# РАЗДЕЛ III
# МЕЖОРГАНИЗАЦИОННЫЕ СЕТИ В ГЛОБАЛЬНОМ И ЛОКАЛЬНОМ КОНТЕКСТАХ

# PART III
# INTER-ORGANIZATIONAL NETWORKS IN THEIR GLOBAL AND LOCAL CONTEXTS

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## 'WE'RE STILL DANCING': HOW THE GLOBAL FINANCIAL NETWORK TOOK THE WORLD ECONOMY TO THE BRINK, AND COULD YET PUSH IT OVER

*A network perspective can improve understanding of the 2007–2009 Global Financial Crisis and continuing vulnerabilities of the global financial network. Financial innovations derived from subprime mortgages diffused over a highly interconnected global network of financial institutions, with incorrectly priced risks of massive defaults when speculative bubbles in real-estate burst. Formal network models and historical evidence indicate that increasing connectivity in financial networks may reduce contagion by dispersing risks, absorbing shocks, and dissipating disturbances. However, if the magnitude of liabilities moves beyond certain a threshold or tipping-point, interconnectedness increases the likelihood of cascading financial contagion. More basic research is necessary on the structures and dynamics of the global financial network to improve model realism and applications, for example, in performing system stress tests to assess the likelihood of future financial crises.*

**Keywords:** *social networks, diffusion of innovation, contagion, financial crisis, derivatives, real estate bubble, credit squeeze, subprime mortgage, bank bail out.*

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## ТАНЕЦ ПРОДОЛЖАЕТСЯ: КАК ГЛОБАЛЬНЫЕ ФИНАНСОВЫЕ СЕТИ ПРИВЕЛИ МИРОВУЮ ЭКОНОМИКУ НА ГРАНЬ КАТАСТРОФЫ И МОГУТ ВЫТОЛКНУТЬ ЕЕ ЗА ЭТУ ГРАНЬ

*Сетевой подход позволяет углубить понимание глобального финансового кризиса 2007–2009 гг. и природу сохраняющейся хрупкости глобальной финансовой сети. Финансовые инновации, связанные с низко-*

*качественными ипотечными кредитами, распространились в глобальной сети финансовых институтов, обладающей высокой связанностью, и привели к неверной оценке рисков крупных дефолтов при разрыве спекуляционных пузырей в недвижимости. Формальные сетевые модели и исторический материал показывают, что увеличивающаяся связанность в финансовых сетях может снизить заражение за счет дисперсии рисков, абсорбирования шоков и диссипации негативных воздействий. Однако если удельный вес задолженностей превысит определенный порог или переломную точку, существующий уровень связанности увеличит вероятность каскадных финансовых заражений. Необходимо более глубокое исследование структур и динамики глобальной финансовой сети для повышения реалистичности модели и ее приложений, например, в проведении тестов на устойчивость системы для проверки вероятности будущих финансовых кризисов.*

***Ключевые слова:*** *социальные сети, диффузия инноваций, заражение, финансовый кризис, деривативы, пузырь на рынке недвижимости, кредитное сжатие, низкокачественный ипотечный кредит, критическое положение банков.*

> “When the music stops, in terms of liquidity, things will be complicated.
> But as long as the music is playing, you’ve got to get up and dance.
> We’re still dancing.”
>
> Charles Prince, CEO of Citigroup
> *Financial Times* (July 10, 2007)

Wall Street giant JPMorgan Chase revealed in May, 2012, that it had lost at least $2 billion in just six weeks from trades intended to lessen its risk profile. Later reports suggested the losses might total $9 billion. JPMorgan’s investment trading group had placed bullish bets on investment-grade corporate debt trades but insufficiently hedged against losses with bearish bets on high-yield securities using credit-default swaps. In a conference call, CEO Jamie Dimon blamed the losses on “many errors, sloppiness, and bad judgment. ... These were egregious mistakes, they were self-inflicted” (Childs and Harrington 2012). JPMorgan was reducing its hedge, he said, “but in hindsight, the new strategy was flawed, complex, poorly reviewed, poorly executed and poorly monitored.” The fiasco evoked disturbing memories of the Global Financial Crisis, just four years earlier, in which cascading failures among large Wall Street institutions brought the U.S. and other national economies close to collapse. Although subsequent regulatory reforms sought to constrain banks from making proprietary bets with their own money, Dimon’s *mea culpa* was a stark reminder that many giant financial institutions appear still too big to manage and too big to fail.

