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Structural Reform as Anitidote to Complexity Capture

Robert Weber

Structural Regulation as Antidote to Complexity Capture

Robert F. Weber*

The [structural] approach rejects the idea that some institutions should be allowed to become "too important to fail". Instead of asking who should perform what regulation, it *asks why we regulate banks*. It draws a clear distinction between different activities that banks undertake. The banking system provides two crucial services to the rest of the economy: providing companies and households a ready means by which they can make payments for goods and services and intermediating flows of savings to finance investment. Those are the utility aspects of banking where we all have a common interest in ensuring continuity of service.[1]

An accepted principle of system design is to avoid complexity and tight integration of different components or interfaces. Complexity is the enemy of both reliability and security, engineers are fond of saying. *The more complex the system, the greater the chance of the unexpected interaction of components, even when they are not faulty in themselves. A truly complex system may be impossible to fully comprehend*, and the unexpected interactions may not appear for a very long time . . . .[2]

INTRODUCTION

This article proposes a new way of thinking about the ways in which financial market complexity threatens the future viability of financial regulation. Much of the contemporary discussion of "complexity" in financial markets suffers from a lack of definitional clarity. This article examines financial complexity in the context of the ample literature on complexity

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[1]Mervyn King, Governor, Bank of Eng., Speech to the Scottish Business Organizations 6 (Oct. 20, 2009), *available at* http://www.bankofengland.co.uk/publications/speeches/2009/speech406.pdf (emphasis added).

[2]Charles Perrow, The Next Catastrophe 260 (3d ed. 2011) (emphasis added).

from the physical and social sciences that has, to date, been underappreciated in law and economics scholarship. According to this physical and social science literature, "complexity" means something more than "very complicated" or "difficult to understand."

Increasingly complex forms of social organization, such as the contemporary global financial system, threaten the theoretical justifications and the everyday practices of the administrative state. For the better part of the last fifty years, the administrative state has struggled to justify its existence in the face of two traditional lines of attack: (1) a political uproar over the perceived excesses of regulatory red tape[3] and (2) the academic "public choice" critique—from both the Left and the Right—that regulators are "captured" by industry, which purchases favorable public policy from regulators in exchange for private benefits such as later employment.

Yet in the financial regulatory arena, administrative law's problems run deeper still. Regulators, like all agents charged with tasks, are limited by their bounded rationality;[4] in other words, they possess limited capacities to process information, maintain their attention, and calculate.[5] While to some extent bounded rationality is endemic in the regulatory context because regulators are not operating the business concerns "on the ground," there are reasons to believe the problem is qualitatively different for contemporary financial regulators. These regulators face a structural,

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[3]The former is evident in the 112th Congress's efforts to pass the REINS Act, which would require significant regulations and rules to be presented before and approved by Congress before going into effect, in the process erecting a presumption of invalidity against regulatory action. *See* Regulations from the Executive in Need of Scrutiny Act of 2011, H.R. 10, 112th Cong. (2011); Editorial, *Undermining the Executive Branch*, N.Y. TIMES, Dec. 5, 2011, at A26 ("In a nutshell, the bill would stop any major regulation issued by a federal agency and costing more than $100 million from taking effect unless it received approval from both houses of Congress and the president."). On December 7, 2011, the House of Representatives passed the REINS Act, but the current Senate is not expected to pass the bill. Felicia Sonmez, *REINS Bill to Expand Congressional Power over Executive Regulations Passed by House*, 2CHAMBERS (Dec. 7, 2011, 5:38 PM), http://www.washingtonpost.com/blogs/2chambers/post/reins-bill-to-expand-congressional-power-over-executive-regulations-passed-by-house/2011/12/07/gIQAs6VMdO_blog.html.

[4]*See infra* notes 35–36 and accompanying text (describing the concept of bounded rationality).

[5]These limitations operate independently of funding shortfalls, and would exist, albeit to a lesser degree, even under an adequately funded regulatory regime.

widening epistemic gap between what they are able to know and what they need to know in order to administer the statutory mandates of their agencies. This epistemic gap results from dramatic increases over the past two decades in the complexity of the markets and institutions regulators are charged with overseeing. New research by complexity scientists has begun to reveal many ways in which financial institutions transact in markets that are authentically complex, rather than merely complicated or difficult to understand.[6] These complex markets are susceptible to unpredictable and nonlinear phase transitions, positive feedback effects, "normal accidents," complexity catastrophes, and conflicting constraints.[7] The regulatory toolkit has changed little in response to these new uncertainties and unpredictable threats; in the meantime, however, regulators' responsibilities have become more difficult by orders of magnitude.

This plays out in problematic ways in the financial regulation context. If financial markets are indeed complex rather than merely complicated, then the statutory mandates of regulatory agencies—the most important of which involve the promotion of systemic financial stability and the safety and soundness of individual institutions—need to be reevaluated. In conditions of complexity, bounded rationality emerges as less of an obstacle to be overcome and more of a structural impediment to the achievement of regulatory objectives. To the extent regulators rely on industry itself to provide the information they require to make a good-faith effort at performing their mandates, they risk *complexity capture*—a soft, hegemonic capture of even virtuous, public-regarding regulators who are resistant to traditional capture efforts by

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[6]Even within the academic community, dozens of definitions of complexity are present. *See* John Horgan, *From Complexity to Perplexity*, Sci. Am., June 1995, at 104, 106 (noting that a physicist affiliated with the Santa Fe Institute counted "at least 31" definitions of complexity as of 1995); *infra* Parts II.C, II.D.2 (summarizing or citing to complexity-related research conducted by physicists, philosophers, economists, biologists, anthropologists, and sociologists). Because complex systems are defined by their unpredictability and resistance to simplifying assumptions, it might be objected that "complexity science" is a contradiction in terms, and that "complexity studies" might be more accurate. *See* John H. Miller & Scott E. Page, Complex Adaptive Systems: An Introduction to Computational Models of Social Life 4 (2007) (describing the "science of complexity" as "an obvious misnomer"). In any event, the lack of consensus as to a fixed definition of the term evidences the fecundity of the research programs under the complexity umbrella.

[7]*See infra* Parts II.C, II.D.

industry.[8] The alternative might be worse still: to ratchet up the granularity of prescriptive rules in an attempt to counteract or temper every emergent property of the financial system that might increase risk or uncertainty, in the process rendering the regulatory system more opaque, arbitrary, and complex in its own right.

But the choice between arbitrary regulation and complexity capture is avoidable. This article promotes a model of structural regulation—as opposed to behavior-based or conduct-based regulation—as an antidote to the complexity conundrum. By ramping back the complexity of those elements of the financial system that regulation is designed to protect, such as savings aggregation and payment system facilitation, lawmakers can give regulators concrete and achievable mandates. But reformers have largely eschewed *structural* reform and instead fixated on implementing their mandates through a reactive and highly particularized system of *behavioral* regulation designed to counteract industry's incentives to assume socially unacceptable levels of risk. Since, as I will show, regulators lack the basic information necessary to administer such a system, they have delegated core regulatory functions to industry. The result is increased complexity capture and regulatory dysfunction.

Part I sets the theoretical framework out of which the notion of complexity capture arises. It synthesizes the traditional public choice account of regulatory capture with the law and economics literature on agency costs. According to the public choice theorists, regulators are bought off by industry in exchange for private benefits such as future employment. The public, of course, suffers from these private arrangements, but is beset by collective action problems that prevent it from becoming informed and organizing opposition. These straightforward observations link up nicely with the theory of agency costs. Of particular importance here is the basic tenet that agency costs increase as it becomes more difficult for citizen–principals to monitor their regulator–agents.

Part II presents the article's main argument regarding how increased complexity in financial markets has created complexity capture and regulatory dysfunction. It begins in Part II.A by introducing how boundedly

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[8]Not only would this hypothetical subset of regulators be immune to temptations to exploit their offices for pecuniary gain, it would also pursue earnestly its delegated responsibilities without embracing conciliation as a result of distaste for confrontation. *See* Ian Ayres & John Braithwaite, Responsive Regulation 80, 90 (1992) (discussing how capture might be explained in part by a desire for a "smoothly running work life" and distaste for confrontation).

rational regulators struggle to promote their statutory mandates during changing circumstances—even those that are not characterized by complexity. As noted earlier, traditional regulatory capture theory focuses on the difficulties of citizen–principals monitoring their regulator–agents. But when regulators struggle with bounded rationality in complex environments, they often come to rely on industry for information in the pursuit of their statutory mandates. This creates a significant, and to date underappreciated, problem: under these circumstances, *industry becomes an agent of the regulators* and a new set of agency costs emerges in the form of complexity capture.[9] When charged with regulating markets characterized by complexity, regulators face the unenviable choice of either subjecting themselves to complexity capture or avoiding excessive reliance on industry-provided information and implementing a system of increasingly particularized, but arbitrary and perhaps illegitimate, regulatory commands. Part II.B ties this theoretical discussion to the specific context of contemporary financial regulation by briefly outlining the statutory mandates with which Congress has charged U.S. financial regulators.

Part II.C summarizes what it means for systems to be "complex." Complexity theory, in the physical and social sciences, comprises several wide-ranging research programs, but certain of its attributes are especially relevant to financial regulation. In particular, Part II.C focuses on how (1) the prevalence of positive feedback effects in complex systems prevents them from settling into stable equilibrium states; (2) network effects can cause complex systems to slip into catastrophe in ways that defy ex ante prediction; and (3) following the work of Charles Perrow, the coexistence of interactive complexity and "tight coupling" of system components results in "normal accidents"—that is, breakdowns in order characterized equally by inevitability and unpredictability.

Part II.D explains why, in many respects, contemporary financial markets can be thought of as complex systems by providing a qualitative assessment of the financial system's network topology and summarizing some recent computer-based experimental research demonstrating the complexity of financial markets. If the contemporary financial system is indeed characterized by complexity, then the system's structure might

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[9]These agency costs should be thought of as a measurement of the extent to which actual regulatory policy and enforcement diverges from what it would be under conditions of better information.

result in the emergence—that is, the development of attributes that are impossible to discern ex ante by observing the behavior of individual actors within the system—of negative externalities such as systemic risk. Most of the legal and economic scholarship devoted to systemic risk inquires into traditional microeconomic issues such as the moral hazard resulting from government safety nets. Though this incentive- and behavior-related scholarship is critically important, recent events and research suggest that the network structure of the financial system merits more attention as a regulatory problem than it currently receives. Once financial system behavior is considered through the lens of complexity theory, the operational challenge to financial regulation emerges in full relief. This analysis suggests a conclusion that many commentators miss, but which is critical to the argument this article presents—the inherent unpredictability of the behavior of complex financial markets might exacerbate the bounded rationality problem to such a degree that it constitutes a structural impediment to the achievement of regulatory objectives. The viability of public regulatory control may be at stake.

Having elaborated on the threat posed by complexity capture, I next turn in Part III to potential solutions. This part describes differences between structural regulation and behavioral regulation, and explains how policy makers have largely opted for the latter, even though by doing so they preserve the conditions where complexity capture is likely to persevere. While the behavioral–structural binary is certainly not the only way to analyze financial regulatory tools and systems, its emphasis on structure holds special promise in addressing the problem of complexity capture, which arises in large part out of the network structure of contemporary financial markets. I propose that structural reform, by directly adjusting the topologies of the networks through which the business of finance is conducted, can pare back complexity and protect the core functions of finance from complexity capture. In the wake of the financial crisis of 2008–2009, two sets of reform packages illustrate the consistent preference for behavioral regulation over structural regulation, despite the presence of several serious structural reform proposals. First, the capital adequacy regime embodied in the Basel III Framework makes minor, reactive adjustments to the risk-weighting rules applicable to bank assets, but leaves in place the general infrastructure that outsources the assessment of risk to regulated banks and rating agencies on the grounds that their assessments are perceived to be more accurate than any prescriptive regulatory methodologies. Second, lawmakers and regulators

have begun to require large, systemically important financial institutions to prepare and discuss with regulators so-called "living wills." Living wills are designed to counteract the tendency to bail out insolvent institutions during times of market distress by setting forth in advance the steps by which an institution will be resolved—that is, wound up—in an orderly manner if it becomes insolvent. Lawmakers perceived correctly that orderly and efficient resolution of insolvent institutions will limit contagion, but lacked confidence in regulators' ability to impose effective plans on large, interconnected institutions. However, the reliance on the regulated firms themselves to prepare the living wills undercuts the likelihood of the initiative's success.

In the cases of capital requirements and living wills, policy makers and regulators have continued to respond to complexity through behavioral regulatory tools that delegate primary responsibilities to industry. Far from confronting the challenges posed to financial regulators by increased complexity, these reforms are precisely the sort of regulatory techniques that are susceptible to complexity capture and regulatory dysfunction. Instead, I argue for increased focus on promoting structural regulatory reforms to build a more resilient financial system.

I. A SYNTHESIS OF TRADITIONAL THEORIES: REGULATORY CAPTURE AND AGENCY COSTS

The purpose of financial regulation is to correct market failures that result in the inefficient or socially suboptimal allocation of resources. These market failures reflect shortcomings of purely private market orderings comprised of transactions among self-interested parties. A privately ordered market outcome can be said to have "failed" if it does not achieve a given socially desirable outcome or objective, which can be purely economic, such as Kaldor-Hicks efficient capital allocation,[10] or predominantly non-economic, such as ensuring that the sick can obtain health insurance by prohibiting coverage denials based on preexisting

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[10]*See* RICHARD A. POSNER, ECONOMIC ANALYSIS OF LAW 12–15 (7th ed. 2007) (describing Kaldor-Hicks economic efficiency as the criterion that a transaction makes at least one person better off by an amount greater than the amount that would be required to compensate third parties who are worse off as a result of the transaction).

conditions.[11] To remedy the failure, the administrative state intervenes to promote outcomes that the market is unable to achieve on its own. The optimal amount of regulation promotes the regulatory objective up to the point where the marginal social benefits of regulation equal the marginal private costs of the regulation.[12] In that way, private parties are made to bear the external costs of their actions. When regulators are captured by industry, they are less able to promote this optimal balance, and the regulatory logic is reversed; industry acquires private benefits at the expense of other societal groups that have not captured the regulator, such as smaller competitors, credit card customers, retail merchants, depositors, insurance policyholders, and even—if bailouts are likely—taxpayers at large.

Because regulatory capture theory looks at regulators' incentives as primary units of inquiry, it can be illustrated through the use of agency theory.[13] According to the traditional two-part agency model of public administration, regulators are agents of the polity charged with correcting market failures. For example, the regulatory agents of the New Deal administrative state were technical experts that conceived of and implemented the "best" solutions to problems.[14] They became expert in modern forms of social life—such as financial markets—in which the polity, whose citizens are busy with their own specializations, could not possibly become

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[11]*See* Daniel A. Farber & Philip P. Frickey, Law and Public Choice: A Critical Introduction 34 (1991) ("Cost-benefit analysis cannot be the only standard for evaluating government decisions. For technical reasons, cost-benefit analysis—or more specifically, the underlying standard of economic efficiency—cannot be applied until a prior decision is made about how to distribute social entitlements."); Susan Rose-Ackerman, *Putting Cost-Benefit Analysis in Its Place: Rethinking Regulatory Review*, 65 U. Miami L. Rev. 335, 338 (2011) (noting that regulatory attempts to correct market failures with economically efficient regulation often end up raising "deep philosophical questions" requiring consideration of distributive effects of regulation in addition to the efficiency-related effects).

[12]*See* Jonathan Gruber, Public Finance and Public Policy 136–38 (2005).

[13]Ernesto Dal Bó, *Regulatory Capture: A Review*, 22 Oxford Rev. Econ. Pol'y 203, 207 (2006).

[14]*E.g.*, Felix Frankfurter, The Public and Its Government 123–67 (1930); Cass R. Sunstein, Free Markets and Social Justice 285 (1997); *see also* Jody Freeman, *The Private Role in Public Governance*, 75 N.Y.U. L. Rev. 543, 558 (2000) (describing faith of "public interest theory" exponents in expert agencies to master technical problems); Orly Lobel, *The Renew Deal: The Fall of Regulation and the Rise of Governance in Contemporary Legal Thought*, 89 Minn. L. Rev. 342, 371 (2004) ("During the New Deal era, a key feature of the organization of law and order was the commitment to centralized, institutional decision-making authorities relying on professional, official expertise.").

expert.[15] New Deal architect James Landis compared regulators to corporate managers, who are charged with the task of using their industrial expertise to "build[] a system which . . . may more nearly approximate a given desideratum."[16] The New Deal administrative state can therefore be said to respond to a corporate logic, in addition to its political-legal attributes that receive more attention in the legal literature.

Corporate law scholars are well familiar with the costs and benefits of delegating to an agent the performance of tasks that require the exercise of the agent's discretion. Adolph Berle, Jr. and Gardiner Means described the new industrial logic of Fordist mass production, which required firms to seek (1) large-scale investment capital more readily obtained from public equity markets than from retained earnings and founding entrepreneurs[17] and (2) a new class of managers that, unlike most founding entrepreneurs, had expertise in increasingly differentiated and specialized fields. Thus, ownership separated from control, leading to the emergence of a class of manager–agents acting on behalf of passive, capital-providing shareholder–principals.[18] These manager–agents could exploit their positions of control and consume perquisites at the expense of the shareholder–principals.

This capital-intensive, specialized mass production system was more efficient in many respects than the previous era, but it created a tax on firm

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[15]*Cf.* James M. Landis, The Administrative Process 23 (1938) ("With the rise of regulation, the need for expertness became dominant; for the art of regulating an industry requires knowledge of the details of its operation . . . .").

[16]*Id.* at 13.

[17]The National Bank Act, the McFadden Act, and the Glass-Steagall Act compelled industrial firms to seek capital in public markets because those laws prevented the formation of large financial intermediaries capable of providing the required sums of capital to finance large-scale industrial projects. *See* Mark J. Roe, Strong Managers, Weak Owners: The Political Roots of American Corporate Finance 3–7, 21–25, 54–59, 94–100 (1994).

[18]*See* Adolph A. Berle, Jr. & Gardiner C. Means, The Modern Corporation and Private Property 3–10, 17, 66–67, 112–15 (2d ed. 1968); *see also* Stephen M. Bainbridge, *The Politics of Corporate Governance*, 18 Harv. J. L. & Pub. Pol'y 671, 672 (1995) (book review) ("Important technological changes during the decades preceding publication of [*The Modern Corporation and Private Property*], especially the development of modern mass production techniques, gave great advantages to firms large enough to achieve economies of scale, which in turn gave rise to giant industrial corporations. These firms required enormous amounts of capital, far exceeding the resources of any single individual or family. Only the aggregation of many smaller investments, accomplished by selling shares to investors, could finance these industrial giants." (footnotes omitted)).

profitability in the form of agency costs, which are the incremental costs of having an agent perform a task on behalf of a principal. In 1976, Michael Jensen and William Meckling formalized in economic terms the problem that Berle and Means had identified decades earlier: total agency costs are the sum of (1) the monitoring costs expended by the principal to limit misappropriations by the agent, (2) the bonding expenditures by the agent to demonstrate loyalty, and (3) the residual loss in the form of self-serving behavior on the part of the agent.[19] Simplifying somewhat, it will be advantageous to the principal to incur monitoring and bonding costs for so long as those costs diminish the residual loss by a greater amount. In the regulatory context, the residual loss refers to the divergence from optimal regulatory policy resulting from regulators' pursuit of their private preference sets at the expense of their regulatory responsibilities.

As a precondition to any effective monitoring of regulator–agents, affected regulatory constituencies need to adequately inform themselves regarding regulated events. The monitoring costs result from the need to acquire, process, and distribute relevant information. Armed with that information, affected groups are better able to police the exercise of regulatory discretion. But a constituency's ability to become informed about events affecting it depends on the complicatedness and salience of the regulated events and the degree of dispersion of the constituency's membership. An understanding of complex transactions in, and obscure corners of, financial markets is often prohibitively expensive.

As an example, consider the plight of concerned taxpayers or small-business credit users who fear the federal banking regulators are not adequately supervising the solvency of a bank. In most industries, the issues giving rise to similar worries would be policed by shareholders and counterparties, but limited shareholder liability, federal deposit insurance, and special super-priority protections that survive in conservatorship dull or eliminate the incentives of these parties to monitor the bank's solvency. Thus, the regulator's role is to supervise the bank and prevent it from taking socially unacceptable levels of risk that could result in bailouts and taxpayer losses or contagion throughout the financial system. Regulators have countless tools to use in exercising this supervisory responsibility, and taxpayers and small business owners have incentives to monitor the

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[19]*See* Michael C. Jensen & William H. Meckling, *Theory of the Firm: Managerial Behavior, Agency Costs, and Ownership Structure*, 3 J. Fin. Econ. 305, 308 (1976).

regulators to ensure they are doing their job. However, taxpayers and small business owners face prohibitively high information costs when it comes to assessing complicated matters such as the optimal level at which regulators should set banks' Tier 1 capital requirement.[20] Further, when the affected constituency is widely dispersed and its membership continually changing—as is the case with small-business credit users, other financial services consumers, and certainly taxpayers—consumer advocacy organizations, journalists, interest groups, and academics incur still more costs to distribute and present the information to constituents in a readily comprehensible way. These further costs are simply the result of the collective action problem that forms the backbone of public-choice scholarship.[21]

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[20]Tier 1 capital consists of those sources of a bank's capital base that are perceived to be of high quality, including, most prominently, common equity. *See* Basel Comm. on Banking Supervision, Basel III: A Global Regulatory Framework for More Resilient Banks and Banking Systems 5 (2010) [hereinafter Basel III Framework], *available at* http://www.bis.org/publ/bcbs189.pdf. Even bank regulation experts have wide disagreements as to the correct answer to the question of the optimal level of Tier 1 capital requirements. In theory, the answer depends on the optimal trade-off between the marginal decrease in systemic risks and bailout costs on the one hand and the marginal increase in banks' cost of capital (and resulting price increases for services) on the other hand. Daniel K. Tarullo, Banking on Basel: The Future of International Financial Regulation 26–27 (2008). It is at once a highly political and highly technical conundrum on which regulators and experts themselves disagree. *See* Anat Admati et al., *Healthy Banking System Is the Goal, Not Profitable Banks*, Fin. Times, Nov. 9, 2010, at 8 ("If . . . at least 15% . . . of banks' total, non-risk-weighted, assets were funded by equity, the social benefits would be substantial."); Editorial, *Time Finally to Make Banks Safe*, Fin. Times, Feb. 1, 2011, at 10 (noting that David Miles of the Bank of England has commented that socially optimal capital ratios might be as much as double the ratios embodied in the Basel III Framework's capital rules to be implemented by 2019); Anat Admati et al., *Fallacies, Irrelevant Facts, and Myths in the Discussion of Capital Regulation: Why Bank Equity Is* Not *Expensive* 57–59 (Stanford Working Paper, 2011) [hereinafter Admati et al., *Fallacies*], *available at* http://www.nber.org/public_html/confer/2011/CFs11/Admati.pdf (suggesting that capital levels of twenty to thirty percent *on an unweighted basis* should not be "unthinkable" and describing capital levels of ten percent "should be seriously considered and thought of as feasible"); Morris Goldstein, *Integrating Reform of Financial Regulation with Reform of the International Monetary System* 6–7 (Peterson Inst. Int'l Econ. Working Paper No. 11–5, 2011), *available at* http://www.iie.com/publications/wp/wp11-5.pdf (claiming that market-induced minimum capital at the bottom of the credit cycle was eight percent of total assets, which, combined with the seven percent of total assets that was wiped out during the crisis, suggested that a required capital ratio of fifteen percent of total assets is appropriate).

[21]*See* David A. Skeel, Jr., *Public Choice and the Future of Public-Choice-Influenced Legal Scholarship*, 50 Vand. L. Rev. 647, 657–59 (1997) (reviewing Maxwell L. Stearns, Public Choice and Public Law: Readings and Commentary (1997)).

Collective action problems and the complicatedness of the regulatory arena can cause the costs of monitoring regulators to increase well beyond the marginal social utility that the monitoring would promote.[22] Where monitoring proves ineffective, the only way to limit the residual loss is to increase bonding expenditures. The traditional response of administrative law has been to impose bonding costs—in the form of antibribery statutes,[23] mandatory recusal for regulators,[24] asset divestiture requirements,[25] postservice employment industry restrictions,[26] judicial review,[27] rotating personnel requirements,[28] and other similar restrictions on agency discretion[29]—to counteract regulators' tendency to exploit their positions by pursuing private preferences at the expense of their delegated responsibilities. These devices aim to redirect regulators' incentives away from private

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[22]If affected regulatory constituencies—in the above example including taxpayers and small business owners—were rational actors, they might incur the bonding costs to avoid the massive knock-on effects of a rash of bank insolvencies on unemployment, gross domestic product, and other economic metrics. *See* Carmen M. Reinhart & Kenneth S. Rogoff, This Time Is Different: Eight Centuries of Financial Folly 223–39 (2009). But monitoring will occur only if the ex ante perceptions of loss avoidance are sufficiently high, which is unlikely, if not impossible, where a credit bubble is developing.

[23]*See, e.g.*, 18 U.S.C. § 201 (2006) (criminalizing, among other things, the receipt by U.S. "public officials" of bribes and illegal gratuities).

[24]*See, e.g.*, Sudeep Reddy, *Fed Tightens Rules on Regional Directors*, Wall St. J., Nov. 27, 2009, at A6 (reporting on the Federal Reserve Board's (FRB's) amended conflict of interest rules in response to controversy over the chairman of the board of the Federal Reserve Bank of New York (N.Y. Fed.) at the time, Stephen Friedman, receiving a waiver from then-existing rules that would have prevented him from holding Goldman Sachs shares, which he eventually sold, while he was a member of the N.Y. Fed. board).

[25]*E.g.*, 5 C.F.R. § 6801.103(a) (2011) (prohibiting FRB employees from holding any debt or equity interests in banks, bank affiliates, and securities firms).

[26]*See, e.g.*, 12 U.S.C. § 1812(e) (2006) (imposing a two-year postservice window within which outgoing members of the Federal Deposit Insurance Corporation (FDIC) board of directors who did not serve their full terms may not be employed by a bank).

[27]*See* 5 U.S.C. § 702 (2006) ("A person suffering legal wrong because of agency action, or adversely affected or aggrieved by agency action within the meaning of a relevant statute, is entitled to judicial review thereof.").

[28]*See, e.g.*, Peter Grabosky & John Braithwaite, Of Manners Gentle: Enforcement Strategies of Australian Business Regulatory Agencies 198 (1986).

[29]*See generally* Rachel E. Barkow, *Insulating Agencies: Avoiding Capture Through Institutional Design*, 89 Tex. L. Rev. 15 (2010) (discussing these and other "equalizing factors" or features of institutional design in administrative law that check capture of regulators).

aggrandizement and towards earnest pursuit of their statutory mandates. They are costly because they restrict the talent pool of individuals willing to serve as regulators and might also limit flexible regulatory action that would otherwise better promote regulatory objectives. Moreover, no matter how thoughtfully and subtly designed, the bonding mechanisms will not counteract every potential abuse and the regulator–agents will be able to exercise some discretion to satisfy personal preferences at the expense of statutory regulatory objectives, particularly if the complicatedness of the regulated arena frustrates ex ante bonding mechanism design.

Thus, regulators are free to exercise their discretion where they can act outside the watching eye of the polity—in other words, the monitoring expenditures are inadequate—and without fear of legal censure—in other words, the bonding mechanisms are not comprehensive. Some theorists have referred to this freedom-to-operate as "slack."[30] The problem of slack can be conceptualized from the opposite direction, as an opportunity for regulators to bribe industry in exchange for keeping the polity in the dark about undesirable industry behavior and not elevating such behavior onto the public regulatory agenda.[31]

Regulatory capture theories founded in neoclassical economics assume regulators are individual "rational actors" seeking to utilize their position, or consume slack, to realize their personal preference sets. But there are reasons to resist the global categorization of regulators in the fashion of *homo economicus*. Regulators' choices are only sometimes determined by those first-order, self-regarding preferences that neoclassical economics predicts—such as later employment,[32] favorable returns on investments in regulated industries, or political support. At other times, their preferences are ideological or psychic and might even operate to the

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[30]*See* Michael E. Levine & Jennifer L. Forrence, *Regulatory Capture, Public Interest, and the Public Agenda: Toward a Synthesis*, 6 J. L. Econ. & Org. 167, 179 (1990).

