Regulating Through Financial Engineering: The Office of Financial Research and Pull of Models

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"Had the regulatory community known in 2005 what we now know, would the outcome [the financial crisis of 2008] have been different? We think the answer is yes, but humility is essential."[1]

INTRODUCTION

This Essay explores the ways in which establishing The Office of Financial Research (OFR), one of the policy responses to the 2008 crisis, represents the extension of financial engineering into the realm of government regulation. The argument is that quant culture has become so pervasive that we are at a point at which quantitative models are at the center of financial regulation. While the push for the OFR was guided by a desire to better regulate, the result has been an overconfidence in the ability to regulate via measuring risk. Thus, ironically, the OFR may actually contribute to a culture that avoids direct regulation of financial institutions, such as by restricting their size—and thus makes our financial system less safe.

I. THE OFR AND THE SCIENCE OF REGULATION

The OFR was created as part of the 2010 Dodd-Frank legislation that the United States Congress passed in response to the 2008 financial crisis. It is housed within the Treasury Department but has an independent budget and is structured to have relative autonomy. The OFR is part of a regulatory scheme that has a very distinct approach. United States policymakers have chosen, under Dodd-Frank, to place a heavy emphasis

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1. OFFICE OF FIN. RESEARCH, 2012 ANNUAL REPORT 7 (2012) [hereinafter OFR 2012 REPORT].

on monitoring "systemic risk" in the financial system and on acting to take remedial measures once that risk has been identified. Of course, governments have long been in the business of regulating risk in financial markets. However, the level and form of regulation takes shape based on political, market, and social forces.

Regulatory responses to limit risk in the financial system could span the range from forbidding certain activities (for example, separating commercial banking from investment banking), limiting the size of financial institutions, or increasing capital requirements. Gramm-Leach-Bliley marked a movement away from the regulation-by-prohibition model of risk management. The shockwaves caused by the 2008 crash were not enough to swing the pendulum back to Glass-Steagall era regulation. As opposed to structural regulatory reform such as separating commercial and investment banking or setting limits on the size of financial institutions, less intrusive prudential measures like capital requirements are the preferred regulatory solutions. Of course, politics has much to do with this, but so does our increased knowledge and perceived ability to control risk through financial engineering. This is evident in the focus on regulating systemic risk. The central idea is that activity should be relatively unregulated, and the government should only intervene when there are signals that unacceptable ("systemic") risk has built up in the system. Of course, this supposes that we have the ability to measure systemic risk—thence the OFR.

The head of the OFR sits on the Financial Stability Oversight Council (Council or FSOC) as a nonvoting member. The Council is the body charged with regulating systemic risk in the financial system. It is chaired by the Treasury Secretary and includes the heads of major federal financial regulatory agencies as voting members.[2] The OFR is charged with providing data and research to the Council regarding systemic risk in the financial system. In many ways, the OFR represents an effort to regulate through knowledge acquisition. A principal promoter of the OFR as part of the Dodd-Frank legislation, Senator Jack Reed, declared: "One of the problems we observed in the recent crisis is that nobody knew who had what . . . . The result was a cascading effect of uncertainty and doubt."[3]

The Committee to Establish the National Institute of Finance (CE-NIF), a leading organization advocating for an OFR-type entity in

2. For a full list of Council members, see *Financial Stability Oversight Council*, U.S. DEP'T TREASURY, http://www.treasury.gov/initiatives/fsoc/about/Pages/default.aspx (last visited May 17, 2019).

3. Edward Wyatt & Sewell Chan, *Senate Bill on Finance to Include Agency That Tracks Financial Risk*, N.Y. TIMES (Mar. 10, 2010), https://www.nytimes.com/2010/03/11/business/11regulate.html.

the aftermath of the 2008 crisis, stated the need as follows:

> Missing from this discussion [on regulatory reform post-2008], however, is a serious and detailed examination of the significant gaps in the informational infrastructure — data and analytic tools — available to regulators and policymakers, which were revealed by these events. Without this infrastructure, decision makers who are charged with safeguarding the health of the financial system are largely flying blind, hence severely restricting their ability to use their granted authorities effectively.[4]

Two members of the CE-NIF, Allan Mendelowitz and John Liechty, struck a similar tone in their written testimony before Congress arguing for a national institute of finance.[5] Mendelowitz and Liechty were particularly concerned that regulators had relied on models constructed by market participants and the ratings (based on those same models) by the rating agencies.[6] Therefore, they argued for "having a regulatory community that is capable of generating independent assessments of the credit quality of a security or the safety and soundness of a bank, market or the financial system."[7] This would require the proposed research center to "develop metrics to measure and monitor systemic risk and continually monitor, investigate and report on changes in system-wide risk levels" with one of the direct benefits being to "reduce the likelihood of systemic crises and costly institutional failures" through risk modeling.[8]

The OFR's inaugural annual report summarizes its goals and objectives. The report articulates the main objective of the OFR to "assess and monitor threats to financial stability; to appreciate how those threats propagate from one institution to many, or from one market to others; and to evaluate mitigants to address those risks."[9] The OFR is based on a belief that the 2008 financial crisis was precipitated, in part, by a lack of information and coordination—"[t]he lack of high-quality, consistent, and accessible data was a key source of risk during the recent financial crisis."[10] In articulating goals, the OFR laid out three priorities: develop

4. Comm. to Establish the Nat'l Inst. of Fin., *A Call to Create the National Institute of Finance*, GOPETITION (July 22, 2009), http://www.gopetition.com/petitions/create-the-national-institute-of-finance.html.

