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Financial Crisis and Global Governance: A Network Analysis

Andrew Sheng



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Dutch Ministry
of Foreign Affairs



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On behalf of the Commission on Growth and Development
1818 H Street NW
Washington, DC 20433
Telephone: 202-473-1000
Internet: www.worldbank.org
www.growthcommission.org
E-mail: info@worldbank.org
contactinfo@growthcommission.org

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About the Series

The Commission on Growth and Development led by Nobel Laureate Mike Spence was established in April 2006 as a response to two insights. First, poverty cannot be reduced in isolation from economic growth—an observation that has been overlooked in the thinking and strategies of many practitioners. Second, there is growing awareness that knowledge about economic growth is much less definitive than commonly thought. Consequently, the Commission’s mandate is to “take stock of the state of theoretical and empirical knowledge on economic growth with a view to drawing implications for policy for the current and next generation of policy makers.”

To help explore the state of knowledge, the Commission invited leading academics and policy makers from developing and industrialized countries to explore and discuss economic issues it thought relevant for growth and development, including controversial ideas. Thematic papers assessed knowledge and highlighted ongoing debates in areas such as monetary and fiscal policies, climate change, and equity and growth. Additionally, 25 country case studies were commissioned to explore the dynamics of growth and change in the context of specific countries.

Working papers in this series were presented and reviewed at Commission workshops, which were held in 2007–08 in Washington, D.C., New York City, and New Haven, Connecticut. Each paper benefited from comments by workshop participants, including academics, policy makers, development practitioners, representatives of bilateral and multilateral institutions, and Commission members.

The working papers, and all thematic papers and case studies written as contributions to the work of the Commission, were made possible by support from the Australian Agency for International Development (AusAID), the Dutch Ministry of Foreign Affairs, the Swedish International Development Cooperation Agency (SIDA), the U.K. Department of International Development (DFID), the William and Flora Hewlett Foundation, and the World Bank Group.

The working paper series was produced under the general guidance of Mike Spence and Danny Leipziger, Chair and Vice Chair of the Commission, and the Commission’s Secretariat, which is based in the Poverty Reduction and Economic Management Network of the World Bank. Papers in this series represent the independent view of the authors.

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Abstract

This paper attempts to use network theory, drawn from recent work in sociology, engineering, and biological systems, to suggest that the current crisis should be viewed as a network crisis. The author surveys the concepts of networks, their defining characteristics, applications to financial markets, and the need for supervision and implications for national and global governance. Then, he briefly examines the current financial crisis in the light of the network analysis and surveys the recent reforms in financial regulation and architecture. The paper concludes with an analysis of the policy implications of network analysis.

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Financial Crisis and Global Governance: A Network Analysis

Andrew Sheng¹

This paper attempts to use network theory, drawn from recent work in sociology, engineering, and biological systems, to suggest that the current crisis should be viewed as a network crisis. Global financial markets act as complex, scale-free, evolving networks that possess key characteristics requiring network management if they are to function with stability.²

The current global financial crisis has elicited several excellent studies and reviews at the regulatory and policy levels.³ While these studies contribute much to analyses of the multiple causes of the crisis, there is no unifying framework to explain the behavioral characteristics of the market and policy makers that led to the crisis.

The widespread use of communication and computer technology in the last 30 years gave rise to increasing awareness that networks play a major role in the growth of financial markets. For example, Metcalfe's law was a widely believed hypothesis that the value of networks was proportional to the square of the number of connected users of the system, n (Shapiro and Varian 1999)² The "law" gave competitors in the financial system a profit- and growth-driven rationale to integrate hitherto segmented markets and products, such as banking, insurance, fund management, and capital markets. In the 1990s, the trend accelerated as financial deregulation permitted banks, insurance companies,

¹ Andrew Sheng is concurrently Adjunct Professor, Graduate School of Economics and Management, Tsinghua University, Beijing and Adjunct Professor of Financial and Monetary Economics, University of Malaya. He has served in various positions with Bank Negara Malaysia, the World Bank, and the Hong Kong Monetary Authority. He was Chairman of the Securities and Futures Commission, Hong Kong (1998–2005) and Chairman of the Technical Committee of the International Organization of Securities Commission, IOSCO (2003–05). Since December 2005, he has been Chief Adviser to the China Banking Regulatory Commission. In addition to chairing the Annual OECD-ADB Roundtable on Capital Markets in Asia, he is a Board Member, Qatar Financial Centre Regulatory Authority (QFCRA) and Sime Darby Berhad, Khazanah Nasional Berhad, and Member of the Council of the International Center for Education in Islamic Finance (INCEIF). He writes a regular column on investor education for *Caijing Magazine*. He is the author of *Bank Restructuring: Lessons from the 1980s*, published by Oxford University Press and the World Bank (1995) and *From Asian to Global Financial Crisis*, published by Cambridge University Press (2009).

² Scale free means that connectivity of nodes is not random, but exhibits power law characteristics. The term was coined by Barabási (2003).

³ See Brunnermeier and others (2009); Commission of Experts (2009); de Larosiere (2009); Group of Thirty (2009); Turner (2009).

securities houses, and funds to merge or form holding companies in a drive to become giant “financial Wal-Marts,” offering one-stop financial services to the consumer and investor.

In a seminal work, *The Rise of the Network Society*, Manuel Castells characterizes society in the information age as a set of global “networks of capital, management, and information, whose access to technological know-how is at the roots of productivity and competitiveness” (Castells 1996: 471). By the time of the 1997–98 Asian financial crisis, there was increasing awareness of the high degree of contagion among not just banks, but also whole financial systems and the complex interlinkages at the trade and financial levels (Sheng 2009a). By the turn of the twenty-first century, network models have become increasingly accepted as useful analytical tools in computer and information systems, cellular telephone networks, and the Internet.

The collapse of Lehman Brothers on September 15, 2008, signified that the nature of modern financial crisis is unprecedented in its complexity, depth, speed of contagion and transmission, and scale of loss. Early papers have been written on the network nature of the crisis, because, without an understanding of the nature of the crisis, regulatory and policy solutions will be flawed (see Sheng 2005, 2009c; Haldane 2009).

There is general agreement that this particular financial crisis was unusual due to its intense complexity (Caballero and Simsek 2009), not just the elaborate interconnectivity of markets and counterparties, but also the almost incomprehensibility of the financial derivatives where almost no one, not even the issuer or major market maker, had a complete picture of the toxicity. Each participant deluded himself that his risks were hedged through various derivative instruments, when in reality the quality of such instruments was highly suspect and in many cases added to risks. When the environment becomes too complex, market participants do not understand the complete picture and unexpected events create confusion, leading to panic and flight to quality.

