

The Quantitative Revolution and the Crisis: How Have Quantitative Financial Models Been Used and Misused?



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Ronald Gilson, the Marc and Eva Stern Professor of Law and Business at Columbia Law School, spoke with Eric Schoenberg, adjunct associate professor at Columbia Business School, and Bruce Kogut, the Sanford C. Bernstein & Co. Professor of Leadership and Ethics at Columbia Business School.

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Hugh Patrick, the R. D. Calkins Professor of International Business Emeritus and director of the Center on Japanese Economy and Business at Columbia Business School, introduced the conference.



Executive Summary

Bruce Kogut and Hugh Patrick

In recent decades financial innovation has generated positive economic effects, ranging from support for the launch of new industries to the adoption of the convenient ATM. However, the net social value of financial innovation of complex financial instruments has yet to be securely established, at least so far as public opinion is concerned in the current crisis. This reflects a failure of the financial industry, as well as deep-seated fears of the uses to which technology may be put.

These fears are no doubt exaggerated, yet nonetheless, they are not completely unfounded where quantitative finance is concerned. The quantitative models used by financial specialists are in many regards more sophisticated and consequential than the models that preceded them. They may confer competitive advantage for the innovator and benefit to the user. However, there are five significant and under-appreciated dangers in their use, which emerge more from the organizational and operational contexts of quantitative finance than from the practice itself:

- First, and most important from a conceptual standpoint, the processes involved in the widespread use of quantitative models can be seen as “counter-performative.” This means that increasing reliance on *similar* models by numerous actors causes the models to diverge collectively from the reality that they are intended to describe. Fundamental value and prices diverge. This effect appeared in the U.S. financial crisis of 1987 as well as the current crisis. In both cases, though in different ways, quantitative models accelerated catastrophe.
- A second practical danger is that many people using quantitative models are doing so in ways that are imprudent, unsophisticated or both. During buoyant times, they overlook factors that may call their models into question. The goal of many market professionals is to ensure that they are in conformity with market trends, which can lead them to override their own best judgments.
- Third, the people who create quantitative models are not the people who decide how they will be used for the fabrication of financial products that are sold to investors.

Thus, the scruples of even the best practitioners may be set aside by other actors, who are under different incentives and competitive pressures.

- The fourth danger is that financial innovations often are traded through very opaque markets and outside of exchanges. The logic for leaving such trading off exchanges and unregulated is similar to that used for patents: To encourage innovation, there must be a period permitted for the reaping of rents. As with patents, this logic presumes that the innovation is of a social value greater than the efficiency loss. This net gain has neither been measured, nor demonstrated. No doubt, since financial innovations are usually easy to copy by professionals, secrecy is important to the earning of profits. However, not only do such informational imperfections hurt market efficiency, but they also contribute to the difficulty of understanding correlated and counterparty risks.
- A final danger resides in assumptions that are rooted in generational, social and cultural factors. Japan was largely spared the impact of the latest crisis because an older generation of financial managers remembered and acted upon the lessons of the “lost decade” of the 1990s. In the U.S., the savings and loan crisis of the late 1980s was the problem of an earlier generation and had little to do with quantitative finance and capital markets. The largely similar profile of executive leadership in the financial sector and the belief that things always work out for the best led to the discrediting of bears and persistence in the rush to crisis.

The above factors strongly suggest that the financial industry cannot be expected to effectively regulate the implementation of its own innovations. The belief that the market will reward competent practitioners and punish inept ones is not entirely false, but it assumes that the consequences of failure are purely individual. However, it can now be seriously argued, on the basis of growing empirical evidence, that the use of quantitative models has pervasive systemic effects that arise from individual actions and that the consequences of using these models include the ruin of innocent bystanders. Regulation aimed at mitigating these effects and consequences is increasingly necessary.

Floyd Norris, chief financial correspondent at the *New York Times*, spoke on the panel "Why Was the Financial Crisis Less Enduring in Japan and Other Countries...This Time Around?"



I. Introduction: The Technology of Crisis

A. Is Financial Innovation a Special Case?

Few postulates are more generally accepted than the idea that innovation is the engine of economic growth in modern societies. Enormous sums are invested by governments, corporations and other organizations to encourage the search for and implementation of innovation. In addition, enormous energy is invested by scholars and organizational strategists in analyzing, anticipating and structuring successful examples of innovation practices. The financial industry is a major contributor to these campaigns, not only by funding them, but also by contributing insight into key success factors of industrial investment and key personnel to work on projects, and through direct participation in management (particularly by venture capital firms).

More recently (and particularly since the 1970s, as will be shown below), the financial industry has undertaken a sustained effort to innovate in its own processes and development strategies. The possibility that these strategies have become an engine of value destruction was evoked only rarely before the financial crisis, and it poses unsettling questions: If innovation is generally desirable, why would financial innovation be undesirable? Is financial innovation being unfairly blamed for the current crisis? If some of the blame is deserved, what mechanisms can we identify that were at work in the crisis, and how can we revise them or prevent their misuse? These questions, in one form or another, were at the heart of the conference.