5. *See generally Equipping Financial Regulators with the Tools Necessary to Monitor Systemic Risk: Hearing Before the Subcomm. on Sec. & Int'l Trade & Fin. of the Sen. Comm. on Banking, Hous., & Urban Affairs*, 111th Cong. 43–49 (2010) (statement of Allan I. Mendelowitz & John C. Liechty, Founding Members of the Committee to Establish the National Institute of Finance) [hereinafter *Equipping Financial Regulators*, Mendelowitz & Liechty Testimony].

6. *Id.* at 44–45.

7. *Id.* at 45.

8. *Id.* at 47.

9. OFR 2012 REPORT, *supra* note 1, at 1.

10. *Id.* at 4. In another section of the report, it is stated that the "financial crisis revealed

financial stability metrics, evaluate stress tests, and promote best practices.[11] Using quantitative models is essential to the OFR's task. Financial models serve two functions. They are used both to create financial products and to assist in measuring the financial products' risk. One of the first activities the OFR undertook was to survey risk measurement models and determine their effectiveness based on historical performance. The conclusion—one of the major issues in applying any model is adequacy of data: The "overriding message is that gaps in financial data constrain the current generation of measures [(models)]."[12] The assumption is that if the correct data is available to market participants and regulators, future financial crises may be avoided. The emphasis on data and knowledge is infused throughout the OFR materials.

In the context of the 2008 financial crisis, a central challenge in gathering this data and fulfilling the mission of regulation through knowledge was the fact that much of the risk associated with the crisis stemmed from sectors outside the traditional (regulated) financial sector—shadow banking. Therefore, the information is not readily accessible. Shadow banks serve much of the same functions as traditional banks but do not fall under their regulatory regime. The problem is that the world of shadow banking is linked to the traditional banking sector, so risk spills over, endangering the entire system. Ironically, while policymakers had become concerned regarding risk in the financial system leading up to the 2008 crisis, it was believed that the dispersion of risk (particularly to nonregulated markets and firms—the shadow banking sector) resulting from financial innovation would mitigate the risk. In general, neither market players nor government officials appreciated the size and scope of the risk.[13] Of course, a few savvy, or perhaps just lucky, investors and firms did make investments that would pay off if the housing market collapsed, and there were voices sounding the alarm regarding a bubble in the housing market.[14] The OFR report

significant gaps in the analytical and empirical understanding of the financial system. " *Id.* at 7.

11. *Id.* at 2.

12. *Id.* at 3.

13. For an account of JP Morgan's navigation of the crisis and how scarce knowledge of the extent to which mortgage-related risk had pervaded the financial system, see GILLIAN TETT, FOOL'S GOLD (2009) (discussing how the entire financial market, including participants like JP Morgan, collapsed due to flawed investment incentives, poor regulatory structures, and little oversight).

14. *See* MICHAEL LEWIS, THE BIG SHORT: INSIDE THE DOOMSDAY MACHINE xviii (2010) (discussing John Paulson, who made $4 billion for himself and $20 billion for investors by betting against subprime mortgages); ROBERT J. SHILLER, THE SUBPRIME SOLUTION 1 (2008) (discussing how the housing bubble, recognized in 2006, had begun rupturing financial markets globally in 2008).

concludes that "[a]n important role for the OFR is to keep track of [the shadow banking industry], particularly when activities increase in markets and institutions that are not being monitored by microprudential supervisors."[15]

On one hand, the OFR represents a continuation of a belief in rationality and knowledge that epitomized the rise of financial engineering—if we refine our models and gather more accurate information, financial calamity can be avoided. However, it also represents a fundamental departure. The OFR's first report cites the heterodox economist, Hyman Minsky, for the proposition that, even under conditions of financial calm and positive economic growth, risk can build up in the system, leading to collapse.[16] This position is explicitly juxtaposed to mainstream economics, which emphasizes the "self-correcting nature of markets and the inherent stability of financial activity," even following the 2008 crisis.[17] For example, free-market economists, such as Alan Greenspan, took the position prior to the 2008 crisis that financial innovation actually adds stability to the system through hedging and diversification. Many economists still opposed regulation even in the wake of the crisis.[18]

The OFR report criticizes key assumptions of mainstream (free market) economics, including that all market participants behave in a homogeneous fashion. It also argues that mainstream economics ignores the risk of default in the economic system, and analogizes this naïve view to the corporate finance literature (articulated by Franco Modigliani and Merton Miller) that has been interpreted as implying that there is no connection between the value of a firm and leverage.[19] (Modigliani and Miller's actual thesis is that firm value cannot be increased based on financing either through debt or equity.) The OFR's focus on financial modeling and data gathering, while criticizing mainstream economics, illustrates the way in which the culture of modeling has become all-pervasive. The modeling culture has been adopted by proregulation advocates (such as the OFR) even though its genesis in the 1980s grew out of the free market milieu of the University of Chicago and Wall Street.[20] The lure of financial engineering crosses political boundaries. It

15. OFR 2012 REPORT, *supra* note 1, at 16.

16. *Id.* at 12.

17. *Id.*

18. Richard Posner (a noneconomist but influential figure in the deregulation movement) and free market economists placed blame for the crisis on government policies. *See, e.g.*, RICHARD A. POSNER, A FAILURE OF CAPITALISM: THE CRISIS OF '08 AND THE DESCENT INTO DEPRESSION (2009).

19. OFR 2012 REPORT, *supra* note 1, at 13.

20. *See* DONALD MACKENZIE, AN ENGINE, NOT A CAMERA: HOW FINANCIAL MODELS SHAPE

is based on a belief in the power of science.