What we need is a framework to simplify the understanding of such complex markets, in which the interaction between market participants operating under asymmetric information is dynamic, but not always stable. Such a framework needs to deal not only with a systemwide perspective, but also with the vulnerabilities at the detail level (the weakest link). We need to recognize that the network analysis does not have predictive capacity, although it is useful in laying out an organizational framework to decipher current behavior, revealing, it is hoped, our lack of appreciation of the problems of externalities, wrong incentives, weak structures, and flawed processes. Its major insight is that the process of change is nonlinear, interactive, interconnected, and the outcome of experimentation, accident, or manipulation by participants, which include financial institutions, investors, regulators, and policy makers.

The paper is organized as follows. After this brief introduction, the paper surveys the concepts of networks, their defining characteristics, applications to

financial markets, and the need for supervision and implications for national and global governance, briefly examines the current financial crisis in the light of network analysis, and surveys the recent reforms in financial regulation and architecture. It concludes with an analysis of the policy implications of network analysis.

Understanding Financial Networks

Networks can be a very useful representation of complex financial systems (Allen and Babus 2008). Since networks of relationships come in all shapes, sizes, and forms, there is no single network or framework to encompass all applications.

Generally speaking, a network describes a collection of nodes and the links between them. In a network, the key elements are the nodes or players and links. Nodes involved in networks can be called “vertices,” “individuals,” “agents,” or “players,” depending on the setting. In the real world, the nodes can be individual people, financial firms, countries, or other organizations; a node can even be a Web page belonging to a person or an organization. The minute a node connects or links with another node, a network is formed.⁴

Nodes link with each other for a common purpose or use in which mutual benefit is derived. In this simple construction, human society is a network whereby citizens join together for common purpose, such as mutual support, security, and economies of scale. Once networks are formed, some nodes are better connected to others because of their superior benefits to users, and these are generally described as “hubs.”

For example, a bank is a hub that connects with its customers in providing payment and credit services. A central bank is a hub of bank hubs, where the commercial banks settle their interbank transactions on a final basis. A stock exchange is a trading and clearing and settlement hub between stockbrokers (nodes) who are, in turn, linked to their own network of customers. We can see from this simple model of financial systems that the same retail customer can be linked to different banks, brokers, or insurance companies through different products. This means that networks exhibit a high degree of interdependence, with both direct and indirect connections between financial institutions and counterparties.

Characteristics of Networks

Like all organizations or social systems, networks have certain characteristics, such as architecture or structure, common purposes or objectives, values, standards, incentives, and processes. However, how different networks link or interact with each other can lead to collective action decisions or outcomes that

⁴. A useful survey of work on networks can be found in Jackson (2008). Other recent books include Barabási (2003) and Newman, Barabási, and Watts (2006).

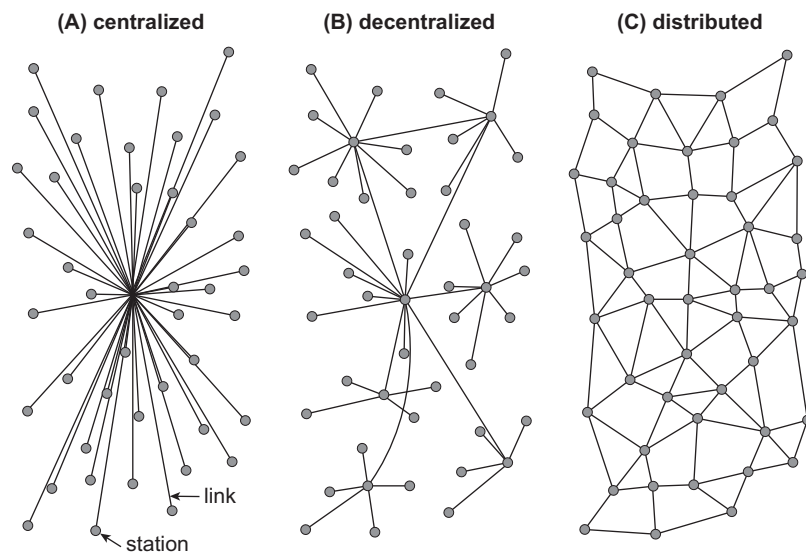
involve conflict, negotiation, cooperation, payoffs, and different games and strategies that result in totally uncharted situations. The insight to note is that nodes or hubs are always “gaming” with each other across the network and that the global financial market is a network of constantly changing networks.

There are two types of networks: networks of informal human relationships and networks of formal organizational structures and platforms. The web-like structure of networks is the formal framework discussed here, but often it is the human networks that control or drive formal institutions.⁵ Networks are almost Darwinian in evolution, but at the same time, it is not clear why some networks survive, some thrive, and some wither and disappear.

First, a network is a set of interconnected nodes that have architecture. It can be a network of individuals, firms, and institutions (market participants) connected in order to exchange information, products, and services or to reduce risks. The goals and purposes could be complex, but common values, rules, processes, codes, or standards generally facilitate interconnectivity and interoperability and therefore bring benefits of collective action, economies of scale, lower transaction costs, and lower risks. Specifically, common standards, such as language, enable more efficient communication and lower transaction or friction costs. The more widely used a common standard, the greater the network.

Network architecture is essentially a tradeoff between efficiency and robustness or stability. There are three basic network topologies: the star or centralized network, the decentralized network, and the distributed network, with the star system being most efficient, as there is only one hub, but the most vulnerable in the event that the central hub fails (see figure 1). The widely distributed

Figure 1. Network Topology: Tradeoff between Efficiency and Robustness



Source: Baran (1964), reproduced in Barabási (2003: 145, fi g. 11.1).

⁵. I am grateful to Dr. Venu Reddy for pointing out this difference. The Chinese call informal network relationships “guanxi” or connections.

network, such as the Internet, is much more resilient to viruses and hacker attacks because of multiple hubs, where links can be shut down, bypassed, and repaired without damaging the whole system, even if a collection of important hubs is destroyed. The self-organizing behavior of the web ensures its own survival, and there is no single architect of it.

Transaction costs are lowered in a star network because linkage is through one central hub, with that hub enforcing standards and protecting property rights for links. Despite its efficiency, the star topology is fragile in the event that the single hub is destroyed by accident, disaster, or competition. Competition between hubs for links or users actually results in different types of architecture as well as different benefits and costs to users.