The 2007–2009 Global Financial Crisis was triggered by a complex set of events and trends — a “perfect storm” of trends converging into a massive global credit squeeze that severely damaged the world economy. Journalists, government investigators, and academic analysts afterward identified several contributing factors that emerged over many years (Cohan 2009; Sorkin 2009; McLean and Nocera 2010; Financial Crisis Inquiry Commission 2011). Chief among the causes were:

**(1) Easy credit conditions**. After the 2000 dot.com stock market bubble, the U.S. Federal Reserve tried to avoid a deflationary spiral by lowering interest rates to historically low levels. The Tax Reform Act of 1986, by retaining tax deductions for mortgage interest on homes but not on consumer debts, encouraged cash-out refinancing of home mortgages. Consumer debts rose to exorbitant levels.

**(2) Lax regulatory mechanisms**. The Glass-Steagall Act, which separated commercial (depository) banking from investment banking, was repealed in 1999, allowing the same financial institution to both lend and invest, setting up potential conflicts of interest. The Clinton Administration pressured Fannie Mae and Freddie Mac, government-sponsored underwriters in the secondary mortgage market, to boost homeownership by low- and middle-income families. To sustain profit growth, Fannie and Freddie weakened their underwriting standards to compete with private-sector mortgage companies in lending to borrowers unqualified for conventional loans. The fees of credit-rating agencies, which assess the risks of securities, were paid by the security issuers, an inherent conflict of interest fostering inaccurate valuations.

**(3) Real-estate bubbles**. Easy credit and steadily rising housing prices activated construction booms in Ireland, Spain, and U.K. and the U.S., leading to bubbles by the early 2000s (Figure 1). Perceptions that housing prices would increase indefinitely motivated speculators to take mortgages in expectation of subsequently selling at high profits. Predatory mortgage companies fraudulently wrote vast quantities of subprime mortgages for people unlikely to make repayments once their adjustable-rate loans reset at higher interest rates. Many colluded in "liar loans" that made no attempt to verify borrowers' incomes.

**(4) Expanded shadow banking systems**. Nonbank lenders — investment firms, hedge funds, insurers, money market funds — grew to rival conventional depository banks, but were largely unregulated and much less transparent. Most paid their senior managers huge salaries and bonuses, encouraging unwarranted risk-taking in pursuit of profits. Many firms recklessly engaged in risky but poorly understood financial innovations.

**(5) High-risk financial innovations**. Financial institutions created complex mortgage-backed securities, described in detail in the next section. Their values were premised on steadily rising home prices and reliable mortgage repayments, but their underlying risks were difficult to price. Investor overconfidence combined with greedy dreams of extraordinary wealth to fuel a gigantic securitized bubble.

In the midst of the Great Depression of the 1930s, John Maynard Keynes cautioned against speculation becoming the dominant economic force: "When the capital development of a country becomes a by-product of the activities of a casino, the job is likely to be ill-done" (Keynes 1936). His warning seemed prophetic 70 years later when unsustainable housing bubbles began bursting. As accelerating numbers of subprime borrowers defaulted on their mortgage payments, investor losses mounted. Uncertain about which financial institutions had sufficient assets to cover liabilities, banks stopped making short-term loans. With credit drying up, home and commercial construction ceased, consumers cut back on purchases, and the real economies of many countries fell into recession. Governments bailed out their nations' financial sectors and implemented emergency fiscal and monetary policies to prevent the ensuing Great Recession from tumbling into a second Great Depression.

A social network perspective can improve our understanding of the 2007–2009 Global Financial Crisis and continuing vulnerabilities of the global financial system. Two key dynamics were involved. First, financial innovations derived from subprime mortgages diffused over a highly interconnected network of financial institutions, with incorrectly priced risks of massive defaults when speculative bubbles in real-estate burst. Second, as toxic mortgage defaults spread, an amplifying liquidity shock swiftly cascaded through the interdependent interbank lending network, freezing credit for real economies. The following sections examine these two network dynamics in detail and the next section considers how social network analysis might help to mitigate future financial follies.