The OFR can be viewed as the US government's regulatory quant shop or science lab. The task before it is quite daunting. The OFR must derive quantitative metrics gauging the risks associated with the complex financial products that saturate the system as a result of financial innovation. It must also derive quantitative metrics gauging the ways in which risk associated with those products is spread (and leveraged) throughout the system (including the shadow banking sector). While the OFR is founded on the idea that knowledge and science are key to our regulatory efforts post-2008, the OFR recognizes the limits of modeling:

> [T]here will always be a fundamental uncertainty about the sources and severity of threats to financial stability, so we must be modest about our ability to judge them. Financial innovation aimed at improving efficiency and promoting better risk-sharing potentially can morph into excessive risk-taking, and knowing when, why, and how healthy activity crosses the line to creating systemwide threats is difficult.[21]

Part of this uncertainty is due to the use of models in finance. The OFR report discusses "model risk" and the "failure to account for the limitations and uncertainties associated with financial risk models" that contributed to the 2008 crisis.[22] Specifically, the OFR points to the CDO (collateralized debt obligations) and MBS (mortgage-backed securities) markets in the run-up to the crisis and how the models used by financial firms, such as those inspired by Gaussian copula, underestimated risk.[23] (The report also pointed to value at risk models that have the potential to underestimate internal firm risk, which famously led to huge trading losses at JP Morgan.) The OFR has taken the position that monitoring model risk will be "an important focal point" for its office.[24] However, the humility regarding modeling prowess and questioning of free-market tenets that are reflected in the OFR's own materials call into question its capacity to perform this function. While the goals and aspirations of the OFR are obviously worthy—enhanced information furthers regulatory objectives and benefits the market—we would do well to guard against having financial regulation dependent upon models. This may be a recipe for future disaster if the OFR does not heed its own warning regarding the limits of modeling.

MARKETS 5 (2006) (discussing how the academic area of "financial economics" was centered on mathematical models of financial markets); TETT, *supra* note 13, at 6–7 (discussing early JP Morgan politics of modeling).

21. OFR 2012 REPORT, *supra* note 1, at 10.

22. *Id.* at 29.

23. *Id.* at 8, 13; *see infra* text accompanying notes 60–62 (discussing the Gaussian copula formula for risk measurement).

24. OFR 2012 REPORT, *supra* note 1, at 29.

II. THE OFR, MODELING, AND THE BLACK SWAN PROBLEM

Might the OFR, while well intended, actually enhance the chance that we have a financial crisis with ruinous consequences? This is the position that Nassim Taleb, author of *Black Swan*, has taken with regard to the OFR. In testimony before Congress, Taleb has charged that the OFR would constitute "the creation of an omniscient Soviet-style central risk manager."[25] This is dangerous, according to Taleb, because the reliance on models to measure risks actually "led in the past to the blind accumulation of Black Swan risks."[26] In order to appreciate Taleb's objection, we need to understand what is meant by the term Black Swan and Taleb's rejection of the financial modeling enterprise. Taleb defines a Black Swan as having three qualities:

> First, it is an *outlier*, as it lies outside the realm of regular expectations, because nothing in the past can convincingly point to its possibility. Second, it carries an extreme impact (unlike the bird). Third, in spite of its outlier status, human nature makes us concoct explanations for its occurrence *after* the fact, making it explainable and predictable.[27]

Taleb's first and second criteria for defining a Black Swan are reminiscent of the OFR's observation that "there will always be a fundamental uncertainty about the sources and severity of threats to financial stability."[28]

Given this definition, financial crises actually do not fall within the definition of a Black Swan—or at least they should not. While they may not fall within the realm of "regular expectations," the past (most recently the 2008 financial crisis) certainly warns us that crises are a possibility. This is the whole point of the OFR and FSOC. Using Taleb's categorization, financial crises are more appropriately defined as "Gray Swans."[29] Taleb argues that we may be able to convert Black Swan events into less dangerous Gray Swans. We do so not by exact prediction of their occurrence but by getting a "*general* idea about the possibility of

25. *Oversight of the Office of Financial Research and the Financial Stability Oversight Council: Hearing Before the Subcomm. on Oversight & Investigations of the H. Comm. on Fin. Servs.*, 112th Cong. 82 (2011) (statement of Nassim N. Taleb, Distinguished Professor of Risk Engineering, Polytechnic Institute of New York University, Principal, Universa Investments LP) [hereinafter *Oversight Council*, Taleb Testimony].

26. *Id.*

27. NASSIM NICHOLAS TALEB, THE BLACK SWAN: THE IMPACT OF THE HIGHLY IMPROBABLE xxii (2d ed. 2010).

28. OFR 2012 REPORT, *supra* note 1, at 10.

29. TALEB, *supra* note 27, at 37 (calling "rare but expected" gray swan events "Mandelbrotian randomness").

their occurrence."[30] It would seem as though the OFR is a perfect fit for this purpose. So why such a strong objection to the OFR on the part of Taleb? The danger is that the work of the OFR may deceive us into believing we can predict financial crises,[31] therefore transforming what should be a Gray Swan (which can be guarded against with appropriate policy) into a Black Swan (with catastrophic effects). However, the OFR in its initial articulation of its mission was acutely aware of "model risk" and the ways in which models actually contributed to the 2008 crisis. The tension between the OFR's approach and Taleb's critique comes down to a difference of opinion regarding the utility of "better" models. In order to tease this thought out, it is necessary to delve further into the OFR's activities after its initial articulation of mission. A useful starting point is its published strategic plan (published five years after its inception and following the 2012 release of its inaugural report discussed above), and the nature of the studies it has undertaken in fulfilling its mission. According to the OFR, the 2015–2019 Strategic Plan "builds on and is the natural successor" to the 2012 report.[32]

The 2015 Strategic Plan (the OFR Plan) lists three strategic goals: (1) establish the OFR as an "essential source of data and analysis" related to financial stability; (2) "improve the quality and utility of financial data"; and (3) lead in the research effort related to improving financial stability.[33] The collection of data and assuring we have more accurate information regarding financial risk is, of course, in and of itself noncontroversial. The interesting issue is what the OFR projects may be done with this data. Can the collection of better information prevent the next financial crisis? Recall, in its initial report, the OFR was at least uncertain regarding modeling and the ability to measure risk in the system.