The financial community's behavior in the crisis and its aftermath has contributed to making these questions highly political. Some leaders of the industry have demonstrated a firm commitment to business as usual against a backdrop of what Hugh Patrick, director of the Center on Japanese Economy and Business at Columbia Business School, calls "lapses in ethical behavior" that sometimes equate to "fraud." The most visible lapse—and the one that most outrages American and European publics, legislators and regulators—

resides in bonuses. Put simply, banks are perceived as offering massive rewards to the same financial innovators who set off the crisis, after being saved from bankruptcy through massive injections of public funds.

By no coincidence, the public increasingly perceives the license to operate in the financial community as resulting in unjustifiable privileges. So do actors like Floyd Norris, chief financial correspondent of the *New York Times*, who asked rhetorically: "We're told we have to pay a CEO \$30 million to do a good job. Why?" Public anger also proceeds in part from an intellectual failure of the financial industry to make its case, as Bruce Kogut, the Sanford C. Bernstein & Co. Professor of Leadership and Ethics, observed in his opening remarks:

"Finance has not demonstrated that its social value is equivalent to the value it creates for certain individuals. The financial sector is 8 percent of GDP. Do we understand why there are such profits in this industry? I've yet to hear a persuasive explanation. Explanations for innovative contributions in other industries, such as microprocessors, are easy to make. The case for the social value of financial innovations has yet to enter into the canonical beliefs held by the public; to the contrary."

B. At the Core of the Crisis: The Dominance of "Quants"

While awaiting that explanation, the task of understanding how some of the most highly educated individuals in our society generated a global catastrophe remains. Kogut noted that the question has hardly been evoked, let alone answered:

"There hasn't been a debate as to whether financial innovation is responsible for consequences in society at large. If financial innovation is a poker game for a few insiders, we don't care. But there are externalities, and we haven't discussed the effects on innocent bystanders."

The specific work of this conference was to focus on the single most important technological innovation implicated in the crisis: the increasing use of quantitative mathematical models to calculate risks and rewards for sophisticated financial products. (The term “quants” is typically applied to the people who make these models.) These innovations, noted Kogut, “diffuse very quickly, from being developed one day to moving around the world... to places in the world that don’t understand [the products or the technologies involved], but are engaged in the systemic risk.”

Quants were evoked in sometimes contemptuous terms at the Bernstein Center’s December 2008 conference “Preventing the Next Financial Crisis: Lessons for a New Framework of Financial Market Stabilization.” For Jean-Charles Rochet, professor of mathematics and economics at the Toulouse School of Economics, the crisis confirmed that quantitative models are based on “ridiculous assumptions,” involving formulas that are “too simple to be true and too complex to be verified by outsiders.”¹ It was also observed that financial innovation before the crisis was specifically designed to circumvent regulatory oversight and thus led to a “shadow” banking system of structured vehicles that contributed greatly to the conflagration.² In retrospect, said Kogut, “A subtext might be that financial innovation is bad and created the crisis. I think that’s suspect. Innovations in other industries are also systemic but are accepted as part of the ‘gale of creative destruction’ described by Schumpeter. So why all the fuss about financial innovation?”

The uproar is as intense as it is novel. Paul Glasserman, the Jack R. Anderson Professor of Business at Columbia Business School, contrasted recent remarks by Michel Rocard, the former French prime minister, (“quantitative models are a crime against humanity”) and Felix Salmon (author of the *Wired* cover story “Recipe for Disaster: The Formula That Killed Wall Street”³) with the “completely different” situation before the crisis. As recently as 2006, a report commissioned by Michael R. Bloomberg, mayor of New York, and Charles E. Schumer, U.S. Senator, on threats to the city’s primacy in financial services concluded that a nascent shortage of capable quants was the critical weakness.⁴ Fixing that gap, recalled Glasserman, would make quantitative finance into “the salvation of math and physics training.” The “dramatic change in public perception,” he hinted, might not be a sign of wisdom. Yet he suggested that quants must accept that in ways both technical and ethical, they will have to respond to these pressures:

“The question is: Does the practice of quantitative finance need to change? Given everything that’s happened, do models need to be updated? At a deeper level, does financial engineering create risk or help to disperse it efficiently? How do we distinguish between financial innovation that creates social value and financial innovation that serves to circumvent regulation?”

1. See “Preventing the Next Financial Crisis: Lessons for a New Framework of Financial Market Stabilization,” Columbia Business School, 2009, p. 24.

2. *Ibid.*, pp. 5, 9.

3. Published on Feb. 23, 2009, available from wired.com.

4. See Michael R. Bloomberg and Charles E. Schumer, “Sustaining New York’s and the US’ Global Financial Services Leadership.” City of New York/Office of the Mayor and U.S. Senate, 2006.

Kogut suggested that suspicion of quants is rooted in a profound and persistent narrative of the modern era—the invention that destroys its creator. Alongside the fear generated by that story, he argued, an ethical question is posed:

“When people think of technology, they think of Frankenstein, and they laugh. It’s an old story. But it’s not too far from the reality... Who’s to blame [when an invention turns rogue]? Financial innovation is software. Is it the people who create or use the software [who are to blame]? Should we have governments regulating their use? Who’s responsible for these things?”