## Diffusion of Derivatives

A *derivative* is a financial instrument whose value is based on (is derived from) an underlying security, such as a stock or bond; a physical asset, such as an agricultural or mineral commodity; a market index; or foreign currency exchange rate. A derivative is a legal contract stating a seller's promise to convey ownership of an underlying asset to a purchaser under specified conditions. For example, an options contract gives the owner the right to buy or sell an asset at a set price on or before a future date. Other major types of derivatives are futures, forwards, and swaps (McLean and Nocera 2010: 53). Derivatives are tools for transferring risk, enabling one party to minimize risks while offering potential high returns at greater risk to a counterparty. An investor seeking protection from unpredictable market fluctuations locks in a fixed price and pays a fee to a counterparty who assumes that risk. If the price rises, the counterparty makes a profit; but, if the price falls, the counterparty loses. In turn, the counterparty often seeks to hedge (reduce) its risk with offsetting trades to additional counterparties. The resulting complex network of derivative trades creates a credit market, but the lack of transparency about connections among all the counterparties generates systemic uncertainty and potentially under-prices the true credit risks.

The emergence and rapid growth in counterparty risks of financial institutions was a key component in the Global Financial Crisis of 2007–2009 (Gregory 2010). Wall Street banks and securities firms created innovative *asset-based securities* whose values derived from underlying mortgages, that is, homeowners' debts. *Collateralized debt obligations* (CDO) consisted of multiple risk-classes (tranches) of home loans that carried diverse degrees of risk, ranging from triple-A ratings to the lowest-rated subprime mortgages (McLean and Nocera 2010: 119-122). CDOs paid investors in sequence depending on how much income accrued from loan repayments. If insufficient cash were generated, the lowest tranches would lose value first. Wall Street investment banks like Bear Stearns, Lehmann Brothers, Merrill Lynch, and Goldman

Sachs bought tens of billions of dollars worth of subprime loans generated from mortgage originators like Countrywide Financial and Ameriquest. They bundled these high-risk assets into CDOs along with less-risky loans and aggressively resold them to insurers, pension funds, and other investors searching for better returns. The proliferating packages were further "sliced, diced then re-bundled for onward sale. As these marketable instruments passed between participants, the network chain lengthened" (Haldane 2009: 7). Intended as strategies for reallocating and reducing risks through diversification, these complex derivative transactions ultimately created much uncertainty about the actual locations and real values of the underlying assets.

Credit-rating agencies (Moody's, Standard & Poor's) certified CDOs with their highest ratings, but failed to take accurately into account the possibility that home prices might collapse and subprime mortgage holders would default on their loans. Another big player was American International Group (AIG), an insurance corporation that sold large volumes of *credit default swaps* (CDS) on CDOs, a form of insurance to protect the mortgage lending companies against home loan defaults. AIG received premiums from the CDS buyers, who would be paid only if the CDOs declined in value because the underlying mortgage holders had defaulted on their loan repayments. Unfortunately, AIG failed to hedge adequately against potential declines in the housing market. Meanwhile, the CDS market attracted speculators who "shorted" (bet against) firms in the CDO market, believing the bubble would burst (Lewis 2010).

Global markets for derivatives grew exponentially in the decade leading up to the Global Financial Crisis (see Figure 2). Among several factors analysts cited for this rapid expansion are abandonment of fixed exchange rates, market volatility, regulatory avoidance, computerized program trading, increasing financial sophistication, even legitimization of derivatives by finance professors (Scalcione 2011). Network diffusion models offer another explanation for the derivative adoption decisions by banks, hedge funds, investment companies, and other financial institutions. The *diffusion of innovation* is "the process by which an innovation is communicated through certain channels over time among the members of a social system" (Rogers 1983: 5). Network diffusion models assume "behavioral contagion through direct network ties" (Valente 1996: 85). Network connections promote the diffusion of innovations by three basic egocentric network mechanisms, involving an ego actor (e.g., a bank) and the set of alter actors (other financial institutions) to which ego is directly connected. (1) Direct ties: the probability of ego adopting the innovation increases as its alters' adoptions reach a threshold. (2) Indirect ties: ego's probability of adoption can be increased by weak ties that involve bridges to diverse sources of favorable information about the innovation. (3) Vicarious learning: Ego either mimics or avoids the actions taken by *structurally equivalent* others; that is, the subset of actors with identical or highly similar ties to all others in the network. In the financial sector, structurally equivalent banks are competitors; for example, Wall Street firms keep an eye on one another's activities. In observational learning theory, a sequential adoption hypothesis asserts that "following the behavior of other similarly-situated decision makers can be a very useful strategy in adoption situations in which there is a great deal of uncertainty" (Browne and Walden 2011). All three mechanisms apparently were involved in the diffusion of derivative innovations that preceded the Global Financial Crisis.