In its executive summary, the OFR Plan states that it intends to "help advance the study and the measurement of potential risks to financial stability."[34] The idea that the OFR will help promote a "stable financial system" is embedded within its vision statement.[35] The key is that, in order to meet its goal of analyzing data, the OFR must inevitably use models. This is where it works to "develop new risk management tools,

30. *Id.* at 213.

31. Jennifer Taub discusses the debate regarding the prediction of financial bubbles and implications for the OFR in Jennifer Taub, *Great Expectations for the Office of Financial Research* 23–24 (Vt. Law Sch., Working Paper No. 11-15, 2011).

32. OFFICE OF FIN. RESEARCH, 2015–2019 STRATEGIC PLAN 2 [hereinafter OFR STRATEGIC PLAN].

33. *Id.* at 3.

34. *Id.*

35. *Id.*

metrics, and methodologies" so that it can "monitor the financial environment for the emergence of new vulnerabilities and migration of activity among parts of the financial system that could threaten financial stability."[36] The OFR Plan goes on to define success as enhancing the capacity to "more readily spot potentially destabilizing trends and vulnerabilities in the financial system."[37] Not only modeling, but the collection of data also holds out the "promise for an improved understanding of the potential risks in the financial system."[38]

The belief in knowledge as the prescription for uncertainty is encapsulated into the OFR Plan's third objective to be a leader in research on financial stability. The purpose of this research is to "improve the monitoring of threats to financial stability."[39] The OFR lauds the "groundbreaking research" it is leading in order to promote financial stability.[40] The goal is to "[m]ake significant advances in modeling financial networks . . . and agent-based models for understanding the dynamics of risk."[41] In large part, this effort situates the OFR as the think tank for understanding and preventing financial crises. The concrete goals include much of what one would aspire to as an academic department chair: increasing the number of staff invitations to speak at conferences, collaboration with star researchers (partly through sponsoring National Science Foundation grants), and increasing the number of citations for OFR-led studies. A principal vehicle for activity is the Financial Research Advisory Committee (FRAC).

Perhaps there can be reconciliation between the critique of mainstream economics and skepticism regarding modeling evinced in the inaugural OFR statement and its more recent strategic plan that seems more optimistic regarding the ability to measure risk. In fact, Andrew Lo, a former member of the OFR's FRAC (and an economist *Time Magazine* named one of the 100 most influential people of 2012), provides a taxonomy of uncertainty (and regulatory proposals) that helps us reconcile this contradiction. In an article coauthored with Mark Mueller entitled, *Warning: Physics Envy May Be Hazardous to Your Wealth!*, Lo discusses the future of financial economics in light of the 2008 crisis.[42] Lo and Mueller do not deny uncertainty. Instead, they rank order levels

36. *Id.* at 5.
37. *Id.* at 9.
38. *Id.* at 11.
39. *Id.* at 13.
40. *Id.*
41. *Id.*
42. *See generally* Andrew W. Lo & Mark T. Mueller, *Warning: Physics Envy May Be Hazardous to Your Wealth!*, J. INV. MGMT., Second Quarter 2010, at 13.

of uncertainty. Their taxonomy of uncertainty based on levels of knowledge is as follows.

"Level 1" is "complete certainty." The quintessential realm of Level 1 certainty is Newtonian physics and its application to most of the physical world.[43] (Of course, at the subatomic level, the universe is subject to the laws of quantum mechanics and its inherent uncertainty.)

"Level 2" uncertainty entails "risk without uncertainty" and is "randomness governed by a known probability distribution for a completely known set of outcomes."[44] This is the level of uncertainty at which Gaussian statistical tools (of which more will be discussed later) are useful.[45] The example Lo and Mueller use is an honest casino.[46]

"Level 3" is referred to as "fully reducible uncertainty" or "situations in which randomness can be rendered arbitrarily close to Level-2 uncertainty with sufficiently large amounts of data using tools of statistical analysis."[47] The problem with this level of uncertainty is that model parameters are not known but can only be estimated over time.[48] To return to the casino example, it is the equivalent of an "honest casino, but one in which the odds are not posted and must therefore be inferred from experience."[49] Despite this level of ambiguity, Level 3 uncertainty is still very much subject to scientific inquiry. Unfortunately, according to Lo and Mueller, "[h]uman interactions are often a good deal messier and more nonlinear [than Level 3 uncertainty], and we must entertain a different level of uncertainty before we encompass the domain of economics and finance."[50]

The finance domain encompasses an even greater level of uncertainty—"Level 4."[51] Level 4 uncertainty is only "partially reducible."[52] With this level of uncertainty, there are aspects of phenomenon that will be unknowable regardless of our data gathering.[53] In addition, there is no assurance that models chosen are correct ("model

43. *Id.* at 20.
44. *Id.*
45. *See infra* notes 60–62 and accompanying text.
46. Lo & Mueller, *supra* note 42, at 20.
47. *Id.*
48. *Id.*
49. *Id.*
50. *Id.* at 21. This dividing line regarding measurable uncertainty was also explored by Frank Knight in *Risk, Uncertainty and Profit*, where he noted the distinction between knowable uncertainty ("risk") and uncertainty that could not be calculated. FRANK H. KNIGHT, RISK, UNCERTAINTY AND PROFIT 214–19, 233–34 (Sentry Press 1964) (1921).
51. Lo & Mueller, *supra* note 42, at 21.
52. *Id.*
53. *Id.*

uncertainty").[54] Therefore, "model-building in the social sciences is much less informed by mathematical aesthetics, and much more by pragmatism in the face of partially reducible uncertainty."[55] This is the dividing line between physics and the social sciences.