[31]*Cf.* Jean Tirole, *Hierarchies and Bureaucracies: On the Role of Collusion in Organizations*, 2 J. L. Econ. & Org. 181 (1986) (exploring the role that collusion plays in three-part agency relationships, particularly with respect to agents bribing supervisors not to report suboptimal efforts to principals).

[32]*See* Michael Lewis & David Einhorn, *The End of the Financial World as We Know It*, N.Y. Times, Jan. 4, 2009, at WK9 (reporting that recent Securities and Exchange Commission (SEC) enforcement directors have gone on to employment at Deutsche Bank, JPMorgan Chase, Morgan Stanley, and Credit Suisse and noting that a "casual observer could be forgiven for thinking that the whole point of landing the job as the S.E.C.'s director of enforcement is to position oneself for the better paying one on Wall Street").

financial detriment of the regulator. But even adopting this more nuanced view of regulators' motivations to include ideological commitments, civic virtue, and moral principles—the satisfaction of which can, as with any preferences, itself be cast in microeconomic terms—requires consideration of the pressures that interest groups (in this case, industry) bring to bear in their attempts to direct administrative action away from the policies of Landis's disinterested experts.

While this discussion of regulatory capture and agency cost theory provides a useful model to evaluate the downside of delegating functions to self-regarding or ideological regulators, it assumes that the regulators themselves are able to consume slack by exploiting the gap between their understanding and that of their constituents. That assumption does not always hold. Sometimes regulators—even those virtuous regulators committed to public-regarding agendas and policies—are captured before they even know it.[33] In the process, industry becomes the agent of the regulators and appropriates the residual loss for itself. Even more troublingly, the residual loss may even increase inasmuch as it affects public-regarding regulators too.

II. How Complexity Capture Frustrates Regulatory Objectives in Financial Markets

This Part describes the central problem this article confronts: how increasing complexity in financial markets might threaten to undermine attempts at regulatory control of the financial sector. The traditional theory of regulatory capture is premised on expert regulators pursuing self-regarding goals at the public's expense. However, as described in Part II.A, under conditions of complexity regulators may find themselves in situations where they lack the basic access to information on which to exercise their discretion in a rational manner, whether to pursue self-regarding profit or their public-regarding regulatory goals. Regulators' bounded rationality becomes the defining characteristic of the regulatory program.

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[33]*Cf.* Wendy E. Wagner, *Administrative Law, Filter Failure, and Information Capture*, 59 Duke L.J. 1321, 1326, 1332 (2010) (noting that "information capture"—defined as a "system that puts the decisionmaker at the mercy of an unlimited flood of information from an unopposed group"—can be "[e]ven more insidious" than traditional capture, because "under the right circumstances capture will take place even if the dominant participants are not trying to manipulate the system").

At that point regulators might be tempted to rely on industry to provide them with information, which results in a form of complexity capture that in some respects is more insidious inasmuch as it affects all regulators and not merely those susceptible to traditional capture.

Any analysis of the effectiveness of regulation or the prevalence of capture must start with an accounting of what the regulatory objectives are. Part II.B provides a summary of certain of the key responsibilities with which bank regulators are charged. In the United States, chief among these responsibilities is the promotion of systemic financial stability and the safety and soundness of individual institutions. The achievement of these objectives, which requires an understanding of the events giving rise to and transmitting instability, is complicated by several degrees of magnitude as our understanding of the financial system transforms from a simple, predominantly equilibrium-based model to a complexity model. Next, Part II.C addresses a lacuna in the argument presented thus far by linking the notion of complexity capture directly to the growing research program of complexity science, with particular attention to the importance of positive feedback mechanisms, network effects, and " normal accidents." Part II.D summarizes some recent experimental research showing that financial markets do in fact have attributes of complex systems and discusses the implications of this complexity for financial regulation.

A. The Problem of Regulators' Bounded Rationality

The traditional regulatory capture story assumes that regulators understand the markets they regulate. It relies on the New Deal model of the expert regulatory agency in possession of superior knowledge to that of the public. If regulators did not understand markets, they would be unable to identify slack and exploit it. Once we relax this assumption to take account of regulators' considerably bounded rationality, it becomes necessary to construct a three-part agency model by introducing industry into the regulator–polity relationship discussed above.

No matter how complex or straightforward a regulated market is, its regulators will always rely to some extent on industry to provide them with information on risks that threaten to frustrate the regulators' delegated responsibilities. In other words, there is always an epistemic gap between what regulators know and what they would optimally know to best effectuate their delegated responsibilities. Max Weber recognized this organizational dilemma: "[T]hose who continuously participate in the

market intercourse with their own economic interests have a far greater rational knowledge of the market and interest [in the] situation than the legislators and enforcement officers whose interest is only ideal."[34]

Economists would refer to this epistemic gap as evidence of regulators' bounded rationality. Herbert Simon coined the term "bounded rationality" to refer to the limited capacities to process information, keep attention, and calculate that economic actors bring to bear in making their economic decisions.[35] In other words, humans are "intendedly rational, but only limitedly so."[36] According to Charles Lindblom's more colorful formulation, "The human condition is small brain, big problems."[37] Whereas the "economic man" of canonical microeconomics maximizes his utility by choosing the optimal solution among a set of options, in the real world all we can do is "satisfice," by which Simon means that we accept courses of action that are just "good enough."[38] In coming to our decisions, we utilize heuristics to facilitate our limited computational abilities in light of the dizzying amount of available information.[39] At best, we can say that economic actors try to make good decisions based on the information and abilities they have, which is a far cry from claims that economic actors weigh *all* available information and formulate an optimal decision.

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[34]MAX WEBER, ON LAW IN ECONOMY AND SOCIETY 38 (Max Rheinstein ed., Edward Shils & Max Rheinstein trans., 1967).

[35]*See* HERBERT A. SIMON, ADMINISTRATIVE BEHAVIOR: A STUDY OF DECISION-MAKING PROCESSES IN ADMINISTRATIVE ORGANIZATIONS xxviii–xxxi (3d ed. 1976); Herbert A. Simon, *Introduction*, in ECONOMICS, BOUNDED RATIONALITY AND THE COGNITIVE REVOLUTION 3, 3 (Massimo Egidi & Robin Marris eds., 1992); *see also* Michael P. Dooley, *Two Models of Corporate Governance*, 47 BUS. LAW. 461, 464 (1992) (describing Simon's bounded rationality as referring to the "psychoneurological limits of the human mind to process information—hence, the limitations on human ability to plan and to solve complex problems"). Simon had discussed the concept of bounded rationality for decades before he coined the term. *See, e.g.*, Herbert A. Simon, *A Behavioral Model of Rational Choice*, 69 Q. J. ECON. 99, 99 (1955) ("Broadly stated, the task is to replace the global rationality of economic man with a kind of rational behavior that is compatible with the access to information and the computational capacities that are actually possessed by organisms, including man, in the kinds of environments in which such organisms exist.").

[36]OLIVER E. WILLIAMSON, THE ECONOMIC INSTITUTIONS OF CAPITALISM 45 (1985) (internal quotation marks omitted).

[37]CHARLES E. LINDBLOM, POLITICS AND MARKETS: THE WORLD'S POLITICAL-ECONOMIC SYSTEMS 66 (1977).

[38]*See* SIMON, *supra* note 35, at xxix.

[39]*See id.*

This discussion of bounded rationality ties into the agency cost model.[40] If the virtuous, public-regarding regulators with which this article is primarily concerned were not boundedly rational, they would be able to implement regulatory regimes that pursued their agencies' statutory objectives in an optimal manner; there would be no ambiguity about the fit between the rules and regulations on the one hand and the market ordering that resulted from those rules and regulations on the other hand.[41] Agencies could devote their limited resources to supervision and enforcement.

As markets become more dynamic and complex, bounded rationality and its attendant agency costs increasingly frustrate attempts to implement an optimal regulatory regime. Under these circumstances, regulators themselves incur significant information costs to make use of their positions at all—whether for ideological or self-regarding consumption of slack, or for pursuit of the regulators' statutory mandates.[42] This dilemma is implicit in regulatory practice; Richard Stewart identified it as a structural impediment to effective regulation over three decades ago:

> Regulated interests have a further advantage in all phases of decisionmaking because the information upon which the agency must ultimately base its decision must come to a large degree from the groups being regulated. . . . It is therefore not surprising that there is a tendency for agencies to rely unduly on facts and arguments advanced by regulated firms.[43]

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[40]*See* Stephen M. Bainbridge, The New Corporate Governance in Theory and Practice 89–104 (2008) (discussing that collective decision-making entities like corporate boards can limit agency costs by constraining tendencies of individuals to, among other things, shirk their duties as a rational response to their bounded rationality).

[41]These hypothetical optimal regulatory regimes would be the public law analog to private law's equally aspirational complete contracts—that is, contracts that specify courses of action for every possible contingency. *See* Paul Milgrom & John Roberts, Economics, Organization and Management 160 (1992) ("Because real people are only *boundedly rational*, complete contracts that specify what they will do in every conceivable circumstance are impossible to negotiate and write.").

[42]*See* Christoph Knill & Andrea Lenschow, *Modes of Regulation in the Governance of the European Union: Towards a Comprehensive Evaluation*, *in* The Politics of Regulation: Institutions and Regulatory Reforms for an Age of Governance 218, 231 (Jacint Jordana & David Levi-Faur eds., 2004) (noting that "in cases of highly detailed regulation," the "regulated industry itself is the best source of . . . information," which "gives the industry a degree of leverage over regulatory arrangements which, in the extreme case, might lead to capture").

[43]Richard B. Stewart, *The Reformation of American Administrative Law*, 88 Harv. L. Rev. 1667, 1713–15 (1975); *cf.* Mark Seidenfeld, *Bending the Rules: Flexible Regulation and Constraints on*

Around the same time, Charles Lindblom noted that "because every person in high authority needs information, he comes to be in some degree a captive of knowledge specialists."[44] But more and more frequently regulators find themselves in the position of the Coast Guard inspector who noted, during congressional testimony about the BP oil spill, that "[t]he pace of technology has definitely outrun the regulation."[45] In a complex operating environment, bounded rationality inhibits regulatory practice and industry can operate without meaningful monitoring by regulators. This freedom to operate, which might be labeled "industrial slack,"[46] is potentially more detrimental to regulatory goals because it affects regulators of all preference sets—whether purely virtuous and public-regarding or venal and rent-seeking.

When charged with regulating an industry characterized by complexity, regulators face a structural dilemma: they can either conduct regulatory policy by, in effect, guessing at what optimal rules and enforcement would be, or they can delegate their duties to industry itself.[47] This problem currently pervades financial regulation. The former approach risks arbitrariness and lacks legitimacy, and the latter exposes the regime to massive agency costs as regulatory practice diverges from

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Agency Discretion, 51 Admin. L. Rev. 429, 464 (1999) ("[F]irms in regulated industries . . . occupy a favored position in regulatory and political structures that allows them the advantage in influencing agency decisions [because they] . . . often have information without which a regulatory agency cannot do its job." (footnote omitted)).

[44]Lindblom, *supra* note 37, at 120.

[45]Richard H. Thaler, *Recipes for Ruin, in the Gulf or on Wall St.*, N.Y. Times, Jun. 13, 2010, at BU4 (quoting a Coast Guard inspector).

[46]*Cf.* Levine & Forrence, *supra* note 30, at 185 (labeling regulators' freedom to operate outside of the public's watchful eye as "slack").

[47]Even assuming trenchant market complexity and the absence of meaningful structural reform to combat it, financial regulators wield a third option: public bailouts of private firms whose complexity poses spillover risks to the rest of the financial sector and economy. I proceed on the assumption that public bailouts are an unacceptable ad hoc regulatory tool. But, as amply illustrated by the trillion-dollar bailouts in the United States and the United Kingdom during 2008–2009, regulators and legislators might invest public funds to prop up insolvent institutions to preserve the ongoing functioning of the financial system. It should be borne in mind that the bailout problem, like the twin threats of arbitrary regulation and complexity capture discussed above, is born out of complexity. To the extent complexity frustrates regulatory control over the largest, most complex firms, and concomitantly creates conditions for bailouts or complexity capture, those firms will guard their complexity as a key source of competitive advantage.

optimal implementation of regulatory objectives. The latter approach, in particular, results in what might be termed complexity capture—a softer, hegemonic regulatory capture that makes regulators behave as if they were captured because they are following industry's lead. This is not to say that industry understands complex markets significantly better than regulators. However, when complexity causes a financial crash, industry can fall back on the excuse that they were taking marching orders from the constituency to which they are accountable: their shareholders, whose attitude is ambivalent to the complexity-risk nexus. After all, shareholders stand to gain in the lead-up to a crash in the form of higher-than-normal returns due to higher leverage. Regulators, by contrast, have no such luxury, as their marching orders from Congress are ambitious and do not admit the possibility of occasional shirking.[48]

Figure 1 below illustrates how complexity capture differs from traditional regulatory capture:
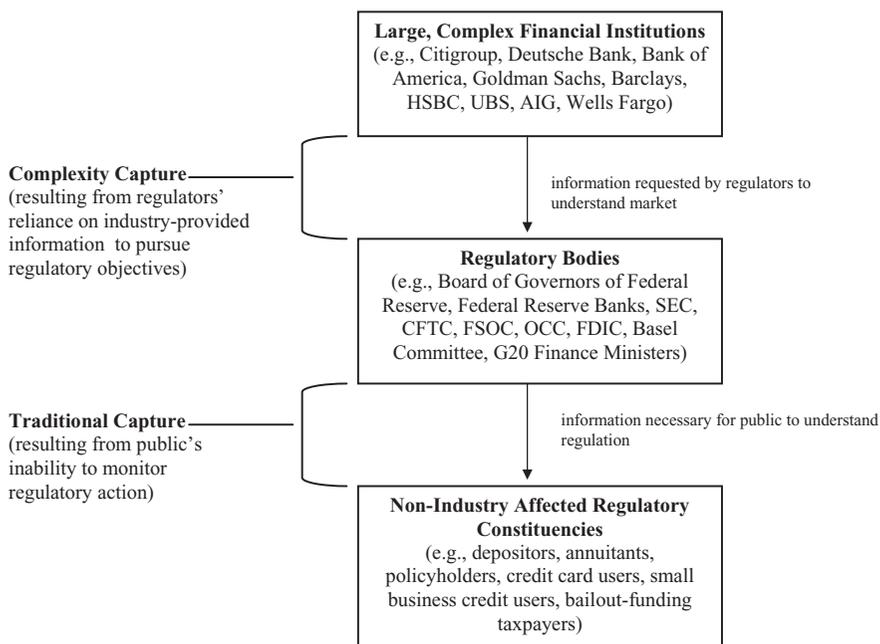

Large, Complex Financial Institutions
(e.g., Citigroup, Deutsche Bank, Bank of America, Goldman Sachs, Barclays, HSBC, UBS, AIG, Wells Fargo)

Complexity Capture
(resulting from regulators' reliance on industry-provided information to pursue regulatory objectives)

information requested by regulators to understand market

Regulatory Bodies
(e.g., Board of Governors of Federal Reserve, Federal Reserve Banks, SEC, CFTC, FSOC, OCC, FDIC, Basel Committee, G20 Finance Ministers)

Traditional Capture
(resulting from public's inability to monitor regulatory action)

information necessary for public to understand regulation

Non-Industry Affected Regulatory Constituencies
(e.g., depositors, annuitants, policyholders, credit card users, small business credit users, bailout-funding taxpayers)

Figure 1. How Complexity Capture Differs from Traditional Capture.

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[48]*See infra* Part II.B.

But before assessing how complexity frustrates the statutory objectives of financial regulators, two clarifications are in order: it is necessary, first, to individuate what those objectives are and, second, to provide much-needed definitional clarity on what it means for a market to be "complex" in the first place.

B. *Static Goals in Shifting Sands: Statutory Objectives of Financial Regulators*

The statutory supervisory mandates of bank regulators are wide-ranging and ambitious. For example, the FRB is charged with supervision of (1) holding companies that contain a depository institution,[49] (2) state banks that are members of the Federal Reserve System,[50] and, (3) since the passage of the Dodd-Frank Act in 2010, nonbank financial institutions that are judged to be systemically important by the newly formed Financial Stability Oversight Council (FSOC).[51] The holding company supervisory responsibilities include, most prominently, examining the financial and operational risks that might pose a threat to either (1) the safety and soundness of any depository institution within the holding company structure[52] or (2) the stability of the financial system in the United States.[53] Its supervisory responsibilities with respect to state member banks consist of

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[49]*See* 12 U.S.C. § 1467a (2006) (setting forth FRB responsibilities in the regulation of thrift holding companies); *id*. § 1844 (setting forth FRB responsibilities in the regulation of bank holding companies).

[50]*See id*. § 1813(q)(3) (listing the FRB as the "appropriate Federal banking agency" for these and certain other categories of banking institutions). The supervisory responsibilities with respect to foreign bank branches operating in the United States are spread among the FDIC, the FRB, and the Office of the Comptroller of the Currency (OCC). *See id*. § 1813(q).

[51]*See* Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010, Pub. L. No. 111–203, § 112(a)(2)(H), 124 Stat. 1376 (directing the FSOC to "require supervision by the [FRB] for nonbank financial companies that may pose risks to the financial stability of the United States in the event of their material financial distress or failure, or because of their activities pursuant to section 113"); *id*. § 113 (authorizing the FSOC to subject nonbank financial companies to FRB supervision and prudential standards); *id*. §§ 161–171 (authorizing FRB to subject nonbank financial companies designated by FSOC to FRB's reporting, capital, and examination requirements, as well as heightened prudential standards and certain restrictions on affiliation, management interlocks, and acquisitions).

[52]For a description of safety and soundness generally, see RICHARD SCOTT CARNELL ET AL., THE LAW OF BANKING AND FINANCIAL INSTITUTIONS 251–308 (4th ed. 2009).

[53]*See* 12 U.S.C.A. § 1844(c)(2)(A)(i)(II) (West Supp. 2011).

monitoring the safety and soundness of the individual institutions. The OCC and the FDIC have safety and soundness supervisory responsibilities with regard to, respectively, national banks and state banks that are not members of the Federal Reserve System.[54] For these regulators, safety and soundness is viewed in the context of the institution as a whole and is restricted only "by its limitation to practices with a *reasonably direct effect* on an [institution's] financial soundness."[55] In a report to Congress during consideration of the 1966 legislation vesting bank regulators with the authority to issue cease-and-desist orders to banks engaging in "unsafe or unsound practice[s]," then-chairman of the Federal Home Loan Bank Board, John Horne, underscored the difficulty of promoting the fixed goal of safety and soundness in the ever-changing banking business:

> The concept of "unsafe or unsound practices" is one of general application which touches upon the entire field of the operations of a financial institution. For this reason, it would be virtually impossible to attempt to catalog within a single all-inclusive or rigid definition the broad spectrum of activities which are embraced by the term . . . . Like many other generic terms widely used in the law, such as "fraud," "negligence," "probable cause," or "good faith," the term "unsafe or unsound practices" has a central meaning which can and must be applied to constantly changing factual circumstances. Generally speaking, an "unsafe or unsound practice" embraces any action, or lack of action, which is contrary to generally accepted standards of prudent operation, the possible consequences of which, if continued, would be abnormal risk or loss or damage to an institution, its shareholders, or . . . the [FDIC].[56]

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[54]*See* 12 U.S.C. § 1(a) ("There is established in the Department of the Treasury a bureau to be known as the 'Office of the Comptroller of the Currency' which is charged with assuring the safety and soundness of, and compliance with laws and regulations, fair access to financial services, and fair treatment of customers by, the institutions and other persons subject to its jurisdiction."); *id.* § 1831p-1(a) (directing "appropriate Federal banking agenc[ies]" to promulgate safety and soundness standards for "all insured depository institutions"); *id.* § 1813(q) (defining "appropriate Federal banking agency" as the FDIC "in the case of a State nonmember insured bank or a foreign bank having an insured branch" and as the OCC in the cases of national banks, federal thrifts, and "any Federal branch or agency of a foreign bank"). In contrast to the FRB, the OCC and FDIC do not have responsibilities to monitor risks to financial stability, even at the institutional level.

[55]Gulf Fed. Savings & Loan Ass'n v. Fed. Home Loan Bank Bd., 651 F.2d 259, 264 (5th Cir. 1981) (emphasis added).

[56]*Financial Institutions Supervisory and Insurance Act of 1966: Hearings on S. 3158 and S. 3695 Before the H. Comm. on Banking and Currency*, 112 Cong. Rec. 26,474 (1966) (memorandum submitted by John Horne, chairman of the Federal Home Loan Bank Board). Horne's comments currently appear in the FDIC's examination manual, testifying to their continued importance in banking law and regulation. *See* Fed. Dep. Ins. Corp., Risk Management Manual

Thus, the safety and soundness regulators are responsible for counteracting events and activities that present a "reasonably direct effect" on an institution's financial health—an open-ended, wide-ranging charge.[57] Or stated in Horne's terms, regulators must remediate activities that are no easier to identify than negligence, good faith, and other open-ended designations. But, unlike the courts that adjudicate disputes regarding those legal terms, bank regulators must perform this task in real-time and without the benefits of hindsight and an elaborate fact-finding trial.

With the passage of the Federal Deposit Insurance Corporation Improvement Act (FDICIA) in 1991, Congress emphasized that bank regulators were responsible for monitoring banking activities closely. Specifically, it instructed the bank regulators to impose standards relating to management, operations, compensation, asset quality, earnings, and stock valuation to use while conducting their safety and soundness examinations of the institutions within their respective purviews.[58] Congress also directed the U.S. banking regulators in FDICIA to promulgate generally applicable risk-based capital requirements on banks and required intervention when banks became undercapitalized.[59] These capital requirements, as will be discussed in detail below, require any entity assessing capital needs, whether a unit within the bank or a regulator, to make

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OF EXAMINATION POLICIES § 15.1 (2011), *available at* http://www.fdic.gov/regulations/safety/manual/section15–1.html.

[57]*See* 12 U.S.C. § 1818(b) (2006) (authorizing bank regulators to issue cease-and-desist orders to banks that engage in any "unsafe or unsound practice"); Federal Deposit Insurance Corporation Improvement Act of 1991, Pub. L. No. 102–242, § 132, 105 Stat. 2236, 2267–70 (adding § 39(e) to the Federal Deposit Insurance Act (FDIA), which provides express authority for bank regulators to, among other things, require a bank to raise more capital in the event it fails to redress violations of guidelines and rules promulgated under bank regulators' safety-and-soundness authority). Some commentators refer to these regulators as "microprudential" regulators to distinguish them from the "macroprudential" regulators that are responsible for regulating employment and credit volume through interest rate policy. *See* Ben S. Bernanke, Chairman, Bd. of Governors of the Fed. Reserve Sys., Implementing a Macroprudential Approach to Supervision and Regulation, Remarks at the Federal Reserve Bank of Chicago's 47th Annual Conference on Bank Structure and Competition 2 (May 5, 2011), *available at* http://www.federalreserve.gov/newsevents/speech/bernanke20110505a.pdf ("The systemic orientation of the macroprudential approach may be contrasted with that of the traditional, or 'microprudential,' approach to regulation and supervision, which is concerned primarily with the safety and soundness of individual institutions, markets, or infrastructures.").

[58]*See* Federal Deposit Insurance Corporation Improvement Act, § 132 (adding § 39(a)–(d) to the FDIA).

[59]*See id.*

judgments about what risk weights to apply to the entire spectrum of a bank's assets.[60] In practical effect, the regulators are charged with designing and implementing a regulatory system that identifies and remediates excessive risk-taking and, should the system fail, ensuring swift intervention to resolve the troubled institution.

The FDIC has the special responsibility under the prompt corrective action regime,[61] as well as the Dodd-Frank Act's "orderly liquidation authority,"[62] for resolving insolvent depository institutions and systemically important financial holding companies. The FSOC, for its part, is responsible for identifying risks to financial stability, promoting market discipline, and responding to emerging threats to financial stability.[63] Of course, U.S. banking regulators have a host of other responsibilities, such as monitoring compliance with the Truth in Lending Act and the Community Reinvestment Act.[64] These regulatory programs, while important, do not present conditions where complexity capture is likely to occur. This article focuses instead on the safety and soundness supervision, capital adequacy regulation, and resolution responsibilities because these supervisory duties require an understanding of risk in conditions of complexity.

C. What Does It Mean to Say a System Is "Complex"?

References to the complexity of social systems, including the contemporary financial system, at times lack definitional clarity. In particular, authors often fail to distinguish complexity from complicatedness. The difference between complexity and complicatedness is nontrivial from the perspective of financial regulation. Simplifying somewhat, complex markets are not only complicated; they are also characterized by uncertainty and unpredictability that call into question the continued viability of public regulatory control over market activities. This section will

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[60]*See infra* Part III.B (discussing generally applicable capital requirements as a behavior-based regulatory tool); *see also* CARNELL ET AL., *supra* note 52, at 259–63 (summarizing how risk-weighted assets are calculated).

[61]*See infra* note 287 (discussing prompt corrective action).

[62]Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010, Pub. L. No. 111–203, §§ 201–217, 124 Stat. 1376.

[63]*See* 12 U.S.C.A. § 5322(a)(1) (West Supp. 2011).

[64]*See* CARNELL ET AL., *supra* note 52, at 23.

summarize some aspects of the burgeoning research programs of complexity science and network effects. These fields of inquiry are vast, and I will undertake the modest task of highlighting only certain of those aspects that are most relevant to legal and regulatory scholarship.

At first blush it might appear strange to analyze financial institutions and markets as networks and nodes in a complex system, but the analogy is not as far-fetched as it might seem. Scholars of internet law,[65] environmental law,[66] and telecommunications law[67] have appreciated the implications of complexity theory on their work. In the economics field, the connection between biological evolution, itself a complex process, and economics has been appreciated for some time, albeit on the margins of mainstream economic theory.[68] The work of Thorstein Veblen represents an important early rejection of equilibrium-based models of the economy and an exploration of the emergent properties of economic activity.[69]

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[65]*See, e.g.*, YOCHAI BENKLER, THE WEALTH OF NETWORKS 241–61 (2006); David G. Post & David R. Johnson, *"Chaos Prevailing on Every Continent": Towards a New Theory of Decentralized Decision-Making in Complex Systems*, 73 CHI.-KENT L. REV. 1055 (1998).

[66]*See, e.g.*, J.B. Ruhl & Harold J. Ruhl, Jr., *The Arrow of the Law in Modern Administrative States: Using Complexity Theory to Reveal the Diminishing Returns and Increasing Risks the Burgeoning of Law Poses to Society*, 30 U.C. DAVIS L. REV. 405 (1997); J.B. Ruhl, *The Fitness of Law: Using Complexity Theory to Describe the Evolution of Law and Society and Its Practical Meaning for Democracy*, 49 VAND. L. REV. 1407 (1996); J.B. Ruhl, *Thinking of Environmental Law as a Complex Adaptive System: How to Clean up the Environment by Making a Mess of Environmental Law*, 34 HOUS. L. REV. 933 (1997).

[67]*See, e.g.*, Barbara A. Cherry, *Institutional Governance for Essential Industries Under Complexity: Providing Resilience Within the Rule of Law*, 17 COMMLAW CONSPECTUS 1 (2008); Barbara A. Cherry & Johannes Bauer, Adaptive Regulation: Contours of a Policy Model for the Internet Economy, Address at the 15th Biennial Conference of the International Telecommunications Society (Sept. 15, 2004), *available at* http://userpage.fu-berlin.de/~jmueller/its/conf/berlin04/Papers/Cherry_paper.pdf.

[68]On the marginal status of evolutionary economics within the academic economic establishment, see Mark Perlman, *Mind-Sets, and Why Veblen Was Ineffectual*, *in* IS ECONOMICS AN EVOLUTIONARY SCIENCE? 13, 13 (Francisco Louçã & Mark Perlman eds., 2000).