A small, closed network disposed Wall Street bankers and firms to view CDOs and similar asset-based derivatives as legitimate and safe innovations. A neoinstitutional analysis by Pozner et al. (2010: 183) noted that "over-embeddedness of central actors within relatively closed networks and superstitious learning processes can exacerbate the biases to which decision makers are susceptible, leading to the institutionalization of a sub-optimal organizational practice." The convergence of competitive, normative, and mimetic pressures created a "dense, clique-like network of co-located institutions" whose members viewed the finance sector from a homogeneous perspective. Increased network cohesion and growing structural equivalence created an unquestioning consensus regarding the low risks of the new financial instruments. High network density induced conformity to a single mind-set, enabling the swift diffusion of highly profitable but eventually dysfunctional subprime mortgages and securitized derivatives. By imitatively adopting a uniform approach to securitization and risk management, banks increased connectivity of the global financial network, making it more dense and complex, but also making it more homogenized and fragile:

> Banks' balance sheets, like Tolstoy's happy families, grew all alike. So too did their risk management strategies. Financial firms looked alike and responded alike. In short, diversification strategies by individual firms generated a lack of diversity across the system as a whole. (Haldane 2009: 8)

Bankers were collectively myopic in disregarding early warning signs of a looming catastrophe, for example, the nationwide fall in U.S. home prices starting in 2006. The Wall Street network lacked structural holes across which diverse, discordant, and challenging information could travel. As early as 2003, Warren Buffett described derivatives as "financial weapons of mass destruction carrying dangers that, while now latent, are potentially lethal" (Buffett 2003: 15). But, the Oracle of Omaha's warnings fell on deaf ears. Instead, going along with the Wall Street crowd sustained everyone's fantasies of spectacular wealth. In Chuck Prince's now-infamous metaphor, "as long as the music is playing, you've got to get up and dance."

Formal network analyses of interorganizational relations provide further evidence of structural vulnerabilities in the finance sector. The global financial network "shows high connectivity among the financial institutions that have mutual share-holdings and closed loops involving several nodes. This indicates that the financial sector is strongly interdependent, which may affect market competition and systemic risk and make the network vulnerable to instability" (Schweitzer et al. 2009: 424). Data on ownership ties among 1,318 transnational corporations (TNCs) revealed a strongly connected component; that is, every firm directly or indirectly owned shares in every other firm:

> In detail, nearly 4/10 of the control over the economic value of TNCs in the world is held, via a complicated web of ownership relations, by a group of 147 TNCs in the core, which has almost full control over itself. The top holders within the core can thus be thought of as an economic 'super-entity' in the global network of corporations. A relevant additional fact at this point is that 3/4 of the core are financial intermediaries. (Vitali et al. 2011: 6)

These financial institutions have lending or credit derivative contracts with one another, which “allows them to diversify risk, but, at the same time, it also exposes them to contagion” (p. 7). That exposure led to the second network dynamic in the Global Financial Crisis, financial contagion.

**Financial Contagion**

Although financial contagion can occur through several mechanisms, network effects from defaults in the interbank lending market were strongly implicated in the Global Financial Crisis (Haldane 2009). An *interbank lending market* is the foundation of an efficiently functioning financial system. It facilitates the trading of *liquid assets* (cash, money market shares, U.S. Treasury securities), whose prices are determined openly and transparently. U.S. financial institutions — commercial and retail banks, savings and loan associations, investment banks — readily lend to one another to meet the daily legally requirements for reserves set by the Federal Reserve. Banks with insufficient liquid assets to satisfy those requirements — for example, due to large depositor withdrawals or a high volume of home loan activity — can borrow from other banks with excess liquidity, typically paying interest at low overnight rates. Interest rates are lower for banks than other customers because high trust and confidence among financial institutions permits interbank loans not secured by collateral (Cecchetti and Schoenholtz 2011). Many financial institutions also depend on short-term borrowing to buy and hold large inventories of securities with longer maturities (stocks, bonds, asset-backed derivatives) and they rely on the interbank market when selling those instruments. Under usual circumstances, complex webs of transactions constitute the global financial network through which vast volumes of liquid funds flow unimpeded.