Completing this taxonomy of uncertainty is Level 5. "Level 5" is a total state of ignorance where nothing can be known through the collection of information.[56] Lo and Mueller qualify this level as the province of the philosopher or theologian.[57]

Lo and Mueller observe that, through progress, problems with higher levels of uncertainty (i.e., Level 4) can become more tractable (i.e., Level 3).[58] Moreover, there can be different levels of uncertainty with respect to different aspects of a problem. Lo and Mueller apply their taxonomy to the 2008 financial crisis and to the impact of the now infamous Gaussian copula formula.[59]

The Gaussian copula function has been notoriously referred to as "The Formula That Killed Wall Street."[60] The Gaussian equation was the invention of David X. Li, a relatively obscure quant (having worked in the financial industry after receiving a Masters in actuarial science and PhD in statistics) who, while working for JPMorgan Chase, published a paper in the *Journal of Fixed Income* titled *On Default Correlation: A Copula Function Approach*.[61] The basic idea of the paper was to solve the problem of calculating the probability of assets in a portfolio cross defaulting, in this case mortgages bundled in CDOs, by applying the tools of actuarial science. Essentially, he treated the risk associated with mortgage assets in the same way insurance companies treat the risk of death in large pools of insureds. This was an important breakthrough in finance because it allowed for pricing, and thence trading, in CDOs and by extension CDSs. The Gaussian copula approach was widely adopted by Wall Street amongst traders and even securities rating agencies and regulators. The problem is that it did not work. It was based on the standard statistical assumptions.[62] In particular, the reliance on a normal

54. *Id.*
55. *Id.* at 22.
56. *Id.*
57. *Id.*
58. *Id.* at 30.
59. *Id.* at 47–57.
60. Felix Salmon, *Recipe for Disaster: The Formula That Killed Wall Street*, WIRED (Feb. 23, 2009, 12:00 PM), https://www.wired.com/2009/02/wp-quant/.
61. *See* David X. Li, *On Default Correlation: A Copula Function Approach*, J. FIXED INCOME, Spring 2000, at 43, 44 (discussing alternative techniques of acturarial science applied to the calculation of the probability of portfolio assets cross defaulting).
62. *See* Donald MacKenzie & Taylor Spears, *'The Formula That Killed Wall Street': The*

distribution function discounted the fat-tail risks that are critical to accounting for possible financial calamity.

Lo and Mueller criticize the characterization that the formula "caused" the crisis, but acknowledge that pricing the financial instruments at the heart of the crisis (CDOs and CDSs) "involves a significant degree of Level-4 uncertainty" so "no single formula will yield a complete description of relevant risks and rewards . . . no matter how sophisticated."[63] Given that Gaussian copula was a central feature of the 2008 financial crisis, though not the sole "cause," how are we to deal with the inevitable uncertainty?

Instead of increasing the complexity of models, Lo and Mueller suggest a careful examination of "institutional and economic structure."[64] Regarding the 2008 financial crisis, on the broader economic front they point to the combination of low interest rates, a booming housing market, and easy money financing as factors working in conjunction with other background conditions that resulted in a type of correlation in mortgage default that was almost unimaginable under the Gaussian copula framework.[65] This is combined with an institutional structure at financial firms in which managers are not incentivized to mitigate risk in the long run because their payout is in the short run. Lo and Mueller also point to biases concerning risk similar to those raised by Taleb: "During extended periods of prosperity, the individual and collective perception of risk declines, i.e., as losses become historically more remote, human perception of small probabilities of loss quickly converge to zero."[66] The OFR's strategic plan made a similar observation: in the run up to the 2008 financial crisis, regulators and market actors "collectively underestimated how disruptions could spread . . . with severe consequences for the U.S. economy."[67]

A more recent articulation of OFR policy by its then-director, Richard Berner, at the Conference on Interdisciplinary Approaches to Financial Stability, is illuminating. The conference, held at the University of Michigan, and cosponsored by the Michigan Center on Finance, Law, and Policy (whose director, Michael Barr, was instrumental in crafting Dodd-Frank) sought to bring together scholars and practitioners from multiple

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Gaussian Copula and Modelling Practices in Investment Banking, 44 SOC. STUD. SCI. 393, 406 (2014) (Gausian copula "couples marginal distributions to form a multivariate normal distribution formula.").

63. Lo & Mueller, *supra* note 42, at 54.
64. *Id.*
65. *Id.*
66. *Id.*
67. OFR STRATEGIC PLAN, *supra* note 32, at 9.

disciplines (law, economics, physics, engineering, biology, epidemiology, data science, etc.) to discuss techniques to promote financial stability. Importantly, Berner began his remarks convening the conference by emphasizing that "[f]inancial stability is not about constraining market volatility, nor can we predict or prevent financial shocks."[68] Instead, the purpose of focusing on financial stability was to foster "resilience"—assuring that "when shocks hit, the financial system will continue to provide its basic functions to facilitate economic activity."[69] This seems very close to Taleb's approach to dealing with financial crises and his notion of antifragility. As is true with Taleb's work, the OFR's work according to Berner is "focused on tail risk, rather than means or modes in normal times."[70] In this light, the OFR's goal is to measure risk in order to identify areas in the financial system that require greater safeguards. Recognizing, however, that "financial innovation" is such a powerful force that the "goals to eliminate gaps in data and analysis, and to devise ideal shock absorbers and guardrails, will always elude us."[71] Instead of the more aggressive policy prescription of "smallness" recommended by Taleb, Berner ascribes to the policy consensus of "new rules for capital and liquidity" for banks (recognizing that more must be done for the nonbanking sector).[72]