[69]*See* Thorstein Veblen, *Why Is Economics Not an Evolutionary Science?*, 12 Q. J. ECON. 373, 393 (1898) ("[A]n evolutionary economics must be the theory of a process of cultural growth as determined by the economic interest, a theory of a cumulative sequence of economic institutions stated in terms of the process itself."); Geoffrey M. Hodgson, *On the Evolution of Thorstein Veblen's Evolutionary Economics*, 22 CAMBRIDGE J. ECON. 415, 420–23 (1998) (discussing Veblen's relation to the concept of emergence and his conception of "the evolution and selection of institutions as emergent entities in the socioeconomic sphere"); Geoffrey M. Hodgson, *Precursors of Modern Evolutionary Economics: Marx, Marshall, Veblen, and Schumpeter*, *in*

Veblen's legacy today is carried on by a research program devoted entirely to evolutionary economics.[70] In 1950, economist Armen Alchian again drew parallels between the economy and biological evolution.[71] And in 1962, Herbert Simon wrote a paper in which he compared the economy to complex, evolutionary systems.[72] More recently, ecologist and complexity theorist Bob May and colleagues observed in their improbably titled article *Ecology for Bankers* that there is "common ground in analyzing financial systems and ecosystems, especially in the need to identify conditions that dispose a system to be knocked from seeming stability to another, less happy state."[73] Brian Arthur of the Santa Fe Institute coined the term "complexity economics" in the late 1990s,[74] which later inspired McKinsey

EVOLUTIONARY CONCEPTS IN CONTEMPORARY ECONOMICS 9, 20 (Richard W. England ed., 1994) (describing how Veblen "characterized his own economics as post-Darwinian and argued that economics should embrace the metaphor of evolution and change, rather than the static ideas of equilibrium that had been borrowed from physics by the neoclassical economists"); *infra* note 100 and accompanying text (describing the importance of emergence to complexity science).

[70]*See, e.g.*, RICHARD R. NELSON & SIDNEY G. WINTER, AN EVOLUTIONARY THEORY OF ECONOMIC CHANGE 3–48 (1982) (advancing a theory of natural selection of firms and industries based on their "organizational genetics" and comparing research and development expenditures to genetic mutation); John Foster & Werner Hölzl, *Introduction and Overview*, *in* APPLIED EVOLUTIONARY ECONOMICS AND COMPLEX SYSTEMS 1, 1–2 (John Foster & Werner Hölzl eds., 2004) ("Evolutionary economists see the economy as a scientific domain characterized by non-equilibrium processes in which economic agents create and adapt to novelty through learning rather than as a system in which there are disequilibrating shocks to stable equilibrium states.").

[71]*See* Armen A. Alchian, *Uncertainty, Evolution, and Economic Theory*, 58 J. POL. ECON. 211, 219–20 (1950). In particular, Alchian presented a microeconomic model according to which firms had imperfect information and therefore were unable to use profit maximization as a guide to action. These firms instead adopted their practices in light of observed profits at other firms through "imitative, venturesome, innovative, trial-and-error adaptive behavior" in a process analogous to biological evolution. *Id.*

[72]Herbert A. Simon, *The Architecture of Complexity*, 106 PROC. AM. PHIL. SOC'Y 467, 468 (1962) ("Roughly, by a complex system I mean one made up of a large number of parts that interact in a nonsimple way. In such systems, the whole is more than the sum of the parts, not in an ultimate, metaphysical sense, but in the important pragmatic sense that, given the properties of the parts and the laws of their interaction, it is not a trivial matter to infer the properties of the whole.").

[73]Robert M. May et al., *Ecology for Bankers*, 451 NATURE 893, 893 (2008).

[74]*See* W. Brian Arthur, *Complexity and the Economy*, 284 SCIENCE 107, 109 (1999) ("Complexity economics is not a temporary adjunct to static economic theory but theory at a more general, out-of-equilibrium level."). Eric Beinhocker dates the phrase's first usage to an earlier 1994 Arthur lecture. *See* ERIC D. BEINHOCKER, THE ORIGIN OF WEALTH: EVOLUTION, COMPLEXITY, AND THE RADICAL REMAKING OF ECONOMICS 458 n.48 (2006).

& Co. researcher Eric Beinhocker to publish a comprehensive account of markets as complex systems.[75] Complexity economics is gradually becoming accepted in certain corners of the academy—for example, physics departments are regularly awarding doctoral degrees to students who write dissertations on economic matters.[76] Most interesting from the perspective of legal and regulation scholars, financial regulators in the United States, United Kingdom, and Japan separately have commissioned studies by, and organized collaborative sessions with, complexity scientists in order to appreciate the role of complexity in financial markets.[77]

1. Positive and Negative Feedback Mechanisms

Traditional financial economics is premised on equilibrium theory, which posits that financial markets will settle at prices that allocate resources optimally in satisfaction of individuals' preference sets.[78] The classic

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[75]*See* Beinhocker, *supra* note 74.

[76]J. Doyne Farmer et al., *Is Economics the Next Physical Science?*, Physics Today, Sept. 2005, at 37; *see also* Beinhocker, *supra* note 74, at 390–91 (describing the influx of "econophysicists"— that is, physicists applying their skills to financial problems—to Wall Street after the end of the Cold War due to their decreased demand in the defense industry).

[77]*See, e.g.*, Kimmo Soramäki et al., The Topology of Interbank Payment Flows, Fed. Reserve Bank of N.Y. Staff Report No. 243, at 1 (2006), *available at* http://www.newyorkfed.org/research/staff_reports/sr243.pdf (finding the U.S. financial payment system can be treated as a specific example of a complex network); Hajime Inaoka et al., *Fractal Network Derived from Banking Transaction: An Analysis of Network Structures Formed by Financial Institutions* (Bank of Japan, Working Paper No. 04-E-04, 2004), *available at* http://www.boj.or.jp/en/research/wps_rev/wps_2004/data/wp04e04.pdf (presenting findings of a study using methods of statistical physicists to analyze network structures of financial transactions); David Aikman et al., Uncertainty in Macroeconomic Policy Making: Art or Science? 2 (Mar. 22, 2010) (unpublished manuscript delivered to The Royal Society Conference on "Handling Uncertainty in Science"), *available at* http://www.bankofengland.co.uk/publications/speeches/2010/speech 432.pdf (mentioning a joint seminar between the United Kingdom's Met (i.e., Meteorological) Office and the Bank of England). For a scholarly account of the implications of complexity theory on financial regulation, see Lawrence G. Baxter, *Internationalisation of Law—The "Complex" Case of Bank Regulation*, in The Internationalisation of Law: Legislating, Decision-Making, Practice and Education 3–37 (Mary E. Hiscock & William van Caenegem eds., 2010).

[78]*See* Kenneth J. Arrow & Gerard Debreu, *Existence of an Equilibrium for a Competitive Economy*, 22 Econometrica 265 (1954). Economist Werner Hildenbrand is said to have referred to general equilibrium theory as the "gothic cathedral" of economics. Beinhocker, *supra* note 74, at 43.

expression of this theory is the efficient capital markets hypothesis (ECMH), according to which security prices reflect the impact of all publicly available information on a security's expected cash flows.[79] The ECMH is recognized by law; it undergirds much of the mandatory securities disclosure regime,[80] and the U.S. Supreme Court has cited it in relaxing the burden of proof in private securities fraud actions.[81] According to equilibrium theory, the balance of financial markets is intermittently upset by human events—such as wars, technology,[82] political turmoil, and other new information—that are outside, or exogenous to, the operation of the markets; but markets will process the new information communicated by such events and settle on a new equilibrium.[83] According to this theory, the economy is brought back to equilibrium through *negative feedback mechanisms*, which act to restore a system's equilibrium by pushing the system back to its original state with a push that becomes stronger the further the system has moved away from that state.[84] This is Adam Smith's metaphorical "invisible hand," which describes the same

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[79]*See* Ronald G. Gilson & Reinier H. Kraakman, *The Mechanisms of Market Efficiency*, 70 VA. L. REV. 549, 554–65 (1984) (describing the "weak," "semi-strong," and "strong" forms of the ECMH and noting that it "is now *the* context in which serious discussion of the regulation of financial markets takes place"); Michael C. Jensen, *Some Anomalous Evidence Regarding Market Efficiency*, 6 J. FIN. ECON. 95, 95 (1978) ("[T]here is no other proposition in economics which has more solid empirical evidence supporting it than the Efficient Markets Hypothesis.").

[80]*See, e.g.*, Adoption of Integrated Disclosure Systems, Securities Act Release Nos. 33–6383, etc., 47 Fed. Reg. 11,380, 11,382 n.9 (Jan. 4, 1982) (citing in support of the SEC's integrated disclosure regime the "premise that information regularly furnished to the marketplace . . . may be reflected in the price of the outstanding securities").

[81]*See, e.g.*, Basic Inc. v. Levinson, 485 U.S. 224, 247 (1988) (holding that a plaintiff bringing an action against an issuer under Rule 10b-5 is entitled to a presumption that it acted in reliance of the defendant's misrepresentations—one of the traditional elements of fraud—because a plaintiff sells its shares into a market in which "most publicly available information is reflected in market price").

[82]Some economists argue that technology is endogenous to the economy and the source of upward-trending growth, as new products and processes are formed from existing technologies. *See, e.g.*, Paul M. Romer, *The Origins of Endogenous Growth*, 8 J. ECON. PERSP. 3 (1994).

[83]*See* BEINHOCKER, *supra* note 74, at 54–55.

[84]*See* LEN FISHER, CRASHES, CRISES, AND CALAMITIES: HOW WE CAN USE SCIENCE TO READ THE EARLY WARNING-SIGNS 75 (2011).

equilibrium-generating process at work in the economy,[85] similar to what we observe in other everyday contexts such as "cruise control" features in automobiles and thermostat-controlled air conditioning. In recent decades, financial economists waged intramural turf wars over whether to modify the ECMH to account for the seemingly irrational behavior of investors, heterogeneous expectations, and the limits of arbitrage.[86] Pure-form ECMH skeptics had some success in poking holes in the ECMH edifice with their "noise theory" arguments. But the fundamental premise of a capital market that generally gets prices right due to smart investors applying negative feedback pressure on mispriced capital assets remains a core precept of traditional economic theory—whether one accepts ECMH or noise theory.[87]

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[85]*See* Edgar E. Peters, Patterns in the Dark: Understanding Risk and Financial Crisis with Complexity Theory 4 (1999). In a broad sense, even the market's invisible hand can be considered a complex ordering mechanism inasmuch as order emerges spontaneously without formal coordination among transacting parties. *See id.* at 44. The ECMH takes it as a token of faith, however, that the order thus emerging is stable, not subject to positive feedback effects, network effects, and other endogenous properties. However, whether the emergent order is in fact stable, depends, as discussed below in Part II.D.2, on the market structure.

[86]*See* Lynn A. Stout, *The Mechanisms of Market Inefficiency: An Introduction to the New Finance*, 28 J. Corp. L. 635 (2003); *cf.* Justin Fox, The Myth of the Rational Market 301 (2009) ("While behaviorists and other critics have poked a lot of holes in the edifice of rational market finance, they haven't been willing to abandon that edifice. . . . [T]hey still trust that . . . 'pervasive forces' are out there somewhere, pushing prices at least in the general direction of where they belong.").

[87]Larry Cunningham identified the importance of nonlinear dynamics to securities regulation early on and distinguished irrational investor behavior (so-called "noise trading") from nonlinear mechanics. *See* Lawrence A. Cunningham, *From Random Walks to Chaotic Crashes: The Linear Genealogy of the Efficient Capital Market Hypothesis*, 62 Geo. Wash. L. Rev. 546 (1994). In particular, he notes that

the descriptive paradigm of ECMH efficiency versus noisy inefficiency and of ECMH rationality versus noisy irrationality seem falsely constrained by a linear frame of reference. The system described is forced into a preconceived box defined in terms of relative efficiency and relative rationality. The nonlinear reality forces the analysis out of this preconceived box and into a multidimensional domain in which notions of rationality and efficiency are only part of the whole story.

Id. at 603–04. Further, "[n]onlinear dependence goes beyond noise theory . . . to suggest that there are deeper structural forces that affect public capital market outcomes that cannot be explained by the psychological and emotional perspective of noise theory alone." *Id.* at 592; *see also* W. Brian Arthur et al., *Asset Pricing Under Endogenous Expectations in an Artificial Stock Market*, *in* The Economy as an Evolving Complex System II 15, 15–19 (W. Brian Arthur et al. eds., 1997) (pointing out that while noise theory differs from rational expectations theory, it also differs from complexity theory). Though Cunningham's article focuses on chaos theory and neither discusses complexity nor addresses network effects, it is an important early

Recently, however, other economists and even physical scientists have called equilibrium theory itself into question by conducting research on economies and markets as complex systems.[88] According to these new models, individual firms can be conceptualized as semi-autonomous agents that process information,[89] interact, and adapt in a system of financial

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endeavor to improve financial regulatory structures by taking into account nonlinear market dynamics. On the general difference between complexity and chaos, see ROBERT AXELROD & MICHAEL D. COHEN, HARNESSING COMPLEXITY: ORGANIZATIONAL IMPLICATIONS OF A SCIENTIFIC FRONTIER xv (1999).

[88]*See* BEINHOCKER, *supra* note 74. The novelty of this research program stems from its experimental methods and ability to harness computing power to simulate large numbers of agent-based interactions. The theoretical foundations of general equilibrium theory have been under attack for over a century. *See, e.g.*, *supra* note 69 and accompanying text (discussing Veblen's objections to equilibrium-based economic theories). Both the Keynesian and Austrian economics traditions have squared off with equilibrium theory as well. *See* GEORGE COOPER, THE ORIGIN OF FINANCIAL CRISES: CENTRAL BANKS, CREDIT BUBBLES AND THE EFFICIENT MARKET FALLACY 13–14 (2008) (describing Hyman Minsky's "financial instability hypothesis" and its debt to Keynes); FRIEDRICH A. HAYEK, INDIVIDUALISM AND ECONOMIC ORDER 35 (1948) ("I have long felt that the concept of equilibrium itself and the methods which we employ in pure analysis have a clear meaning only when confined to the analysis of the action of a single person and that we are really passing into a different sphere and silently introducing a new element of altogether different character when we apply it to the explanation of the interactions of a number of different individuals."); JOHN M. KEYNES, THE GENERAL THEORY OF EMPLOYMENT, INTEREST, AND MONEY 249–54 (Harvest/Harcourt 1964) (1953) (explaining how the "environment and psychological propensities of the modern world" result in prices and business cycles that are only "moderately stable"); Timothy A. Canova, *Financial Market Failure as a Crisis in the Rule of Law: From Market Fundamentalism to a New Keynesian Regulatory Model*, 3 HARV. L. & POL'Y REV. 369, 369 (2009) ("The microeconomic fixations of today's law and economics school have replaced [the] comprehensive Keynesian model of financial regulation . . . [with] a neoclassical equilibrium model that is highly abstract and mathematical, often based on unrealistic assumptions and ignorant of historical contexts and the many complex dynamics and interdependencies of human behavior and market psychology."); Israel M. Kirzner, *On the Method of Austrian Economics*, *in* THE FOUNDATIONS OF MODERN AUSTRIAN ECONOMICS 40, 40 (Edwin G. Dolan ed., 1976) ("Austrian economists are subjectivists; they emphasize the purposefulness of human action; they are unhappy with constructions that emphasize equilibrium to the exclusion of market processes . . . .").

[89]The main actors in financial markets are legal entities such as corporations and limited liability companies. These entities are themselves constellations of separate stakeholder agents, such as stockholders, workers (and their labor unions), bond holders and other creditors, tort claimants, customers, suppliers, managers, and executives. The allocation of decision-making power among these stakeholders will impact a firm's reactions to stimuli, such that the same event might trigger two very different reactions for two for-profit corporations organized under the same statutes and operating in the same markets. These intracorporate networks complicate further—or perhaps *complexify* is the better word—the assessment of financial market outcomes.

markets in response to one another and to external environment inputs.[90] The agents in a complex system have the ability to adapt to and evolve in a changing environment on a continual, rolling basis, such that predicted behavioral responses are inherently unreliable due to the inability to know how other agents within the system will react.[91] Complex systems are characterized by extensive, idiosyncratic, and nonlinear interdependence of their agents.[92] These interactions are often poorly understood.[93] In contrast to what occurs in equilibrium systems, change arises endogenously, not exogenously. These systems are also susceptible to positive feedback effects, which, in contrast with negative feedback's equilibrium vector, increasingly drive systems to change at a continuously accelerating rate.[94] As such, unpredictable outcomes are a hallmark of complex, adaptive systems.[95]

By contrast, traditional general equilibrium economics assumes that positive feedback mechanisms and their resulting nonlinearities do not impact market behavior. If any such forces are at work, they are washed out by the predominance of negative feedback mechanisms, such as arbitrage, that push prices back to their equilibrium levels.[96] Scholars have pointed out that the theory relies on concepts, such as perfect competition, market liquidity, no-arbitrage and market completeness, that foreclose completely any consideration of the feedback effects of trading strategies

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[90]*See* BEINHOCKER, *supra* note 74, at 18 ("Scientists refer to parts or particles that have the ability to process information and adapt their behavior as *agents* and call the systems that agents interact in *complex adaptive systems*."); J.B. Ruhl, *Law's Complexity: A Primer*, 24 GA. ST. U. L. REV. 885, 887 (2008).

[91]*See* Arthur, *supra* note 74, at 108 (applauding recent forays by economists into the study of "how actions, strategies, or expectations might react in general to (might endogenously change with) the aggregate patterns these create").

[92]*See* THOMAS A. BASS, THE PREDICTORS 68 (1999).

[93]*See* CHARLES PERROW, NORMAL ACCIDENTS: LIVING WITH HIGH-RISK TECHNOLOGIES 9 (2d ed. 1999) ("In complex industrial, space, and military systems, the normal accident generally (not always) means that the interactions are not only unexpected, but are *incomprehensible* for some critical period of time.").

[94]*See* FISHER, *supra* note 84, at xv.

[95]*See* AXELROD & COHEN, *supra* note 87, at 11–15; PERROW, *supra* note 2, at 260 ("A truly complex system may be impossible to fully comprehend, and the unexpected interactions may not appear for a very long time, and especially not in the short period before [rolling out a system].").

[96]*See* Arthur, *supra* note 74, at 108.

and market dynamics.[97] By simplifying their questions, equilibrium economists obtain precise and clear answers.[98] But if the economy is a complex system, this precision comes at the cost of accuracy.[99]

Those seeking to understand complex systems must understand not only the attributes—and motivations, in the case of social systems—of agents, but also the ways by which properties of the system *emerge* from positive feedback mechanisms.[100] Emergence in this sense connotes something more than the aggregate of individual agent contributions, such as the sum of a number of small weights tipping a scale.[101] Emergent system attributes are nonlinear[102] and may emerge suddenly and without warning in what physicists refer to as "phase transitions."[103]

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[97]*See* Fabio Caccioli et al., *Eroding Market Stability by Proliferation of Financial Instruments*, 71 Eur. Phys. J. B 467, 467 (2009).

[98]*See* Fox, *supra* note 86, at 301 (attributing traditional economics' tendency to make simplifying assumptions so to achieve precise answers to its heavy borrowing from nineteenth century physics); Arthur, *supra* note 74, at 107 ("Conventional economic theory chooses not to study the unfolding of the patterns its agents create but rather to simplify its questions in order to seek analytical solutions."); Farmer et al., *supra* note 76, at 40 ("The hypothesis of rational choice, in contrast, has the great virtue of parsimony. It makes strong predictions from simple hypotheses and, in that sense, is more like a physics theory.").

[99]*See* Foster & Hölzl, *supra* note 70, at 5 ("The great task is to provide a universally valid set of principles that can offer simple representation of the structures and processes in the real economy—not principles that avoid confronting this reality but those that acknowledge the fact that we are dealing with complex systems and related complex processes. By definition, such a set of principles is orthogonal to conventional ones as embodied, for example, in Walrasian general equilibrium theory. Such a theory is simplistic . . . .").

[100]*See* John H. Holland, Emergence: From Chaos to Order 2 (1998) ("We are everywhere confronted with emergence in complex adaptive systems—ant colonies, networks of neurons, the immune system, the Internet, and the global economy, to name a few—where the behavior of the whole is much more complex than the behavior of the parts.").

[101]*See* Andy Clark, Mindware: An Introduction to the Philosophy of Cognitive Science 112–17 (2001).

[102]*See* Holland, *supra* note 100, at 121–22 ("Emergence is above all a product of coupled, context-dependent interactions. Technically these interactions, and the resulting system, are *nonlinear*: The behavior of the overall system *cannot* be obtained by *summing* the behaviors of the constituent parts.").

[103]The analogous concept in evolutionary biology of "punctuated equilibrium" is also relevant here. As positive feedback pushes a complex system to undergo a phase transition, the system settles on a new equilibrium point until a subsequent phase transition. *See* Beinhocker, *supra* note 74, at 173 (discussing the relevance of Steven Jay Gould's concept of punctuated equilibrium to economic analysis); *cf.* Mark J. Roe, *Chaos and Evolution in Law and Economics*,

2. Complex Systems and Network Effects

The tendency of a complex system to slip into catastrophe depends on the characteristics of the interconnections of the nodes of the networks that comprise the system—what network scientists refer to as the networks' *topology*.[104] In particular, complexity scientists look to (1) the number of the network's nodes; (2) the density of the nodal interconnections;[105] and (3) the regularity in the behavior of the nodes.[106]

Complexity science teaches that network effects are at once a source of tremendous productive and scalable possibilities and a source of chaos and instability. An increase in a company's workforce from 10 to 100 is one order of magnitude—in other words, the exponent in the quantity 10^1 (10) is greater than the exponent in the quantity 10^2 (100) by one. But this simple ninety-employee increase causes the number of possible employee relationships to increase by many trillions. To the extent that employee collaboration is correlated with outcome improvements, the firm experiences a nonlinear scaling up of its productive and creative possibilities. But the qualification that improved outcomes are correlated with increases in interactivity is the key assumption. In complex systems, a minor change in one network node—or one component of the subsystem, and so forth— can cause catastrophic changes in the system's behavior.[107]

To illustrate, consider a complicated, serial—but ultimately linear and noncomplex— system like an assembly line manufacturing process. If a screw comes loose in an equipment component in a way that causes the equipment edge to scrape the product as it makes its way through the manufacturing process, system managers and engineers will notice the scratched but otherwise as-designed end products and will trace the defect

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109 Harv. L. Rev. 641, 663–65 (1996) (applying Gould's punctuated equilibrium theory to legal regimes governing corporate finance).

[104]*Network Topology*, ATIS Telecom Glossary, http://www.atis.org/glossary/definition.aspx?id=3516 (last visited Feb. 12, 2012).

[105]Biologists refer to the interconnectedness of an organism's genes as "epistasis." *See* Stuart Kauffman, At Home in the Universe 170 (1995).

[106]*See* Beinhocker, *supra* note 74, at 148.

[107]*See* Kauffman, *supra* note 105, at 152; Perrow, *supra* note 93, at 86 ("In complex systems, removing a component or shutting it down means temporarily severing numerous ties with consequent readjustments, capping, product storage, removal to get access, and reconfigurations because parts and units tend to be multiply linked.").

to the faulty screw. Managers will know which of the numerous system components might cause such a defect because they will know how each component interacts with the components that follow it in a direct sequence. Even if this linear manufacturing process were comprised of thousands of steps, it would be neither interactively complex nor characterized by significant network effects.[108] On its own, numerosity of nodal connections does not lead to complexity.

Now contrast that process with dynamic, interactive systems such as the human immune system, a nuclear power plant, an ecosystem, or a large corporation with different departments and divisions, in which system components require coordination to function optimally. As the nodal interrelatedness of a network increases, it becomes subject to what complexity theorists refer to as "conflicting constraints," which describes the inability to simultaneously promote competing and contradictory priorities that are linked together.[109] As a result of conflicting constraints, it becomes more difficult to manage the enhanced productive possibilities optimally.[110] Biologist Stuart Kauffman has vividly described this phenomenon in the evolutionary context as a "complexity catastrophe."[111] An unexpected event in one component can cause a cascade of events, or a positive feedback loop, that undermines the system's effectiveness and may even push the system into chaos.[112] Writing about complex, human-engineered systems such as nuclear power plant management, cultural

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[108]*See* RICHARD BOOKSTABER, A DEMON OF OUR OWN DESIGN: MARKETS, HEDGE FUNDS, AND THE PERILS OF FINANCIAL INNOVATION 155–56 (2007) (discussing how post office activities constitute a complicated but ultimately linear process); KARL E. WEICK & KATHLEEN M. SUTCLIFFE, MANAGING THE UNEXPECTED: RESILIENT PERFORMANCE IN AN AGE OF UNCERTAINTY 90–92 (2d ed. 2007).

[109]BEINHOCKER, *supra* note 74, at 158 ("A small change in one part of the network . . . [leads] to cascades of change and [makes] it impossible to predict . . . patterns. . . . In an organizational context, it is these cascades of change that then run into conflicting constraints.").

[110]*See* KAUFFMAN, *supra* note 105, at 173 ("Because so many constraints are in conflict, there is a large number of rather modest compromise solutions rather than an obvious superb solution.").

[111]*See* STUART A. KAUFFMAN, THE ORIGINS OF ORDER: SELF-ORGANIZATION AND SELECTION IN EVOLUTION 52, 71–74, 216–18 (1993).

[112]*See* KAUFFMAN, *supra* note 105, at 173 ("As the density of the interconnections increases, changing a single gene (or bit in the program) will have effects that ripple throughout the system.").

anthropologist Constance Perin described the conflicting constraints problem as an "infrastructure of conundrums."[113]

Regarding the regularity of the network's nodes, complexity scientists refer to the *bias* of network nodes to denote their tendency to create orderly outcomes in spite of their high connectivity. The intuition is straightforward: no matter how many interconnected nodes a network has, if the behavior of the nodes is predictable, then they will tend to be more orderly than if their behavior were random. As Kauffman puts it, "'homogeneity clusters' of elements that have frozen values link with one another and percolate across the network" as the "dynamic behavior of the network becomes a web of frozen elements and functionally isolated islands of changeable elements."[114] In other words, network equilibrium and order are more likely to emerge when nodes behave predictably rather than randomly—according to "frozen" behavioral patterns. There is some evidence that "disassortive" networks—that is, networks where nodes exhibit a bias to be connected to dissimilar nodes—are more resilient.[115]

3. "Normal Accidents" and the Problem with "Tightly Coupled" System Components

Not only are complex network systems prone to unpredictable behavior, the seeds of their destruction may be sown in their initial properties. Sociologist Charles Perrow maintains that systems characterized by interactive complexity and *tight coupling* among the system's components are subject to what he terms "normal accidents."[116] If "normal accident" sounds like a contradiction in terms, it should not. "Accident" only contradicts "normal" to the extent that the examined system's normal state is equilibrium; where, however, a system is volatile and unstable, the contradiction disappears. Perrow describes a network as "tightly coupled" when its nodes are critically interdependent; the networked system is unable to

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[113]*See* Constance Perin, Shouldering Risks: The Culture of Control in the Nuclear Power Industry 263 (2004).

[114]Stuart Kauffman, *Antichaos and Adaptation*, Sci. Am., Aug. 1991, at 78.

[115]*See* May et al., *supra* note 73, at 893–94 (tying disassortivity to the concept of modularity, which is discussed *infra* in Part III.A).

[116]*See* Perrow, *supra* note 93, at 7–9 (introducing the concept of "normal accident").

stop or counteract processes, or add substitutes or replacements.[117] With tightly coupled systems, the consequences of failure in one subsystem quickly stress or overcome a related subsystem.[118] They are highly responsive to shocks, and their responses to disturbances may be disastrous.[119]

Consider, for example, the experience of the transport planes that dropped members of the U.S. Airborne divisions behind enemy lines in the early morning hours before the D-Day amphibious assault on Nazi-occupied Normandy.[120] The paratrooper drop proved largely ineffective due to an unexpected event, which caused an operational failure that ramified quickly through tightly coupled system components. In other words, a normal accident occurred.