But, a high density of ties among participants makes that network vulnerable to stresses and disruptions. Like infectious illness epidemics starting with a “patient zero,” financial contagion often arises when a “liquidity shock” at one or a few banks spreads rapidly and widely among interconnected institutions in the financial sector. An initial trigger might be a single institution’s failure to meet its interbank liabilities, forcing the sale of its assets at heavily discounted (fire sale) prices to pay its creditors. A bank’s inability to repay its borrowings produces losses at the creditor banks to which it is linked. “Contagious defaults occur if the losses on the exposures to the defaulting bank exceed the capital of a creditor. Since every default weakens the surviving bank, this could lead to a cascade of bank failures, resembling a chain of domino pieces” (Upper 2007: 1). Spreading failures undermine general confidence in other banks perceived as occupying structurally equivalent positions in the network. Uncertainty about bank insolvencies (negative balance between assets and liabilities) compel the remaining creditor banks to refuse to keep lending, even at much higher interest rates for shorter periods. Instead, fearful but rational bankers hoard liquid assets for their own anticipated needs, drying up available funds sought by floundering banks. A vicious circle — successive waves of reduced interbank lending, rising loan costs, plummeting confidence, and bank failures cascading across the financial sector — generates a credit squeeze that soon impacts the real economy as production and consumption collapse. Whether a financial contagion erupts into a systemic liquidity crisis, or quickly dampens out, depends greatly on the structure of the global financial network. The following two subsections review research on formal contagion models and historical evidence from empirical cases, providing some network analytic insights for the third subsection on why contagion in the Global Financial Crisis was so catastrophic.

### Model Simulations

During the past decade, finance economists working at central banks and universities have studied financial contagion by constructing formal network models and simulating structural effects by varying model parameters (e.g., Pericoli and Sbracia 2003; Leitner 2005; Battiston et al. 2009; Hurd and Gleeson 2011; Martinez-Jaramillo et al. 2012). The possibility of contagion depends on credit exposures in the interbank network, with some types of structures amplifying and others dampening the propagation of liquidity shocks. Allen and Gale (2000) constructed a simple four-bank model of interbank depository relations with varying interconnectedness (Figure 3). They demonstrated that a shock in some network structures results in contagion, but the same shock in other structures does not. In a completely connected network of symmetric risk exposures (3A), where the amount of interbank deposits held by each bank is evenly spread over the three others, a liquidity shock to one bank is absorbed because all banks bear a small portion of the shock. “Better-connected networks are more resilient because the proportion of losses in one bank’s portfolio is transferred to more banks through interbank agreements” (Allen and Babus 2009: 370). But, risks are less dispersed in other network structures. In an incomplete network (3B), where banks are connected to fewer counterparties, an amplifying shock is more likely to spread contagiously through the system. Disconnected networks (3C) are also contagion-prone but they prevent a shock from spreading to all banks in the system.

Nier et al. (2007) used random graph theory to examine the role of direct interbank connections as sources of systemic risk and the potential for “knock-on defaults” created by interbank exposures to risk. In their model, four key parameters affected system resilience to contagious defaults: the number of banks (10 to 25), net worth as percentage of total assets, percentage of interbank assets in total assets, and the probability of any two banks being connected (varying from 0 to 1.00). In experimental simulations that varied one parameter at a time, they found that contagion was a nonmonotonic function of the number of interbank connections: “When the level of connectivity is low, an increase in the number of links increases the chance of contagious defaults. However, when connectivity is already high, a further increase in the number of links increases the capacity of the system to withstand shocks” (p. 2054). And more concentrated banking systems are more prone to systemic breakdowns – “as the number of banks decreases, each bank becomes big enough to make a significant impact on the rest of the system” (p. 2046). Gai and Kapadia (2010) applied their model to a simulated network with 1,000 banks in which default contagion spread through two channels: direct contagion via the interbank lending network and indirect contagion in which "distress at some financial institutions on asset prices can force other financial entities to write down the value of their assets" (p. 2401). Their simulations revealed that financial systems have a "a *robust-yet-fragile* tendency: while the probability of contagion may be low, the effects can be extremely widespread when problems occur" (p. 2403). In a highly connected network, losses of a defaulting bank are more widely dispersed and absorbed by others, but high connectivity increases the probability that any banks surviving an initial round of defaults will be exposed to more than one defaulting counterparty at subsequent rounds.