The "tail risk" Brener described led to precisely the type of unexpected event that constitutes a Black Swan, and is the reason why Taleb is so critical. It is not only that the OFR's aspirations, as they have developed, are impossible in the eyes of Taleb ("there are limitations to our ability to measure the risks of extreme events")[73]—OFR's efforts may have negative consequences. The OFR includes measuring risk as one of its goals. Taleb regards this as tilting at windmills because the very nature of the risk associated with financial stability is "fat tail" risk.[74]

68. Richard Berner, Dir., U.S. Office of Fin. Research, Remarks at the University of Michigan Conference on Interdisciplinary Approaches to Financial Stability (Oct. 22, 2015), https://www.financialresearch.gov/public-appearances/2015/10/22/interdisciplinary-approaches-to-financial-stability/ [hereinafter Berner Remarks]. Berner made a similar statement in an address at the Annual Meeting and Public Policy Forum of the Academy of Actuaries: "Financial stability is not about constraining market volatility. Nor can we predict or prevent financial shocks. Rather, financial stability is about resilience." Richard Berner, Dir., U.S. Office of Fin. Research, Remarks at the Annual Meeting and Public Policy Forum of the American Academy of Actuaries (Nov. 12, 2015), http://financialresearch.gov/public-appearances/2015/11/12/american-academy-of-actuaries/.

69. Berner Remarks, *supra* note 68.

70. *Id.*

71. *Id.*

72. *Id.*

73. *Oversight Council*, Taleb Testimony, *supra* note 25, at 82.

74. TALEB, *supra* note 27, at 170.

Distributions that have fat tails have a greater likelihood of extreme events.[75] Taleb refers to conditions under which this is the case as "extremistan" in *Black Swan*.[76] In extremistan, the world is subject to wild fluctuations and unpredictable instances of observations falling at the edges of fat tails.[77] This contrasts what Taleb describes as "mediocristan," or situations in which we expect observations to generally fall near the average or mean.[78] In mediocristan, which is dictated by the famous "bell curve," tails are razor thin and observations at the edges are rare.[79] The fact that events are unpredictable in extremistan does not mean that we have no knowledge of this domain. Turning back to the Lo/Mueller taxonomy, we can mark the dividing line between their Level-3 and Level-4 uncertainty as mirroring Taleb's mediocristan/extremistan dichotomy.

Taleb cites specifically to the work of Benoit Mandelbrot, whom he admires greatly for his insight into the statistical nature of exetremistan. Mandelbrot first burst onto the finance scene in the 1960s. He is a mathematician by academic training. As a student in the French university system, Mandelbrot rejected the pursuit of the conventional mathematical problems of the day and instead focused on geometric methods—the analysis of geometric shapes as a method for gaining insight into phenomenon. This led to his much-lauded discovery—"fractal geometry."[80] Fractal geometry is the study of fractured shapes, such as mountain ranges, in the natural world. Mandelbrot's essential observation was that there are a lot more extremes in the world than might be expected.[81] He began exploring these aberrations not only in the natural world, but also in the social world (particularly as related to income distribution). Mandelbrot would eventually bring this insight to the study of financial markets, the fundamental implication being that while market behavior may be random, it is more along the line of "random jumps" as opposed to a "random walk."[82] The connection between Mandelbrot's insight and finance is rather serendipitous. As he was preparing for a talk at the Harvard Economics Department in 1961, he visited the office of Hendrik Houthakker and noticed a graph that looked very similar to the income

75. *Id.* at 354.
76. *Id.* at 33.
77. *Id.* at 36.
78. *Id.* at 32.
79. *Id.* at 36.
80. *See generally* BENOIT B. MANDELBROT, THE FRACTAL GEOMETRY OF NATURE (1982).
81. TALEB, *supra* note 27, at 256.
82. *Id.* at 251.

distribution chart Mandelbrot was planning to discuss as part of his talk.[83] When he was informed that Houthakker's chart was actually of cotton prices, Mandelbrot realized that his theory of randomness had implications for financial markets.[84]

The statistical implication of Mandelbrot's discoveries is that there are situations where the mainstream, Gaussian, finance assumption of a normal distribution (with "skinny tails" or low probability of extreme events) does not apply. In other words, there are consequential contexts for which "fat tail" scenarios are applicable, including financial markets. Initially, finance theorists were enthusiastic regarding Mandelbrot's insights. They helped explain certain anomalies in financial markets—bubbles and market crashes, which were supposed to be extremely rare events. However, the luster of Mandelbrot's approach quickly wore off because it does not allow for the precise statistical prediction associated with Gaussian (bell curve) statistical methods.

Adopting Mandelbrot's theory assists us in rendering financial crises into Gray Swans as opposed to Black Swans, because we are more likely to prepare for (and thus mitigate) their consequences. The danger of the OFR is that if its activities cause us to be overconfident regarding modeling and prediction, it can actually transform these Gray Swans into Black Swans. We may lose track of the fact of uncertainty and consequently fail to take adequate preventative measures. This is what disturbs Taleb so greatly. As Taleb expresses the point: "Risk measurement and prediction—any prediction—has side effects of increasing risk-taking, even by those who know they are not reliable [i.e., the OFR]."[85] Taleb ascribes this to what behavioral economists refer to as the "anchoring effect," and the "narrative fallacy"—the very same defects Lo and the OFR identify as contributing to the 2008 financial crisis.

