

The advantage of a bank-specific conversion trigger is that a bank's capital position will be improved precisely when a bank needs it. Some, however, argue for triggers based on systemic risk in order to reign in more risk-taking by shareholders if conversion implies some debt forgiveness ex ante (Squam Lake Working Group on Financial Regulation, 2009). Another issue is whether triggers should be based on market conditions, which are more forward-looking than financial soundness indicators, which are based on a bank's balance sheet, in their ability to flag financial distress. Markets, however, can be distorted and might be subject to price manipulation (e.g., via short-selling) that could induce confidence-induced downward spirals, requiring a premature trigger to conversion. To mitigate this concern, market indicators could be combined with supervisory stress tests.

Similarly, setting the right rate of conversion requires an assessment of how potential dilution affects the burden-sharing between shareholders and bondholders. Setting the conversion rate so that debt securities convert into equity below the par value of the debt lowers the possibility of a speculative attack, since holders of contingent capital would benefit less from a negative shock triggering conversion into new equity in exchange for par value. However, smaller dilution risk could fail to deter ex ante risk-taking by existing shareholders. Conversion in terms of a number of shares prevents these unwanted effects by better aligning incentives of both parties (Flannery, 1994, 2002). Shareholders would be able to anticipate their potential dilution, and holders of convertibles are unlikely to profit from conversion.

Contingent capital could foster a self-correcting market mechanism aimed at restoring bank balance sheets before financial stresses become systemic. By requiring banks to issue a certain amount of contingent capital (relative to their size), regulators ensure that individual distress and/or adverse market conditions result in automatic recapitalization, which helps limit the public cost of leveraged financial intermediation. There are, however, some open issues that require further study, such as the implications

Box 2.5 *(concluded)*

of different conversion rates for issuer incentives and the possible contagion risk to other institutions that may result when one institution is forced to convert. Moreover, some practical concerns about pricing and creating sufficient investor demand might impede the marketability of contingent capital, especially if regulations require its issuance. Hence, although helpful as an additional buffer, it remains to be seen whether regulatory contingent capital can be designed to appreciably curb excessive risk-taking in order to mitigate systemic risk while preventing unintended market reactions. However, in conjunction with other tools to mitigate systemic risk it has the advantage of providing appropriate incentives.

Classification of Categorization of Trigger Conditions and Conversion Rates of Contingent Capital

Trigger	Bank-specific	Financial soundness indicator(s) Supervisory stress test Market indicator for the bank's credit risk
	Systemic	Broad market factors Credit loss trigger Declaration of a "systemic event"
	Combined	Combination of bank-specific and systemic triggers
Conversion rate	Relative to holds of contingent capital	At par value Below par value At/below/above trading price of contingent capital at time of conversion
	Relative to shareholders	Fixed dilution Relative dilution
	Relative to capital need	Book value multiple Risk-weighted-assets multiple

charges based on measures of the systemic component of over-the-counter derivatives' counterparty credit risk (as argued in Chapter 3 of this report); (3) a broader adoption of contingent capital initiatives (Box 2.5); (4) limiting the size and business activities of financial institutions; or (5) designing "living wills" and strengthening resolution processes.

Finally, because the analysis contains numerous simplifying assumptions, the reader may wonder about the robustness of the main findings in this section. For example, the chapter assumed that there is a stable trade-off between a regulator's desire to avoid bank failures and to maintain the agency's financial position. Also, by structuring the analysis as if regulators and banks interact only once, the analysis becomes tractable, but ignores some potentially important dynamic interactions. Nevertheless, as discussed in Espinosa-Vega and others (forthcoming), the main findings in this section are robust to the relaxation of these types of assumptions.[17]

Policy Reflections

The recent financial crisis has triggered a rethinking of the supervision and regulation of systemic con-

[17]Repeated interactions between banks and regulators will, over time, cause adjustments both in the riskiness of the investments chosen and in the size of the capital and liquidity buffers adopted by the banks; for the purposes of this exposition all of these are held constant, although they can be incorporated into the analysis. Repeated interactions between depositors and banks and regulators will endogenize liquidity demand, that is, that a fear of a closure or failure will trigger increased depositors' withdrawals. However, it is worth noting that, although repeated interactions among independent regulatory authorities could lessen the problems of the externalities they impose on one another, they would not eliminate them.

nectedness. As this chapter reports, there has been a flood of proposals covering the regulation of financial institutions and the regulatory architecture to better deal with systemic risks. Unfortunately, most of the proposals are still in the formative stages, limiting a critical evaluation of their merits.[18]

This chapter has aimed to contribute to this debate on two fronts: first, by presenting a methodology for computing systemic-risk-based surcharges that are also cycle-neutral; and second, by reviewing the regulatory architecture.