Haldane and May (2011) discussed a stylized "toy model" in which a bank fails if liquidity shock wipes out external assets exceeding its capital reserves ($\gamma$). If the failed bank's z creditors losses exceed $\gamma$, these banks in turn fail, propagating a third shock phase, and so on. But, a failing bank's losses are divided among its z creditors, which attenuates each loan-driven shock wave by a factor of z. Haldane and May (p. 353) identified three processes that may amplify or dampen the propagation of a liquidity shock through the system:

(1) If initial shock is to external assets, the system's fragility is maximized by having net worth values intermediate between 0 and 1, which "in some ways very roughly corresponds to banks substantially engaged in both retail and investment (high-street and casino) activity. ... an increase in the system's connectivity, z, causes the region of instability to shrink; high connectivity distributes, and thereby attenuates risk."

(2) Shock propagation arises from losses in external asset values, "caused by a generalized fall in market prices, a rise in expected defaults, or a failing bank's 'fire sale' actions. ... In all cases and in sharp contrast to the attenuation in interbank loan shocks, liquidity shocks amplify as more banks fail." Relatively small initial shocks potentially create strong systemic risk.

(3) Diminished availability of interbank loans, often by liquidity hoarding in interbank funding markets, cascades through a banking network as one bank calls in loans or shortens the terms, and affected banks in turn do likewise. "The result is a liquidity-hoarding shock that is not subject to the attenuation characteristic of interbank default shocks."

Finally, summarizing 15 studies simulating contagion in the interbank market, Upper (2011: 111) concluded that "contagious defaults are unlikely but cannot be fully ruled out, at least in some countries. If contagion does take place, then it could lead to the breakdown of a substantial fraction of the banking system, thus imposing high costs to society."

Formal models generally indicate that increasing connectivity in financial networks may reduce contagion by dispersing risks, absorbing shocks, and dissipating disturbances. However, if the magnitude of liabilities moves beyond a certain threshold or tipping-point, interconnectedness increases the likelihood of cascading financial contagion. "The system acts not as a mutual insurance device but as a mutual incendiary device" (Haldane 2009: 9). This robust-yet-fragile quality of a financial network may explain why, after prolonged swelling of real estate bubbles in which subprime mortgage risks had supposedly been dispersed and diminished, their sudden bursting produced such devastating consequences for the global financial network.

## Empirical Investigations

Some researchers applied social network methods in empirical investigations of financial systems. Three analyses identified increasing interconnectedness in the global financial network as a key factor in financial contagion. One study examined bilateral cross-border bank lending among 184 countries from 1978 to 2009 (Minoiu and Reyes 2011). The network was “relatively unstable”, having “structural breaks in network connectivity and centrality, and documented volatile interconnectedness rankings for countries, especially borrowers” (p. 18). Density rose and fell following cycles of capital flows, while connectivity diminished during and after crises. The Global Financial Crisis of 2008-09 stood out as “an unusually large perturbation to the cross-border banking network” (p. 3). A partition analysis of banking groups in 21 nations, which measured the ease of transmitting stress among banks in clusters, found structural changes in the network from 1985 to 2009 (Garratt et al. 2011). Increased interconnectedness of banks’ claims on one another raised the potential for global financial contagion, in which liquidity shocks hitting one part of the system could be transmitted to the rest. The researchers combined cluster analysis of relational data to identify modules (clusters) of nations and measures of the probability of contagion, to assess how financial stress might amplify or dampen:

> In the late 1980s four important financial centres formed one large supercluster that was highly contagious in terms of transmission of stress within its ranks, but less contagious on a global scale. Since then the most influential modules have become significantly smaller and more broadly contagious. The analysis contributes to our understanding as to why defaults in US sub-prime mortgages had such large global implications. (Garratt et al. 2011: 2).

Galina Hale (2011) analyzed the global network of syndicated loans among 7,938 bank and nonbank institutions in 141 nations from 1980 to 2009 and the effects of recessions and crises on financial ties. The network grew more dense, more clustered, and less symmetrical, “all of which is likely to have increased its fragility and potential for contagion” (p. 33). Network structure changed with business cycles and “during recessions in the United States, clusters tend to become less common in the network, while the span of the network tends to shrink” (p. 5). The global financial network appeared more sensitive to banking crises than to mundane recessions, while “during country-specific recessions or banking crises past relationships become more important as few new relationships are formed” (p. 7). Banking relations were vulnerable and responsive to economic and financial shocks. A vicious structural dynamic transpired, with banking crises spreading faster in concentrated networks and crises accelerating network concentration. Increasing connectivity starting in the late 1990s suggested “a possibility that this increased density, if indeed associated with higher fragility and greater liquidity needs, could be partly responsible for the dramatic propagation of the global financial crisis” of 2007-09 (p. 5). Although recessions seemed to encourage new loans, particularly from central to peripheral nations, banks grew very cautious about lending during that crisis, making almost no new network connections in 2009.