The advances the OFR seeks are focused on exploring what we are not capable of knowing. While, as is evident by its initial Report, OFR officials are acutely aware of failures in assumptions and modeling associated with the 2008 financial crisis, the OFR's emphasis is on "getting it right" with better data and more sophisticated analysis (modeling). A typical example of this is the OFR's focus on complexity and agent-based models. This search for alternative methods highlights Taleb's counterpoint that "[h]ad the last crisis been predictable within

83. Boris Salazar, *Mandelbrot, Fama and the Emergence of Econophysics*, 69 CUADERNOS DE ECONOMÍA 637, 644 (2016) (citing to a note written by Mandelbrot in 1982 recollecting his visit to Harvard).

84. *Id.*

85. *Oversight Council*, Taleb Testimony, *supra* note 25, at 84.

these quantitative methods, then central banks with access to all manner of information, and thousands of PhDs on their staff, would have been able to see it."[86] The OFR is attempting to use different (beyond mainstream corporate finance) and better tools of analysis. However, Taleb, in discussing the OFR to a congressional panel, is skeptical: "[t]he same [statistical] limitations apply with even more force to the newly minted—and overhyped—methods based on 'complexity theory' or new buzzwords like 'agent-based models'. . . . [that] are interesting descriptions of the world, but their predictions do not seem to work outside of research papers."[87]

Taleb's skepticism regarding new modes of inquiry beyond the neoclassical/mainstream finance paradigm is a bit perplexing because it would presumably incorporate the very same type of research he supports in *Black Swan*, and that is at the cutting edge of the "new finance" (which is embraced by the OFR). In fact, Taleb is proud to announce that he is a member of the Society of Judgment and Decision Making, which is associated with the research program championed by one of his academic heroes, Daniel Kahneman. The Society is decidedly not composed of neoclassical economists, but is populated mainly by "empirical psychologists and cognitive scientists whose methodology hews strictly to running very precise, controlled experiments (physics-style) on humans and making catalogs of how people react, with minimal theorizing."[88] This is valuable not because it allows us to create better models, but because these experiments provide concrete evidence of biases that color our perception of risk (particularly Black Swans). In particular, empirical psychology can demonstrate the human tendency toward confirmation bias and the narrative fallacy. Confirmation bias is our tendency to favor information that reinforces our initial beliefs. Narrative fallacy refers to our habit of infusing our own narrative about the world into any sequence of facts. It is our way of making sense of the world. Both of these behavioral traits lead us to mythologize the world in a way that discounts the possibility of Black Swans. Taleb's hope is that cognitive and behavioral science will assist us in resisting these emotional urges and comprehend the cold hard facts.[89] In this sense, Taleb is not "against science." He rejects science that diverts us from coming to grips with the fact of uncertainty.

The limitations of financial models, given the relationship between financial economics and neoclassical economics, not only have technical

86. *Id.*
87. *Id.* at 83.
88. TALEB, *supra* note 27, at 81.
89. *Id.* at 83–84.

implications but political relevance as well. Critiques of the neoclassical paradigm came from all quarters post-2008 crisis—ranging from neoclassical insiders whose beliefs were shaken, such as Alan Greenspan and Richard Posner, to those who had previously been skeptical of free-market economics. A short list of texts either reconsidering or critiquing the neoclassical paradigm due to the weaknesses the 2008 crisis demonstrated include Posner's *The Crisis of Capitalist Democracy*, Fox's *The Myth of the Rational Market*, Stiglitz's *The Non-Existent Hand*, Krugman's *How Did Economists Get It So Wrong?*, and Galbraith's *Who Are These Economists, Anyway?*—just to name a few.[90] The Fox critique is properly characterized as internal to financial economics—but attacking neoclassical economics by extension. Fox identifies rationality as the theoretical basis underlying financial economics.[91] As the basis for the Efficient Market Hypothesis, rationality is at the core of modern finance. However, as Fox argues: "Most of the scholars who backed this hypothesis [(rationality)] early on didn't mean for it to be taken as a literal description of reality. It was a scientific construct, a model for understanding, for testing and engineering new tools."[92] Fox goes on to note that the rise of this "scientific construct" is "intertwined with the widely chronicled rebirth of pro-free-market ideology after World War II. But rational market finance was not at heart a political movement. It was a scientific one."[93] I respectfully disagree with this statement. The history of financial economics is, at its core, a scientific and political narrative. The principle of rationality made its way into financial economics by way of its progenitor, neoclassical economics (a decidedly political project).

Another form of attack—exemplified by Stiglitz, Krugman, Galbraith, and Posner—which illustrates the nature of the politics involved, was to note that neoclassical economists failed us by placing too much faith in free markets. Stiglitz argues that the move away from Keynesian economics to a belief in limited government intervention and reliance on monetary policy (as opposed to fiscal policy) played an important role in

90. *See generally* RICHARD A. POSNER, THE CRISIS OF CAPITALIST DEMOCRACY (2010); JUSTIN FOX, THE MYTH OF THE RATIONAL MARKET: A HISTORY OF RISK, REWARD, AND DELUSION ON WALL STREET (1st ed. 2009); Joseph Stiglitz, *The Non-Existent Hand*, LONDON REV. BOOKS, 22 April 2010, at 17 (reviewing ROBERT SKIDELSKY, THE RETURN OF THE MASTER (2009)); Paul Krugman, *How Did Economists Get It So Wrong?*, N.Y. TIMES, Sept. 6, 2009, § 9 (Magazine), at 36; James K. Galbraith, *Who Are These Economists, Anyway?*, THOUGHT & ACTION: NEA HIGHER ED. J., Fall 2009, at 85.

91. FOX, *supra* note 90, at xiii.

92. *Id.* at xiv.