Systemic-Risk-Based Surcharges

By illustrating how to make systemic-risk-based capital surcharges operational while also removing their inherent cyclicality, this chapter contributes to a critical review of, among other things, the merits of this and alternative methodologies; the likely data requirements; the potential procyclical effects of systemic-risk surcharges; the need to evaluate alternative available methodologies; the means by which effective communication among supervisors can be enhanced; and cross-border regulatory issues that need to be confronted.

- *Data requirements.* The first step in rendering systemic-risk-based charges operational is the measurement of potentially systemic (direct and indirect) financial linkages. This requires more detailed, regular cross-market and cross-border exposures data for individual institutions that could be reported to relevant data repositories, possibly the Bank for International Settlements. When necessary to address confidentiality concerns, national laws should be modified to allow supervisors to fulfill this commitment. At a minimum, national supervisors could rely on international arrangements—such as the Financial Stability Board—to share confidential information at restricted forums with the appropriate safeguards.
- *Procyclicality of systemic-risk-based capital surcharges.* It is important that newly designed systemic-risk-based surcharges do not have procyclicality features. The surcharge designed in this chapter shows how this can be done.
- *Evaluation of alternative methodologies.* In order to advance the debate on how, and whether, to impose systemic-risk-based capital charges, it is important to draft concrete, practical proposals that can be reviewed and evaluated.
- *Cross-border issues.* Were capital surcharges to be introduced, they would need to be designed and implemented from a global perspective in order to be effective. The chapter illustrated some potential problems in designing surcharges for globally active institutions from a local perspective. The lesson is very relevant for those who oversee globally active large and complex financial institutions.
- *Communication.* To facilitate communication among regulators—within and across countries—confidential systemic risk reports could be prepared on a regular basis. Such reports would be an effective and parsimonious way to track institutions deemed systemically important and their relative ranking.

Most proposals for capital charges will likely accomplish the goal of raising capital buffers in line with the systemic importance of an institution—an important objective, but one that does not explicitly show institutions how they can adjust their behavior so as to be less systemically important. However, more analysis is required to design capital surcharges in a way that would induce institutions to take into account their spillovers to the rest of the global financial system. The task is difficult because, among other things, measures of systemic risk should consider second- and third-round effects following a distress event, and these effects are often beyond the direct control of the institution. Market-based measures do not allow institutions to trace back their individual effect on systemic risks either.

Furthermore, financial institutions may respond to the introduction of these surcharges by attempting to reverse the effects of the regulation (as institutions have attempted to do through, say, off-balance-sheet transactions) or by attempting to exit the perimeter of systemic risk oversight altogether. Therefore, it is important to consider the implementation of capital surcharges in conjunction with other proposals aimed at lessening systemic linkages (e.g., limiting business activities and channeling derivative transactions through central counterparties). This is another reason why there is a need to assess multipronged approaches to mitigate systemic risk. Moreover, all these possible

[18]To date, Bank of England (2009) is a notable exception, offering a discussion of operational issues.

approaches will require further examination through quantitative impact studies.

Regulatory Architecture

This chapter argues that an important missing ingredient from most architecture reform proposals is the analysis of regulators' incentives—including regulatory forbearance incentives—that vary under the alternative regulatory configurations under consideration. The analysis provided in the chapter suggests that:

- Under an expanded mandate to explicitly oversee systemic risks, both the unified regulators and multiregulators would be more lenient with systemically important institutions facing difficulties and tougher with nonsystemic institutions facing difficulties.
- This last insight—the fact that, even under a specific mandate to oversee systemic institutions and without regulatory retooling, regulators may continue to be more forbearing with systemic institutions facing difficulties—suggests the need to consider more direct methods to address systemic risks. It is not enough to mandate that regulators "monitor" systemic connections closely or that they treat systemic and nonsystemic institutions differently. It may be necessary for regulators to design regulation so as to prevent institutions from posing systemic risk.
- Thus, there is a need to carefully evaluate proposals such as instituting systemic-risk-based capital surcharges, directly limiting the size of certain business activities that financial intermediaries engage in, or establishing central counterparty clearing systems before deciding which of them would be best to adopt.

Annex 2.1. Highlights of Model Specification

This annex describes some of the key features of the model (Espinosa-Vega and others, forthcoming) underlying the analysis presented in the section in this chapter entitled "Reforming Financial Regulatory Architecture Taking into Account Systemic Connectedness." In particular, the model under consideration is an extension of Repullo (2000) and Kahn and Santos (2005), who study the political economy of banking regulation. Espinosa-Vega and others extend this analysis to examine the optimal institutional allocation of bank regulation when regulatory agencies are explicitly mandated to oversee financial institutions according to their degree of systemic importance.