## Contagion in the 2007–2009 Crisis

Analyses of more than 300 historical crises spanning 800 years in 66 countries — encompassing banking, external debt, and domestic debt crises — found several common conditions preceded these crises, including: massive current-account and trade deficits; asset price inflation, particularly real-estate bubbles; mounting household leverage and falling output; and financial liberalization and innovation (Reinhart and Rogoff 2009). The United States and several other countries exhibited most these conditions prior to the Global Financial Crisis of 2007–2009. Moreover, cross-border contagion apparently spread via network connections:

> Without doubt, the U.S. financial crisis of 2007 spilled over into markets through direct linkages. For example, German and Japanese financial institutions (and others ranging as far as Kazakhstan) sought more attractive returns in the U.S. subprime market ... Indeed, after the fact, it became evident that many financial institutions outside the United States had nontrivial exposure to the U.S. subprime market. This is a classic channel of transmission of contagion, through which a crisis in one country spreads across international borders. (Reinhart and Rogoff 2009: 242)

The trigger for contagion in the Global Financial Crisis of 2007–2009 was the bursting of the U.S. housing bubble. Home prices peaked nationally in mid-2006 and declines accelerated in 2007. As subprime mortgage holders begin defaulting in early 2007, walking away when their home loan payments ballooned, 50 loan originators, including New Century Financial and American Home Mortgage, declared bankruptcy. The infection spread rapidly to other financial institutions. In July 2007, Bear Stearns announced the bankruptcy of two hedge funds heavily invested in mortgage-backed securities. A month later, France's BNP Paribus closed two hedge funds exposed to the sub-prime mess. Central banks of the U.S., Canada, European Union, Japan, and Australia started to inject money to keep their credit markets afloat. In September 2007, Northern Rock suffered the UK's first depositor run in 150 years and was subsequently taken over by the national government. In March 2008, hedge funds skeptical of Bear Stearns' liquidity pulled out their money; after the Federal Reserve granted an emergency loan, JPMorgan Chase agreed to buy Bear for $2 a share. Major commercial bank IndyMac collapsed — to be followed shortly by Washington Mutual and Wachovia — and the U.S. government seized control of federal mortgage insurers Fannie Mae and Freddie Mac. On September 15, 2008, investment bank Lehmann Brothers filed for the largest bankruptcy in American history when the U.S. Treasury refused to bail it out. The next day, after credit-rating agencies downgraded giant insurer AIG, the Federal Reserve gave it an $85 billion loan, motivated by fear that its "failure under the conditions prevailing would have posed unacceptable risks for the global financial system and for our economy" (Bernanke 2009). Congress and President Bush enacted a $700 billion Troubled Assets Relief Program (TARP) to stabilize financial markets by recapitalizing large financial institutions, while the Federal Reserve provided another $900 billion in short-term lending. But, by that time, lasting severe damage had already been done to many real-world economies.

**Foiling Future Follies**

The global financial network was too interconnected to avert the catastrophic crisis of 2007–2009 as real-estate bubbles burst around the world. Contagious defaults rippled through the interbank lending market, taking down overextended institutions and forcing governments to implement drastic actions to prevent a Second Great Depression. In hindsight, knowledge of both formal network models and historical precedents might have sensitized regulators and policymakers to the looming disaster. An important, but still unlearned, lesson from the Global Financial Crisis is the need for better network data collection, analysis, and interpretation. Social network analytic methods could assist in assessing risks and suggesting structural changes that might reduce the magnitude of future calamitous contagions. More basic research is necessary on the structures and dynamics of the global financial network to improve model realism and precision. For example, earlier assumptions that banks lend directly to one another are supplanted by two-tier or center-periphery models in which money center banks act as intermediaries in the interbank lending network (Freixas et al. 2000; Craig and von Peter 2010; van Lelyveld and in 't Veld 2012). These analyses could help to pinpoint which banks are most crucial to system stability.