Second, nodes do not connect with each other at random. If Metcalfe's law is to be believed, each hub will try to increase the number of connections or users in order to increase its own value. Network scientist Albert-László Barabási has called the competition between nodes for links their "fitness." Whether a node decides to link with another node is what Barabási calls "preferential attachment," the deciding factor being the cost of communication. The scale-free topology and preferential attachment are the explanatory factors driving the creation of the Internet, whereby Google, Yahoo, and other Web sites compete for more links in order to enhance their own value and the value to their users. In order to attract more nodes, the hub would have to offer more "free goods" than competitors through the principle of "the more you give, the more you receive" or what I call the network altruism principle. This explains the "loss leader" sales attraction in supermarkets and the way Google offers free Web addresses and superior search services in order to gather the most users.

Third, hubs and clusters are efficient, because the shortest route between two distant nodes may be through a hub. In social networks, this is popularly known as the six degrees of separation, as distant contacts can connect usually through at least six well-networked persons. The more the efficient hubs cluster together and share and exchange information, the greater the network externality, as each node benefits from higher efficiency in accessing information and knowledge and can cooperate to produce greater output (Economides 1993). This is known as the cluster effect of knowledge hubs. Economies of scale increase with clusters and critical mass, but mostly because production and distribution processes (including exchange of information and decision making) occur at faster speed, enabling faster decision making and less expensive transactions.

Fourth, preferential attachment and network externalities taken together explain why a "winner take all" situation is common to networks. The hubs compete with each other until one or several leading hubs emerge to dominate activities. In other words, networks exhibit power law characteristics. Globally, more than two-thirds of financial information is distributed through two major information networks (Reuters and Bloomberg). Similarly, airline bookings are through two

major reservation or airline alliances (Star Alliance and One World). More than 80 percent of global credit card business goes through Visa, MasterCard, or American Express.

This “rich get richer” aspect of networks can be seen in the way that markets have become more and more concentrated, with a small number of big players dominating the business and a large number of small players feeling marginalized. For example, there were 100 or so stock exchanges in the United States during the nineteenth century. With the arrival of the telegraph and now the Internet, the global equity market trading is essentially dominated by two dominant exchanges, the New York Stock Exchange/Euronext and Nasdaq/Open Mobil Exchange. Physicists have also noted that the appearance of power laws often signals a transition from disorder to order (Barabási 2003: 72).

According to this network perspective, the United States is today the super hub of global financial markets, with the U.S. dollar as the dominant currency. The second major hub is the London market, which shares the common-law background and English language advantage, plus London’s historical, political, and economic ties with Europe and the rest of the world. Hence, between London and New York, where most of the wholesale banks, investment houses, and asset management funds are operationally located, the two financial centers may account for more than half of global market transactions.

An important study commissioned by the National Research Council (National Academy of Sciences) and the Federal Reserve Bank of New York found that the Fedwire interbank payment network, which transacts \$1.2 trillion daily, has 66 banks accounting for 75 percent of daily value, with 25 banks completely connected (Kambhu, Weidman, and Krishnan 2007, quoted in May, Levin, and Sugihara 2008).

Fifth, networks are scale free and not static, because each hub continually seeks to increase its links through its own competition or cooperation strategy. The nodes of a scale-free network are not randomly or evenly connected. Scale-free networks include many “very connected” nodes, hubs of connectivity that shape the way the network operates. The ratio of very connected nodes to the number of nodes in the rest of the network remains constant as the network changes in size. If one hub becomes dominant, the smaller hubs can cooperate or ally with other hubs to compete with the dominant hub. At the local level, some networks can become dominant by imposing control over their links through enforcement of rules or standards. As there is no universal law, there is no single architect for the global network of markets. The world is always evolving through continuous competition between different hubs arising from innovation, technology, and even random events. Just as there are competing standards, there are competing values and competing networks. Networks are therefore path dependent, because they emerge from different social, historical, and political environments.

Sixth, since markets are by their nature competitive, they adapt and evolve around their environment. A body of work by Andrew Lo, professor at the Massachusetts

Institute of Technology, and others contends that financial markets are adaptive and evolutionary through competition, adaptation, and natural selection (Lo 2004, 2005). Markets operate through four key types of arbitrage: cost arbitrage, information arbitrage, taxation arbitrage, and regulatory or governance arbitrage. Markets simply shift to areas with the lowest transaction costs. In local markets, if there are obstacles to growth, the market simply moves offshore, which is why we have witnessed the rapid growth of offshore financial centers relative to onshore financial markets. Markets are, by their competitive nature, pluralistic, disciplined, and adaptive, with good feedback mechanisms (Kay 2003).

Once we begin to look at markets as networks through either engineering or sociological perspectives, we move outside classical economics into the realm of political and institutional dynamics. Competitive behavior and the use of common standards and rules often lead to procyclical behavior, particularly since interactions between different market participants with different information and values carry significant leads and lags. Networks therefore have inherent feedback mechanisms that are sometimes stable and sometimes violently destabilizing.

Applying Network Theory to Financial Markets and Institutions

The above insights have powerful implications for the way we look at financial markets and institutions (Sheng 2005). The decision tree of multiple network games fans out into complex areas, some of which may be dead ends and some may open up new avenues of opportunity. Every now and again, the system may experience a crisis.

We can see that financial markets evolve through the innovation of specific products and standards that improve their “preferential attachment,” attract more users, and therefore dominate other networks. These networks develop externalities through common standards, processes, and infrastructure that generate positive economies of scale that attract links to other networks.

In other words, domestic markets are networks of different networks, and property rights are cleared in hubs called exchanges and clearinghouses and protected through courts and regulatory agencies. Of course, property rights can also be protected through self-regulatory or collective behavior.

The global market is a network of local networks, in which the weakest link is possibly the weakest node, link, cluster, hub, or local network. We do not know why or where the system is weak, until it is subject to stress. Hence, we need to look at global financial stability holistically or throughout the whole network to identify the weakest links.

In sum, the network perspective forces us to look at the issues more forensically, within the total context and a longer time frame. We must stress test not just the nodes and hubs, but also the crucial linkages that could bring about the vulnerabilities. We have to trace the roots of problems to their source.

Network Characteristics of the Current Global Crisis

Globalization has networked together hitherto highly localized financial markets, and a series of historical events and macro trends created the conditions that led to the current crisis.

First, the global imbalance, which led to excessive liquidity that generated excessive credit and leverage, was due to the decline in the U.S. saving rate and U.S. dependence on external resources. Indeed, the U.S. banking system evolved from a traditional retail banking system to a highly leveraged wholesale banking system funded largely through the securitization of assets to facilitate growth of the global imbalance.

In the surplus economies, such as Japan, inappropriate policies led to the asset bubbles in the 1990s that created post-bubble loose monetary policy to combat the resultant deflation. Low interest rates encouraged growth of the leveraged carry trade and, given disparities in national interest rates and exchange rates, gave rise to large capital flows. The Asian crisis of 1997–99 and the 2000 dot-com bubble were all consequences of excessive leverage, large capital flows, loose monetary policy, and lax financial regulation.