The conference began the work of addressing that question by pulling together the viewpoints of two very different communities: business scholars and high-level financial practitioners. The scholars all share a common characteristic: They have done extensive fieldwork among traders and financial innovators. (Clearly, they enjoyed the experience and do not despise the people they encountered.) The practitioners, too, share a common characteristic: They are proud of the personal success that their excellent quants created. So far as this conference could show, their ability to conceive the dangers of their still-new technology is circumscribed by the simple fact that for them and their clients, quantitative models work quite well.

However, what worked for the most talented practitioners of the financial community visibly did not work for everyone else. Thus on one level, quantitative models remain emblematic of the gap that still exists between financial innovation and its wider effects on society. They are also symbolic of a debate on social justice that resides one level down from the purely economic issues that emerged in the crisis. Hugh Patrick commented:

“Floating in all this is the idea of how to allocate resources efficiently. We take it for granted that’s what we’re concerned about. Systems that misallocate capital and other resources we label as inefficient. But there are other values—who decided the allocation? The fundamental issue for every society is: What is the fair distribution of income?”

The conference did not seek to answer that question, postponing that analysis in preference to understanding *who* may be considered financial innovators, and *what* are their innovations and the resulting effects. The focus of the proceedings was on the underlying principles of models, the drivers of their rapid worldwide adoption and the dynamics that transformed them into instruments of value destruction for many. That outcome, suggested Donald MacKenzie, professor of sociology at the University of Edinburgh, can in retrospect be seen as a “predictable surprise” (cf Bazerman and Watkins).⁵ But it was nonetheless counterintuitive. More exactly, in MacKenzie’s terms, it was “counterperformative.”

5. See Max Bazerman and Michael D. Watkins, *Predictable Surprises: The Disasters You Should Have Seen Coming*, Harvard Business Press, 2004.



Conference guests discuss the day's topics during a coffee break.

II. How Performativity Becomes Its Negation

In a world obsessed with performance, *performativity* is a subtler and subversive notion. Donald MacKenzie of the University of Edinburgh began with a simple definition: "Supposing I was late to give this talk, came in and said, 'I apologize.' That utterance is what J.L. Austin⁶ called a performative utterance: It doesn't describe a state of affairs, but brings it into being." In short, a *performative* statement is one that alters the material world.

MacKenzie noted that "the postulates of economics aren't simple performative statements in that sort of sense." (For example, declaring that a certain procedure results in wealth does not necessarily create it.) What MacKenzie calls "generic" performativity is when a postulate no longer figures just in economic textbooks, but is used in practice. Specifically, it is used at the point where economic postulates begin to have an effect on real-world economic processes.

The term "Barnesian performativity" (after the sociologist of science Barry Barnes⁷) describes one such phenomenon: The application of an economic principle transforms real-world processes in a way that makes them resemble the principle. MacKenzie has identified another inverse case, which he calls counterperformativity. In this case, some aspect of economics is put into practice, and the effect on processes is to move them away from the initial postulates. MacKenzie summed up by saying, "Performativity is when the use of a model increases predictive fit [with outcomes]; counter-performativity is when its use decreases predictive fit."

Where Barnes saw how life can imitate our beliefs about it, MacKenzie argues that real-world actions can subvert the economics that inspire them. A given postulate may be perfectly valid in the abstract, but processes based on it, and

6 John Langshaw Austin (1911–1960) was a philosopher who invented the notion of an "act of language" (such as "I do thee wed"). His influence as an Oxford professor was massive, despite the fact that he published no books during his lifetime, because he thought there were already plenty of them.

7 Barnes is currently professor of sociology at the University of Exeter, UK.

the way they are applied by human beings, may subvert the predicted and desired effects. Thus in a recent book chapter, MacKenzie argued that the occasionally catastrophic impact of quants has been "not primarily" due to the fact that their underlying models were wrong:

"Had they been simply external representations, with no effects on the processes they modeled, they might have remained reasonably accurate. Rather, they were *made* wrong in part by the processes...of which they were an integral part."⁸

The question then becomes: "How does the use or development of a model change when actors take into account that others are using it?" MacKenzie sought to answer it, based on the recent history of major financial markets.

A. How a Single Model Transformed the Options Market

Economic postulates in the marketplace—and in particular option pricing theory—have a long history, noted MacKenzie. The "most influential model of all" for option pricing, he added, was the Nobel Prize-winning Black-Scholes-Merton theory.⁹ MacKenzie called it "in all likelihood the most-used equation for anything like the same complexity in history, more than any equivalent equations of science and engineering." It enabled a market of \$668 trillion U.S., \$100,000 for every human currently alive. It also contributed to a previous market crisis, as we will see in the next section.

In essence, Black, Scholes and Merton (the first two initially working separately from and in parallel with the third) provided an account of how economic processes determine the price of options. They postulated that asset prices (and by extension,

8 Donald MacKenzie, "Is Economics Performative? Option Theory and the Construction of Derivatives Markets." Author's manuscript, 24 June 2006.

9 Fischer Black & Myron Scholes, "The Pricing of Options and Corporate Liabilities," *Journal of Political Economy* (1973) and Merton, Robert C. (1973). "Theory of Rational Option Pricing." *Bell Journal of Economics and Management Science*, 4 (1): 141-183.