Paratroop drops are complex systems that rely on coordinating multiple components in conditions of meteorological and military uncertainty. In this case, D-Day planners sent over eight hundred transport planes across the channel from the United Kingdom, each laden with eighteen paratroopers, who were to jump out at a height of approximately 600–700 feet.[121] The paratroopers needed to be dropped in a concentrated area in order to be able to coordinate operations, so the planes flew in a tight "V-of-V" formation to ensure they did not separate.[122] To eliminate the possibility of the enemy intercepting radio transmissions, there was no communication between the planes and command or among the planes themselves. After arriving in pitch-black Normandy skies with the V-of-V formation intact, the pilots encountered an unexpected event—a dense low-altitude cloud formation.[123] Several planes diverted slightly from the

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[117]See Perrow, *supra* note 2, at 261; Bookstaber, *supra* note 108, at 144 ("Tight coupling means that components of a process are critically interdependent; they are linked with little room for error or time for recalibration or adjustment.").

[118]See Perrow, *supra* note 2, at 262; Perrow, *supra* note 93, at 89–90 ("[T]ight coupling is a mechanical term meaning there is no slack or buffer or give between two items. What happens in one directly affects what happens in the other." (alteration omitted)).

[119]Perrow, *supra* note 93, at 92.

[120]See Max Hastings, Overlord: D-Day and the Battle for Normandy 73–75 (1984); John Keegan, Six Armies in Normandy: From D-Day to the Liberation of Paris 69–93 (1982).

[121]Keegan, *supra* note 120, at 76.

[122]*Id*. at 80–82.

[123]See id. at 83. The secrecy of the D-Day planning made the operation more complex. An earlier reconnaissance mission had flown the same route of the paratroop drop and had

formation, which caused still other planes to alter their course to avoid mid-air collisions with the out-of-formation, but still nearby, planes.[124] Before long, the V-of-V formation had disintegrated and without the benefit of nearby planes as points-of-reference, pilots found themselves flying blind. The paratroopers were dropped in a haphazard, uncoordinated fashion—both in terms of coordinates and altitude—with disastrous results, as most paratroopers found themselves too far from their intended drop zones to conduct their operations.[125] Scores of less fortunate paratroopers were dropped into flooded lowlands where they drowned laden with their own equipment[126] or died from impact after having been dropped from altitudes too low for parachutes to deploy.[127]

   Though the complexity of the planes' V-of-V networked formation was in itself modest when compared with most social systems, the interactions between the unexpected shock that the dense cloud formation presented and the elaborate aerial formation posed a threat to the operation.

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encountered the same clouds. However, due to the ban on radio transmissions the information could not be communicated to the incoming pilots and no measures were taken to bolster the operation's resilience—or, stated differently, to reduce the tightness of the coupling of the operation's components—by, for instance, increasing the distance between planes. *See* STEVEN J. ZALOGA, D-DAY 1944 (2): UTAH BEACH AND THE US AIRBORNE LANDINGS 28–29 (2004).

[124]*See* DAVID BELCHEM, VICTORY IN NORMANDY 78 (1981) ("While the cloud did reduce aircraft casualties[,] . . . it seriously upset navigation, and this factor, combined with the exaggerated evasive action of the pilots, greatly increased the difficulty and hazards of jumping."); NAPIER CROOKENDEN, DROPZONE NORMANDY: THE STORY OF THE AMERICAN AND BRITISH AIRBORNE ASSAULT ON D-DAY 1944, at 81 (1976) (noting also how enemy fire aggravated confusion caused by clouds and resulted in pilots taking evasive action as "rolling, pitching aircraft knocked many men off their feet" at the precise moment they required a "steady jump platform"); KEEGAN, *supra* note 120, at 83 ("This bank of cloud, unpredicted and probably unpredictable by the meteorologists, stood across the approach routes of both the 82nd and the 101st. . . . Pilots instinctively separated, horizontally and vertically, so that the tight V's of V's dissolved . . . ."); ZALOGA, *supra* note 123, at 29.

[125]*See* BELCHEM, *supra* note 124, at 78 ("The troops of 101 Division were scattered over a wide area, and by dawn only 1,100 paratroops had reached their rendezvous points out of a total of 6,600"); CROOKENDEN, *supra* note 124, at 81–83, 113–17 (chronicling how most paratroopers in the 82nd and 101st Airborne Divisions fell far afield of their intended drop zones); HASTINGS, *supra* note 120, at 74–75 (noting that wide dispersion of paratroopers had fortuitous, if unintended, consequence of "bringing confusion and uncertainty to the Germans across the whole breadth of the Cherbourg peninsula").

[126]HASTINGS, *supra* note 120, at 74.

[127]*See* KEEGAN, *supra* note 120, at 88.

Moreover, the tight aerial formation, the lack of communication, and the narrow target drop area were tightly coupled and ensured there was little to no slack available with which to manage the interaction between the clouds and the formation. Tight coupling prevented any kind of stop lever.[128]

Perrow, in his own work concerning the North American electricity grid, has documented the results of tight coupling of long-distance electricity transmission lines following deregulation of electricity production and transmission in the United States.[129] According to Perrow, deregulation has made the grid network more susceptible to catastrophic failure by requiring owners of transmission lines to offer to transmit competitors' electricity across their lines.[130] Prior to deregulation, the grid infrastructure was localized and had weak connections across long distances.[131] It consisted of clumps of networks that glommed onto one another as power needs grew. With the reform, the few inter-regional, long-distance lines were supposed to allow for excess electricity to be transferred from low-price markets to high-price markets, in the process achieving greater price uniformity in a national market for electricity.[132] The stability of the grid was made to depend, then, on the reliable function of the long-distance transmission lines; local electricity transmission became tightly coupled to long-distance lines. The pre-reform system, it must be admitted, was characterized by lower price uniformity,[133] but it possessed redundancies and modularity that, as discussed below in Part III, are important in maintaining a system's resilience in the face of unpredicted events. Perrow describes the grid's present network structure as less reliable and more vulnerable than before deregulation.[134]

The D-Day and electricity grid examples demonstrate how the characteristics of a network's interconnections can give rise to vulnerability to

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[128]*Cf.* Bookstaber, *supra* note 108, at 256 (attributing the Three Mile Island and Chernobyl nuclear power plant disasters and the 1996 Valujet crash to "tight coupling from one link to the next[, which] precluded any kind of stop lever").

[129]*See* Perrow, *supra* note 2, at 211–47.

[130]*Id.* at 227–29, 231–34.

[131]*Id.* at 218–20, 223–31.

[132]*Id.* at 228.

[133]*Id.* at 230–32.

[134]*Id.* at 246–47.

perturbation. By focusing on dense interconnectivity and the tight coupling of nodes as destabilizing factors, Perrow provides a useful conceptual framework with which to consider the vulnerabilities of other complex systems.

D. Contemporary Financial Markets as Complex Systems

The next question to address is whether, and in what respects, contemporary financial markets are properly characterized as complex systems with tightly coupled system components. If financial markets are complex systems, regulators face formidable challenges in implementing their statutory objectives of promoting systemic stability and the safety and soundness of the institutions transacting in those markets. In fact, they might even have to become familiar with the science of complexity.[135] Most worrisome from the standpoint of financial regulation, financial network effects might result in the emergence—that is, the development of attributes that are impossible to discern ex ante by observing the behavior of individual agents—of negative externalities such as systemic risk. Most of the legal and economic scholarship devoted to systemic risk inquires into traditional microeconomic issues such as the moral hazard resulting from government safety nets. Though this incentive- and behavior-related scholarship is critically important, recent events and research suggest that the network *structure* of the financial system merits more attention as a regulatory problem than it currently receives.[136] While network theory is silent about behavioral considerations, it is "particularly well suited for dealing with heterogeneity of agents, charting the dynamic propagation of shocks within the financial system and identifying the non-linearities that characterise financial instability in a parsimonious way."[137]

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[135]*See* Lawrence G. Baxter, *Adaptive Regulation in the Amoral Bazaar*, 128 S. Afr. L.J. 253, 257–64 (2011); Andrew G. Haldane, Exec. Dir., Fin. Stability, Bank of Eng., Why Banks Failed the Stress Test, Speech at Marcus-Evans Conference on Stress Testing 5 (Feb. 9–10, 2009), *available at* http://www.bis.org/review/r090219d.pdf.

[136]*See* Erland Nier et al., *Network Models and Financial Stability*, 31 J. Econ. Dynamics & Control 2033, 2034 (2007) ("A number of determinants of systemic failure, including the role of . . . government safety nets[,] have been studied extensively in the literature. . . . However, relatively little is known about how the *structure* of a banking network may affect its susceptibility to systemic breakdown.").

[137]Prasanna Gai et al., *Complexity, Concentration and Contagion*, 58 J. Monetary Econ. 453, 454 (2011).

For financial regulators in charge of systemic financial stability, such as the newly formed FSOC,[138] care must be given to forecast phase transitions during which new propensities to instability and contagion emerge. Even safety and soundness regulators whose supervisory responsibilities are limited to individual institutions, such as the OCC and the FDIC, must attune themselves to the effects of these risks on the firms they supervise. The viability of public regulatory control may be at stake. This section takes up this question by (1) presenting a qualitative assessment of the networks across which financial business is conducted in order to illustrate their complexity and the tight coupling of their nodes and (2) summarizing some computer-based experimental studies that suggest that contemporary financial markets do in fact behave like complex systems.

1. A Qualitative Assessment of Financial Networks

The discussion below describes how the contemporary financial system becomes interactively complex as a result of its network structure. In it, I provide some concrete illustrations of certain attributes of the financial system that are susceptible to positive feedback, nonlinear phase transitions, and normal accidents, as well as the networks through which those events are propagated. In particular, I focus here on legal entity networks, market networks, and the network effects of regulation and uniform trading strategies. These descriptions set the stage for the subsequent summary of certain computer-based experimental studies demonstrating that such events can in fact occur and propagate through the system.

    a. Legal entity networks. The emergence of the large financial conglomerate means that financial businesses are conducted across dense and elaborate networks of legal entities. Sixteen large, complex financial conglomerates identified by the International Monetary Fund and the Bank of England have 2.5 times more majority-owned subsidiaries than the sixteen largest multinational manufacturing firms.[139] Of these financial conglomerates, eight have over 1000 majority-owned subsidiaries, and

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[138]*See supra* note 63 and accompanying text.

[139]Richard J. Herring, *Wind-Down Plans as an Alternative to Bailouts* 3 (PEW Econ. Pol'y Grp. Fin. Reform Project, Briefing Paper No. 15, 2009), *available at* http://fic.wharton.upenn.edu/ fic/policy%20page/Wind-down-plans-formatted-final-2–25–10–1.pdf.

one—Citigroup—has nearly 2500 majority-owned subsidiaries.[140] Though data are not available, the numbers would increase significantly if minority interests in subsidiaries and the real, if often extralegal, affiliations with off-balance sheet financing vehicles such as securitization special-purpose entities, asset-backed commercial paper conduits, and structured investment vehicles are counted.[141] In addition to the web of legal relationships, the affiliates are likely linked together through cross-affiliate credit and business relationships and reputational goodwill.[142] As a theoretical matter, conglomerates economize on capital costs by forming separately shielded subsidiaries because creditors will extend credit on better terms if they are assured liquidation priority and legal protection from corporate parents distributing the subsidiaries' assets.[143] But this efficiency can come at a cost in the form of uncertainty where conglomerate structures are complex enough to cause confusion regarding the ultimate owners of the conglomerate's assets. Adding to this increased uncertainty is the interposition of a multilevel management structure for each legal entity and business line. As a former Citigroup risk manager explained, this accretion of management structures "put[s] distance between data gatherers and users in senior management," and as a result "information gets lost in the compression and transmission of the data."[144] This discussion recalls the conflicting constraints problem discussed earlier,[145] and it is not difficult to imagine

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[140]Richard Herring & Jacopo Carmassi, *The Corporate Structure of International Financial Conglomerates: Complexity and Its Implications for Safety and Soundness*, *in* The Oxford Handbook of Banking 195, 200 (Allen N. Berger et al. eds., 2010).

[141]One of the first steps for a junior corporate lawyer working on a mergers-and-acquisitions transaction is to prepare a "corporate structure chart" that shows the relationships between affiliates in the target company group. As a junior attorney charged with putting together a structure chart of AIG for clients contemplating bids for AIG assets in the aftermath of its September 2008 bailout and restructuring, I can attest from personal experience to the massive complexity of financial conglomerate legal structure. The AIG structure chart—which was subject to a de minimis exception and did not include all majority-owned subsidiaries—folded out to span approximately four feet by four feet. It was double-sided.

[142]*See* Herring & Carmassi, *supra* note 140, at 217.

[143]*See* Reinier Kraakman et al., The Anatomy of Corporate Law: A Comparative and Functional Approach 6–7 (2d ed. 2009) (describing the protections creditors obtain from entity shielding).

[144]Bookstaber, *supra* note 108, at 126–27.

[145]*See supra* notes 109–13 and accompanying text.

how an instance of defective data transmission regarding, for example, a large-volume buy or sell order might precipitate a complexity catastrophe within the corporate group.

It seems a safe assumption that the complex network of legal entities generally responds rationally to organizational demands to minimize regulatory, tax, and capital costs. Nevertheless, an unwelcome side-effect of these linkages and uncertainties is that they significantly complicate resolution of insolvent financial firms, which is one of the central tasks of financial regulators—especially those charged with supervising large conglomerates posing systemic risks. In particular, the cross-jurisdictional operations of conglomerates, conducted through hundreds or perhaps thousands of subsidiaries and affiliates, complicate efforts to coordinate resolution of a failing firm. While operations have internationalized, politics remain solidly local, and judicial or administrative authorities charged with resolving such a firm will rush to ringfence and liquidate assets subject to their jurisdiction. Under these circumstances, an orderly liquidation will likely prove impossible, which will cause the disappearance of a key market participant and, more importantly, massive liquidations of positions that will cause asset values to decline. This is the Lehman Brothers problem.[146] Moreover, this problem of cross-jurisdictional conglomerate resolution illustrates how corporate structure complexity interacts dynamically with risk exposure complexity: as a single business unit's risk exposures cause financial stress in one part of Conglomerate A, the inability to unwind that business unit in an orderly manner can cause Conglomerate A itself to come under stress, which can in turn spill over to business units within Conglomerates B and C that rely on Conglomerate A for liquidity.[147]

b. Market networks. In today's financial systems, an intricate web of contractual obligations links the balance sheets of a wide variety of intermediaries, such as banks and hedge funds, into a network structure. Both the number and interrelatedness of the nodes in financial market networks have increased dramatically in quantity since the 1980s, in the process

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[146]*See infra* note 240 (discussing the Lehman Brothers collapse).

[147]*See infra* notes 215–18 and accompanying text (describing the contagion effects of "liquidity hoarding").

introducing unpredictable contagions and spillover effects.[148] The advent of "sophisticated" financial instruments that comprise networks of claims in their own right—such as securitized debt,[149] credit default swaps (CDSs), and collateralized debt obligations (CDOs)—has heightened the complexity of these balance sheet connections still further.[150] Eric Beinhocker has observed that "the networks of the economic world are arranged in hierarchies of networks within networks," which is particularly true of the financial sector.[151]

Gone are the days when the banking business consisted merely of accepting deposits, paying interest, and making loans.[152] Today's business of banking—defined to mean what banks actually *do*—consists not only of traditional deposit-taking and lending but also of CDOs, CDSs, securitization, interbank transactions such as securities lending and repurchasing, loan syndication, fixed income trading (primarily in derivatives markets), and warehouse lending and custody-and-advisory services to hedge funds, mutual funds, and mortgage lenders. And more recently, the network of participants in these new markets, particularly the securitization market, expanded to include money market funds, securities firms, and issuers of

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[148]*See infra* Part II.D.2.

[149]Securitization describes the process by which loans or other financial obligations are transferred to a separate legal entity that issues securities to be paid out of the proceeds of the cash flows associated with the underlying transferred assets. *See* Kenneth C. Kettering, *Securitization and Its Discontents: The Dynamics of Financial Product Development*, 29 Cardozo L. Rev. 1553, 1564–66 (2008).

[150]Prassana Gai & Sujit Kapadia, *Contagion in Financial Networks*, 466 Proceedings Royal Soc'y A 2401, 2401 (2010). Related to the development of new financial instruments is the broader phenomenon of financial disintermediation, understood as the marginalization of financial institutions in the process of converting savings into investment, which has resulted in the development of numerous new, interconnected, and decentralized capital market networks. For an authoritative discussion of the economic roots of financial disintermediation, see Arthur E. Wilmarth, Jr., *The Transformation of the U.S. Financial Services Industry, 1975–2000: Competition, Consolidation, and Increased Risks*, 2002 U. Ill. L. Rev. 215, 225–406 (2002). Prominent examples of disintermediation include the development of corporate bond, mutual fund, commercial paper, and securitization financing channels.

[151]Beinhocker, *supra* note 74, at 141.

[152]During these sleepier days of banking, bank executives were said to follow the "3–6–3 rule," according to which they accepted deposits bearing three percent interest, made loans at six percent interest, and hit the golf course by 3 p.m. *See* John R. Walter, *The 3–6–3 Rule: Urban Myth?*, 92 Econ. Q.–Fed. Res. Bank Richmond 51, 51 (2006).

commercial paper.[153] Andy Haldane of the Bank of England identified the proliferation of securitization transactions as a prime culprit in the ramping up of interconnectedness:

> Securitisation increased the dimensionality, and thus complexity, of the financial network. Nodes grew in size and interconnections between them multiplied. The financial cat's-cradle became dense and opaque. As a result, the precise source and location of underlying claims became anyone's guess. Follow-the-leader became blind-man's bluff. In short, diversification strategies by individual firms generated heightened uncertainty across the system as a whole.[154]

Patricia McCoy and Kathleen Engel colorfully describe the credit default swap corner of the securitization world as "creat[ing] multilateral exposure through *daisy chains of liability*, in which one swap seller's ability to meet its CDS obligations to a buyer depends on another seller's solvency down the line."[155]

Figure 2 below, taken from a Bank of England paper, illustrates the increasing interconnectedness of the global financial sector from 1985 to the most recent credit crisis in 2008.[156] The nodes in the graphs represent countries, while the links reflect the cross-border banking claims between them. The thickness of the links reflects the amounts of these claims.

The diagram illustrates the rapid increases in the density of the interconnections since the 1980s. For those who have kept apace of recent

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[153]*See* Hyun Song Shin, *Financial Intermediation and the Post-Crisis Financial System* 2 fig.3 (Bank of Int'l Settlements, Working Paper No. 304, 2010), *available at* http://www.bis.org/publ/work304.pdf.

[154]Andrew G. Haldane, Exec. Dir., Fin. Stability, Bank of Eng., Rethinking the Financial Network, Speech Delivered at the Financial Student Association 7 (Apr. 2009), *available at* http://www.bankofengland.co.uk/publications/speeches/2009/speech386.pdf.

[155]Kathleen C. Engel & Patricia A. McCoy, The Subprime Virus: Reckless Credit, Regulatory Failure, and Next Steps 219 (2011) (emphasis added). A CDS contract is like an insurance contract on a debt security; the buyer pays a fee in exchange for a promise from the seller to become liable for the loss should the obligor of the debt security default. *See* Viral V. Acharya et al., *Centralized Clearing for Credit Derivatives*, *in* Restoring Financial Stability: How to Repair a Failed System 251, 254 (Viral V. Acharya & Matthew Richardson eds., 2009) [hereinafter Restoring Financial Stability].

[156]Andrew Haldane, Exec. Dir., Fin. Stability, Bank of Eng., On Tackling the Credit Cycle and Too Big to Fail, Presentation at the Inst. of Int'l and European Affairs, slide 13 (Jan. 2011), *available at* http://www.iiea.com/event/download_powerpoint?urlKey=andrew-haldane-on-fixing-finance (reprinted with permission).
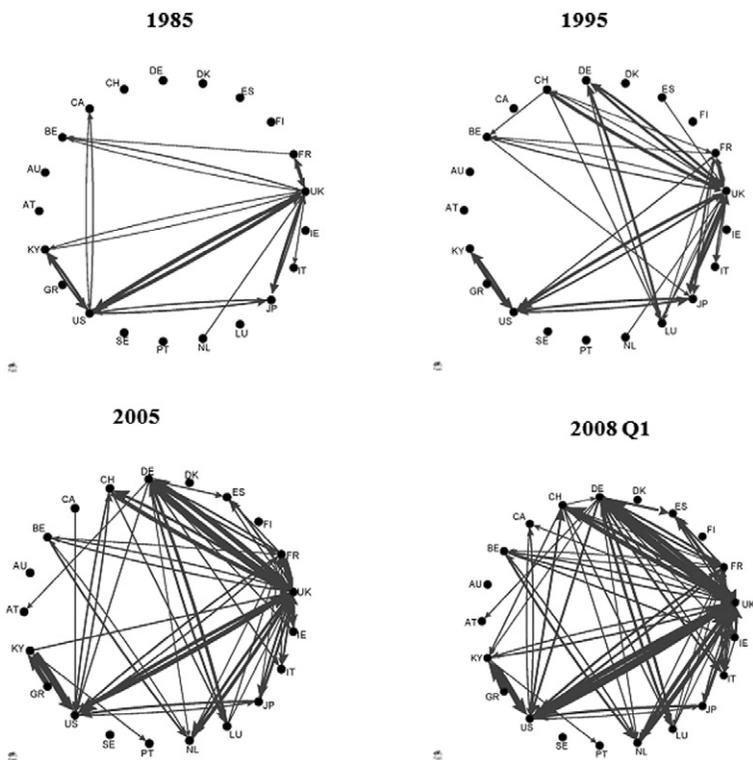
Figure 2. Interbank Network Connectivity Balloons (1985–2008).

financial market developments, this is hardly surprising; a full two-thirds of the increase in bank balance sheets in recent years has taken the form of claims against other financial institutions.[157] The recent credit bubble that burst in 2007–2008 occurred predominantly within the banking sector, as most of the borrowed money failed to reach the "real" economy. Some provocative "cognitive capitalism" critiques go so far as to suggest that the increased prevalence of trading of leveraged financial claims among financial institutions has obliterated the distinction between the real and financial sectors of the economy; on this theory, the rearrangement of financial

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[157]*See* Gai et al., *supra* note 137, at 456 fig.3 (showing that financial corporate debt comprised approximately two-thirds of credit growth in the United Kingdom from 2003 to 2007); Andrew G. Haldane & Robert M. May, *Systemic Risk in Banking Ecosystems*, 469 NATURE 351, 351 (2011).

claims—via derivatives and securitization—is a pillar of the postindustrial economy.[158]

These interfirm networks are not only opaque; they are also tightly coupled—which frustrates attempts by regulators, or anyone else, to understand their system dynamics. As discussed above, Perrow's normal accident theory predicts that such systems are bound to fail catastrophically.[159] Examples of complex and tightly coupled financial markets abound. For example, a bank seeking to hedge against risk exposure to subprime mortgage-related assets must take a position that is inversely correlated with subprime mortgages.[160] The market for derivative instruments relating to subprime mortgages is illiquid, so the bank would instead need to take a short position in an asset that is correlated with subprime mortgages, such as high-yield bonds. Thus, the bank obtains its hedge by shorting high-yield bonds or purchasing protection in the high-yield bond derivative market. Either hedge would push high-yield bond prices down and yields up, raising the cost of financing for sub-investment-grade borrowers.[161] In the process, problems in the mortgage market ramify through the financial system via derivatives to raise interest rates and possibly create financial strain for borrowers relying on capital in the seemingly unrelated high-yield debt market.

The May 6, 2010, "flash crash" provides a more dramatic example of a normal accident in financial markets. In that episode, major equity indexes in futures and securities markets plunged five to six percent in a matter of minutes, only to recover those losses almost as quickly.[162] Some

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[158]*See generally* Christian Marazzi, The Violence of Financial Capitalism 26–42 (2011) (discussing the "financialization" of the "post-Fordist" global economy and critiquing the division between the "real" manufacturing economy and the leveraged financial business model that contributes to large shares of corporate profits and gross domestic product).

[159]*See supra* notes 117–19 and accompanying text.

[160]*See* Aline van Duyn, *Subprime's Toxic Spill Is Still Capable of Contamination*, Fin. Times, Jun. 18, 2011, at 11.

[161]For an explanation for how the price of credit derivatives affects borrowers' cost of credit, see Charles K. Whitehead, *Creditors and Debt Governance* 13–14 (Cornell L. Sch., Res. Paper No. 011–04, 2011), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1760488.

[162]U.S. Commodity Futures Trading Comm'n (CFTC) & U.S. Sec. & Exchange Comm'n, Findings Regarding the Market Events of May 6, 2010, at 1–6 (2010), *available at* http://www.sec.gov/news/studies/2010/marketevents-report.pdf (summarizing events responsible for May 6, 2010, "flash crash").

individual stocks dropped much further, such as Accenture plc, which declined from about $40 to $0.01 in seven seconds.[163] According to the joint CFTC-SEC report on the matter, a single equity-index futures sell order from a mutual fund caused the crash. The culprit sell order was large and executed through an automated execution algorithm that executed sales on the exchange in increments that were calibrated to the total volume of trading in the market for the subject futures contract.[164] The order was executed rapidly over twenty minutes because increased market volatility resulted in higher-than-expected trading volumes. The high trading volumes, however, were not due to deep liquidity—in other words, many willing buyers and sellers—but rather a more limited subset of high-frequency traders (HFTs) executing rapid automated trades without taking meaningful long or short positions.[165] So the rate of execution of the mutual fund's sell order, which was tied to trading volumes, ramped up as volumes increased, selling into a market where, because liquidity was sparse, there were very few willing buyers. The result was a sudden and marked decrease in the price of the subject equity-index futures contract that was "corrected"—that is, counteracted by negative feedback pressure—only after the sell order was completed. The high-volume, low-liquidity trading strategy of the HFTs interacted dynamically with the structure of the futures trade, temporarily bouncing the market outside equilibrium. Little slack existed in instant-execution trading markets so trade orders—and even trading strategies—become tightly coupled.

Another set of tightly coupled transactions caused the futures indexes' volatility to cascade through the stock markets themselves. The anomalous events occurring in the equity futures market triggered built-in pauses in the automated trading systems used by investment banks and hedge funds that provide much of stock market liquidity.[166] As risk

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[163]*Id.* at 83.

[164]*Id.* at 2.

[165]The report defines high-frequency traders as "proprietary trading firms that use high speed systems to monitor market data and submit large numbers of orders to the markets." They "utilize quantitative and algorithmic methodologies to maximize the speed of their market access and trading strategies." *Id.* at 45.

[166]The built-in pauses in automated trading systems are designed to facilitate human judgment when it appears the data on which the automated trades are being executed is questionable or perhaps that a cataclysmic event, as-yet undiscovered by the firm operating the platform, has occurred. *See id.* at 4–5, 35–38.

managers and traders analyzed these unexpected events, they decided to pull back liquidity.[167] Many market makers, which execute trades for clients internally rather than on exchanges, elected to send client orders to public exchanges rather than take long positions (even for a brief period of time) in a rapidly declining market.[168] Because the general market sentiment was broadly negative that day,[169] this withdrawal of liquidity led to concentrated downward price pressure. This in turn triggered additional built-in pauses to the extent the events in the equity futures indexes had not already done so, causing a positive feedback effect that pushed prices further downward.[170] The "flash crash" illustrates how endogenous events and market structure can destabilize financial markets in unpredictable ways. The homogenous programming of the built-in pause feature resulted in tight coupling and the disappearance of slack that could otherwise allow negative feedback to "correct" prices. If the mutual fund's large sell order was not executed by reference to trading volumes, or if the trading platforms' risk management systems were not roughly homogenously programmed to withdraw liquidity upon the occurrence of non-modeled events, or if the HFTs did not augment trading volume and allow the execution of the large sell order over twenty minutes rather than twenty hours, the market would not have experienced a nearly $1 trillion loss in capitalization. But the flipside is also true: there are many near-miss normal accidents that are still waiting to emerge from financial markets in unpredictable ways.

c. Network effects of regulation and trading strategies. Regulation, too, interacts dynamically with market actors and their transactions. In particular, capital adequacy regulation renders firms susceptible to positive feedback effects, termed "cyclicality" to connote an acceleration of the normal credit cycle. The Basel Committee on Banking Supervision, which has been since 1988 the de facto capital adequacy regulator for large banks, is straightforward about this: "[I]t is not possible

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[167]*Id.* at 35 ("In general we found that many (though not all) firms we interviewed significantly curtailed or completely halted their trading activities at some point during the afternoon of May 6.").

[168]*Id.* at 37–39.