Second, the fall of the Berlin Wall led to the arrival of cheap labor from the former centrally planned economies, which created low inflation and boosted global trade and economic growth.

Third, global trade and finance were encouraged through the massive deregulation in tariffs and capital controls. The age of deregulation, which was intellectually bound in free-market fundamentalist philosophy, allowed the huge regulatory arbitrage in accounting, tax, and regulatory standards that created the rise of “shadow banking.” Innovation through financial engineering gave rise to new financial instruments and derivative products, ostensibly to hedge risks, but inadvertently allowed the creation of embedded leverage and huge systemic risks.

Fourth, financial engineering and globalization could not have happened without massive improvements in information and communication technology. The speed and complexity of innovation dazzled policy makers and central bankers, who believed that the growth in prosperity was due to improved productivity, improved risk management, and successful monetary policy skills. In hindsight, prosperity was created largely as a result of leverage.

In short, the four global megatrends of wage, interest rate, knowledge, and regulatory arbitrage gave rise to the four excesses of liquidity, leverage, risk taking, and greed.

Fundamentally, the U.S. economy went into unsustainable deficits, and its subprime mortgage market was the basis for financial leverage and engineering that ultimately financed consumer expenditure in excess of capacity. The reversal of the housing bubble and problems in the subprime mortgage market were the triggers that pricked the U.S. bubble in 2007.

Viewing the global financial market as a network of national networks highlights several significant network features of the present crisis:

- The network architecture played a role in determining its fragility or vulnerability to crises. Network concentration created a number of large, complex financial institutions that dominate global trading and are larger than even national economies. However, they are regulated by an obsolete regulatory structure that is fragmented into national segments and further compartmentalized into department silos, none of which has a systemwide view of the network that allows the identification of systemwide risks.
- Increasing complexity of networks is related to their fragility. Complexity is also positively correlated with the externalities of network behavior, and few regulators understood or were able to measure these externalities.
- The high degree of interconnectivity drove the value as well as the risks of hubs or financial institutions. The failure of one hub, such as Lehman Brothers, revealed interconnections that were not apparent to regulators, such as the impact on American International Group (AIG) and, through AIG, on the solvency of banks and investments.
- Networks have negative and positive feedback mechanisms due to the interactivity between players and between hubs and nodes as they compete. The regulators assumed that only negative feedback was prevalent, so that markets would return to equilibrium. Instead, the markets had positive feedback, because of momentum trading and rules or codes that embed procyclicality features.
- There was no lack of information or transparency, but too much information was not understandable.
- Regulators ignored the distorted incentive structures that promoted risk taking, and regulators failed to minimize moral hazard, even though there were clear lessons from earlier financial crises.
- The roles and responsibilities for network governance were not allocated clearly. In the absence of a single global financial regulator, effective enforcement of regulation across a global network requires complex cooperation between different regulators. How do we avoid regulatory competition and a “race to the bottom”?

Systemwide View of Networks

There is now consensus that the primary problem of the current global financial architecture is that it is global in terms of transactions, but national in terms of legislation and supervision. As Bank of England Governor Mervyn King (2009) vividly expressed, “Global banking institutions are global in life, but national in death.” This is the inherent problem of a global architecture that is regulated in

national silos. Worse, the regulation of financial activities even within a nation can be segmented into so many departments that regulatory arbitrage is a major game for financial institutions. The fact that AIG Financial Products, the subsidiary of AIG most responsible for its losses, was regulated by the Office of Thrift Supervision, which had little comparative advantage in regulating such complex derivatives, is a classic example of regulatory arbitrage.

Financial markets have become highly integrated, but financial regulation remains largely compartmentalized into separate jurisdictions. The result is that no one body is responsible or accountable for the whole system. Each agency—the central bank, the financial regulator (irrespective of whether it is a super regulator or multiple regulators), and the ministry of finance—felt that the root problems and solutions might be outside their own jurisdiction.

Hence, the Group of Thirty (2009: 8) was correct in its Core Recommendation I: “Gaps and weaknesses in the coverage of prudential regulation and supervision must be eliminated. All systemically significant financial institutions, regardless of type, must be subject to an appropriate degree of prudential oversight.”

There is also recognition that current regulatory competition engenders a “race to the bottom,” as each financial regulator deregulates for fear of business drifting to underregulated or unregulated financial centers.

To avoid this race to the bottom, there should be coherent, appropriate oversight of all financial institutions, markets, and activities, consistent with their risks; gaps and underregulated areas should be avoided. However, to do this, one needs a comprehensive regulatory system that has universal coverage and is, at the same time, effective and legitimate. In other words, we need an effective system of global financial regulation that fairly allocates gains and losses of financial activities.

We are unable to arrive at a global financial regulator for two important reasons. First, there is no fiscal mechanism to allocate or distribute losses arising from uniform monetary and financial policies or to obtain taxation to do so. No sovereign country is willing to cede fiscal and monetary sovereignty to a global financial authority. Second, no independent global judiciary can arbitrate property rights disputes over such loss allocation, particularly in the bankruptcy of global financial institutions.

The only regional body that seems able to move in that direction is the European Union (EU), partly because it is both a political and a monetary union with European laws and an institutional framework for allocating gains and losses. Even in the EU, the allocation of fiscal and bank rescue costs is controversial, and, in the short run, the costs are still paid for largely at the national level.

This inability to arrive at a global financial regulator contrasts with the global trade system, whereby the World Trade Organization (WTO) is able to enforce trade disputes through a system approved by treaty. Perhaps, the

fundamental reason for this difference is that the benefits of free trade are obvious, as were the mistakes of trade protectionist action during the 1930s. However, since the services trade is historically more protected at the national level and the concentration of financial services skills is predominantly Anglo-Saxon, some countries are reluctant to open up to free trade in financial services. Even WTO members accept the general argument that countries can impose prudential rules in financial services, provided they are not discriminatory to foreign players. It is likely that no global financial regulator will evolve unless the costs of the current crisis or future financial crises are so large as to force national authorities to cede their sovereign powers to a global body.

Complexity

Their scale-free and gaming nature suggests that networks inherently grow more and more complex. What is the motivation behind the growing complexity?

The two core issues of all institutions are the principal-agent problem and information asymmetry. There is inherent inequality in all societies and economies because of an unequal endowment of knowledge and access to information. However, increasing complexity is the tool by which the agent can take advantage of the principal. The greater the information asymmetry or complexity, the greater the ability of the agent to cheat the principal and the weaker is the agent's accountability.