Paul Glasserman, the Jack R. Anderson Professor of Business at Columbia Business School, moderated the panel "Does the Practice of Quantitative Finance Need to Be Changed?"



asset pricing models) can be calculated in the context of a risk-free position that must be attained in equilibrium, because any deviation from those prices will disappear through arbitrage. Their model, said MacKenzie, "is also quite simple—there's only one free parameter, volatility." In his fieldwork, he saw that "people used the model in a variety of ways—in particular, the strategy called 'spreading,' where you simultaneously bought an underpriced option and sold an overpriced option on the same stock." This is also called hedging, and portfolios of such options are currently called "hedge portfolios." In theory such a strategy is riskless, "so it can earn only the riskless rate of interest," noted MacKenzie. "Otherwise, there's an opportunity for arbitrage." (See figure 1.)

This was a sturdy, understandable model that real traders could apply in the heat of the market, if they cared to. Not all did, at least not when MacKenzie began studying the options trading pits of Chicago, around the time in 1973 when Black, Scholes and Merton published their equations. A Chicago

Black-Scholes Equation (1969-70)

$$\frac{\partial w}{\partial t} = rw - rx \frac{\partial w}{\partial x} - \frac{1}{2} \sigma^2 x^2 \frac{\partial^2 w}{\partial x^2}$$

w is option price, x stock price, σ volatility of stock, r riskless rate of interest, t time. Stock pays no dividends & option "European" (can be exercised only at expiry). Characteristics of option give boundary condition (at expiry, w is a known function of x).

Volatility: the extent of the fluctuations of the price of an asset (annualized standard deviation of continuously compounded returns on the asset).

Riskless rate: the rate of interest paid by a borrower who creditors are certain will not default.

Figure 1: Donald Mackenzie, professor of sociology at the University of Edinburgh, presented the early Black-Scholes equation during his keynote presentation.

trading room can hold 500 traders, and their work was intensely physical, recalled MacKenzie:

"Deals are entered into by voice, or by hand when it gets too noisy. Fingers indicating how much, palm toward or away from the body. The stories traders tell me are about the body—the voice coach who taught them to shout all day, the small, polyester jackets on hot human bodies, their knees giving way in middle age from standing all the time, the way you stand, the top rung being the best, where the big brokers bring the big orders...people compete to stand, fistfights break out, and people are monitoring each other's bodies for uneasy movements, eyes flicking around that indicate fear."

Traders who carried printed sheets of theoretical option prices (provided by Fischer Black himself for a fee) could be challenged by others: "Trade like a man!" MacKenzie recalled, "They'd throw his papers to the ground and say, 'See if you can trade now.'" But before long, he said ironically, "The wimps won out over the real men." The inherent validity of the Black-Scholes-Merton model was not the only reason; it was also publicly available, easy to use and relatively cheap. Competing models were proprietary or more expensive to obtain.

The model had a measurable empirical effect on the market, according to MacKenzie: "From 1973 on, market prices fell toward Black-Scholes-Merton levels." In his view, this occurred not only or solely because the theory was correct. It also mattered that the theory helped legitimize the options market, which was previously regarded as too close to outright betting in both public and legal opinion. Thanks to Black-Scholes-Merton, traders could provide a rationale for the price of options, based on their volatility. And in using the model, they generated results highly similar to those it predicted:

"A spreader looks for underpriced options to buy—the higher the volatility, the lower the price—and overpriced options to sell. [The equation provided] simple instructions to perform spreading. The effect of spreaders doing this was to shift prices to a flat line. So

the use of the model shifted practice toward the results of the model.”

B. 1987: The Model and the Market Diverge

The success of the Black-Scholes-Merton model in options trading led to its application in portfolio insurance. The key innovation here was the “replicating portfolio.” The idea was that an asset portfolio can be constructed in such a way that the cashflows it generates replicate the cost of the underlying assets over time. Once again, this model simplifies the work of traders. They do not need to set an arbitrary (and hence suspect) discount rate on the assets. Nor must one calculate the term structure of interest rates, because they are automatically accounted for.

What Black, Merton and Scholes contributed here was the insight that “given certain assumptions, it’s possible to replicate an option continuously,” noted MacKenzie. It was also possible to carry hedging a long step further, by creating “a replicating portfolio that mimics the portfolio,” in which downside and upside risks, bets and counter-bets, continually balance each other. Thus, said MacKenzie, “The second important place where theory and practice got together was

portfolio insurance: You create the replicating portfolio to give you a floor below which the value of your portfolio should not fall.”

However for that strategy to work, he added, the replicating portfolio cannot remain static: “It’s continually adjusted and demands that you sell when prices are falling.” This, he said, “was almost certainly a significant contribution to the crash of 1987.”

It was not the only factor, but it was a mighty one. It amplified the latent fear of ruin in exchange actors. In Chicago, MacKenzie observed, it fed into “the pattern of bodily interaction in the Mercantile Exchange. The crowd detected the panic of a guy who had to sell as the market went lower.” The floor below the portfolios was falling even faster than their value. The model called for selling, and selling in a falling market accelerates the loss of value. Because so many people were using the same or similar models, the fall became a crash.

But following the crash, the Black-Scholes-Merton model remained effective for market actors, with the addition of further refinements (which we’ll discuss below), for two decades. And then, replicating portfolios helped once again to replicate disaster.