93. *Id.* at xiv–xv.

the scope of the crisis.[94] His ultimate conclusion is much the same as Fox's—criticizing the belief in market rationality that underlay financial engineering. The belief in rationality also supported the free-market ideology that cleared the way for deregulation of the financial markets and the resulting crisis. However, Stiglitz makes a deeper point that goes beyond contemporary financial engineering. He points out that booms and busts, exuberant and panicked markets, are not new to us, so we cannot lay the most recent turn of events solely at the altar of financial engineers.[95] Speculation is a constant in financial history. The difference now is that, with technology and advances in financial engineering, the ability of speculators to do harm to the "real economy" has increased enormously. This makes it all the more imperative that we aggressively regulate financial markets. Keynes did not focus on financial markets. However, his pro-government intervention framework created space for the type of post-Great Depression era financial regulation that was dismantled in the run up to 2008.

Krugman argues that the belief in the efficient market hypothesis is the core blind spot of financial economists, and that "economists, as a group, mistook beauty, clad in impressive-looking mathematics, for truth."[96] This is dictated by adopting the rational actor model. Irrationality is "messy" and not subject to mathematical modeling. Even the "New Keynesians," the macro counterweights to University of Chicago free market theorists, were part of the consensus regarding rationality in the financial sphere and general belief that markets operate efficiently. Events such as the 1973–1974 stock market crash, LTCM debacle, and the 1987 stock crash did not shake economists from their belief in the "force of a beautiful idea. The theoretical model that finance economists developed by assuming that every investor rationally balances risk against reward . . . CAPM [(Capital Asset Pricing Model)] . . . is wonderfully elegant."[97] Although the Great Recession has caused some economists, behavioral economists specifically, to move off of the rationality assumption and focus on market imperfections and bubbles, the problem is that "[i]t will be a long time, if ever, before the new, more realistic approaches to finance and macroeconomics offer the same kind of clarity, completeness and sheer beauty that characterizes the full neoclassical approach."[98] We can thus expect some economists to "cling

94. Stiglitz, *supra* note 90.
95. *Id.*
96. Krugman, *supra* note 90, at 37.
97. *Id.* at 39.
98. *Id.* at 43.

to neoclassism."[99]

With this critique, one might assume the neoclassical paradigm, and by extension free market presumptions, would not survive post-crisis. However, there was a strong counteroffensive defending neoclassical economics.[100] One strategy was to simply blame the crisis on other causes. For example, the crash was attributed to all too ubiquitous "toxic assets." As Mirowski argues, in pinning the crisis on toxic assets, in other words, an aberrant toxin to be flushed out of the system, attention was diverted from inherent problems with the system.[101] The market would in time work the toxins out of the system.[102]

CONCLUSION

I have purposefully juxtaposed the "moderate" views of Lo and the OFR regarding the usefulness of models to the "radical" view of Taleb. Lo still has a fundamental belief in the scientific project whereas Taleb rejects scientism. Interestingly, there is surface agreement between OFR supporters and Taleb regarding the uncertainty in models. Medelowitz, one of the leading champions for the OFR, admits that the "cause of tomorrow's crisis [is] likely . . . different" and we "cannot prepare for tomorrow's crisis by simply . . . building . . . models."[103] This is reflected in the 2015 OFR strategic plan:

> Financial institutions and other market participants still find it difficult to produce accurate and consistent metrics to identify, measure, and report their exposures and risks. Solutions to this challenge will continue to elude us, given the dynamic trends previously noted.[104]

Both Medelowitz and Lo make an analogy to government risk management efforts in other areas, for example, hurricanes (National Hurricane Center) and disease pandemics (Center for Disease Control).[105] Just as we both attempt to predict hurricanes and yet also

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99. *Id.*

100. *See generally* PHILIP MIROWSKI, NEVER LET A SERIOUS CRISIS GO TO WASTE: HOW NEOLIBERALISM SURVIVED THE FINANCIAL MELTDOWN (2013) (mapping out the interconnection between neoliberal defense of free market economics and defense of neoclassical economic enterprise).

101. *Id.* at 169.

102. BAIRD WEBEL, CONG. RESEARCH SERV., R41427, TROUBLED ASSET RELIEF PROGRAM (TARP): IMPLEMENTATION AND STATUS 2 (2013).

103. *Equipping Financial Regulators*, Mendelowitz & Liechty Testimony, *supra* note 5, at 46.

104. OFR STRATEGIC PLAN, *supra* note 32, at 7.

105. *Equipping Financial Regulators*, Mendelowitz & Liechty Testimony, *supra* note 5, at 48 (proposing the creation of the National Institute of Finance, which would use data and analytics to evaluate market weakness). *See* Andrew W. Lo, *Regulatory Reform in the Wake of the Financial Crisis of 2007–2008*, 1 J. FIN. ECON. POL'Y 4, 23 (2009) (discussing government management of systematic risks); Taub, *supra* note 31, at 23 (drawing upon the storm-warning example).

have building codes to help withstand hurricanes, Lo would have us limit the consequences of financial shocks—"any financial companies that are 'too big to fail' should be broken up into smaller entities that are no longer too big to fail."[106] Taleb argues for the same policy prescription.[107] Of course, how rigorous one would be in arguing and enforcing such a policy depends upon what one believes is the domain of uncertainty. Taleb is a lot more suspect regarding our scope of knowledge and the ability of science to conquer our uncertainties.[108] I tend to agree, but I am uncertain we will be able to resist the pull of models.

106. Lo, *supra* note 105, at 7.

107. TALEB, *supra* note 27, at 226–27.

108. The fundamental difference in Taleb and Lo is belief in progress and nuance regarding domains. Lo & Mueller, *supra* note 42, at 13–14. See also Lo on progress in physics as analogy. *Id.* at 47–50.