Social network analysis could make an important contribution to the conducting of financial system stress tests. During the bank bailouts following the Global Financial Crisis, the Federal Reserve and other industry regulators required the 19 largest remaining U.S. bank holding companies to undergo stress tests to determine how much capital resources they would need to survive in a deep recession and global economic slowdown. (Similar stress tests were conducted by the European Banking Authority and the Committee of European Banking Supervisors.) Each institution estimated its potential losses, in loan and securities portfolios and other liabilities, under a baseline and a more adverse economic scenario. In May 2009, the stress test results showed that 10 of the 19 banks would need to raise almost $75 billion in capital to absorb additional losses if the Great Recession worsened (Ellis 2009). However, the stress tests applied only to each U.S. institution's conditions, not to the entire global financial network (for a description of the methodology, see Federal Reserve 2012). "Stress-testing to date has focused on institutional, idiosyncratic risk. It needs instead to focus on system-wide, systemic risk" (Haldane 2009: 23). Ultimately, stress test methods could be expanded to collect data and construct models incorporating network-level processes, using measures such as bank degree distributions and path distances as diagnostic tools for evaluating systemic robustness and fragility. Running stress simulations with contemporaneous data would assess whether the global financial network had grown more or less susceptible to contagious defaults. Results might help to identify structural positions whose breakdown could pose dangers to the world and national economies. Test results could enable regulators and policymakers to decide whether and where to intervene to head off a crisis, or at least reduce the severity of its impacts. Central bank actions targeting specific institutions revealed as potential sources of liquidity shocks might prove more effective in dampening contagion than widely injecting rescue funds after a crisis is well underway. However, as Christian Upper (2011: 111) cautioned, contagion models are still too simplistic to be used for stress testing, cost benefit analysis, or crisis management "primarily due to their lack of behavioral foundations." Whether such foundations will ever be laid can only be resolved through further research and development.

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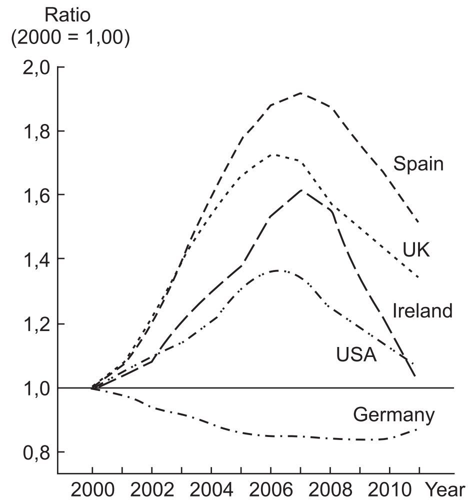



*Figure 1. House prices changes in five nations with 2000 = 1.000*

Source: OECD Economic Outlook No. 91, Statistics and Projections (database)

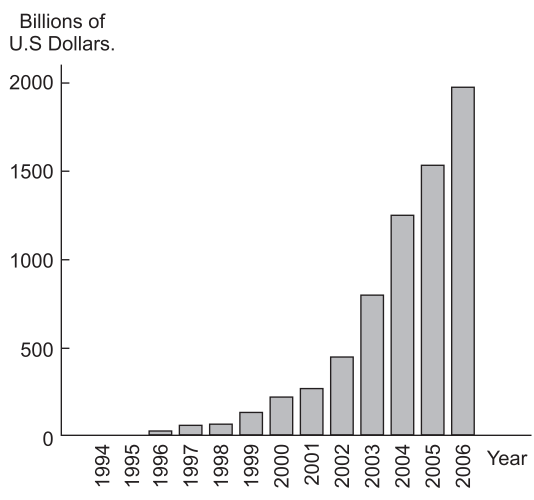
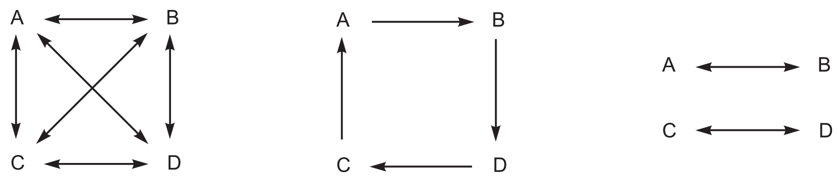



*Figure 2. Estimated Size of the Global Collateralized Debt Obligations Market, 1994–2006*

Source: Celent [http://www.celent.com/reports/collateralized-debt-obligations-market].




3A. Complete market structure    3B. Incomplete market structure    3C. Disconnected incomplete market structure

*Figure 3. Interbank networks of four banks with varying interconnectedness*

Source: Allen and Gale (2000).