[169]*Id.* at 9–10.

[170]*Id.* at 36.

to achieve greater risk sensitivity across institutions at a given point in time without introducing a certain degree of cyclicality in minimum capital requirements over time."[171] Capital requirements can inadvertently cause a downward spiral in prices as initial signs of price weakness in asset *A*, if large enough, can trigger increases in capital requirements. As capital requirements increase banks might be forced to sell asset *B* to maintain their capitalization levels, which could put pressure on other banks holding asset *B*, and so forth.[172] Similar effects have been observed in connection with trading strategies and standardized contracts; where banks are utilizing the same strategies or contracts, seemingly insignificant events can cause the emergence of massive and unpredictable price movements.[173] In such circumstances, distinct components of banks' networked operating environment—for example, the capital adequacy regime and price levels—can become tightly coupled. These procyclical phenomena have been referred to as "financial accelerators"[174] and are obviously more pronounced when firms are operating in a highly leveraged environment.[175]

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[171]Basel III Framework, *supra* note 20, at 5.

[172]*See* Charles K. Whitehead, *Destructive Coordination*, 96 Cornell L. Rev. 323, 341–56 (2011).

[173]Such correlated trading strategies caused the 1987 stock market crash and the May 2010 "flash crash." The culprit in the former was so-called "portfolio insurance" that had proliferated rapidly through the market in the 1980s. *See* Peter L. Bernstein, Against the Gods: The Remarkable Story of Risk 314–20 (1996). A contributory cause to the latter was a widespread tendency for high-frequency traders to use automated high-volume algorithmic trading strategies without taking large short or long positions in the traded securities, which resulted in spiked trading volumes that interacted in unpredictable ways with a large single order. *See supra* notes 162–70 and accompanying text.

[174]Simon Johnson & James Kwak, 13 Bankers: The Wall Street Takeover and the Next Financial Meltdown 29 (2010).

[175]The Basel Committee's Basel III Framework imposes a countercyclical capital buffer to guard against the operation of the financial accelerator. *See* Basel III Framework, *supra* note 20, at 57–60. The countercyclical buffer is inspired by the "dynamic provisioning" technique employed by Spanish bank regulators. It requires each jurisdiction to authorize an agency to implement an additional countercyclical capital buffer where the agency has adjudged that "excess credit growth" has occurred. Because it will require a regulator to make a prudential evaluation of the total volume of credit in the economy, it can be categorized as a "macroprudential" regulatory tool. *See id.* For a skeptical analysis on the promise of macroprudential regulation, see Dan Awrey, *Macro-Prudential Financial Regulation: Panacea or Placebo?*, 1 Amsterdam L.F., no. 3, 2009 at 17.

2. Experimental Demonstrations of Financial Complexity and Network Effects

Advances in computer technology have enabled scientists and economists to conduct experiments involving millions of network interactions among thousands of adaptive hypothetical agents in a financial market. These "agent-based models" utilize an inductive approach under which the experiment designers make assumptions about how prices are formed and how agents make decisions.[176] The computer then simulates real-world interactions among the agents as they make decisions. These network simulations hold advantages over empirical tests that use actual or estimated data to simulate the contagion effects of a shock—sometimes called "counterfactual simulations"—because researchers conducting such tests are unable to discern which data to change, and in what increments, to test for contagion effects.[177] The empirical studies therefore suffer from a "black box" problem. The computer-based experiments, by contrast, are deterministic because the programs and the parameters are fixed. Outcomes are highly sensitive to initial starting conditions. While these conditions may be modeled ex ante, no marriage of economics, computer science, and physics is anywhere close to being able to create a complete model of real financial markets,[178] so the results of these studies are not

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[176]J. Doyne Farmer, *Toward Agent-Based Models for Investment*, 2001 AIMR Conf. Proc.: Dev. Quantitative Investment Models 61, 61–64, *available at* http://tuvalu.santafe.edu/~jdf/papers/aimr.pdf.

[177]*See* Christian Upper, *Using Counterfactual Simulations to Assess the Danger of Contagion in Interbank Markets* 14 (Bank for Int'l Settlements, Working Paper No. 234, 2007), *available at* http://www.bis.org/publ/work234.pdf.

[178]The chief complicating factor is that the key decision-making actors in the economy are human beings, who have heterogeneous and shifting beliefs about the future and are even prone to irrational processing of information. *See* Aikman et al., *supra* note 77, at 6–9; *cf.* Arthur, *supra* note 74, at 107 ("[U]nlike ions in a spin glass, which always react in a simple way to their local magnetic field, economic elements (human agents) react with strategy and foresight by considering outcomes that might result as a consequence of behavior they might undertake."); Farmer et al., *supra* note 76, at 39 ("The most fundamental difference between a physical system and an economy is that an economy is inhabited by people, who have strategic interactions. Because people think and plan, and then make decisions based on their plans, they are much more complicated than atoms."). Thus, actual risk interacts with perceptions of risk to affect future actual risk. George Soros has used the term "reflexivity" to refer to this dynamic process in financial markets. *See* George Soros, The Alchemy of Finance: Reading the Mind of the Market 27–45 (2d ed. 1994). Stated another way, "Outcomes are endogenous to beliefs about the likelihoods of the outcomes." Aikman et al., *supra* note 77, at

predictive of real market behavior. However, they have tremendous utility in unveiling emergent network properties and isolating the sensitivity of financial networks to changes in certain parameters. Moreover, in contrast to the counterfactual simulations that look at empirical data, experimental research can individuate *how* the parameters cause the emergent properties with greater precision.

Two sets of experiments merit mention here because they establish the nonlinear dynamics of even simplified, computer-modeled financial markets. In the first set of experiments summarized here, researchers explore how a complex, interactive financial market could become subject to nonlinear phase transitions (sometimes referred to as "shocks") based only on the internal structure of the market. The second set of experiments look at financial network topology by modeling how positive feedback can cause an initial shock at a single institution to propagate through a financial system.

a. How shocks arise endogenously from market structure. In one study, a group of physicists, computer scientists, and economists affiliated with the Santa Fe Institute ran an experiment to see what a market would look like when a group of hypothetical heterogeneous investor–agents drew from a preformulated bank of trading strategies, observed their results, and adapted them in light of their experience—all on a continuous, rolling basis.[179] Because of the dynamic interaction between the investor-agents, and the fact that the investor–agents' adaptive selections of trading strategies depended in large part on which trading strategies they anticipated their trading partners would adopt, prices were driven endogenously by the expectations of the investor–agents.[180] Thus, the authors describe, "[I]ndividual beliefs or expectations become endogenous to the market, and constantly compete within an ecology of others' beliefs or expectations."[181] In this ecology of expectations where, most importantly, price is set by demand for assets among a group of

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7. While it is true that "the odds on a 100-year storm do not change because people think that such a storm has become more likely," the odds of a bank run are very much affected by subjective human perceptions of its likelihood. JOHN KAMBHU ET AL., NEW DIRECTIONS FOR UNDERSTANDING SYSTEMIC RISK: A REPORT ON A CONFERENCE COSPONSORED BY THE FEDERAL RESERVE BANK OF NEW YORK AND THE NATIONAL ACADEMY OF SCIENCES 48 (2007).

[179]*See* Arthur et al., *supra* note 87, at 15.

[180]*Id.* at 38.

[181]*Id.* at 15.

heterogeneous investor-agents, deductive reasoning is unhelpful because investor–agents are unable to know what their trading partners are thinking.[182] The authors note that the expansive use of heuristic, inductive rules-of-thumb can create positive feedback:

> Under heterogeneity, however, not only is there no objective means by which others' dividend expectations can be known, but attempts to eliminate the other unknowns, the price expectations, merely lead to the repeated iteration of subjective expectations of subjective expectations (or, equivalently, subjective priors on others' subjective priors)—an infinite regress in subjectivity. Further, this regress may lead to instability: If investor i believes that others believe future prices will increase, he may revise his expectations to expect upward-moving prices. If he believes that others believe a reversion to lower values is likely, he may revise his expectations to expect a reversion. We can, therefore, easily imagine swings and swift transitions in investors' beliefs, based on little more than ephemera—hints and perceived hints of others' beliefs about others' beliefs.[183]

The results of the study demonstrated that whether the system settled on equilibrium depended on the frequency with which the investor–agents were allowed to adopt new trading strategies.[184] Under the first scenario, investor–agents traded less frequently and an equilibrium emerged whereby prices tended to correspond with fundamental value. On the other hand, under a higher, more realistic trading frequency, the results changed dramatically. The authors found instead systematic evidence of instability in the form of bubbles and crashes, driven by trading volumes that were three times larger than those obtained in the first scenario as investor–agents searched desperately for successful trading strategies. Thus, by adjusting the trading frequency alone, the system underwent a phase transition to a system characterized by punctuated equilibrium with intermittent chaotic episodes.[185] The authors determined that this second scenario corresponded more closely to actual stock market behavior.[186]

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[182]*See id.*

[183]*Id.* at 21.

[184]*See id.* at 38.

[185]The authors refer to the punctuated equilibrium phenomenon as "volatility clustering." *Id.* at 35 n.14.

[186]*Id.* at 31 ("We note that fat tails and high volume are also characteristic of price data from actual financial markets.").

Though the authors did not expressly address network effects, it is obvious that an increase in the trading frequency would expand the interrelatedness of the market network's nodes. Network effects theory would predict the increase in volatility and instability that the authors observed. The authors impliedly tied their results to network theory:

> Once in a while, randomly, more successful expectations will be discovered. Such expectations will change the market, and trigger further changes in expectations, so that small and large "avalanches" of change will cascade through the system . . . . Changes then manifest in the form of increased volatility and increased volume . . . . The larger [the trading frequency] is, the faster individual agents "switch" among their predictors. Thus the more such switches should cascade.[187]

In a study a few years later, Santa Fe Institute physicist Doyne Farmer ran a series of experiments that demonstrated that bubbles could arise in asset markets *even when the investor–agents knew what the fundamental values of the assets were*. Farmer posited a single-asset market that consisted of: (1) a single value investor, who assesses a security's value and buys it if it is underpriced; and (2) a single market maker, who takes both the buy and sell side of a transaction, pocketing the spread as a profit.[188] His value investor knew the fundamental values of securities, so under general equilibrium conditions the price would immediately converge with the value. But Farmer found that whether prices tracked fundamental values depended on the risk aversion of the market maker.[189] If the market maker was risk-averse and executed transactions at a slow rate to avoid taking on large net positions, the price effects of changes in fundamental value did not occur instantaneously but rather showed what physicists refer to as a "temporal structure."[190] This temporal structure of price effects in turn created trends in prices, but the system behaved linearly and nonchaotically. Importantly, the temporal structure did not arise from noise trading because Farmer's hypothetical market provided for a single value investor with perfect information. Instead, the price-value mismatch arose entirely from the dynamic interaction of the market's agents.[191]

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[187]*Id.* at 33–35.

[188]*See* Farmer, *supra* note 176, at 66.

[189]*See id.*

[190]*Id.* at 65.

[191]*Id.* at 70.

Farmer then introduced new agents into his market ecosystem: a "seasonal trader" who bought and sold according to factors external to the asset market—for example, a farming concern that needed to sell its crop—and a technical investor who tried to spot price trends and take advantage of the seasonal trader.[192] The technical investor—like the investor–agents from the earlier Santa Fe trading-strategies experiment— selected from a bank of trading heuristic rules and adapted its behavior in light of experience.[193] When Farmer simulated the market interactions among the market maker, the value investor, the seasonal trader, and the technical investor, he found that price gradually settles, at an increasing rate, to fundamental value as time advanced from $t = 0$ to $t = 5000$.[194] This result obtains because the technical investors learn how to time the market to exploit the seasonal traders.[195] However, after $t = 5000$, the technical investors, who by that point possess nearly all the wealth, begin exerting the largest influence on the market. The heuristics that the technical investors had used to bring the market to a near-equilibrium are now inappropriate in the context of a new market structure where seasonal traders no longer contribute significantly to price formation. The results are dramatic, chaotic oscillations in price driven by complex interactions among the agents.[196] And the apparent chaos is not short-lived: "The statistical properties of prices continue to change, even tens of thousands of iterations later, as the feeding relationships of who is exploiting whom shift around."[197] These experiments evidence the nonlinear dynamics of even simple, stylized markets for financial assets with limited numbers of agents of limited irrationality.

In another more recent experiment, a team of Italian "econo-physicists" modeled how a stylized derivatives market would behave as the

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[192]*See id.* at 68.

[193]*See id.*

[194]*Id.* at 69 & fig.5. Farmer measured time at discrete moments at t, $t+1$, and so forth, in order to be able to synchronize trades. *See id.* at 66. Among other things, this enabled Farmer to register price patterns as the market maker unloaded its position a bit at a time, depending on its risk aversion. *Id.* at 67. The important point here is that t measures the time series along which transactions occur rather than any calendar time space.

[195]*See id.* at 69.

[196]*Id.* at 70.

[197]*Id.*

number of derivative financial instruments increased.[198] Their results were consistent with the "complexity catastrophe" and "conflicting constraints" threats that Kauffman warns about in the context of biological evolution.[199] The authors found that while increasing the number of tradable financial instruments at first enhanced the market's efficiency—because traders were able to arbitrage away any pricing inefficiencies with the increasingly differentiated mix of instruments—a nonlinear phase transition arose when the number of financial instruments reached a critical level.[200] An increase in the number of tradable financial instruments amounted to an increase in the market's complexity, as traders could take on positions and hedge them or arbitrage away inefficiencies by taking on positions in other financial instruments.[201] The complex interactions between the increasing numbers of financial instruments caused a phase transition that knocked the market out of equilibrium. Networked systems that exhibit initially increased abilities to absorb shocks, but are vulnerable to sudden phase transitions, have been described as "robust-yet-fragile."[202] This "double-edged sword" trait of interconnectedness recalls the previous discussion of how the productive advantages of network connectivity can quickly bump up against conflicting constraints.[203]

Figure 3 below illustrates the jarring emergence of sharp swings in demand.[204] The vertical axis (S) represents the demand for the financial instruments and the horizontal axis (n) represents the number of tradable financial instruments in the market. The lines represent different risk premia (ε) that the financial intermediaries executing the trades require from the parties requesting the trades.[205]

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[198]*See* Caccioli et al., *supra* note 97.

[199]*See supra* notes 109–11 and accompanying text.

[200]*See* Caccioli et al., *supra* note 97, at 468.

[201]*Id.* at 469.

[202]*E.g.*, Gai & Kapadia, *supra* note 150, at 2401; Haldane, *supra* note 154, at 9.

[203]*See supra* Part II.C.2.

[204]Caccioli et al., *supra* note 97, at 472 fig.2 (reprinted with the kind permission of the *European Physical Journal B*).

[205]In the portion of the paper discussed here, the authors assume that the risk premia are identical for all financial instruments for any given scenario. *See id.* at 470–71.
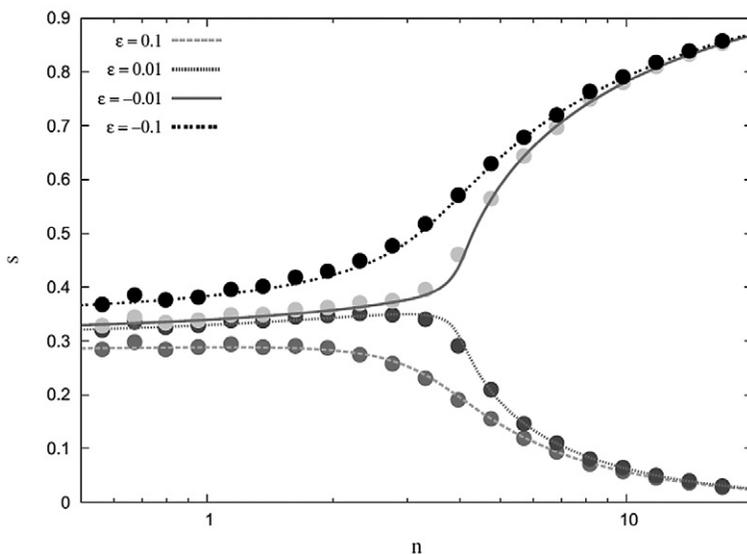
Figure 3. Interactions between Demand and Number of Tradable Financial Instruments.

The two most interesting implications of Figure 3 for present purposes are (1) the razor-tight sensitivity of demand to the banks' risk premia and (2) the dramatic and unexpected shift in demand when n reaches approximately 4.1 financial instruments. In a later paper, Andrew Haldane of the Bank of England and physicist Robert May interpreted the experiment's results as evidence that

> once there are enough derivatives to span the space of available states of nature (the net supply of derivatives within the system necessary to meet true hedging demand from non-banks), the market is essentially complete in the [traditional general equilibrium] sense . . . . Once that happens, gross derivatives positions within the system are essentially unbounded. So long as there is an incentive to supply new instruments—a positive premium to trading— banks will continue to expand gross positions, independent of true hedging demand from non-banks. Such trades are essentially redundant, increasing the dimensionality and complexity of the network at a cost in terms of stability, with no welfare gain because market completeness has already been achieved.[206]

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[206]Haldane & May, *supra* note 157, at 352 (footnote omitted).

b. How financial networks cause initial shocks to spread contagion. As provocative as these experimental results are, they illustrate how an unpredictable initial shock to financial markets would arise from the dynamic interaction of agents in a network. This is only half of the problem. As previously discussed, a network's susceptibility to contagion by means of a positive feedback catastrophe depends on its topology—that is, the number, interconnectedness, and bias of its nodes—and can be exacerbated by the presence of tight coupling.[207] Recent studies have begun to take up the question of network topology by modeling how shocks at the institutional level propagate through financial systems through both the asset and liability side of bank balance sheets.[208] These studies model a network by making assumptions about the key parameters that define its topology and then run computer simulations to test how the network reacts to changes.

One study investigated the contagion effects on the banking system of an idiosyncratic—in other words, not system-wide—shock to a single bank's external assets. The study modeled the following network topology parameters: (1) the interconnectedness of the banks, each of which comprised a node of the network; (2) the percentage of the banks' assets comprised of interbank, as opposed to out-of-network, claims; (3) the concentration of the banking market; (4) the banks' net worth; and (5) the effects of illiquidity upon the resolution of an insolvent bank.[209] The authors of the study ran thousands of computer simulations, varying the parameters slightly to individuate their effects. Some of their findings were expected; for example, they found that a banking system is more susceptible to contagion when banks have impaired capital positions and when the banking industry is highly concentrated—in other words, when the network has fewer nodes.[210]

But other findings are more intriguing from a regulatory perspective. For instance, the authors discovered that a bank's vulnerability to contagion from another bank's default increased as its percentage of interbank—in other words, in-network—liabilities increased.[211] Moreover,

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[207]*See supra* Part II.C.

[208]*See* Gai & Kapadia, *supra* note *150*; Nier et al., *supra* note 136.

[209]Nier et al., *supra* note 136, at 2035, 2042–47.

[210]*See id.* at 2042–43, 2046–47, 2053–54.

[211]*See id.* at 2043–44, 2054.

interesting nonlinear results presented for the network connectivity parameter. At first, an increase in the interbank connectivity increases the risk of contagion, but once the network is highly connected, further increases in connectivity make the system more resilient because the shock is absorbed by a greater number of banks.[212] This latter phenomenon is only present where the banking system is well-capitalized; in a poorly capitalized banking system, greater connectivity will result in quicker transmission of contagion through the system.[213] In other words, the banks become tightly coupled to one another. Not surprisingly, the authors found that liquidity pressures resulting from fire-sale dispositions of failing banks' assets increased the banking system's vulnerability, especially if the system is highly concentrated.[214]

Other recent studies examine how network topology affects contagion on the liability side of the balance sheet through so-called "liquidity hoarding."[215] During the credit freeze of 2007–2008 and through much of 2009, banks doubted the solvency of their counterparties and refused to lend capital in the interbank markets, instead opting to hold excess reserves with central banks and forgo the spread they could have earned by lending.[216] Prasanna Gai, Andrew Haldane, and Sujit Kapadia found that network properties of the unsecured interbank loan market can cause positive feedback loops that result in banks dramatically retrenching from the interbank market. The findings suggest that "tipping points may be embedded in the financial network . . . [that] depend on the level of liquid asset holdings, the amount of interbank activity, and the size of haircuts on banks' assets."[217] In particular, the authors illustrate the dynamic interaction between the unsecured interbank lending market and the secured "repo" lending market. A repo transaction entails borrowing money using

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[212]*Id.* at 2044–46, 2054.

[213]*Id.*

[214]*See id.* at 2047–51, 2054. Liquidity shortages result in reduced "slack" in the financial system and tighter coupling among markets and individual transactions, as demonstrated amply by the May 2010 "flash crash." *See supra* notes 162–70 and accompanying text.

[215]*E.g.*, Gai et al., *supra* note 137, at 454.

[216]*See* Florian Heider et al., *Liquidity Hoarding and Interbank Market Spreads: The Role of Counterparty Risk* 7–8 (European Cent. Bank, Working Paper No. 1126, 2009), *available at* http://www.ecb.int/pub/pdf/scpwps/ecbwp1126.pdf.

[217]Gai et al., *supra* note 137, at 454.

securities as collateral. It is structured as the spot sale of securities for cash, coupled with an agreement to repurchase the same securities at the initial price plus interest at a particular date in the future. When the borrowed cash is lower in amount than the current market value of the securities used as collateral, the discount is referred to as a "haircut."[218] In a repo transaction, the lenders bear the market risk associated with the lent securities, and they impose haircuts to compensate for the risk that the borrower defaults and the collateral declines in value. When counterparties demand deeper haircuts, borrowers naturally have less cash. The Gai-Haldane-Kapadia model assumes that a bank will hoard liquidity—that is, it will withdraw or refuse to roll over existing interbank lending—when it faces a liquidity shortage brought on by increased haircuts.[219]

　　Their model produces some illuminating results from a networks perspective. In their baseline scenario, the authors assumed the interbank network had a so-called Poisson structure, meaning that the links between banks are distributed roughly uniformly rather than in a concentrated manner.[220] They assumed further that a single bank received a liquidity shock in the form of an increased haircut for its repo borrowings. They tested the model for various levels of average interconnectedness of the interbank lending network, which they denote by the parameter z, ranging from $z = 0$ (no connectivity) to $z = 100$ (each node is connected to all other nodes). The z parameter can be considered a rough proxy for the complexity of the funding aspect of the financial system—that is, the liabilities side of banks' balance sheets.[221] In this baseline scenario, there was a low frequency of contagion at very low levels of interconnectedness, a high frequency of contagion for moderate levels of interconnectedness ($3 < z < 12$), and a low frequency of contagion when $12 < z < 15$, which became zero around $z = 15$.[222] The researchers identify $z = 7.5$ as the

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[218]*Id.* at 454 n.2.

[219]*Id.* at 454.

[220]*Id.*

[221]This relation obtains because interbank funding represents a large portion of a bank's funding base. *See supra* note 157 and accompanying text.

[222]Gai et al., *supra* note 137, at 462 fig.6. The probability of contagion is nonmonotonic, meaning that it first rapidly increases, only to later decrease with still further interconnectedness. *Id.* at 462. When $z = 0$, the probability of contagion must also be zero because there is no channel through which contagion may occur. Contagion "remains positive for higher

tipping point at which further increases in interconnectedness will increase the system's resilience to contagion.[223] The authors found that for nearly all values of z, when contagion did spread throughout the network, it was complete and nonlocalized.[224] For higher levels of interconnectedness, there was no contagion because the shock was absorbed across a wider array of banks on account of the greater interconnections. The authors then tested how the network would react to the same singular shock but this time in combination with an across-the-board increase of the aggregate haircuts required by all repo lenders from 0.1 to 0.2.[225] Not surprisingly, the haircut increase lowered the resilience of the network to contagion because banks had less of a cushion with which to absorb a liquidity shock. Here, the system underwent contagion spillovers with a high frequency when $3 < z < 25$, and contagion occurred with a lower frequency for all values of z higher than 30.[226] The tipping point increased from $z = 7.5$ to around $z = 15$, meaning that the haircut, by draining liquidity from the interbank network, resulted in contagion occurring for a wider range of interconnectedness.[227] The direct relationship between thin capitalization and susceptibility to contagion recalls the earlier discussion of tight coupling: the thinner a bank's capitalization, the more tightly its financial well-being is coupled to that of its counterparties.[228]

   In the next set of experiments, the authors changed the structure of the network from a Poisson structure to a so-called geometric structure, in which a certain number of banks are more interconnected than others.

[than 7.5] values of z . . . due to the randomness of the network structure which means that contagion can still break out under certain configurations." *Id.* Moreover, "the reason contagion is not always certain for smaller values of z is that the initial shock may hit a bank which either has no interbank assets, and is therefore unable to trigger any contagion by hoarding liquidity, or is in an isolated subset of the network." *Id.*

[223]*Id.*

[224]*Id.*

[225]*Id.*

[226]*Id.* fig.6. As with the baseline scenario, the probability of contagion is nonmonotonic in connectivity. *See supra* note 222.

[227]Gai et al., *supra* note 137, at 462.

[228]*See supra* notes 213–14 and accompanying text.

The authors correctly point out that this simulation, with its assumption of a few densely connected banks, approximates real-world financial markets,[229] which have undergone dramatic increases in concentration levels over the past three decades.[230] In this scenario, the isolated singular shock never results in the high likelihood of contagion observed with respect to the Poisson network.[231] However, frequencies are moderately high for a wider range of interconnectedness. And frequencies of contagion do not converge at zero until z equals almost seventy—in sharp contrast to the singular shock to the Poisson network, where contagion virtually disappears by the time $z = 15$.[232] When the percentage of a bank's liabilities that are comprised of interbank transactions increases from fifteen percent—as the authors assumed in their baseline scenario—to twenty-five percent, the frequencies of contagion are amplified. They are quite high even at low levels of interconnectedness and persist over a still wider range of interconnectedness—until z equals almost 80.[233] Thus, "for a broad range of connectivity, higher concentration in the network makes the system more susceptible to a systemic liquidity crisis."[234]

When an isolated shock at a single bank occurs in the concentrated geometric network, the results depend on whether the singular shock hits a periphery bank or a highly connected bank at the center of the network. If the targeted bank is a highly connected bank, contagion occurs more frequently than in the targeted Poisson network simulations, and it is a near certainty for a vast range of z.[235] These results are troubling but not altogether surprising. The authors note that the results demonstrate that the most dangerous banks from the standpoint of network stability are

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[229]Gai et al., *supra* note 137, at 463.

[230]*See id.* at 456 fig.2; *see also* Int'l Monetary Fund, Global Financial Stability Report 67 (2010), *available at* www.imf.org/external/pubs/ft/gfsr/2010/01/pdf/text.pdf (describing the interbank lending market as a network configuration in which "a few large banks that are highly interconnected, and a larger number of smaller banks that are connected to the rest of the network (mostly) through one of the larger banks").

[231]*See supra* note 222 and accompanying text.

[232]*See* Gai et al., *supra* note 137, at 463 fig.7.

[233]*Id.* at 463 fig.7, 464.

[234]*Id.* at 464.

[235]*See id.* at 462 fig.6, 463 fig.7, 464.

those that are especially prone to an initial shock and those that propagate the shock widely.[236] At present, the same large, complex banks fit both of these descriptions—the former on account of their heavy involvement in repo activity and the latter on account of their high degree of connectedness with the interbank network.[237] As a result, the financial system is susceptible both to frequent shocks and to fast transmission of those shocks through the network.

These financial network topology studies are noteworthy because they demonstrate the existence of sharp nonlinear events in financial market networks. They also uncover patterns between changes in the interconnectedness and concentration of markets and market stability. While fixing the ex ante parameters of the experiments permits those conducting the studies to make probabilistic predictions of network behavior, it is not possible in real life to identify and estimate accurately all relevant parameters in order to divine the singular events that engender threats to institutional safety and soundness and to market-wide financial stability. In other words, if the experimental research shows unpredictable tipping points and singularities when we *are* able to set up a deterministic system, then it is immeasurably more difficult to predict system behavior when the parameters are uncertain. How can regulators, in light of their bounded rationality, identify and remediate threats to financial stability at the systemic level and unsafe and unsound practices at the institutional level? This is the crux of the problem for financial regulators. Increasing complexity might result in bounded rationality transforming from an obstacle to be overcome to a structural impediment to sensible regulatory control.