Donald MacKenzie, professor of sociology at the University of Edinburgh, delivered the keynote presentation on “Models, Markets and Crises.”

C. Overview: The Three Phases of Performativity

The story so far indicates three phases in the evolution of the Black-Scholes-Merton model from performativity to counter-performativity, argued MacKenzie:

- In the first phase, a model is introduced and shows itself to be “a reasonable but approximate fit” with market reality. In other words, it works well enough to offer some advantage to those who use it. For Black-Scholes-Merton, that phase took place roughly from 1973 to 1975.
- In the second phase, the model works even better, “because reality adjusts to fit the model.” The fact that so many people are using it means that they are in effect reshaping the market to better fit the model. MacKenzie dates that phase from the mid-1970s to the summer of 1987. By that time performativity had been built into the infrastructure of the Chicago exchange through features like Autoquote, which prices illiquid options off liquid options.
- The third phase is still underway. For the first time since 1987, MacKenzie sees “a systematic deviation between the model and reality: a volatility skew.” Market prices for options no longer seek the flat level predicted by Black-Scholes-Merton. They continue to decline. The spell no longer works its magic. According to Kent Daniel, director of equity research for the Quantitative Investment Strategies group at Goldman Sachs, market professionals had been aware of that fact even before the crash of 1987: “The Black-Scholes-Merton model had to be replaced by something more sophisticated... The market became more sophisticated and challenged the underlying assumptions.”

In any case, observed MacKenzie, when a model is replaced by another model, sooner or later history repeats. Twenty years after the crash of 1987, it happened again with another model.

D. Gaussian Copula and the Crash of 2007-2008

The market in collateralized debt obligations (CDOs), whose crash triggered the ongoing financial crisis, shares two major characteristics with the history outlined by MacKenzie: It was legitimized, and enabled, by a quantitative model. The creator of that model, the Gaussian copula, is generally acknowledged to be David Li of the China International Capital Corporation Ltd. The abstract of his September 1999 paper, "On Default Correlation: A Copula Function Approach," is worth quoting:

"This paper studies the problem of default correlation. We first introduce a random variable called 'time-until-default' to denote the survival time of each defaultable entity or financial instrument, and define the default correlation between two credit risks as the correlation coefficient between their survival times. Then we argue why a copula function approach¹⁰ should be used to specify the joint distribution of survival times after marginal distributions of survival times are derived from market information, such as risky bond prices or asset swap spreads."

What Li did for the market in CDOs in essence was similar to what Black, Scholes and Merton did for option pricing: He created a relatively simple model that practitioners could apply and refine in the real world. In 2005, Li told the *Wall Street Journal* that "the most dangerous part [of the model] is when people believe everything coming out of it."¹¹ He was not addressing an abstract danger. By then, noted the *Journal*:

"The model [had] fueled explosive growth in a market... that barely existed in the mid-1990s[.] The model Mr. Li devised helped estimate what return investors in certain credit derivatives should demand, how much they have at risk and what strategies they should employ to minimize that risk. Big investors started using the model to make trades that entailed giant bets with little or none of their money tied up. Now, hundreds of billions of dollars ride on variations of the model every day."

This, said MacKenzie, is "the most obvious place to look" for the phenomenon of counter-performativity in the financial crisis. He emphasized that the underlying issue is not the excellence of Li's model: "The assumptions start out perfectly justifiable, where default assumptions are consistent with the history of ABS [asset-backed securities]. It's not about picking bad assumptions. It's about the assumptions turning bad because of the model turning bad in practice."

10 A "copula" is defined as a multivariate distribution on marginally uniform random variables. A copula function is a statistical method that enables a multivariate distribution to be formulated in a way that allows various general types of dependence to be represented. The underlying concept is that marginal variables can be simply transformed so that each has a uniform distribution. The dependence structure can then be expressed as a multivariate distribution of the resulting uniform distributions.

11 Mark Whitehouse, "How a Formula Ignited Market That Burned Some Big Investors: Credit Derivatives Got a Boost From Clever Pricing Model," *Wall Street Journal*, September 12, 2005.



Daniel Beunza, lecturer in the department of management at the London School of Economics, spoke on the use of quantitative financial models.

For MacKenzie, "the essence [of that process] is how the ratings agencies rated CDOs." By accepting the assumptions of the Gaussian copula and effectively enabling a gigantic market, the ratings agencies hastened the moment when practice would turn against theory. Certainly, the ratings agencies did not act spontaneously: MacKenzie cited recent work by Gillian Tett of the *Financial Times* on a unit of J.P. Morgan that used Li's Gaussian copula to demonstrate to ratings agencies that their innovative derivatives could be rated as safe investments.¹² The profits generated by those bankers and others, in turn, seemed to validate the model's acceptance by the ratings agencies.

At this point, the story diverges from the run-up to 1987. "There's a difference from the Black-Scholes-Merton case, because there's no equivalent phase of the skew being flattened out by the equivalent of spreading," said MacKenzie. There has also been a much shorter lag between the diffusion of Gaussian copula and counter-performative phenomena: "We don't have that long history yet for ABS in the critical years of 2005-2007."

12 Gillian Tett, *Fool's Gold: How the Bold Dream of a Small Tribe at J.P. Morgan Was Corrupted by Wall Street Greed and Unleashed a Catastrophe*, Free Press, 2009.