Hence, the current incentive structure within financial institutions (read financial engineers) is to make situations more complex, because the higher the "knowledge premium," the more they profit at the expense of the principal (read investors and regulators). The financial engineers persuaded the investors and the regulators that their models were hedging and managing the risks, whereas in reality, the higher profits from the complex derivatives were derived from higher levels of embedded leverage. Unfortunately, the regulatory system failed to conduct sufficient due diligence on behalf of the principal, the public at-large.

The conclusion from this analysis is that we cannot solve a crisis by adding complexity; instead, we should try to resolve it by identifying and simplifying "coarse" rules and enforcing these rigorously. As hedge fund risk manager Richard Bookstaber (2007) pointed out in his congressional testimony, "If the potential for systemic risk stems from market complexity, adding layers of regulation might actually make matters worse by increasing the overall complexity of the financial system."

Externalities

The Geneva report on the fundamental principles of financial regulation correctly identifies that financial regulation is justified "where there are sufficient externalities that the social, and overall, costs of market failure exceed both the private costs of failure and the extra costs of regulation" (Brunnermeier and others 2009: 2). The report argues that the two risk-spillover externalities are fire-

sale externalities and interconnectedness externalities. The fire-sale externality arises since each individual financial institution does not take into account the impact that its own fire sales will have on asset prices in a possible future liquidity crunch. The second negative externality is the fact that financial institutions have become so interconnected that they become not just “too big to fail,” but “too interconnected to fail,” creating the moral hazard that they will be bailed out in times of crisis.

The reality is that, through implicit deposit insurance, the current system subsidizes institutions that cause negative externalities for others. Micro behavior of excessive risk taking has wide systemic risks.

In an important study of complex systems with reference to banking, diverse researchers from oceanography, biology, and zoology bring parallels in the ecological system to the study of banking. May, Levin, and Sugihara (2008) observe that “tipping points,” “thresholds,” and “breakpoints” describe the flip of a complex dynamic system from one seemingly stable state to an unstable lower-level state. They lament the fact that very little is spent on studying systemic risk as compared with what is spent on managing conventional risk in individual firms, but the costs of a systemic risk event for a national or global economy are huge.

There are three possible reasons why systemic risk was overlooked. The first is sheer ignorance. Private sector participants may simply have had no idea that what they were doing carried huge social costs. The second is that they could have been aware of the social costs, but were not able to measure such externalities and assumed that these would be taken care of by the regulators or the government. This is classic moral hazard behavior. The third is that, since financial regulators allowed the financial innovation or financial engineering that created the massive leverage without testing or verifying the possible social costs, they inadvertently permitted the moral hazard to reach crisis levels.

Unfortunately, the inherent nature of externalities is that it is almost impossible for an individual firm to calculate the extent of the spillover externality and even the interconnectedness externalities. This requires information and expectations about the future that are highly subjective and most likely to be wrong. Indeed, this would be a highly contentious area of financial regulation. Until disaster happens, private sector participants would argue vehemently that regulatory costs or restrictions to limit these two externalities are too high in (a) preventing financial innovation and (b) overestimating the costs of failure. Regulatory arbitrage and competition between financial centers would inevitably shift the transactions to another “user-friendly” center until the collective action becomes a race to the bottom.

Indeed, one defense why financial regulators allowed such financial innovation without detailed due diligence (like the U.S. Food and Drug Administration in approving new drugs) was that the externalities were outside their experience. Until the current crisis, financial engineering appeared to

distribute risks outside the banking system, and respected leaders such as Alan Greenspan repeatedly affirmed this untested belief.

Interconnectivity

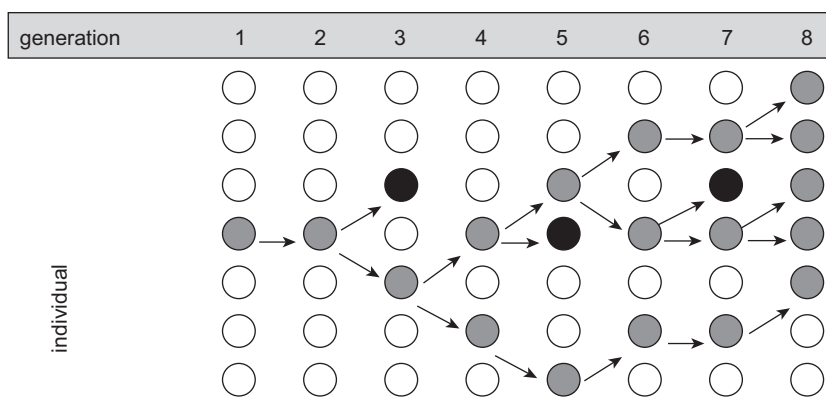
Interconnectivity between institutions, markets, and systems lies in the spillover or externalities inherent in products, institutions, and activities. Network interconnectivity occurs not simply through mutually exclusive channels, but through highly complex interrelationships that are not always fully understood or observable.

Economic historian Michael Bordo (2001) correctly points out that contagion between two or more nodes should be termed transmission, noting, “In the golden age, financial crises were transmitted across the world through the links of the fixed exchange rate gold standard.”

How is loss or fear of loss transmitted and spread throughout the network? German economist Friedrich Sell (2001) was the first to integrate notions of contagion in epidemiology and financial markets. He drew the parallel between the spread of an epidemic to contagion in financial markets (see figure 2). In epidemiology, disease is transmitted when the reproductive rate of a virus reaches a critical mass and more and more humans are infected. However, humans also develop immunity until at some stage most humans become immune to the disease. The pandemic process is similar to a decision tree in game theory.

Loss can cascade throughout the (financial market) network like a pandemic, because the failure (or loss) in one node causes losses in other nodes through its links. Loss-avoidance behavior therefore can result in panic as the losses spread throughout the network.

Figure 2. Expansion Process of an Epidemic



Source: Sell 2001.

This cascading impact of loss-avoidance behavior was noted by a 2007 research study initiated by the National Research Council (National Academy of Sciences) and the Federal Reserve Bank of New York on systemic risk (Kambhu, Weidman, and Krishnan 2007): “Market-based systemic crises are often characterized by a coordination failure: a wide cross section of market participants simultaneously decide to reduce risk taking and effectively refrain from financial activities, such as trading stocks, issuing debt and equity, and lending.”

Interconnectivity means that the regulator as well as the financial institution would need to have radically different management information systems (MISs) that can detect connections and risks that are not apparent from current MIS models. For example, most banks do not have very good information on the links of their counterparties, especially whether different counterparties are either affiliated or interconnected in different manners.

Interactivity of Feedback Loops in Networks

Interactivity means the continuous interaction and games being played between different market participants and between the private sector and the regulators and policy makers. The dynamic gaming leads to outcomes that are not always predictable, in the same way that action by regulators may suffer from the law of unintended consequences. A common fallacy among market participants is that the action of a single market player has no consequence for the market as a whole. In practice, this is often not true, as even very small-value transactions in a thinly traded market could have dramatic influence on price volatility.