3. Implications of Complexity for Financial Regulation

Financial regulators are not investment managers, and they are not in the prediction business. But their statutory mandates are broad.[238] Under conditions of complexity, the task of monitoring the safety and soundness

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[236]*See id.* at 464.

[237]*See id.*

[238]*See supra* Part II.B.

of a financial institution, to say nothing of promoting the stability of an entire financial system, requires at a minimum that the regulators familiarize themselves with the topology and dynamics of the intrafirm and market-wide networks through which nonlinear episodes of contagion could spread. In these complex, highly networked environments, a core assumption of the New Deal administrative system—namely, that agencies possess the requisite expertise to build a regulatory system that promotes the administrative objectives—ceases to obtain. It is probably not a coincidence that the rapid acceleration in financial innovation and complexity during the 1980s coincided with a heightened faith in markets as ordering mechanisms and, by implication, a belief that the administrative state had become obsolete. In a way, it was beginning to do just that—just not in the way that the trumpeters of market efficiency envisioned. Yet ideology only tells part of the story; in a very real way, increased complexity, along with widening information asymmetries between regulators and regulated firms, has removed regulators from their privileged perch as "expert" superintendents as contemplated by the New Deal theorists.[239] Even commentators indisposed to purely market-based, private ordering of events should recognize the challenge to the viability of the administrative state.[240]

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[239]*See supra* notes 14–16 and accompanying text.

[240]It is hardly surprising therefore, given the state of the contemporary financial industry, to read the Financial Crisis Inquiry Commission Report recount the inability of bank regulators, even with the help of industry competitors, to gauge a simple concept like the balance sheet solvency of Lehman Brothers on the eve of its collapse. According to the Report:

> Solvency should be a simple financial concept: if your assets are worth more than your liabilities, you are solvent; if not, you are in danger of bankruptcy. But on the afternoon of Friday, September 12, 2008, experts from the country's biggest commercial and investment banks met at the Wall Street offices of the Federal Reserve to ponder the fate of Lehman Brothers, and could not agree whether or not the 157-year-old firm was solvent.

Fin. Crisis Inquiry Comm'n, The Financial Crisis Inquiry Report: Final Report of the National Commission on the Causes of the Financial and Economic Crisis in the United States 324 (2011). No doubt the Federal Reserve's task was complicated by the over one million derivatives positions that were outstanding on that date. *See* Serena Ng & Mike Spector, *The Specter of Lehman Shadows Trade Partners*, Wall St. J., Sept. 17, 2009, at C1 (documenting 1.2 million derivatives transactions outstanding with 6500 counterparties); *see also* Aline van Duyn, *Dodd-Frank Deadline Looms but Derivatives Are Still in Flux*, Fin. Times, Jan. 29, 2011, at 15 (referring to "too much interconnection" in derivatives markets and noting that a "key plank of financial market reform" is "[r]educing these connections").

III. Structural Regulation versus Behavioral Regulation

Any assessment of a regulatory approach or toolkit must start with consideration of "whether it offers assistance in addressing the challenges regulators face in practice."[241] This Part takes up that question in the context of financial regulation by analyzing the comparative effectiveness of structural regulatory tools and behavioral regulatory tools under conditions of complexity.[242] By "structural tools" I refer to restrictions on firm

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[241]Robert Baldwin & Julia Black, *Really Responsive Regulation*, 71 Modern L. Rev. 59, 59 (2008); *see also* Julia Black & Robert Baldwin, *Really Responsive Risk-Based Regulation*, 32 Law & Pol'y 181, 183 (2010) ("[O]nce regulators have established their objectives, they should consider how any given regulatory approach comes to grips with the . . . fundamental tasks involved in implementing regulation so as to further those objectives.").

[242]The structural–behavioral binary is not meant to describe all the dimensions along which the problems of contemporary financial regulation could be considered. I have elsewhere advocated for a focus on "meta-risk management" and "new governance" regulatory techniques in financial regulation. *See* Robert F. Weber, *Combating the Teleological Drift of Life Insurance Solvency Regulation: The Case for a Meta-Risk Management Approach to Principles-Based Reserving*, 8 Berkeley Bus. L.J. 35, 90–99 (2011) [hereinafter Weber, *Teleological Drift*]; Robert F. Weber, *New Governance, Financial Regulation, and Challenges to Legitimacy: The Example of the Internal Models Approach to Capital Adequacy Regulation*, 62 Admin. L. Rev. 783, 836–67 (2010) [hereinafter Weber, *Internal Models*]. Other helpful analytical distinctions abound in this context, including, to mention only a few, "enforced self-regulation," "management-based regulation," and "reliability"-focused regulation. *See, e.g.*, Ayres & Braithwaite, *supra* note 8, at 19–27 (describing the "benign big gun" as a linchpin of an "enforced self-regulation" regime, aiming to appeal to the social responsibility of actors to obtain voluntary compliance, but also standing ready to deploy deterrent threat sanctions of increasing severity to motivate purely economically motivated rational actors and incapacitate chronic law violators); Cary Coglianese & David Lazer, *Management-Based Regulation: Prescribing Private Management to Achieve Public Goals*, 37 Law & Soc'y Rev. 691, 691 (2003) (advocating for "management-based regulation" as an alternative to "technology-based regulation" and "performance-based regulation" that will be optimal when "regulated entities are heterogeneous and regulatory outputs are relatively difficult to monitor"); William H. Simon, *Optimization and Its Discontents in Regulatory Design: Bank Regulation as an Example* 1–12 (Columbia Law Sch. Pub. Law & Legal Theory Working Paper Group, Paper No. 9180, 2009), *available at* http://lsr.nellco.org/cgi/viewcontent.cgi?article=1072&context=columbia_pllt (promoting a "reliability" perspective to bank regulation to counter the "vulgar optimization" perspective that can "lead[] in practice to a preoccupation with decisional simplicity and cost minimization at the expense of complex judgment and learning"). These general strategic regulatory orientations, which incidentally are better categorized as behavioral regulation than as structural regulation, share a focus on achieving objectives in conditions of uncertainty and volatility, and are therefore motivated by the same challenges I undertake to address in this article. Given the present structure of the financial system, however, the likelihood of implementing an effective new governance or meta-risk management regime is low. *See* Weber, *Teleological Drift*, *supra*,

size or the scope of activities in which firms are permitted to engage that have the effect of removing the incentives for undesirable behavior.[243] By "behavioral tools" I refer instead to initiatives that acknowledge the incentives for undesirable behavior and aim to counteract or mitigate their effects.[244] Both the structural and behavioral toolkit are broad; the former includes both forced break-ups and restrictions on activities, and the latter spans from highly detailed and prescriptive capital adequacy regulation[245] to the imposition of open-ended common law fiduciary duties for courts to administer.

A question lurks in the background of recent financial regulatory reform debates: whether to adopt a behavioral regulatory regime that reacts via incremental, ad hoc responses to a complex industrial logic subject to significant uncertainty or instead to adopt a structural regulatory regime that shapes, by adjusting financial market network structures, the industrial logic itself so as to minimize its vulnerability to perturbation.[246] Another way of conceptualizing this concededly rough binary is

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at 98 (highlighting difficulties raised "[w]hen regulators are captured, either literally or through the operation of more hegemonic forces"). Introducing more robust participation by civil society in governance might blunt the tendency to capture, but would likely require public funding and formal deputization of affected constituencies to participate in matters that impact financial firms' governance. *See* Saule Omarova, *Bankers, Bureaucrats, and Guardians: Toward Tripartism in Financial Services Regulation*, 37 J. Corp. L. (forthcoming 2012), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1924546 (proposing creation of a "Public Interest Council" to serve as a representative of the public interest in a "tripartite" regulatory regime that ensures participation of public regulators, civil society, and regulated industry); Weber, *Internal Models*, *supra*, at 863–65 (describing how robust participation by constituencies affected by financial industry decisions is complicated by wide dispersion of members of affected constituency, who cannot "marshal their resources as effectively as regulated financial institutions to engage regulators in a debate"). The emphasis in this article on the network topologies of finance and their resultant complex attributes accordingly focuses on the ways in which these problems, which are by their very nature structural, can be remediated through structural reform.

[243]*See* John Kay & John Vickers, *Regulatory Reform in Britain*, 3 Econ. Pol'y 285, 314 (1988) ("The regulation of structure is designed to reduce or remove the opportunity for undesired conduct rather than prohibit it from occurring.").

[244]*See supra* Part I (describing the general purpose of financial regulation to counteract market failures).

[245]*See infra* note 288 and accompanying text (discussing whether a prescriptive capital adequacy regime might be so coercive that it would effect an intended structural change).

[246]*See* Nat'l Performance Review, From Red Tape to Results: Creating a Government That Works Better and Costs Less 62 (1993) (describing "governance" as "setting priorities, then

whether to create a regulatory system that structures optimal incentives for economic actors, or one that seeks to control behavior arising from suboptimal incentives through ever-increasingly complicated rules and regulations.[247]

The structural regulatory approach would mean paring back complexity. Structural reform through enforced simplicity poses a macroengineering challenge: how to construct a resilient regime that structures the right incentives from the outset. Economists refer to this as "mechanism design."[248] In a networked environment, this means "act[ing] directly on the topology of the network."[249] The goal of structural regulation is to address market failure by deploying public power to set up a system that largely can run on its own; the need for ongoing supervision is diminished because the system has been structured so that secured regulatory objectives occur organically through self-interested transacting parties. By contrast, proposals to regulate *behavior* within existing complex network structures pose a microengineering problem of how to construct finely tuned rules that foster regulatory objectives.

The structural approach is attractive because, recalling Haldane and May, where markets are complete, additional market activity increases the complexity of a system at a cost of stability with no welfare gain.[250] In adopting the structural approach, lawmakers could minimize the twin threats of complexity capture and arbitrary regulation by altering market structure so that bounded rationality no longer constitutes an impassable

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using the federal government's immense power to steer what happens in the private sector"); Marc Schneiberg & Tim Bartley, *Regulating or Redesigning Finance? Market Architectures, Normal Accidents, and Dilemmas of Regulatory Reform*, in Markets on Trial: The Economic Sociology of the U.S. Financial Crisis, Part A 281, 283 (Michael Lounsbury & Paul M. Hirsch eds, Emerald Books Research in the Sociology of Organizations Series vol. 30A, 2010) ("If we take seriously the notion that regulation constitutes markets, rather than merely intervening in markets 'after the fact,' then the current moment becomes an opportunity to rethink market architecture, in light of the problems of complexity and tight coupling.").

[247]*See* John Kay, *The Nightmare of Taking on "Too Big to Fail*," Fin. Times, Apr. 13, 2011, at 9.

[248]*See generally* Eric S. Maskin, *Mechanism Design: How to Implement Social Goals*, 98 Am. Econ. Rev. 567 (2008) (discussing that part of mechanism design called implementation theory, which, given a social goal, characterizes a mechanism that can be designed with predicted outcomes that coincide with the desirable outcomes, according to that goal).

[249]Gai et al., *supra* note 137, at 469.

[250]*See supra* note 206 and accompanying text.

roadblock for regulators, who can then more easily supervise a less complex market structure.

In recent years, however, legislators and financial regulators have largely eschewed structural reforms of the financial industry that would limit the size, scope, and complexity of financial firms.[251] Instead, they have focused their efforts on making incremental changes to existing frameworks in order to manage the behavior of actors transacting in the complex, unstable, and uncertain networks through which financial functions are conducted. But because the effects of given behaviors in complex systems are often unpredictable and subject to positive feedback effects, regulators are incapable of implementing *ex cathedra* and ex ante a system of behavioral regulation that achieves statutory objectives. As such, they look to regulated firms themselves, which naturally have better access to information about the risks such businesses face, to provide the relevant information. In the process, however, they have created a regulatory environment where complexity capture pervades.

A. Structural Regulation as "Resilient" Regulation

This article proposes that structural reform to the financial sector would minimize the salience of the bounded rationality problems today's regulators face by helping to remediate complexity capture and its resulting regulatory dysfunction. It does not advocate for a specific structural reform proposal. Nevertheless, it bears mention that policy makers' focus on behavioral regulation is not inevitable; several serious structural reforms were proposed in recent years. In this section I will briefly highlight three of these proposals and describe the ways in which they are appropriately thought of as an attempt to bolster the *resilience* of the financial system. I will also discuss why the bounded rationality of regulators presents less of a problem in the context of a resilient regulated market.

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[251]*See* Kay & Vickers, *supra* note 243, at 288 (distinguishing structural regulation from conduct regulation on the grounds that the former is concerned with "the way in which a market is organized"). Whether this course of action is best explained by a traditional capture analysis, whereby legislators and regulators traded favorable legislation and regulatory interpretations for campaign funding and political support, is outside the scope of this article, though other scholars have weighed in on this question. *See, e.g.*, Timothy A. Canova, *The Federal Reserve We Need: It's the Fed We Once Had* (Chapman Univ. L. Res. Paper No. 11–12, 2011), *available at* http://ssrn.com/abstract=1788325.

Each of the proposed structural reforms discussed below is designed to pare back financial complexity and is motivated by the concept of resilience.[252] Scholars and policy makers have been focusing more on the concept of resilience as an operational ideal for managing systems characterized by dynamism and complexity. For example, telecommunications scholar Barbara Cherry exhorts policy makers to "embrace the challenge of developing greater regulatory resilience; that is, to create regulatory structures and policies that are more adaptive to the complexity and the increasing pace of technological innovation and ensuing economic and social changes."[253] Resilient systems are designed to deal better with uncertainty, and as such they offer the promise of achieving concrete objectives in complex, fast-moving environments. Examples of resilient system management include (1) forest fire management, which introduces firebreaks to control the spread of wildfire; (2) utility service management, where the network grid has built-in latencies to avoid overload and contagion; (3) infectious disease control, which requires quarantine and travel restriction responses; and (4) avalanche prevention through "snow seeding," wherein small avalanches are induced to reduce the likelihood of a large, catastrophic event.[254] Perrow's discussion of tight coupling has implications for resilient regulation too.[255] Systems characterized by loosely coupled components exhibit their own resilience because "there is a better chance that expedient, spur-of-the-moment buffers and redundancies and substitutions can be found, even thought they were not planned ahead of time."[256] By contrast, control of systems characterized by tightly coupled components requires advance planning: "In tightly coupled systems, the buffers and

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[252]The first sentence of the new Basel III Framework notes that the new accord is inspired by resilience: "This document . . . presents the Basel Committee's reforms to strengthen global capital and liquidity rules with the goal of promoting a more resilient banking sector." BASEL III FRAMEWORK, *supra* note 20, at 5 (footnote omitted).

[253]Cherry, *supra* note 67, at 6.

[254]*See* Andrew G. Haldane, Exec. Dir., Fin. Stability, Bank of Eng., The $100 Billion Question, Comments at the Institute of Regulation & Risk 7 (Mar. 30, 2010), *available at* http://www.bis.org/review/r100406d.pdf; Larry Elliot, *Mervyn King Urges System of Economic "Fire Breaks,"* GUARDIAN (Mar. 22, 2010, 16:10 EDT), http://www.guardian.co.uk/business/2010/mar/22/mervyn-king-economic-policy (proposing that policy makers could impose a firebreak between the payments system network and risky activities).

[255]*See supra* Part II.C.3.

[256]PERROW, *supra* note 93, at 95.

redundancies and substitutions must be designed in; they must be thought of in advance."[257] But when the system is also characterized by interactive complexity, advance planning of normal accidents will prove impossible, and resilience is only achievable through scaling back complexity.[258]

Systems engineers cite *modularity* and *robustness* as two principal ways to bolster a system's resilience. A modular system is one that is designed such that a failure of one system component does not compromise the integrity of the entire system.[259] A robust system is engineered to avoid extreme outcomes in volatile, unpredictable environments through deliberate structuring and simplification in the system's design.[260]

The relevance to financial regulation is obvious. Each of the examples of resilient system management and regulation discussed below aims to promote a dynamic stability, even in changing and volatile conditions.[261] Importantly, resilient systems are better equipped to run themselves and require less supervision, regulation, and enforcement from authorities. As such, the proposed structural reforms discussed below would counteract the bounded rationality problem—as well as its attendant complexity capture problem—by imposing simpler structures on financial firms and channeling their activities through more reliable and comprehensible forms. Under such circumstances, the ordering principle should resemble the equilibrating "invisible hand" of the market rather than the sharp nonlinear singularities observed in the experimental markets.[262]

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[257]*Id.* at 94.

[258]*See supra* note 116 and accompanying text.

[259]*See* May et al., *supra* note 73, at 894 (defining modularity as "the degree to which the nodes of a system can be decoupled into relatively discrete components"); Henry E. Smith, *Modularity in Contracts: Boilerplate and Information Flow*, 104 MICH. L. REV. 1175, 1180 (2006) ("Modularity allows complexity to become manageable by . . . partially closing off some parts of the system and allowing these encapsulated components to interconnect only in certain ways." (emphasis omitted)).

[260]*See* Aikman et al., *supra* note 77, at 5.

[261]*See* Erik Hollnagel, *Resilience: The Challenge of the Unstable*, *in* RESILIENCE ENGINEERING: CONCEPTS AND PRECEPTS 9, 16 (Erik Hollnagel et al. eds., 2006) ("The essence of resilience is therefore the intrinsic ability of an organization (system) to maintain or regain a dynamically stable state, which allows it to continue operations after a major mishap and/or in the presence of a continuous stress.").

[262]*Compare supra* note 85 and accompanying text, *with supra* Part II.D.2.

Most structural reform proposals would introduce some degree of separation between less risky activities like the savings aggregation and payments-system functions of banking and riskier activities like derivatives trading. As such, these utility-like functions of banking would be easier to supervise while the riskier activities would be subject to market discipline on the premise that they would not be supported by safety nets. These proposed reforms would (1) simplify and protect the business units—be they legal entities or markets—that raise regulatory concerns and (2) foster a market-based supervisory mechanism for business units outside the protective regulatory fence, by making clear that those activities would not have access to public safety net subsidies such as deposit insurance and lender-of-last-resort privileges.

As an example, consider John Kay's proposal for a "narrow banking" industry, which would require all deposit-taking institutions to back their accounts with secure assets and impose strict limits on permissible bank activities.[263] Larry Kotlikoff advances a similar "limited purpose banking" proposal that would permit deposit-taking banks only to operate as pass-through mutual fund companies, thus returning to their traditional role of financial intermediaries—the middlemen who transform household savings into investment capital.[264] Simon Johnson and James Kwak offer a more modest structural solution of breaking up the largest banks so that none is of such size and interconnectedness that its failure would pose contagion risks.[265]

The U.K.'s Independent Commission on Banking (ICB), led by former chief economist of the Bank of England Sir John Vickers, has advanced a "retail ring-fence" proposal that would see commercial banking units separately capitalized as well as operationally and legally independent from affiliates incurring higher levels of risk.[266] This

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[263]*See* John Kay, Narrow Banking: The Reform of Banking Regulation (Sept. 15, 2009) (unpublished manuscript), *available at* http://www.johnkay.com/wp-content/uploads/2009/12/JK-Narrow-Banking.pdf.

[264]*See* LAURENCE J. KOTLIKOFF, JIMMY STEWART IS DEAD: ENDING THE WORLD'S ONGOING FINANCIAL PLAGUE WITH LIMITED PURPOSE BANKING 123–88 (2010).

[265]*See* JOHNSON & KWAK, *supra* note 174, at 189–222.

[266]INDEP. COMM'N ON BANKING, FINAL REPORT RECOMMENDATIONS 35–36, 233–37 (2011) [hereinafter ICB FINAL REPORT], *available at* http://bankingcommission.s3.amazonaws.com/wp-content/uploads/2010/07/ICB-Final-Report.pdf.

proposal, which is self-consciously presented as a structural reform,[267] aims to prevent leakage of government subsidies from commercial banking—which serves important policy objectives such as savings aggregation and the reliability of the payments system—to the riskier activities.[268] The ICB had, in its earlier Interim Report, proposed a complete separation of commercial banking from wholesale and investment banking. As such the ICB Final Report is a more tentative step towards a structural solution.[269] In fact, from the perspective of U.S. bankers, the ICB Final Report might appear less radical than it appears to British bankers. The U.S. banking system already has in place, after all, significant restrictions on transactions between banks and their affiliates,[270] and U.S. banks must already meet capital requirements on a standalone basis.[271] But the ICB Final Report is noteworthy because it seeks to transform the highly integrated U.K. model of commercial and investment banking into a more modular structure by erecting a wall of separation between the two businesses that is in fact even higher than the wall currently in force in the United States. It proposes to accomplish this not only by requiring separate capitalization and restricting asset flows out of a bank to its affiliates but also through outright bans on (1) trading derivatives or any other asset class and (2) incurring any exposure to a non-ring-fenced bank.[272]

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[267]*See id.* at 9–11.

[268]*Id.* at 69, 74, 131 (describing how the Report's proposals are designed to curb subsidy leakage); *id.* at 20 (highlighting the maintenance of credit flows and the payments system as the Report's "aims").

[269]Indep. Comm'n on Banking, Interim Report: Consultation on Reform Options 89–90 (2011) [hereinafter Interim ICB Report], *available at* http://s3-eu-west-1.amazonaws.com/htcdn/Interim-Report-110411.pdf.

[270]Section 23A of the Federal Reserve Act sets forth interaffiliate restrictions and exposure limits, and section 23B imposes an arms-length requirement on interaffiliate transactions, as well as restrictions on purchases of securities by banks from affiliates and a prohibition on banks indicating they are responsible for obligations of affiliates. *See* Kenneth M. Lapine et al., 3–78 Banking Law § 78.12 (2011). Sections 23A and 23B apply equally to FDIC-insured banks and thrifts that are not members of the Federal Reserve System. *See* 12 U.S.C. § 1828(j) (2006).

[271]*See infra* notes 299–303 and accompanying text.

[272]*See* ICB Final Report, *supra* note 266, at 51–52. The U.S. Congress included a similar provision, known as the "swap push-out rule," in the Dodd-Frank Act at the behest of U.S. Senator Blanche Lincoln of Arkansas. *See* Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010, Pub. L. No. 111–203, § 716, 124 Stat. 1376; Peter Eavis, *A Bank Overhaul Too Weak to Hail*, Wall St. J., June 26, 2010, at B14; Kevin Wack, *House Panel Votes to Protect Bank*

As for post-crisis regulatory reforms in the United States, the so-called Volcker Rule, included in a watered-down form in the Dodd-Frank Act, is an overture to a structural reform approach.[273] It prohibits affiliates of large

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Data, Am. Banker, Feb. 17, 2012, at 17. Senator Lincoln's initial proposal would have prevented any affiliate of a bank from dealing in derivatives. *See* David Skeel, The New Financial Deal: Understanding the Dodd-Frank Act and Its (*Unintended*) Consequences 89–90 (2011). The final rule was pared back to apply only to FDIC-insured banks—and more troublingly, the final version includes wide-ranging carve-outs for significant derivatives business lines. *See Swaps Pushout Provisions*, Davis Polk & Wardwell LLP (July 23, 2010), http://www.davispolk.com/webcasts/swaps-pushout-provisions-departments/ (beginning at 2:19).

[273]The Dodd-Frank Act's Volcker Rule is designed to prevent bank holding companies (including the large securities firms) and their affiliates from conducting proprietary trading and taking equity positions in private equity and hedge funds. Dodd-Frank Wall Street Reform and Consumer Protection Act § 619. The statutory Volcker Rule requires the applicable federal financial regulators—in this case the OCC, FRB, SEC, FDIC, and the Commodity Futures Trading Commission (CFTC)—to adopt implementing rules to carry it out. *See id.* (introducing section 13(b)(2)(A) of the Bank Holding Company Act of 1956). The FDIC, FRB, OCC, and SEC published proposed rules and requests for comment on November 7, 2011. *See* Prohibitions and Restrictions on Proprietary Trading and Certain Interests in, and Relationships With, Hedge Funds and Private Equity Funds, 76 Fed. Reg. 68,864 (Nov. 7, 2011) (FDIC, FRB, OCC, SEC). On February 14, 2012, the CFTC (the only remaining regulator holdout) published a proposed set of rules and requests for comment in substantial conformity with the other agencies' proposed rules. *See* Prohibitions and Restrictions on Proprietary Trading and Certain Interests in, and Relationships With, Hedge Funds and Covered Funds, 77 Fed. Reg. 8332 (Feb. 14, 2012) (CFTC). As of the time of this article's publication, the agencies were considering comments and preparing the final rules to implement the Volcker Rule. Irrespective of when the final rules are promulgated, the FRB has clarified that firms covered by the Volcker Rule will have until July 21, 2014 to bring themselves into conformity with the new rules. *See* Statement of Policy Regarding the Conformance Period for Entities Engaged in Prohibited Proprietary Trading or Private Equity Fund or Hedge Fund Activities, *available at* http://www.federalreserve.gov/newsevents/press/bcreg/bcreg20120419a1.pdf. As presently proposed, the extent to which the rule will achieve its initial structural reform objective to limit high-risk trading activity on the part of the corporate group enjoying a government safety net will depend on federal banking regulators being able to distinguish between permitted "market making" and prohibited "proprietary trading." *See* Scott Patterson, *Regulators Go to Bat for the "Volcker Rule*,*"* Wall St. J., Jan. 19, 2012 at C3. Financial institutions have been all too eager to help the regulators with this interpretive task. From July 2010 to October 2011, financial institutions met with federal regulators to discuss this and other issues related to the Volcker Rule 351 times, compared to only 19 times for public interest groups. Annie Lowrey, *Facing Down the Bankers*, N.Y. Times, May 31, 2012, at B1. There is no reason to expect that the industry participation ratio is any different during the current ongoing comment period. In light of the difficulty of the task and the unbalanced participation in the rulemaking process, I am inclined to share David Skeel's skepticism on the likelihood that regulators are able to agree on a rule that amounts to structural reform. *See* Skeel, *supra* note 272, at 88 (predicting that "[c]reative interpretation of proprietary and nonproprietary trading will permit a great deal of banks' current trading to continue").

bank holding companies and other systemically significant firms[274] from engaging in "proprietary trading" or sponsoring or owning interests in private equity funds and hedge funds.[275]

The Kay, Kotlikoff, and ICB approaches are inspired by the concept of robustness.[276] Each would promote a more robust financial infrastructure through restructuring the financial network. Each would to some extent hive off the core banking activities from the riskier network nodes discussed above. In particular, they offer the promise of protecting both the core savings-aggregation function of deposit taking and the payments system by minimizing subsidy leakage from the public safety net to many of its riskier nodes and links. The public safety net, consisting of deposit insurance and access to the discount window for deposit-taking institutions, exists to support these traditional banking business lines. By insulating them from riskier business lines—and the contagion threats they pose—policy makers can avoid extreme outcomes, a hallmark of robust systems. The effects of these activity restrictions are analogous to stripping a poker deck of wildcards or snow seeding to prevent avalanches.[277]

Modularity inspires the Johnson-Kwak and ICB proposals. Thus, in a modular financial system any insolvent bank, no matter its size and complexity, could be resolved—even in a complex, drawn-out process—without posing contagion effects to the rest of the network. Part II.D.2.b explained how a geometric market structure comprised of a few large, nerve-center banks that are highly interconnected to the rest of the financial system can result in greater frequencies of contagion spillovers.[278] The Johnson-Kwak proposal to impose meaningful size restrictions on financial firms shows how smallness promotes not only the competition objectives of

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[274]The newly created FSOC will designate these nonbank, systemically significant firms. *See supra* notes 51, 63 and accompanying text (discussing the creation and responsibilities of the FSOC).

[275]See Dodd-Frank Wall Street Reform and Consumer Protection Act § 619.

[276]Kay makes this point expressly. *See* Kay, *supra* note 263, at 16–17. They are also inspired by the Glass-Steagall Act (GSA), a Depression-era law that mandated separation of commercial banking from the securities and insurance businesses until it was repealed in 1999. *See* Wilmarth, *supra* note 150, at 219–22 (noting that while the Gramm-Leach-Bliley Act formally abrogated the GSA in 1999, federal bank regulators had by that point already eviscerated its force through regulatory accommodation).

[277]*See supra* note 254 and accompanying text.