CDO Evaluator three-year default probability assumptions versus realized default rate of U.S. subprime mortgage-backed securities issued from 2005 to 2007

	CDO Evaluator three-year default probability assumptions, as of June 2006 (percent)	Realized incidence of default, as of July 2009 (percent)
AAA	0.008	0.10
AA+	0.014	1.68
AA	0.042	8.16
AA-	0.053	12.03
A+	0.061	20.96
A	0.088	29.21
A-	0.118	36.65
BBB+	0.340	48.73
BBB	0.488	56.10
BBB-	0.881	66.67

Sources: Adelson (2006a); Erturk and Gillis (2009).

Counterperformativity of use of Gaussian copula by rating agencies to rate ABS CDOs. Assuming modest correlations and low default probabilities of underlying assets sets in train processes that dramatically undermine those assumptions:

1. ABSs change mortgage market
2. ABS CDOs change ABS market

Estimates from yearly regression of interest rates on FICO (borrowers' credit scores) and LTV (loan-to-value ratio)

	β_{FICO}	β_{LTV}	R ² (in %)	Observations
1997	-0.004	0.030	3	24067
1998	-0.007	0.035	7	60094
1999	-0.007	0.020	8	104847
2000	-0.010	0.035	14	116778
2001	-0.012	0.038	20	136483
2002	-0.011	0.071	18	162501
2003	-0.012	0.079	32	318866
2004	-0.010	0.097	40	610753
2005	-0.009	0.110	48	793725
2006	-0.011	0.115	50	614820

Source: Adapted from table II of Uday Rajan, Amit Seru and Vikrant Vig, "The Failure of Models that Predict Failure: Distance, Incentives and Defaults" (October 2008), *ssrn.com/abstract=1296982*. Underlying dataset: 16.5 million U.S. residential mortgages in private-label securitisations. Statistical significance of all β s 0.0005 or better.

Counterperformativity of logistic regression or hazard rate models used to rate the underlying mortgage-backed securities: as use of these models become more central to mortgage lending, they became (much) less accurate.

Figures 2 (left) and 3 (above): Default probabilities and regression estimates, as presented by Donald MacKenzie, professor of sociology at the University of Edinburgh.

Nonetheless, he argued that:

"There's clear evidence of counter-performativity in the use of Gaussian copula by rating agencies for CDOs. Assuming low correlations for underlying assets sets in motion processes that undermine those assumptions. ABS CDOs changed ABS, and ABS changed the mortgage market in ways that undermine the empirical validity of the models."

MacKenzie's strongest evidence is that the realized default rate on ABSs for subprime mortgage-backed securities was around one hundred times what was assumed in the Gaussian copula that was modeled to rate ABS CDOs. "Is it model error?" asked MacKenzie rhetorically. "Of course, but a very particular type of model error: counterperformativity. The use of the model made the market processes less like what the model predicted." (See figures 2 and 3.)

Arbitrage, not fully accounted for in Li's model, was one factor. "The role of arbitrage here was subtler" than before 1987, noted MacKenzie. "It wasn't like spreading, when people were gaming other market participants. It was arbitrage of the use of the model by the rating agencies." In other words, people leveraged the ratings. One of the takeaways for regulatory policy, he observed, is that "if you build models into regulatory structures, expect people to game those models. Expect one of the possibilities to be the

creation of phenomena at odds with the postulates of the model." (See figures 2 and 3.)

MacKenzie also suggested indirectly that the typical insistence of organizations on rapid returns accelerated the counterperformativity effects of arbitrage:

"Many arbitrage trades are what people call 'negative carry'—they involve you in losing money for some time until you get the money. That can be a hard thing to sustain organizationally. I haven't met an arbitrageur working for an investment bank who was not ordered to withdraw from a position he thought would turn good. How long will it take? How will management take to it?"

Also because the model was used on such a massive scale, its predictions ultimately diverged just as massively from the market reality. (The comment of Takatoshi Ito, visiting professor at Columbia University and professor of economics at the University of Tokyo, was that "a fat tail kills a fat cat.") In response to a question from the floor, MacKenzie said:

"It's a perfectly sensible strategy if only a small number of people are doing it. The large numbers created a counter-performative effect. The other condition is the elimination of diversity. The dangerous situations are where too many people are trying to do the same thing. When everyone is trying to sell, that's plain dangerous."



Jacques Longerstae, executive vice president and chief risk officer at State Street Global Advisors, discussed the causes and effects of 2008 financial crisis.

Kent Daniel of Goldman Sachs observed a very similar process in 2006–2007:

“In late 2006, the prices of subprime mortgages began to fall. The problems in the subprime market then moved into commercial and higher grade mortgage securities in early 2007, and into corporate credit markets in a big way in July of 2007. Then, in August 2007, a lot of quant positions started losing money in a very big way. Stocks that were labeled cheap got cheaper, stocks that were expensive got more expensive. Quant positions took a real pounding. It was kind of a spiral. A number of multi-strategy funds had lost money in the credit space in July, needed capital and started selling equities, which depressed prices and set off a race for the exit.”