Interactivity, or the gaming in the network, leads to feedback loops, which in turn explain the inherent procyclicality of financial markets. Feedback mechanisms exist because of information asymmetry, leads and lags in behavior between transactors in a network transaction, and differences in transaction costs. The prevailing efficient-market hypothesis assumes that markets will occasionally diverge, but eventually return to equilibrium, in what engineers recognize as *negative* feedback—volatility recedes back to the mean (Umpleby 2009).

Experienced fund manager George Soros has argued that financial markets also have *positive* feedback, through what he calls reflexivity (Soros 1998). As market activity gathers momentum, information bias and herd behavior occur and drive the market in larger and larger oscillations, causing a wrecking ball effect, with volatility and movements becoming larger and larger until the system crashes.

The real concern of regulators is not whether such procyclicality exists, but whether tools exist to dampen or stop the damage from such procyclicality and *when* the regulator should intervene.

How to deal with procyclicality boils down to three choices. The first and noncontroversial issue is to remove procyclical elements within the existing rules

and standards, such as mark-to-market accounting, the Basel Capital Accords, and dynamic loan-provisioning requirements. The regulatory community has agreed to this action after the horse has bolted out of the stable.

The second is to construct rules that guide regulators on when to act anticyclically. For example, Goodhart and Persaud recommend that capital be increased after assessment of risks using a few simple, transparent rules (Brunnermeier and others 2009). The Bank of Spain uses dynamic provisioning rules as risks escalate. Regulators like to use such rules to avoid taking personal responsibility for making judgments on when and how to take anticyclical action. Hence, rule-based decision making is fine if the markets behave according to the rules, but in the complex, interactive, and interconnected world, the evidence to support such decision-making rules may not be clear-cut, and regulators and policy makers must make informed judgments on the balance of risks and whether or not to take anticyclical action.

The third choice is to recognize that the only way to break out of the classic paralysis of collective action is for individual leaders to be willing to take tough action, even though the evidence may not be complete. In essence, to quote former Fed chairman William McChesney Martin, one has to be willing to take personal responsibility for “taking away the punch bowl when the party gets interesting.”

Transparency and Information Overload

Transparency refers to a process by which information about existing conditions, decisions, and actions is made accessible, visible, and understandable to market participants. The strange thing about this current crisis is that it happened in full transparency and in front of everyone. The reforms made after the Asian and dot-com crises made more information accessible and visible, with major reforms in accounting and corporate disclosure. Full risk warning and information were disclosed on the Web sites of Lehman Brothers, AIG, the Federal Reserve, the Bank of England, the European Central Bank, and the International Monetary Fund, but the crisis still happened.

Everyone also agrees that the roots of the crisis are so complicated that almost no one understood where to begin to stop it. The problem was not a lack of information, but too much information that was not understandable. The financial derivatives such as centralized debt obligations (CDOs), credit-default swaps (CDSs), and conduits were so complicated that investors, the originating and selling banks, and their financial regulators did not understand their complexity and toxicity. Would more rules on transparency help? I doubt it.

In practice, transparency has become a game of information overload so that the receiver is misled or does not want to admit that he either does not understand or does not know what to do with most of the information. With the legal requirement to have full disclosure, the system was “gamed” by companies and financial institutions supported by their expensive lawyers learning how to

disclose so much information and risks that they are responsible for nothing when anything goes wrong. The truth is buried in fine print, but only if you know how to find it. The law was satisfied under “legal transparency,” but ultimately society as a whole paid the price.

This is where the governance structure is critical. The onus should be on boards of directors of financial institutions to understand or demand from management the information needed to assess risks, including systemic and concentration risks. If the board is made fully accountable for the identification and disclosure of such risks, then action will be taken to undertake the due diligence needed to understand where the true risks are. Consequently, the board must question thoroughly: if profits look too good to be true, then they are too good to be true.

Hence, one area of reform is, instead of making a complex system more complex, we should try to make it more simple and understandable. Even 2,500 years ago, the Chinese legalist philosophers and bureaucrats understood that laws should be made simple, easy to understand, easy to learn, and easy to implement and enforce.

Incentives

There is consensus that the primary incentive for excessive risk taking in the financial community was a management compensation scheme that rewarded short-term risk taking and ignored future costs or losses. Rewarding bank management and hedge fund managers with hefty bonuses and options based on short-term risk taking pushed the financial sector toward processes and standards that tried to take profits up-front, without measuring the inherent long-term risks.

A slew of market practices mutually reinforced the path to crises. The application of fair-value accounting and use of models to measure the value of financial derivative products resulted in future profits being measured on discounted present-value terms, while ignoring (difficult-to-measure) future costs and disexternalities. The lower the level of interest rates due to loose monetary policy and high liquidity from the global imbalance, the higher the price of these leveraged products. Since these products were marked either to market or to models, unrealized capital gains were taken to profits without considering the sustainability of such high profits or the possibility of a sharp reversal due to crowded trades or market illiquidity. Needless to say, the higher the recorded profits, the higher the bonuses.

Thus leverage was built into the behavior of bankers, without the financial regulators appreciating that the growing derivative trade and valuation were a castle built on sand.

Although it was widely acknowledged in the academic community after the Asian crisis that moral hazard is the most dangerous incentive in a system where the state stands to guarantee (implicitly or explicitly) the financial system, most

regulators took little action against moral hazard until it surfaced in the Northern Rock runs in 2007. Why was there little appreciation that the higher the inherent leverage in the financial system, especially in the financial derivative business, the greater the moral hazard?

A possible explanation lies in the failure of financial regulators to appreciate the enormous risks inherent in financial markets in what can be called the Soros asymmetry of risks. Soros's insight, used to explain why credit-default swaps are dangerous and should be banned, can be generalized for the asymmetry of risks in all financial products. The first step is to recognize that "there is an asymmetry between long or short in the stock market ... going long has unlimited potential on the upside, but limited exposure on the downside. Being short is the reverse. The asymmetry manifests itself in the following way: Losing on a long position reduces one's exposure, while losing on a short position increases it" (Soros 2009: 166).

In other words, given the high degree of leverage in the system, the systemic risks were nonlinear and exponential. Since the financial regulators could not agree on a simple measure of overall leverage and allowed banks to use internally rated models to measure their own risks and therefore capital needs, the embedded leverage increased sharply. The total leverage of the global financial system (using the notional value of financial derivatives) could be as much as 14 times GDP, compared to current upper limits of traditional leverage (measured as banking asset, stock market capitalization, and debt market value) of roughly five times GDP (Sheng 2009b: 331). Including below-the-line liabilities, the fact that the five U.S. investment banks at the end of 2007 were leveraged 88 times capital meant that the moral hazard was extremely high.