[278]*See supra* notes 230–33 and accompanying text.

antitrust law but also the core functions of financial regulation—namely, macroprudential systemic financial stability and microprudential safety-and-soundness of financial institutions. But lawmakers have largely chosen not to use structural reform to bolster the system's resilience. Instead they have continued to focus on incremental changes designed to manage the *behavior* of actors transacting in the increasingly complex, unstable, and uncertain networks through which financial functions are conducted. Most of the recent behavioral regulatory reform initiatives, both in the United States and abroad, have centered on two objectives: (1) improving the capital adequacy rules applicable to financial institutions and (2) limiting the moral hazard of bailouts by providing clarity for regulators' resolution authority—that is, prescribing rules and procedures regarding what happens when a large firm is liquidated.[279] With each successive reform, these behavioral tools either place greater demands on industry to provide information or construct systems of increasingly particularized rules that might ultimately bear scant rational relationship to their objectives.

B. Capital Requirements

Throughout the recent history of banking regulation, lawmakers and regulators have focused on capital requirements as a tool of behavioral regulation to promote safety and soundness.[280] In order to construct a coherent behavioral regulatory regime in the current complex market environment, a familiar dynamic arises where regulators react to market events by attempting to more narrowly tailor their capital regulation tools so as to cover new proliferating risks as they are discovered. As a result, the standard-setting and enforcement functions require intensive involvement from industry. In the process, regulators are presented with an unenviable choice: either ignore industry information and risk arbitrary regulation or rely on industry information and risk complexity capture. Since the initial imposition of generally applicable capital requirements in the 1980s, regulators have consistently chosen the latter.

Capital adequacy regulation serves a twofold purpose. First, it ensures that a loss buffer is present to absorb losses without threatening a

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[279]Though legislative and regulatory efforts to restrain excessive executive pay are not the subject of this article, they constitute another example of postcrisis behavioral regulation.

[280]*See* CARNELL ET AL., *supra* note 52, at 251 (stating that capital requirements are the central set of restrictions and requirements designed to keep regulated banks safe and sound).

bank's solvency.[281] Second, it operates as a "risk tax" by requiring a bank to set aside funds for each new extension of credit.[282] Though much of capital regulation can be mind-bendingly Byzantine—for example, the system of risk weights discussed in greater detail below—its basic mechanics are surprisingly straightforward. Generally speaking, modern capital regulation in the banking industry consists of two quantities and a relation, or ratio, between them.[283] The first quantity is the amount of "capital" that comprises those claims that stand first in line to absorb future losses. Historically, this quantity has consisted of stable funding sources thought to be effective at absorbing losses, including most prominently common equity and hybrid debt instruments, though the latter are being phased out by bank regulators after they proved ineffective loss absorbers in 2008.[284] This quantity of regulatory capital is the numerator of the ratio.

The second quantity is a measure of the exposure to risk against which the capital is intended to protect. This measurement, referred to as "risk-weighted assets,"[285] comprises the denominator of the ratio. Holding all else equal, a bank will register a higher measure of risk exposure for $10 billion of assets perceived to be risky, such as loans to corporations and

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[281]Weber, *Internal Models*, *supra* note 242, at 792–93. To accomplish the loss buffer effect, capital instruments must both be capable of absorbing losses and serve as "patient" capital that cannot be redeemed or exchanged when financial stress occurs. *Id.* at 798 n.38.

[282]*See id.* at 792–93. The metaphor of "setting aside funds" is imperfect because it assumes that a bank's funding remains constant. *See* Admati et al., *Fallacies*, *supra* note 20, at 10–11. It is more accurate to say that the risk tax requires firms to either set aside funds *or* change their capital structure by raising more funds; in either case, the expected return on equity (ROE) is reduced. *See* BASLE COMM. ON BANKING SUPERVISION, CAPITAL REQUIREMENTS AND BANK BEHAVIOUR: THE IMPACT OF THE BASLE ACCORD 15 (1999), *available at* http://www.bis.org/publ/bcbs_wp1.pdf. This ROE reduction is the risk tax.

[283]The systems of capital adequacy regulation in the insurance and securities industry operate similarly. *See* Weber, *Teleological Drift*, *supra* note 242, at 61; Weber, *Internal Models*, *supra* note 242, at 830–35.

[284]*See* BASEL III FRAMEWORK, *supra* note 20, at 2 ("Innovative hybrid capital instruments with an incentive to redeem through features such as step-up clauses, currently limited to 15% of the Tier 1 capital base, will be phased out."); Patrick Jenkins, *Q&A: How Regulators Gave Banks Eight Years to Strengthen Their Capital Structures*, FIN. TIMES, Sept. 14, 2010, at 18 ("In the financial crisis many highly geared banks with a lot of non-equity (such as hybrid debt) in their capital structures were left looking very weak because losses burnt through their relatively thin equity cushions quickly.").

[285]CARNELL ET AL., *supra* note 52, at 259–63.

junk bonds, than it would if it held $10 billion of assets perceived to be safe, such as government bonds. The relation between the two consists of a required minimum ratio of capital to that risk exposure.[286] Thus, decreases in capital—the numerator of the ratio—and increases in risk-weighted assets—the denominator—cause the ratio to shrink. As the ratio shrinks below statutorily specified trigger points, the regulator is empowered or required to exercise greater control, eventually subjecting the firm to resolution procedures.[287]

At this point, a clarification is in order as to why capital requirements, at least as they are currently designed, are better categorized as behavioral regulation rather than structural regulation. It is theoretically possible to require a loss buffer that would require banks to radically restructure their business models such that the requirement would amount to serious structural reform.[288] For example, lawmakers could design a system of capital requirements that would, in effect, require banks to retrench from all activities that require high deployment of

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[286]Arturo Estrella, *A Prolegomenon to Future Capital Requirements*, 1 Fed. Res. Bank of N.Y. Econ. Pol'y Rev. 1, 2 (1995), *available at* http://ssrn.com/abstract=1028830.

[287]In the United States, the FDIC is in charge of enforcing the capital adequacy regime, referred to as the prompt corrective action (PCA) regime. Congress created the PCA regime in 1991 after the savings and loan debacle of the 1980s. The PCA regime was designed to provide for mandatory and timely FDIC intervention, as well as least-cost resolution of failing banks. Under PCA, the FDIC is required to take a series of actions as a bank's capital level declines past statutorily prescribed trigger points. *See* Skeel, *supra* note 272, at 120. The purpose of the PCA was to combat the tendency for regulators to forbear—that is, to put off regulatory intervention in the hope that conditions improve or, more cynically, that regulated banks fully implode on some other regulator's watch—which greatly magnified losses to the deposit insurance fund during the savings and loan debacle. *See* Lawrence G. Baxter, *Administrative and Judicial Review of Prompt Corrective Action Decisions by the Federal Banking Regulators*, 7 Admin. L.J. Am. U. 505, 528 (1993) (explaining the importance of the "triggers for mandatory" action ushered in by the new PCA regime). While the PCA's least-cost-resolution requirement has likely limited losses to the deposit insurance fund without imposing any offsetting inefficiencies, the FDIC's record of PCA action has hardly been prompt. *See* Skeel, *supra* note 272, at 124 (noting that in two-thirds of bank closures during the recent crisis, the FDIC's first intervention came when the bank was placed into resolution—which is the last required intervention step under the PCA).

[288]*See* Anonymous, *Tarullo's Capital Idea*, Wall St. J., June 16, 2011, at A18 ("The Occam's razor solution is to drop the micromanagement of bank business and instead have them build a bigger capital cushion. As with [the] Basel III [Framework], any new capital requirements would kick in gradually over many years, but markets would begin to respond to the prospective changes immediately.").

leverage such as overnight repo borrowing and proprietary trading.[289] A mandate to maintain common equity of forty percent of total assets would certainly do the trick.[290] The example of capital requirements demonstrates that policy makers can deploy the same regulatory tools to achieve structural reform or behavioral regulation. The devil is in the details of implementation. While structural reform through capital regulation is possible, regulators in major banking jurisdictions have stopped well short of imposing structural reform and have opted instead to use capital requirements as a linchpin in a system of behavioral regulation. These capital requirements are designed to impose a narrowly tailored, precise risk tax on each of a bank's risk exposures.

The purpose of the risk tax is to counteract instability in the banking sector by discouraging firms from stockpiling riskier assets on a leveraged basis. A regulatory intervention is necessary to accomplish this goal because public safety nets, most prominently deposit insurance and access to emergency liquidity at the Federal Reserve Banks' discount window, strip private-market participants such as stockholders and creditors of the incentives to check a bank's risk-taking.[291] Because banks enjoy these

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[289]The theoretical equivalence of a stringent capital requirement and forced separation by regulatory command recalls Martin Weitzman's observation that there is no *a priori* reason to prefer either commands or fixed prices as a mode of regulatory control. *See* Martin Weitzman, *Prices vs. Quantities*, 41 Rev. Econ. Stud. 477, 477–78 (1974). The ICB's Interim Report makes this point explicit: "One policy approach would be structural radicalism—for example to require retail banking and wholesale and investment banking to be in wholly separate firms. Another would be to be *laisser-faire* about structure and to seek to achieve stability by very high capital requirements across the board." Interim ICB Report, *supra* note 269, at 6.

[290]It should also be pointed out that an increase in capital requirements short of that required to accomplish meaningful structural reform may nevertheless promote robustness to the extent that it increases the loss-absorptive capacity of financial institutions. The experimental research on market networks demonstrates an unambiguous link between low capitalization and liquidity levels and financial instability. *See supra* notes 209–37 and accompanying text. However, as discussed below in this part, enhancing robustness by increasing the numerator of the capital ratio will be frustrated if the denominator remains subject to complexity capture or arbitrary regulation. *See infra* notes 344–55 and accompanying text.

[291]In other words, a moral hazard problem emerges as a result of the safety net. Alan Greenspan, former Chairman of the Board of Governors of the Federal Reserve System, described the problem while testifying in the Senate:

The safety net—deposit insurance, as well as the discount window—has so lowered the risks perceived by depositors as to make them relatively indifferent to the soundness of the depository recipients of their funds, except in unusual circumstances[.] With depositors exercising insufficient discipline through the cost of deposits, the incentive of some

government safety net subsidies, their creditors bear less risk of loss than they would absent those safety nets.[292] In the case of the largest banks that have come to dominate the industry, the too-big-to-fail phenomenon—which describes the reality that government will prevent the failure of a systemically significant institution even when discount window and deposit insurance prove insufficient bulwarks—the subsidy is even larger and more distortive.[293] Consequently, stockholders and creditors—the corporate stakeholders that direct corporate governance in nonfinancial enterprises—are immunized from the consequences of losses and, in the case of the creditors, default. The result is perverse incentives for banks to take on excessive risks.[294] The risk tax function of capital requirements aims to impose discipline on banks that creditors, who are risk-averse since their return on capital is not a function of the firm's profitability, would normally impose through monitoring and contractual covenants in loan documentation and bond indentures. It does so by calibrating a firm's capital requirements to the perceived riskiness of its assets through the risk-weighting system described above.[295]

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banks' owners to control risk-taking has been dulled. Profits associated with risk-taking accrue to owners, while losses in excess of bank capital that would otherwise fall on depositors are absorbed by the FDIC[.]

Testimony Before S. Comm. on Banking, Hous. & Urban Affairs, 101st Cong. 1–2 (1990) (statement of Alan Greenspan, Chairman, Bd. of Governors of the Fed. Reserve Sys.), *available at* http://fraser.stlouisfed.org/historicaldocs/782/download/27814/Greenspan_19900712.pdf.

[292]Stockholders also benefit from the subsidy, particularly during boom periods of the credit cycle, when the subsidies permit the bank to incur indebtedness at lower interest costs than it would otherwise be required to pay absent a public safety net. This higher leverage increases returns on equity because the bank is able to increase its earnings without expanding its equity base.

[293]*See* Johnson & Kwak, *supra* note 174, at 80; King, *supra* note 1, at 4 ("The massive support extended to the banking sector around the world, while necessary to avert economic disaster, has created possibly the biggest moral hazard in history."); Harvey Rosenblum, *Choosing the Road to Prosperity: Why We Must End Too Big to Fail—Now*, *in* 2011 Annual Report of the Federal Reserve Bank of Dallas 3, 17 (2011), *available at* http://www.dallasfed.org/assets/documents/fed/annual/2011/ar11.pdf ("[Too-big-to-fail] banks' sheer size and their presumed guarantee of government help in time of crisis have provided a significant edge—perhaps a percentage point or more—in the cost of raising funds.").

[294]The risks are excessive only from a societal standpoint, due to the instability they engender with core payments functions and steady credit supply. From the standpoint of bank creditors and stockholders, the risks might even be optimal.

[295]*See supra* note 285 and accompanying text.

The history of capital regulation in the United States, especially risk weighting, is one of increasing systematization and particularity. But prescriptive law is limited in its capacity to anticipate events in complex systems that, like the wetness of water, have properties that are more than the sum of their parts. The inherent limitations of a system of behavioral regulation administered by boundedly rational regulators have become increasingly evident in recent decades.

The first hundred years of federal banking regulation lacked any ongoing supervision of capital levels.[296] From the passage of the National Bank Act of 1864, which first authorized federally chartered banks,[297] until the International Lending Supervision Act (ILSA) of 1983, bank regulators lacked authority to impose any such requirements.[298] ILSA

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[296]An exception to this general rule is the regulation of savings and loan associations, which under section 403(b) of the Federal Housing Act of 1934 (FHA) were required at all times to maintain capital reserves in an amount of at least five percent of all amounts insured by the Federal Savings and Loan Insurance Corporation (the FDIC analogue for the S&L industry before it was merged into the FDIC in 1989, in the wake of the savings and loan crisis). *See* National Housing Act, Pub. L. No. 73–479, tit. IV, §403(b), 48 Stat. 1246, 1258 (1934). Also, as early as the 1950s, other U.S. bank regulators developed risk-sensitive leverage ratios for internal informational purposes. *See* Joseph Jude Norton, *Capital Adequacy Standards: A Legitimate Regulatory Concern for Prudential Supervision of Banking Activities?*, 49 Ohio St. L.J. 1299, 1317 (1989) (noting that in the 1950s the FRB began to use a "simplistic" capital-to-adjusted-risk analysis for internal purposes); *see also* Eugene N. White, The Comptroller and the Transformation of American Banking: 1960–1990, at 30, 75 n.40 (1992) (describing the OCC's 1974 "Victor program," which compared "classified loans"—defined as "100 percent of substandard loans, fifty percent of loans especially mentioned [and] fifty percent of doubtful loans"—to total adjusted capital in order to individuate troubled national banks; those banks with a ratio in excess of sixty-five percent would automatically receive special attention).

[297]*See* An Act to Provide a National Currency, Secured by a Pledge of United States Bonds, and to Provide for the Circulation and Redemption Thereof, 38th Cong., ch. 106, §§ 5–63, 13 Stat. 99, 100–18 (1864) (codified as amended in scattered sections of chapter 2 of 12 U.S.C.) (authorizing formation of national banking associations and setting forth the statutory regime governing their formation and operations). Ten years later, Congress formally designated the 1864 Act as the National Bank Act. An Act Fixing the Amount of United States Notes, Providing a Redistribution of the National-Bank Currency, and for Other Purposes, 43d Cong., ch. 343, § 1, 18 Stat. 123 (1874) (codified at 12 U.S.C. § 38).

[298]*See* International Lending Supervision Act of 1983, 98 Pub. L. 181, § 908(a)(2), 97 Stat. 1153, 1280 (codified at 12 U.S.C. § 3907(a)(2)) ("Each appropriate Federal banking agency shall have the authority to establish such minimum level of capital for a banking institution as the appropriate Federal banking agency, in its discretion, deems to be necessary or appropriate in light of the particular circumstances of the banking institution."). Prior to the enactment of ILSA, each of the FRB, OCC, and FDIC had published capital adequacy guidelines in response to the Latin American sovereign debt crisis, but the statutory

empowered regulators to establish generally applicable minimum bank capital levels.[299] The ILSA also provided (1) that a bank's failure to maintain prescribed capital adequacy standards may be deemed an "unsafe and unsound" practice, which would trigger the formal enforcement powers of federal banking regulators[300] and (2) that each federal banking regulator could require a bank to submit and adhere to a capital improvement plan that is acceptable to the regulator.[301]

By 1985, each of the FDIC, the OCC, and the FRB had promulgated under its ILSA authorization minimum capital standards for banks within its regulatory purview.[302] In January 1986, U.S. banking regulators

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authorization for these regulatory standards was unclear. In response to the Latin American sovereign debt crisis that eventually prompted Congress to enact ILSA, each of the FRB, the OCC, and the FDIC published capital adequacy guidelines, but the statutory authorization of these regulatory standards was unclear. *See* Joint News Release of Comptroller of the Currency and Federal Reserve Board, *reprinted in* 1 Fed. Banking L. Rep. (CCH) § 5554A, at 3406 (Dec. 17, 1981); Federal Deposit Insurance Corporation Statement of Policy on Capital Adequacy, 46 Fed. Reg. 62,693 (Dec. 28, 1981). The seventeen banks with assets in excess of $15 billion were not covered by this guidance, as their capital levels were at the time of publication below the levels set forth in the guidance. In 1983, the agencies removed this large bank exception. Tarullo, *supra* note 20, at 36–37.

[299] § 908(a) (codified at 12 U.S.C. § 3907(a)). Some contemporary commentators ascribed to this particular provision a congressional intent to shield cease-and-desist orders regarding capital from judicial review under the Administrative Procedure Act's (APA) "substantial evidence" standard. *See* Jack S. Older & Howard N. Cayne, *Capital Standards: Regulators Wield Big New Stick*, Legal Times, Apr. 30, 1984, at 11 (discussing First Nat'l Bank of Bellaire v. Comptroller of the Currency, 697 F.2d 674, 685–86 (5th Cir. 1983), in which the Fifth Circuit Court of Appeals found that the portion of an OCC cease-and-desist order premised on failure to maintain adequate capital levels was not supported by substantial evidence under APA review); *see also* Kenneth M. Lapine et al., 2–23 Banking Law § 23.08 (2009) ("This broad Congressional authorization came in response to, and effectively overruled, the decision by the United States Court of Appeals for the Fifth Circuit in *First National Bank of Bellaire v. Comptroller of the Currency*."). No longer would bank regulators face the prospect of judicial review of their determinations regarding adequate capitalization.

[300] § 908(b)(1) (codified at 12 U.S.C. § 3907(b)(1)).

[301] *Id.* § 908(b)(2)(B) (codified at 12 U.S.C. § 3907(b)(2)(B)).

[302] Membership of State Banking Institutions, 50 Fed. Reg. 16,057 (Apr. 24, 1985) (FRB); Capital Maintenance, 50 Fed. Reg. 11,128 (Mar. 19, 1985) (FDIC); Minimum Capital Ratios; Issuance of Directives, 50 Fed. Reg. 10,207 (Mar. 14, 1985) (OCC). Under the FHA, savings and loan associations had been subject to a statutory capital requirement since 1934. *See supra* note 296. In 1989, Congress enacted the Financial Institutions Reform, Recovery, and Enforcement Act of 1989, which established the Office of Thrift Supervision (OTS) within the U.S. Department of the Treasury as the successor agency to the Federal Home Loan Bank Board (FHLBB) and applied ILSA provisions to the OTS. *See* Financial Institutions Reform,

announced a plan to unilaterally implement a risk-based capital adequacy regime that took into account the various risks to which banks' capital bases are subject.[303] By the mid-1980s, Congress had transformed the regulation of capital from a matter of ad hoc enforcement actions to "an ongoing feature of basic bank supervisory policy."[304] An equally important matter was that by formalizing regulatory capital adequacy standards and homogenizing their vocabulary, ILSA had set the ground for coordination among U.S. regulators vis-à-vis their international counterparts, which assumed tremendous importance in the post-ILSA era of international banking.

While the foregoing summary traces the gradual emergence of capital as a primary regulatory concern for ensuring bank solvency, tensions embedded within the post-ILSA capital framework persist today. First, the minimum capital requirements established by the FRB, the OCC, and the FDIC pursuant to ILSA lacked sophisticated risk sensitivity, in spite of the significant financial innovation and concomitant accretions to risk and complexity in international banking. Second, the United States was the first major economy to establish minimum capital standards for its domestic banks, which created a regulatory imbalance that affected international capital flows by causing international banking business to migrate offshore—especially to Japan—where capital regulation was virtually non-existent.[305] The federal banking regulators in effect imposed a risk tax on

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Recovery, and Enforcement Act of 1989, Pub. L. No. 101–73, §§ 101(6), 201(b), 301, 103 Stat. 183, 187–88, 277–94, 302–04 (substituting the OTS for the FHLBB and adding sections 3–5 to the amended Home Owners' Loan Act of 1933 to establish the OTS and direct it to subject savings and loan associations to ILSA capital adequacy regulation). The Dodd-Frank Act folded the OTS into the OCC. *See* Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010, Pub. L. No. 111–203, §§ 313–314. 124 Stat. 1376.

[303]The American Association of Bankers objected strenuously to this proposal on grounds that were based on international competition rather than the risk sensitivity concept itself. Specifically, the U.S. banking industry was chary to incur another capital charge when it was already reeling from aggressive Japanese pricing in the international lending market. *See* John D. Wagster, *Impact of the 1988 Basle Accord on International Banks*, 51 J. Fin. 1321, 1333 (1996).

[304]Michael P. Malloy, *Capital Adequacy and Regulatory Objectives*, 25 Suffolk Transnat'l L. Rev. 299, 302 (2002).

[305]*See* Stavros Gadinis, *The Politics of Competition in International Financial Regulation*, 49 Harv. Int'l L.J. 447, 500–03 (2008); Sun Bae Kim & Ramon Moreno, *Stock Prices and Bank Lending Behavior in Japan*, 1994 Econ. Rev.–Fed. Res. Bank S.F. 31, 32; Weber, *Internal Models*, *supra* note 242, at 801.

U.S.-based banks, which now had to withhold capital as a reserve for each new extension of a loan, without any restrictions keeping capital from migrating offshore. To address each of these problems, the U.S. banking policy establishment pushed international policy coordination under the auspices of the Basel Committee on Banking Supervision, eventually resulting in the 1988 Basel Accord.[306]

The 1988 Basel Accord set a minimum capital-to-risk-weighted assets ratio of eight percent.[307] More importantly for present purposes, it divided all banking assets into five categories, each of which carried a different risk weight according to its perceived credit risk.[308] Each risk category carried a specified risk-weighting factor—0%, 10%, 20%, 50%, or 100%.[309] Bank assets considered to pose a low credit risk, such as U.S. Treasury securities, received a zero percent risk weighting—that is, they were not added into the denominator of the capital-to-risk exposure ratio—and other assets representing incrementally higher credit risk received higher risk weights.[310] For example, claims against Organisation for Economic Co-operation and Development banks and securities issued by state and local governments each received a twenty percent risk weight; revenue bonds issued by state and local governments and first mortgage loans on one-to-four family residences each received a fifty percent risk weight; and property, plant, and equipment, as well as most loans to households and corporate borrowers, received a 100% risk weight.[311] Amounts at risk pursuant to off-balance-sheet items such as contingent liabilities and derivative instruments would be multiplied by a "credit conversion factor" that reflected the Basel Committee's judgment of the likelihood that the off-balance-sheet item will give rise to a balance sheet liability.[312] The

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[306]*See* Gadinis, *supra* note 305, at 502–03.

[307]*See* Basle Comm. on Banking Supervision, International Convergence of Capital Measurement and Capital Standards 14 (1988), *available at* http://www.bis.org/publ/bcbs04a.pdf.

[308]*See id.* at 8. The 1988 Basel Accord's focus on credit risk reflected the then-current perception that credit risk posed the greatest risk to bank solvency. *See id.* at 8–9 ("For most banks the major risk is *credit risk*, that is to say the risk of counterparty failure . . . .").

[309]*Id.*

[310]*Id.* at 21.

[311]*Id.* at 22.

[312]*Id.* at 23–27. "Credit conversion factors" were applied to the replacement cost rather than the nominal amounts of derivative instruments. *Id.* at 12–13.

normal risk weights applicable to the counterparty were then applied to the resulting amounts to yield the required capital to be held against the off-balance sheet item.[313] However, an additional fifty percent reduction applied to most derivative instruments—though the Committee promised to "keep a close eye on the credit quality of participants in [derivatives] markets and reserve[d] the right to raise the weights if average credit quality deteriorate[d] or if loss experience increase[d]."[314]

While the ink was drying on the 1988 Basel Accord, bank regulators began to perceive that its five crude "risk buckets" failed to take account of new innovations in the banking business, particularly asset securitization and derivatives. Moreover, the exclusive focus on credit default risk meant that there was no risk tax to counteract the increasing levels of market risk and operational risk that were building up in the ever-larger universal banking conglomerates.[315] FDICIA, which statutorily implemented the 1988 Basel Accord into U.S. law,[316] addressed some of these omissions and required U.S. federal banking agencies to revise their risk-based capital standards for insured depository institutions to ensure that these standards take account of interest rate risk, concentration of credit risk, and the risks of "nontraditional activities."[317]

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[313]*Id.* at 23–24.

[314]*Id.* at 27.

[315]Market risk, as defined by the Basel Committee, describes "the risk of losses in on and off-balance-sheet positions arising from movements in market prices." Basel Comm. on Banking Supervision, Amendment to the Capital Accord to Incorporate Market Risks 1 (2005), *available at* http://www.bis.org/publ/bcbs119.pdf. The buildup of market risk in bank asset portfolios resulted from the shift from core lending activities to so-called "noninterest income." *See* Fed. Dep. Ins. Corp., Regional Outlook, Banking Risk in the New Economy 11 (2nd Qtr. 2000) (noting an increasing proportion of earnings from noninterest sources by FDIC-insured banks); Basle Comm. on Banking Supervision, The Supervisory Treatment of Market Risks 1 (1993), *available at* http://www.bis.org/publ/bcbs11a.pdf ("[C]hanges in technology, in market practices and in the nature of many 'banking' activities have made it even more important that the 1988 Accord be broadened to take into account market risk."); *id.* at 4 ("Deregulation of interest rates and capital controls, the liberalisation of banks' permitted range of activities and the rapid development of financial markets have all increased the opportunities for banks to incur market risks. In particular, banks' trading in derivative products has continued to grow at a rapid rate."); Weber, *Internal Models*, *supra* note 242, at 805–06.

[316]FDICIA was also the legislation that created the PCA regime. *See supra* note 287.

[317]*See* Federal Deposit Insurance Corporation Improvement Act of 1991, Pub. L. No. 102–242, § 305(b), 105 Stat. 2236. The FDICIA did not address operational risk.

A year after Congress enacted FDICIA, the Basel Committee began considering how to integrate market risk into the 1988 Basel Accord.[318] In 1996, the Basel Committee published its market risk amendments to the 1988 Basel Accord,[319] in which the Committee acquiesced to industry demands that the amendments allow banks to set their market risk capital requirements by reference to the firm's internal risk estimates. Banks had lamented that the standardized formula-based approach that the Committee had initially proposed was too prescriptive—indeed, even "bureaucratic and antiquated."[320] Many bank regulators at the time were no less impressed with banks' internal proprietary risk measurement capacities than the banks themselves. Alan Greenspan is best associated with this position. During 1994 Congressional testimony, Greenspan provided a preview for the 1996 market risk amendments, noting the following:

> Although the market risks of many banking instruments, including many derivative contracts, can be accurately assessed using . . . simple models [such as the initial 1988 Basel Accord formulae to calculate credit risk capital requirements], a considerably more sophisticated approach is necessary to assess more complex instruments, especially those with options characteristics[,] and to aggregate different categories of market risk[.] The recognition of the need for a more sophisticated approach has led banking regulators in the United States and abroad to explore carefully the potential for allowing banks to use their own internal models to assess the need for capital to cover market risk[.][321]

The 1996 market risk amendments presaged the so-called Basel II Framework, a more radical and comprehensive 2004 reform that dramatically reworked the risk-weighting methodology of the initial 1988 Basel Accord and permitted banks to set capital requirements with respect to credit risk by reference to their own internal estimates of risks.[322] It also required, for the first time, a regulatory capital charge with respect to

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[318]*See* Weber, *Internal Models*, *supra* note 242, at 822.