Espinosa-Vega and others consider a three-period model in which there are two banks (one of them systemic—Bank A—and one that is not systemic—Bank B). Both banks hold illiquid assets funded by (implicitly or explicitly) insured short-term funding such as deposits. In addition, they face two types of potential shocks: liquidity shocks (represented by unexpected withdrawals by depositors) and solvency shocks (represented by a decrease in the expected value of their assets). Bank profits are random variables with the following distribution functions:

Assumption 1. If Bank A invests Y_A in loans at period 0 it will receive $Y_A\tilde{R}$ in period 2, where

$$\tilde{R}=\begin{cases} R \text{ with probability } u_A \\ 0 \text{ with probability } 1-u_A \end{cases}$$

Assumption 2. The expected return from lending (net of second period bankruptcy costs) for Bank A exceeds the zero return from holding liquid assets, that is,

$$E(U_A)[R + c] > 1 + c.$$

Assumption 3. Systemic interconnections are modeled as follows: the bankruptcy of Bank A negatively affects Bank B's payoffs by lowering its probability of obtaining a high payoff (see assumption 4 below). It is also assumed that the default of Bank B has no effect on Bank A—in other words, Bank B is not systemic.

Assumption 4. If Bank B invests YB in loans in period 0 then, provided that Bank A does not fail, Bank B will receive $Y_B\tilde{R}$ in period 2, where

$$\tilde{R}=\begin{cases} R \text{ with probability } u_B \\ 0 \text{ with probability } 1-u_B \end{cases}$$

The expected return from lending (net of second period bankruptcy costs) for Bank B exceeds the zero return from holding liquid assets, that is,

$$E(U_B)[R + c] > 1 + c.$$

If Bank A fails, then the distribution for $Y_A\tilde{R}$ in period 2 is

$$\tilde{R}=\begin{cases} R \text{ with probability } u_B-\gamma \\ 0 \text{ with probability } 1-u_B+\gamma \end{cases}$$

where $0 < u_B < \gamma$.

At $t = 0$, banks decide on the structure of their balance sheet. Investment in assets Y_i is financed by deposits D_i and capital K_i, $i \in \{A,B\}$. Given a minimum regulatory capital requirement, banks are subject to funding risk. In particular, if the new level of deposits D_i at $t = 1$ is such that $D_i < \tilde{D}_i$, banks are forced to seek emergency liquidity from a lender of last resort. In turn, if banks fail to secure enough funding, they are liquidated at period 1. Banks can also be liquidated if there are insufficient funds at period 2 to meet remaining obligations.

The liquidation of banks entails societal costs c, which is meant to capture the administrative costs and other negative externalities associated with bank failures. Banks' loan portfolios can be liquidated in period 1 to yield a "fire sale" value L, with $0 < L < 1$. The liquid asset yields the market interest rate (which is normalized to zero).

Timing of the model. In period 0, both Banks A and B raise funds, D_i, simultaneously. In period 1, the probability of success for Bank A, u_A , is observed by the regulator, and if necessary, a regulatory liquidation decision is made for this bank. Regulators know that the fortunes of Bank B are linked to those of Bank A. Once the fate of Bank A is decided, the probability of success for Bank B, u_B , is observed and, if necessary, a regulatory liquidation decision is made for Bank B.

The next set of assumptions characterizes the risks faced by the banks.

Assumption 5. For each bank, the amount of deposits not withdrawn at $t=1, \tilde{D}_i$, is an independent random variable with distribution function $G(D)$, where $G'(0) > 0$. The amount of deposits is publicly observable at date $t = 1$.

Assumption 6. The probability of success of bank i, u_i, is an independent random variable with distribution function $F(u)$. This variable, u_i, is publicly observable at date 1, but it is not verifiable.

Illustration: The Problem of a Unified Regulator

To illustrate how Espinosa-Vega and others (forthcoming) study excessive forbearance incentives under alternative regulatory structures, consider the problem faced by a unified regulator charged with liquidity provision and administration of the deposit insurance for both systemic and nonsystemically important institutions. For a liquidation value of L, a lender of last resort will lend to Bank B at a rate of P, when Bank A has been liquidated, if Bank B's continuation prospects (the left-hand side of the inequality) exceed the regulator's net political benefit of closing bank B (the right-hand side of the inequality) in equation (1).

$$(u_B-\gamma)\mathrm{P}(D_B-\tilde{D}_B)+(1-u_B+\gamma)(-\alpha c_B-D_B) \\ >LY_B-D_B-\alpha c_B \tag{1}$$

Similarly, as shown in Espinosa-Vega and others (forthcoming), the lender of last resort will weigh a more complex trade-off when Bank A is in need of a liquidity injection.

It is important to mention that these are only a few of the trade-offs analyzed in Espinosa-Vega and others. These trade-offs underlie the graphical representation in Figures 2.6–2.8.

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