Daniel Beunza, lecturer in the department of management at the London School of Economics, commented that MacKenzie’s story resembles “a marriage gone astray— between mortgage bankers, people behind asset-backed securities and derivatives bankers who were behind CDOs. The marriage of ABS and CDOs turned out to be disastrous.” Missing from this marriage, he argued, were “the mezzanine investors, the savvy investors who could have prevented the gaming from taking place. The absence of these actors, [and their consequent inability] to produce dissonance, is what enabled the gaming.” On one level, these investors were no doubt quietly pursuing their interests elsewhere; it is not their job or in their immediate interest to stop others from losing money. One implication is that market actors will never play the role that wise regulators (who were also largely silent in the build-up to the crisis) can and must play. On another level, challenge within the market appears as a key obstacle to counter-performativity. However, challenge disappears when everyone is using the same models.

Adam Parker, chief investment strategist and director of quantitative research at Sanford C. Bernstein & Co., later addressed the question of just how alike the models are. The short answer is: *They consider the same factors, but the best performers put them together in a slightly different way.*

Parker had apparently tired of the criticism of his people, and of the quant profession in general, that “everyone’s doing the same thing.” To see whether it was justified, he said:

“We got access to the alpha buy models of 30 firms. We discovered that firms can have the same factors but different performance. So we asked people to think about the factors. Something as simple as the sample period used can impact performance. All these construction techniques can have an effect, so you try to think about how you can be different. It’s not just using the same factors, it’s using different construction techniques.”

These nuances clearly matter for individual performance. They may matter less for the market as a whole. From that perspective, MacKenzie’s ideas go a long step beyond the classic economic postulate that the diffusion of a given competitive advantage ultimately results in no advantage, because everyone is applying it. MacKenzie holds that in the recent history of the financial markets, the general application of similar models not only wiped out competitive advantage for most actors, but created massive, mutual *disadvantage* for actors as well as bystanders. One need not be a Marxist to observe that this is coherent with Marx’s dictum that at some point, changes in quantity become changes in quality. However, one only needed to be at the conference to observe that for the few who escape the fate of most market actors, MacKenzie’s ideas remain deeply counterintuitive. An exception was Jacques Longerstae, executive vice president and chief risk officer at State Street Global Advisors, who later in the day illustrated MacKenzie’s prediction of a “systematic deviation between the model and reality”:

“There are still markets in the United States that are not functional. Housing is not functional. There are whole asset classes where buyers have disappeared... You now have entire segments of those markets where if you modeled using traditional assumptions you’d find huge values... You’ll get numerous things that look like great investments but that you would not be able to execute on because of lack of liquidity.”



III. Does the Practice of Quantitative Finance Need to Change?

A. Models as Metaphors

Emanuel Derman, a professor in the department of industrial engineering and operations research at Columbia University and head of risk at Prisma Capital Partners, confessed that “I lost my illusions about models years ago.” In the process, he worked through some confusion about models that he sees as very common in this crisis:

“The big distinction is between models and theories. All models are really metaphors or analogies, in that they compare something you don’t understand well to something you do understand, in theory or practice. Calling a computer an electronic brain, for example, is a metaphor that once cast light on the function of computers. Nevertheless, a computer is not an electronic brain... We try to explain what we don’t understand by what we do understand—models take what we understand and project it.”

The utility of good metaphors, he continued, is that “they are expansive: they let you see in a new light the thing you know and the thing you’re trying to explain.” (Such as, he suggested, Schopenhauer’s remark that “Sleep is the interest we have to pay on the capital which is called in at death, and the higher the rate of interest and the more regularly it is paid, the further the date of redemption is postponed.” In this example, he said, “The loan of principal is life and consciousness, death is the final repayment, and sleep is *la petite mort*, a periodic little death.”)

The objective is “to find a common property between two things and extend it.” His insight was strongly supported by Kent Daniel of Goldman Sachs: “A model is a metaphor. Most things we buy and sell are too complex to grasp intuitively, so we create models embedding analogies.”

In contrast, Derman said, “Theories are the real thing—they don’t compare, they try to describe and explain.”

“My favorite example is from 1928: Dirac’s theory of the electron. He sought an equation that satisfied both quantum mechanics and relativity. He found an equation with four solutions. Two of them described the electron that physicists already knew about, a particle with negative charge and the two spin states. But Dirac’s equation had two additional solutions, similar to the ones he’d already found, except that they had incomprehensible negative energy. The positive-energy solutions described the electron so well that Dirac felt obliged to make sense of the negative-energy ones too. In 1932 the discovery of the positron led other people to take it seriously.”

Thus, he said, “Theories tell you what something is. Models tell you only what something is *more or less* like. Unless you constantly remember that, therein lies their danger.” (See figure 4.)

Theories
<ul style="list-style-type: none"> ▪ Models are analogies and relative. Theories are the real thing. ▪ The Dirac equation for the electron: <ul style="list-style-type: none"> ▪ theory → metaphor of the Dirac sea → theory. ▪ Theories are absolute: “I am what I am.” ▪ Theories tell you what something is. Models tell you what something is <i>more or less</i> like.

Figure 4: Presented by Emanuel Derman, a professor in the department of industrial engineering and operations research at Columbia University.