[319]*See* BASEL COMM. ON BANKING SUPERVISION, AMENDMENT TO THE CAPITAL ACCORD TO INCORPORATE MARKET RISKS (1996), *available at* http://www.bis.org/publ/bcbs24.pdf.

[320]*See* Tracy Corrigan, *Searching for Consensus on Risk Assessment*, FIN. TIMES, June 23, 1994, at 30.

[321]*Testimony before the Subcomm. on Telecomm. & Fin. of the H. Comm. on Energy & Commerce*, 103rd Cong. 11 (1994) (statement of Alan Greenspan, Chairman, Bd. of Governors of the Fed. Res. Sys.), *available at* http://fraser.stlouisfed.org/historicaldocs/805/download/27981/Greenspan-19940525.pdf.

[322]*See* Weber, *Internal Models*, *supra* note 242, at 826–29.

operational risks, also to be assessed by banks' internal risk-management functions.[323] In this respect, like the FDICIA a decade earlier, it expanded both the granularity of the risk weights and the range of risks taken into account. In the process, the Basel capital regime expanded from the initial thirty-page 1988 Basel Accord[324] to a sprawling 347-page Basel II Framework,[325] rife with complicated mathematical formulae.[326]

With the Basel II Framework, the Committee published formulae that banks were required to use in computing their capital requirements for credit risk, but banks were permitted to determine the values to assign to the key variables on their own. Banks electing to perform these functions on their own would be subject to a modified "internal ratings-based" (IRB) capital regime.[327] Thus, under the IRB regime, the amount of capital a bank needs to support a given exposure would depend on the bank's own assessment of the probability of default (PD), the exposure at risk (EAD), and the loss given default (LGD) with respect to that exposure.[328] For banks not subject to the IRB approach, their capital requirements would continue to be set by a "standardized" formula-based approach that prescribed how the parameters were calculated in excruciating detail.[329] The one exception to the IRB's outsourcing of credit assessment to regulated industry was the treatment of securitization exposures.

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[323]*See* Kimberly D. Krawiec, *The Return of the Rogue*, 51 Ariz. L. Rev. 127, 133–34 (2009),

[324]*See supra* note 307.

[325]Including "The Application of Basel II to Trading Activities and the Treatment of Double Default Effects" and the "Amendment to the Capital Accord to Incorporate Market Risks," each of which is incorporated into the Basel II Framework, the page total sums to an even 500 pages. *See* Basel Comm. On Banking Supervision, International Convergence of Capital Measurement and Capital Standards—A Revised Framework (Comprehensive Version) 5 (2006) [hereinafter Basel II Framework], *available at* http://www.bis.org/publ/bcbs128.pdf.

[326]To provide a typical example, the formula below determines the capital requirement applicable to corporate, sovereign, and bank exposures subject to a third-party guarantee:

$$K_o = LGD_g \cdot \left[N \left(\frac{G(PD_o) + \sqrt{\rho_{os}} \cdot G(0.999)}{\sqrt{1 - \rho_{os}}} \right) - PD_o \right] \cdot \frac{1 + (M - 2.5) \cdot b}{1 - 1.5 \cdot b}$$

Id. at 66.

[327]*See* Weber, *Internal Models*, *supra* note 242, at 827.

[328]Basel II Framework, *supra* note 325, at 52.

[329]*See id.* at 19.

For these exposures, the Committee instructed regulators to set capital requirements by reference to external credit ratings published by the credit rating agencies.[330]

Whether looking at securitization or nonsecuritization assets, a common theme runs throughout the Basel II Framework: as asset markets become too complex for regulators to set finely grained capital requirements based on risk assessments, regulators grant discretion to parties perceived to have better access to and ability to process relevant information. With the Basel II Framework, the Committee expressed its belief that the trend in bank capital regulation would be in the direction of increased reliance on internal estimates of risk and decreased reliance on regulatory command. In particular, the Basel II Framework states that

> the [internal ratings-based] approach represents a point on the continuum between purely regulatory measures of credit risk and an approach that builds more fully on internal credit risk models. In principle, further movements along that continuum are foreseeable, subject to an ability to address adequately concerns about reliability, comparability, validation, and competitive equity.[331]

Later that year, the SEC took that trend to its logical end in its Consolidated Supervised Entities Program, which did away with regulator-prescribed formulae altogether and allowed securities firms that are subject to SEC capital regulation to set their net capital requirements entirely on their own.[332]

In the aftermath of the 2008 financial crisis, U.S. Secretary of the Treasury Timothy Geithner framed the response in terms of capital

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[330]*Id.* at 133–36 (providing that capital requirements related to securitization exposures that are either rated or for which an "inferred rating" may be postulated due to similarities with a rated exposure are to be set by reference to external credit ratings). Other securitization exposures carry capital requirements that are set by reference to either external ratings or a highly detailed and prescriptive "supervisory formula." *See id.* at 134, 136–44 (providing that liquidity facilities and credit enhancements, which by their nature are unrated and ineligible to use the "inferred rating" approach, carry capital requirements that are "mapped to equivalent external ratings" and that all other securitization exposures carry capital requirements as set forth in the "supervisory formula").

[331]*Id.* at 5.

[332]*See* Alternative Net Capital Requirements for Broker-Dealers That Are Part of Consolidated Supervised Entities, 69 Fed. Reg. 34428 (June 21, 2004) (codified at 17 C.F.R. pts. 200, 240 (2012)); John C. Coffee, Jr. & Hillary A. Sale, *Redesigning the SEC: Does the Treasury Have a Better Idea?*, 95 Va. L. Rev. 707, 735–36 (2009).

regulation, urging Congress during the lead-up to the Dodd-Frank Act debate that "[t]he top three things to get done are capital, capital and capital."[333] The Dodd-Frank Act, among many other things, clarifies that systemically important financial institutions, even if they are not banks, will be subject to capital requirements and FRB supervision.[334] But lawmakers declined to amend capital requirements legislatively, preferring instead to defer to the Basel Committee, as urged by the U.S. Treasury and banking industry.[335]

For its part, the Basel Committee observed that "[o]ne of the key lessons of the crisis has been the need to strengthen the risk coverage of the capital framework."[336] The Committee also expressly acknowledged that increasing the risk sensitivity of the capital regime would require consideration of the network effects of contagion: "[E]xcessive intercon-nectedness among systemically important banks . . . transmitted shocks across the financial system and economy."[337] In the immediate aftermath of the crisis, the Committee published a document entitled *Enhancements to the Basel II Framework* (Basel II Enhancements),[338] and by the end of 2010 it had published a more comprehensive amendment to the Basel II Frame-work known as the Basel III Framework.[339]

These documents, particularly the Basel III Framework, are note-worthy for reasons other than their revisions to the risk-weighting of assets. For example, the Basel III Framework also (1) imposes for the first time at the Basel Committee level a leverage ratio and two liquidity ratios, referred to as the "net stable funding" ratio and the "liquidity coverage" ratio;[340] (2) restricts the set of instruments that count as "capital" for

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[333]David Leonhardt, *Heading off the Next Financial Crisis*, N.Y. Times Mag., Mar. 28, 2010, at 36.

[334]*See supra* note 51 and accompanying text.

[335]*See* Simon Johnson, *The Big Banks Fight on*, NYTimes.com (June 15, 2011, 5:00 AM), http://economix.blogs.nytimes.com/2011/06/15/the-big-banks-fight-on/.

[336]Basel III Framework, *supra* note 20, at 3.

[337]*Id.* at 7.

[338]Basel Comm. on Banking Supervision, Enhancements to the Basel II Framework (2009) [hereinafter Basel II Enhancements], *available at* http://www.bis.org/publ/bcbs157.pdf.

[339]Basel III Framework, *supra* note 20.

[340]*See id.* at 4, 8–9, 61–63. The U.S. bank laws have imposed a leverage ratio since FDICIA was enacted in 1991. *See* Baxter, *supra* note 287, at 516.

purposes of setting the numerator of the capital ratio to exclude certain instruments that proved to be poor loss absorbers during the crisis;[341] (3) increases the base amounts of capital that banks must maintain and introduces a new "capital conservation buffer";[342] and (4) provides for a new countercyclical capital buffer that will wax and wane with the credit cycle.[343] But the entire architecture of the capital regulation regime depends on the interaction of the required ratios, the definition of capital, and the risk-weighting methodology. It will, *ceteris paribus*, enhance financial stability to increase the required capital ratio or to ratchet up the loss-absorption capacity of capital instruments. But if the risk-weighting methodologies are not sound, the system will nevertheless behave in unpredictable ways or, at worst, be only arbitrarily connected with its regulatory purpose. Modest adjustments to the capital ratio will not matter where "the 'riskiness' of a bank's activities and the liquidity of its funding can change suddenly and radically as market expectations shift."[344] In those circumstances, "what appeared to be an adequate capital or liquidity cushion one day appears wholly inadequate the next."[345]

The Basel III Framework's treatment of risk weighting continues the Committee's dialectic practice of identifying new risks and addressing them by increasing the granularity of risk weights, expanding the range of risks covered, and ultimately delegating discretion to industry. The vector of reform is always in the direction of ever more complicated formulae and increased industry discretion. The Committee's approach to "resecuritisation" risk weights shows this dynamic in operation. The 2009 Basel II Enhancements define resecuritization as "a securitisation exposure in which the risk associated with an underlying pool of exposures is tranched and at least one of the underlying exposures is a securitisation exposure."[346] Prior to the Basel III Framework, resecuritizations were treated

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[341]*See* BASEL III FRAMEWORK, *supra* note 20, at 2–3, 12–27.

[342]*See id.* at 6–7, 54–57.

[343]*See id.* at 5–6, 57–60.

[344]King, *supra* note 1, at 4.

[345]*Id.*

[346]BASEL II ENHANCEMENTS, *supra* note 338, at 2.

the same as securitizations, and their risk weights were to be calculated in virtually the same manner as ordinary securitization exposures.[347]

By incorporating resecuritization exposures in the capital accord, the Committee addressed a key source of financial instability: the collateralized debt obligation (CDO). CDOs are securities constructed from pools of debt obligations, including securitized debt securities such as the residential mortgage-backed securities (RMBS) that wreaked so much havoc in the 2008 financial crisis.[348] By arranging and distributing CDOs, investment and commercial banks reaped large fees and increased the total exposure to the mortgage market.[349] They even constructed "synthetic" CDOs—derivative securities, the returns of which tracked referenced securitized debt, but which were not actually backed by the collateral.[350] At the tail end of the credit bubble, CDO-squared and CDO-cubed transactions, involving CDOs of CDOs of CDOs, gained popularity.[351] Troubles with the CDO market ramified to the CDS markets too. The collapse of AIG was triggered indirectly by defaults in certain tranches of CDOs, which triggered an obligation on the part of an AIG affiliate to make its CDS contract holders whole.[352]

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[347]The only reference to resecuritization exposures in the Basel II Framework is a specification of how two particular formulae would apply in the case of a resecuritization exposure. *See* BASEL II FRAMEWORK, *supra* note 325, at 141. Prior to the Basel II Enhancements, the Basel II Framework provided no formal definition of what a resecuritization exposure was in the first place. The formulae were only applicable in the case of a bank using the "supervisory formula" to calculate its securitization-exposure capital requirement. *See supra* note 330 and accompanying text. In the cases of any rated resecuritization exposure such as a rated collateralized debt obligation, a bank using the IRB approach would be required to calculate the capital requirement by reference to the external rating. *See id.*

[348]*See* ENGEL & McCOY, *supra* note 155, at 51–53.

[349]*Id.* at 51.

[350]*Id.* at 52.

[351]*Id.*

[352]*See* Viral V. Acharya et al., *Regulating Systemic Risk*, *in* RESTORING FINANCIAL STABILITY, *supra* note 155, at 283, 299–300. The details of the AIG collapse are well beyond the scope of this article, but it bears mention that they read like a case study of a multidimensional "normal accident." The losses on the CDS contracts on their own did not cause AIG to collapse. Instead, AIG's CDS obligations required it to fork over significant amounts of capital. That, in turn, resulted in other counterparties demanding that AIG comply with the terms of nondefaulting CDS contracts that required AIG to post collateral in the event its financial condition deteriorated, to compensate counterparties for the added credit risk. At a certain point, it became obvious AIG could not satisfy all the collateral calls, and government

External Rating (Illustrative)	Risk weights for senior positions and eligible senior IAA exposures	Base risk weights	Risk weights for tranches backed by non-granular pools
AAA	7%	12%	20%
AA	8%	15%	25%
A+	10%	18%	35%
A	12%	20%	
A-	20%	35%	
BBB+	35%	50%	
BBB	60%	75%	
BBB-		100%	
BB+		250%	
BB		425%	
BB-		650%	
Below BB- and unrated		Deduction	

Figure 4. Basel II Securitization Risk Weights under IRB Approach.

In response to the incremental risk posed by the CDO innovation, the Committee created two more categories of securitization exposures, as illustrated by Figure 4[353] and Figure 5.[354] The response was to require increases in the amount of capital to be held against these CDO-type exposures. Because the committee sought to impose new risk taxes to newly discovered risks, its approach is prototypical behavioral regulation. Moreover, the continued delegation of authority to the credit rating agencies shows that the regulators have been overwhelmed by market complexity.

The enhanced securitization risk-weighting framework simply layers an additional set of risk weights onto an already highly particularized risk-weighting matrix. Because the applicable weights depend on third-party rating agencies' assessments of risk, it is no exaggeration to say that

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institutions bailed out AIG to prevent the possible default on all of AIG's CDS contracts, which threatened to "cause a fire sale of assets that could ripple across the financial system." *Id.* The regulator responsible for supervising the AIG holding company conceded, "'We missed the impact' of the collateral call triggers. It was the triggers—not actual credit losses on the company's credit default swaps—that ultimately brought AIG down." Engel & McCoy, *supra* note 155, at 223 (quoting C.K. Lee, managing director of Complex and International Organizations at OTS). Lee's comments portray a normal accident that was at first unpredictable yet also, in retrospect, inevitable. Moreover, the comments demonstrate the difficulties involved in supervising large, complex financial institutions.

[353]Basel II Enhancements, *supra* note 338, at 135.

[354]*Id.* at 3.

Long-term Rating	Securitisation Exposures			Resecuritisation Exposures	
	Senior, Granular	Non-senior, Granular	Non-granular	Senior	Non-senior
AAA	7	12	20	20	30
AA	8	15	25	25	40
A+	10	18	35	35	50
A	12	20	35	40	65
A-	20	35	35	60	100
BBB+	35	50	50	100	150
BBB	60	75	75	150	225
BBB-	100	100	100	200	350
BB+	250	250	250	300	500
BB	425	425	425	500	650
BB-	650	650	650	750	850
Below	Deduction				

Figure 5. "Enhanced" Securitization Risk Weights under IRB Approach.

a capital requirement associated with a securitization exposure is con-
structed from a highly imprecise risk weight based on an imperfect, rough
proxy for credit risk. The Basel Committee's response to increasing com-
plexity has been to replace the initial Accord's five "risk buckets" into
which all bank exposures were allocated with (1) the IRB approach, which
represents a dramatic outsourcing of the risk-weighting function to indus-
try, and (2) an additional layer of risk weights to address risks not covered
in the Basel II Framework. Consider the example of resecuritization and
CDOs. If the spread of contagion in the CDO market during 2008 was a
complex event that occurred due to unpredictable network effects among
the transacting parties in the housing, RMBS, and CDO markets, then
there is little hope that trebling the capital requirements for resecuritiza-
tion exposures will prevent a future similar event. Instead, by pre-
committing to a system of risk weighting as behavioral regulation, the
Basel Committee has opted for an immanently dysfunctional regulatory
regime.

The emphasis on capital requirements is puzzling in many respects.
Greater uncertainty complicates both the risk-tax and loss-buffer objectives
of capital adequacy regulation. Balance sheet opacity, leverage, and dense
network interconnections among firms and markets, by frustrating or even
preventing an ex ante assessment of risk, make calibrating the risk tax
much more difficult. In turn, as the effects of the risk tax become more
uncertain, the greater the loss buffer must be to achieve the desired
protective effect. Not surprisingly, opinions vary drastically as to the

appropriate level of capital buffers.[355] In a sense, the loss buffer is a gauge more of regulators' uncertainty about the risk tax calibration and less a precise determination of the absolute level of capital sufficient to keep the firm operating under severe conditions. In this respect, the Basel Committee is to be applauded for insisting that banks hold increased amounts of loss-absorbent capital. Whether it will be enough is, for at least as long as conditions of complexity predominate in financial markets, largely unpredictable.

C. Living Wills

Another linchpin of the postcrisis financial reform toolkit has been the "living will." One of the main shortcomings of the precrisis regulatory regime was the inability of regulators to resolve and wind down systemically significant institutions. As a result, regulators cajoled lawmakers into massive commitments of public capital to bail out the insolvent institutions and preserve the continued viability of core financial functions. "Faced with a complex and opaque structure, authorities have little choice but to rescue the whole bank" rather than isolate and wind down problematic units on their own.[356] Living wills are designed to prevent bailouts by setting forth in advance the steps by which a firm will be resolved in an orderly manner over a weekend in the event of insolvency.[357] Bailouts are not required when it is possible to "dismantle a bank in a way that doesn't damage the system."[358] The living will regulatory technique is inspired by the concept of modularity,[359] but it is vulnerable to complexity capture. As

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[355]This is due in part to the political nature of setting the required capital levels. *See supra* note 20.

[356]Emilios Avgouleas et al., *Living Wills as a Catalyst for Action* 3 (Duisenberg School of Finance, Policy Paper No. 4, 2010), *available at* http://ssrn.com/abstract=1533808.

[357]*See* Ron Feldman, *Forcing Financial Institution Change Through Credible Recovery/Resolution Plans: An Alternative to Plan-Now/Implement-Later Living Wills* (Fed. Res. Bank of Minneapolis, Econ. Pol'y Paper No. 10–2, 2010), *available at* http://www.minneapolisfed.org/pubs/eppapers/10–2/eppaper10_2_wills.pdf.

[358]Henny Sender, *Dimon Backs Means to Close down Banks*, Fin. Times, Oct. 28, 2009, at 4 (reporting remarks of Jamie Dimon, Chief Executive Officer of JPMorgan Chase, the second-largest U.S. banking conglomerate, in favor of a comprehensive resolution mechanism for large banks).

[359]*See supra* note 259 and accompanying text.

with capital requirements, regulators will allow banks themselves to prepare their living wills on the grounds that banks rather than regulators have access to information on their susceptibility to contagion. Hence the living wills will be as effective as industry wants them to be.

When contagion is spreading rapidly throughout financial markets, resolving affected firms is a necessary first step in containing the contagion. But where those markets and firms are characterized by complexity, it threatens an insurmountable challenge. The effects of resolving a single firm might cause ripple effects throughout the financial system in ways that are impossible for the regulators to predict. These "channels of contagion" include (1) opaque and dynamic-state interconnectedness with other large financial institutions, (2) the potential inability of an insolvent firm to continue to provide systemically important services as it is resolved, and (3) the legal complexity of resolving a large, internationally active conglomerate where both domestic and foreign regulators scramble to preserve the value of affected operations within their respective jurisdictional purviews.[360] Greater ex ante certainty of what will happen in the event of insolvency might promise to mitigate the harm from the first and third channels. As for the second channel, it might be possible to provide an ex ante framework pursuant to which any systemically important business units are easily separated from other business units and are able to run on an independent basis regardless of financial stress at their affiliates.

The Group of Twenty (G20) nations included living wills as a high-priority reform in the immediate aftermath of the 2008 financial crisis, calling on G20 governments to rapidly develop "internationally consistent, firm-specific recovery and resolution plans."[361] In the United States, section 165(d) of the Dodd-Frank Act now requires large bank holding

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[360]Richard J. Herring, *Wind-Down Plans as an Alternative to Bailouts: The Cross-Border Challenges*, *in* Ending Government Bailouts as We Know Them 125, 128 (Kenneth E. Scott et al. eds., 2009) ("The plan should also identify operational interdependencies such as IT systems, liquidity, and risk management procedures that would impede the separation of one unit from another.").

[361]U.K. Chair of the G20, Progress Report on the Economic and Financial Actions of the London, Washington, and Pittsburgh G20 Summits, para. 45 (2009), *available at* http://blogs.law.uiowa.edu/ebook/uicifd-ebook/progress-report-economic-and-financial-actions-london-washington-and-pittsburgh-g20-sum.

companies and conglomerates designated by the FSOC as systemically significant nonbank financial companies to "report periodically to the [FSOC], the Board of Governors, and the [FDIC] the plan of such company for rapid and orderly resolution in the event of material financial distress of failure."[362] Congress included certain minimum requirements for the living wills, including as follows:

(A) information regarding the manner and extent to which any insured depository institution affiliated with the company is adequately protected from risks arising from the activities of any nonbank subsidiaries of the company;

(B) full descriptions of the ownership structure, assets, liabilities, and contractual obligations of the company; [and]

(C) identification of the cross-guarantees tied to different securities, identification of major counterparties, and a process for determining to whom the collateral of the company is pledged . . . .[363]

One glaring omission from the Dodd-Frank Act is any express requirement that the living will—or "resolution plan" in Dodd-Frank parlance[364]—identify operational interdependences such as those related to information technology (IT) and risk management.[365]

The FSA moved faster even than the United States, requiring its six largest banks to submit resolution plans in 2009.[366] It mandated that the banks' plans meet three requirements. First, they need to outline which businesses and subsidiaries they would sell to raise emergency funds. Second, they must include a "contingent resolution plan" for transferring client assets to a third party in a crisis. Third, they must stipulate how they

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[362]Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010, Pub. L. No. 111–203, § 165(d)(1), 124 Stat. 1376.

[363]*Id.* § 165(d)(1)(A)–(C) (codified at 12 U.S.C. §§ 5365(d)(1)(A)–(C) (Supp. 2011)).

[364]*Id.* § 165(d) (codified at 12 U.S.C. § 5365(d) (Supp. 2011)).

[365]*Cf.* Herring, *supra* note 360, at 135–36. In fact, during discussions with the U.K.'s Financial Services Authority (FSA) over its IT infrastructure, a major U.K. bank discovered it possessed a single global license to Microsoft Office, so its various subsidiaries would be unable to communicate if the parent were liquidated. Brooke Masters, *Resistance to Living Wills Could Prove Futile and Foolish*, Fin. Times, Aug. 23, 2011, at 16.

[366]*See* Masters, *supra* note 365; Brooke Masters & Gillian Tett, *U.K. Regulators Step up Efforts to Force Banks to Compile Living Wills*, Fin. Times, Sept. 16, 2009, at 15.

would liquidate the assets on their trading book within sixty days.[367] In the meantime, the FSA has published draft rules that would require more than 250 financial institutions to propose such plans to the FSA by the end of 2012.[368] U.S. bank regulators promulgated a final rule implementing section 165(d) of the Dodd-Frank Act in November 2011.[369]

It is anticipated that the living wills proposed by banks and other financial institutions will be the starting point for discussions with regulators over their viability.[370] In the United States, for example, when the FDIC and the FRB believe a living will does not facilitate an orderly resolution of the proposing firm, they may require a firm to resubmit a plan and, if the deficiencies are not remediated, order the firm to "divest certain assets or operations . . . to facilitate an orderly resolution of such company" in the event of its failure.[371] The FSA enjoys similar authority to require a firm to simplify its opaque structure if the FSA adjudges a living will proposal to be unlikely to facilitate orderly resolution.[372]

A heavy informational, analytical, and computational burden thus falls onto the regulators' shoulders. Rick Herring describes the regulators' new responsibilities under the living will laws as follows:

> [T]he primary supervisor must evaluate the wind-down plan in detail (if appropriate with a national college of supervisors). It must certify that the plan is feasible, and the estimated time for the wind-down is plausible and acceptable. In addition, it must ensure that all systemically important activities have been identified and properly insulated, so that they could be spun off to another firm in the event of insolvency.[373]

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[367]Masters & Tett, *supra* note 366.

[368]Masters, *supra* note 365.

[369]Resolution Plans Required, 76 Fed. Reg. 67,323 (Nov. 1, 2011) (relating to FDIC and FRB).

[370]*See* Avgouleas et al., *supra* note 356, at 2 ("[T]here should be discussions between a bank and its supervisors about winding down its operations in crisis times, and forcing a bank to simplify its often opaque structure.").

[371]Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010, Pub. L. No. 111–203, § 165(d)(5), 124 Stat. 1376 (codified at 12 U.S.C. §§ 5365(d)(4) (Supp. 2011)).

[372]FIN. SERVS. AUTH., TURNER REVIEW CONFERENCE DISCUSSION PAPER: A REGULATORY RESPONSE TO THE GLOBAL BANKING CRISIS: SYSTEMICALLY IMPORTANT BANKS AND ASSESSING THE CUMULATIVE IMPACT 27–28 (2009), *available at* http://www.fsa.gov.uk/pubs/discussion/dp09_04.pdf.

[373]Herring, *supra* note 360, at 137.

Ron Feldman, a senior regulator at the Federal Reserve Bank of Minneapolis, notes in a brief article on living wills that "bank supervisors would identify those attributes of financial institution operations, structure and funding that curtail effective, bailout-free recovery or resolution."[374] In other words, for the living will regime to function properly bank regulators need to identify where complexity in relevant markets and institutions might require government intervention to protect the integrity of core financial functions.

Here again lawmakers have charged regulators with a mandate to regulate behaviors and promote stability in domains characterized by normal accidents, phase transitions, hidden embedded properties, and punctuated equilibria. Of course it will be possible to reprimand derelict banks that make little attempt at all to submit a meaningful living will, but in the vast majority of cases a regulator will be hard pressed to identify specific reasons why a living will's resolution plan is not "feasible" and its timeframe is not "plausible and acceptable." To do so would require anticipation of the events that might precipitate financial distress at the bank.

The great promise of living wills is that, by drafting them, banks will confront their operational complexity before financial distress materializes and will decide to streamline operations. Such streamlined operations should, in turn, facilitate regulatory tasks of supervision and resolution. But banks currently are able to externalize the costs of their complexity onto taxpayers, and the policy establishment is committed to behavioral regulation rather than meaningful structural reform. Given that background, banks will likely propose half-hearted living wills without any meaningful organizational deliberation of *in extremis* events.[375] Regulators will then bear the rhetorical burden of establishing that a bank's practices are likely to prevent orderly resolution. Their bounded rationality in these matters will likely prevent them from formulating the responses, and the complexity capture problem will persist. The central objection here is that resolving complex operations is at a minimum exceedingly difficult and perhaps impossible; structural proposals such as the ICB's "retail ring

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[374]Feldman, *supra* note 357, at 2.

[375]*See* SKEEL, *supra* note 272, at 141 ("[M]anagers are unlikely to devise serious and realistic plans unless regulators are unusually vigilant in enforcing the new obligation [to draft a living will].").

fence" reform make the resolution process easier by "[s]eparating activities . . . especially because those services whose continuous provision isessential [to the economy] tend not to be those whose complexity makes resolution difficult."[376]

CONCLUSION

Where regulators are charged with supervising complex realms of human action, the administrative state confronts a crisis. The problem of regulators' bounded rationality emerges as less of an obstacle to be overcome than a structural impediment to effective policy. Nowhere is this problem more evident than in the financial sector, where today as in previous, simpler decades, regulators are responsible for ensuring systemic financial stability and supervising individual institutions, despite the increasingly complex market environment. This article's contribution to the financial regulatory literature is to investigate in detail the question of financial market complexity, drawing on recent research by complexity scientists showing that, along certain dimensions, financial markets are indeed complex rather than merely complicated. But highlighting the inherent difficulties of regulating complexity is only a diagnostic, preliminary step. What is missing is a systematic theory for how to rehabilitate the regulatory system so that it is better able to preserve the continued reliability of the core functions that the financial industry provides to the economy. I hope that this article, by developing the notion of complexity capture and demonstrating the problems associated with continued reliance on industry-provided information and highly particularized systems of behavioral regulation, also makes a modest contribution to efforts to theorize a regulatory approach to combat the instability that complexity necessarily entails. Bearing in mind that current network infrastructures of financial markets are susceptible to harmful endogenous phenomena such as positive feedback effects, normal accidents, and conflicting constraints, policy makers need to think more seriously about building a resilient market structure.

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[376]ICB FINAL REPORT, *supra* note 266, at 25.