The second step is to recognize that "the CDS market offers a convenient way of shorting bonds. In that market, the risk-reward asymmetry works in opposite ways to stocks. Going short bonds by buying a CDS contract carries limited risk but unlimited profit potential; by contrast, selling CDSs offers limited profits but practically unlimited risks" (Soros 2009: 166). Selling CDSs to the market ultimately was AIG's fatal mistake.

Soros goes one further. "The third step is to take into account reflexivity and recognize that the mispricing of financial instruments can affect the fundamentals that market prices are supposed to reflect ... This means that bear raids on financial institutions can be self-validating, which is in direct contradiction to the efficient market hypothesis" (Soros 2009: 167).

If I interpret Soros correctly, the combination of Soros asymmetry of risks, moral hazard, and reflexivity created a self-fulfilling situation in which financial institutions became more and more leveraged until their own speculators collapsed the system through bear raids.

During the 1997–99 Asian crisis, several central banks that had insufficient foreign exchange reserves to rescue their domestic banks or corporations that were grossly overextended in foreign exchange and maturity mismatches

became vulnerable to bear raids on their currencies. The collapse of the currencies brought the economies to low-level equilibrium situations that took various years to recover from.

We should, therefore, pay more attention to why there were no incentives for regulators and policy makers to act anticyclically more effectively and forcefully.

Recent debate in the United Kingdom suggests that there should be an independent body (a financial policy committee) responsible for macro prudential systemic financial stability, with the central bank being responsible for micro prudential regulation. Presumably, the independent body would strengthen the “trust but validate” function of external supervision, in contrast to the current “comply and explain” approach.

Division of Labor between Home and Host Regulators

The consensus that the scope of regulation should cover the whole perimeter of systemically important financial institutions and activities means that we have to define what is systemic and who should do what. The present crisis has demonstrated that risk concentrations can rapidly emerge from unregulated black holes or underregulated “shadow banking” areas where managers, regulators, and policy makers have little or no information on what is happening. Hence, there is general agreement that regulation should be made more consistent and that supervisory oversight and enforcement should converge toward international standards of best practices. This is more easily said than done.

First, what is not systemic in a mature market can be highly systemic in an emerging market. For example, a hedge fund that is not systemically important in a mature large home market can indeed be very systemic in an emerging market, especially when it can act in concert with other hedge funds in the unregulated over-the-counter (OTC) market. The issue is not just about systemic size of trading or exposure, but also about misselling, market manipulation, insider dealing, and fraud.

Second, recent experience suggests that what was thought not to be systemic can rapidly evolve to become highly systemic. Indeed, few regulators were aware that the CDS market had such systemic implications for the health of the banking system and the liquidity of the asset-backed securities market. AIG had to be rescued in order to stem the systemic contagion if it failed.

Third, as long as a financial institution or activity is not supervised in its home territory, and in the absence of the cooperation and legal authority of the home authority, it would be impossible for the host authority to obtain the necessary information to assess systemic implications or to undertake investigation and enforcement, when trading activities can involve several markets and also OTC or unregulated markets. Without effective international

cooperation, no host regulator can protect host-country investors and counterparties.

Fourth, the present memorandum of understanding between home and host regulators does not have sufficient legal standing or powers of mediation in the event of disagreements between home and host regulators.

Indeed, the questions raised by the de Larosiere report on important supervisory failures within the EU are directly applicable to the international arena (de Larosiere 2009: 39–41), including

- Too much emphasis on supervision of individual firms and too little on the macro prudential side
- Ineffective early-warning mechanisms, especially no mechanisms to ensure that assessments of risks are translated into action
- Lack of competencies; the failure of oversight points to the need for well-staffed, experienced, and well-trained supervisors in all states
- Failure to challenge supervisory practices on a cross-border basis; there is no mechanism to enable host countries to challenge effectively the decisions of home regulators who failed to recognize risks
- Lack of frankness and cooperation between supervisors; supervisors in different states were not prepared to discuss with appropriate frankness and at an early stage the vulnerabilities of the financial institutions that they supervised
- Lack of consistent supervisory powers between member states; these differences, including differences in insolvency laws, would require changes in law
- No means for supervisors to take common decisions; this inability may be due to lack of legal powers to take decisions or inability to reach coordinated responses within nations and also with cross-border counterparties.

Conclusions and Policy Implications

At the Davos meeting on January 27, 2009, Forum chairman Klaus Schwab argued, “What we are currently experiencing with the financial crisis and its consequences is the birth of a new era—a wake-up call to overhaul our institutions, our systems, and, above all, our thinking.” I conclude by drawing some highly tentative observations on how the network framework can be used to improve financial sector governance.

First, appreciating the dynamics of market behavior suggests that too much stability or overregulation could breed complacency of market participants and, hence, a lack of immunity against market volatility. This calls for greater tolerance of risk and willingness to open markets gradually to stresses on a

controlled basis. Gradualism seems preferable to “big bang” in raising system immunity. Opening up, or reforming in modular form or “chunks,” seems a sensible and tested way forward.

Second, resilience of networks comes from openness to diversity and new ideas and technology. The resilience of networks is honed through actual market stresses, so that participants learn through their mistakes. In other words, immunity cannot be built up through protection. Taking an open-minded approach to market risk and trusting market participants to learn from their mistakes are more helpful than micromanaging the intermediation process. Allowing more competition and diversity of products, institutions, and processes would avoid “monoculture” and therefore greater concentration and fragility.

Third, networks operate not only on interconnectivity and interactivity, but also on interdependence. Policy and outcomes in networks are not the responsibility of one person or institution, but the cooperative effort of multiple stakeholders. Cooperative efforts in network management and governance are a given. How we cooperate or deal with the consequences of lack of cooperation will shape network behavior or outcomes. The current outcome is a global tragedy of the commons, whereby lack of cooperation resulted in a race to the bottom and financial and ecological disasters.

Fourth, network perspectives suggest more caution on regulatory intervention. The self-organizing power of networks suggests that there is a basic instinct for survival and resilience. Banks engaging in derivative activities are engaging in risk diversification. Government intervention to rescue basically failed institutions may have much larger unintended consequences than we can imagine. The dilemma is that bad incentives, particularly moral hazard, are being entrenched, which explains why salaries in many rescued institutions have not declined as much as salaries in the real sector.

If complex networks cannot be disentangled or repaired overnight, not even at the national level, then it is quite realistic to assume that the global financial architecture will not reform so quickly or voluntarily. It will evolve from competition within the system.

The net conclusion is that there is unlikely to be a “big bang” in financial sector reforms, even as the current financial crisis evolves, until there is much better understanding of the causes and characteristics of the change in the ecology of financial markets. This suggests that a research agenda on network analysis could yield many fruitful insights on how to improve financial and global governance.

What are the implications of this brief survey of the network framework for the current global financial architecture and the direction of regulatory change? To recap, the network analysis views the global financial structure as a complex, evolutionary network of local networks, highly concentrated with power law distribution of transactions by value, highly interactive, and currently prone to financial instability due to volatile capital flows arising from structural

imbalances and policy errors. Although the balance of economic power is changing from the rich to the emerging large countries such as China and India, the basic rules of the game have not changed. There is still considerable momentum to maintain the status quo, so that the inherent push by vested interests for asset bubbles and higher leverage remains intact.

We have to live with the reality that, unless the social losses are traumatic, the status quo will only change incrementally, not radically. Since the power centers, including large, complex financial institutions and other vested interests, are continually protecting their interests, it is unlikely that those in control will relinquish their powers voluntarily. Indeed, the European presence on the Financial Stability Board increased further with the addition of Spain and the European Commission, so that Europeans now account for six out of 20 members.

How would the network framework assist us in thinking about reforming the current global financial architecture? First, the network topology or structure matters. We need a systemwide view with a good understanding of the weakest links and risk concentrations. Given the inherent existence of power laws in networks, we have to recognize that networks are not equal and that increasing concentration through “too big to fail” or “too interconnected to fail” are real risks. We need to think more about bringing more competition and diversity into the global networks, in order to avoid oligopolistic behavior from preventing innovation and the tendency toward “monoculture.” Avinash Persaud and others have pointed out how the use of uniform accounting standards (fair-value accounting) and similar models encouraged markets to move in one direction, thus adding to procyclicality. This is particularly evident when similar trading models, using basically similar information, create large herding effects, perpetuating momentum trading and self-fulfilling expectations.

Second, financial regulators should address the issue of *complexity* using different tools and techniques. I mention only two. As pioneered by J. Doyne Farmer (2001), Andrew Lo (Khandani and Lo 2007), May, Levin, and Sugihara (2008), and others, regulators should use more financial market modeling, looking at financial markets as dynamic, evolving, adaptive ecosystems that experience periods of instability, rather than as mean-reverting, stable systems that return to equilibrium. Systemwide modeling using balance sheets and flows would enable regulators and the market to understand better the stress levels and tolerable limits of leverage.

Regulators should use more forensic techniques, using cross-jurisdictional examinations of product trail on an “end-to-end” basis, looking at how financial products evolve from origination, trading, clearing, and settlement to distribution throughout the system. The audit trail should look at how each investor or intermediary manages its risks. This cross-sectional forensic study would yield much more industrywide information and behavioral patterns than the current emphasis on institution-based stress tests and examinations.

Regulators must also have systemwide data on embedded leverage, by insisting that popularly traded products be cleared or registered on central clearing platforms. Financial regulators have to adopt the perspective of public health policy.

As a matter of regulatory philosophy, regulators must try to reduce complexity in the system, so that products, standards, and rules are easily understandable by all parties alike. However difficult the task, all rules and processes should be reduced to key principles and objectives, so that the rules can be interpreted against these fundamental principles. This calls for more judgment by both regulators and regulated alike.

In general, what regulators should appreciate is that mass behavior is influenced more by a few clear and simple rules, firmly enforced, than by multiple complex rules, lightly or underenforced.

Third, on the issue of interconnectivity, network engineers in information technology understand the importance of working in modules. Technological breakthroughs are generally achieved in modular form. Network reforms should divide the systems into modules, with relevant firewalls and risk controls, so that reforms can be achieved on a *modular* basis (Beinhocker 2007: 175). For example, interconnectivity and related leverage can be understood by building key settlement and clearing infrastructure on a modular basis, product-by-product, and analyzing such data. Regulators spend too few resources mining the information at their command.

On the question of whether large, complex financial institutions are too large and complex because of their interconnectivity, the modular solution suggests that we should create firewalls between their key lines of business, so that the high-risk areas are segmented from the public utility part of banking business.

Fourth, the issue of interactivity or feedback mechanisms should be addressed by removing the procyclical bias in current standards and rules. There is now agreement on this move. However, regulators must be aware that what matters is the reflexive action of market participants to the perceived behavior of regulators themselves. If regulators do not firmly and decisively act to stop moral hazard behavior or tolerate risky behavior, then market participants will behave as if regulators permitted such behavior. In a sense, regulatory discipline through enforcement is the thin red line stopping excessive risk taking by market participants.

My personal opinion is that the attempt to go for clear-cut, transparent rules rather than discretion has gone too far. No rule is applicable for all time, given the interactive gaming of financial markets. The reality is that such rules require information that may not be available for clear decisions to be made. The risk of waiting for definitive evidence may mean that regulatory action is too little, too late. Regulators always have to make judgments based on partial or sometimes unreliable information. The community at-large must support independent regulators to make such informed judgments and accept the fact that sometimes

those judgments are made on the risk-aversion side, since the costs of financial crises are unpredictable.

Fifth, on the incentive structure, the U.S. Congress has recently passed legislation to enable regulators to control or ban certain compensation arrangements for financial executives that are perceived to encourage excessive risk taking. There is strong resistance within Wall Street to cut bonuses and salaries on the assumption that financial skills are scarce and that to cut salaries would reduce financial sector performance. This argument is self-serving.

In my view, the level of bonuses and profits is derived not from the skills of these financial executives, but from the scale of leverage they embed in the system. Hence, if the regulation limits the level of leverage, the bonuses will be capped. This raises a fundamental question on whether the financial industry will forever grow faster and more profitable than the real sector. At the heart of the issue are the tolerable limits of leverage in the whole economy, at both the sectoral and the national levels. There is no fixed formula for the limits of leverage, but for each economy, and on a global level, there must be limits, which should be identified and strictly enforced.

In sum, it is hoped that the network framework will open up new avenues of research into the complexities of the financial sector and its links with the real economy.

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This paper attempts to use network theory, drawn from recent work in sociology, engineering, and biological systems, to suggest that the current crisis should be viewed as a network crisis. The author surveys the concepts of networks, their defining characteristics, applications to financial markets, and the need for supervision and implications for national and global governance. Then, he briefly examines the current financial crisis in the light of the network analysis and surveys the recent reforms in financial regulation and architecture. The paper concludes with an analysis of the policy implications of network analysis.

Andrew Sheng, *Adjunct Professor, Tsinghua University and University of Malaya*

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www.growthcommission.org
contactinfo@growthcommission.org