The implications for finance begin with the fact that “in finance, mostly, the point of models is not prediction. A model is only as effective as what we already know, which is the



Kent Daniel, director of research at Goldman Sachs, discussed the practice of using quantitative finance.

basis of any metaphor or analogy.” He offered a practical example:

“How do you estimate the price of a seven-room apartment on Park Avenue if someone tells you the market price of a typical two-room apartment in Battery Park City? Most likely, you figure out the price per square foot of the two-room apartment. Then you multiply by the square footage of the Park Avenue apartment. Finally you make some rule-of-thumb corrections for location, park views, light, facilities and so on. The model’s critical parameter is the implied price per square foot. You *calibrate* the model to Battery Park City. Then you use it to interpolate or extrapolate to Park Avenue.”

The danger point in this example resides in calibration: “It’s fitting an approximate model to the world, and then using it to extrapolate or interpolate. The closer your model is to the behavior of the world, the less dangerous your calibration.” (See figure 5.)

Models in Finance

- The point is usually divination, which rarely works
- A typical valuation model: apartment pricing and calibration
- Models transform intuitive linear quantities into nonlinear dollar values
 - Price per square foot to apartment price
 - Future yield to bond price
 - Future volatility to option price
- Models in finance calibrate the future, predict the present
- Models are used to rank securities by value on a 1-D scale
- Models interpolate from liquid prices to illiquid ones

Figure 5: Presented by Emanuel Derman, a professor in the department of industrial engineering and operations research at Columbia University.

If a theory is the reality of what it describes, a model is *only* a “picture,” argued Derman. For that picture to have some accuracy, he warned, “simple, clear models with explicit assumptions about small numbers of variables” are essential. So is being aware of what is *not* captured by the model: “All models sweep dirt under the rug. A good model makes the absence of the dirt visible.” For these reasons and others, he defended the Black-Scholes-Merton model, which he believes is “now often fashionably and unjustly maligned” and remains “a good example for models”:

“It is clear and robust. It tells you how to manufacture an option out of stocks and bonds and what that will cost you, under ideal dirt-free circumstances that it defines. The world of markets doesn’t exactly match the ideal, but you know exactly what has been swept out of view, and so you can acknowledge the omissions.”

In practice, suggested Kent Daniel, a great many people do not take such precautions:

“People *always* had models. In most decisions individuals make, they use models that aren’t too good... In stories from the popular press, person X bought a house in Florida and the price went up, same as for someone else. No examination of the empirical evidence, just a lot of stories. *But the stories become models.* In the tech bubble, we were [supposedly] in a new world, where there’s no competition. Not a lot of thought went into these models, and they had no empirical reality. Do real estate prices ever fall? Yes. There are *lots* of bubbles in history.”

Like Derman, Daniel implicitly situated the misuse of models at the individual level, within and outside the market. The sanction is also individual: loss of the invested wealth. The difference of perspective between Daniel and MacKenzie (and as will be shown below, Daniel Beunza) was striking. The scholars argue that the mass of actors ultimately outweigh the few brilliant players in determining the effects of a given model. By definition, there are more mediocrities in



Emanuel Derman, professor in the department of industrial engineering and operations research at Columbia University and head of risk at Prisma Capital Partners, presented his view on the practice of quantitative finance.

their estimation of merger success. They calculated the spread and decided to take a decision."

That was at 8 a.m. At 10 a.m., the traders checked the spreads and read them as a positive sign. Two hours later, said Beunza, "They decided that *the same number* was cause for concern. What was going on?" He answered:

"They were in effect taking the spread...as a sign of the confidence the market has in the merger. By using a modeling technique they were able to get at the probability that the spread was incorrect. The arbitrageurs used the spread to get the implied merger probability. The use of the spread led them to question whether they were right or wrong. They went back to their databases and searched for news that could cast doubt on the merger. Having found none, they increased their exposure."

There was "magic" in this process, which Beunza observed over three years in the company of traders: "You don't need to talk to anybody. You have the right model, you have the prices, you know how the market is thinking." The magic does not require the faith of the magician, observed Kent Daniel:

"One book I used to assign my students was *The New Market Wizards* by Jack Schwager.¹³ In this book, Schwager interviewed Blair Hull, [who] learned the Black-Scholes formula, went to Chicago and started trading options...and made a lot of money. Amazingly, Hull found that he could use Black-Scholes model and make money. Yet Hull knew that *the model's assumptions were wrong*. However, it was better than the models being used by others, so it allowed him to make money. Later on, he noted, he needed models far more sophisticated than Black-Scholes to make a profit."

any field than real talents. The crisis demonstrates that the consequences of their errors are not only personal, but social. Thus if the scholars are correct, there is a social interest in defining the appropriate use of models, and in determining how they are to be used.

B. Watching Traders Use Their Models

On May 27, 2003, Daniel Beunza was at a merger arbitrageurs' trading desk when a merger was announced between two education companies. The immediate issue for the traders was how to profit from the merger. They were as excited as fans watching "Hollywood celebrities getting married," said Beunza. Their first question was, "When the merger is announced, will it take place?" They began debating that point early in the morning following the announcement. It was a quantitative procedure where "they estimate the probability that the merger will take place within six months. They get the value from the merger and the price of the stock, and split the differences."

"I saw them typing the data into their models that showed merger success for all the cases. They used their judgment: What was the industry category for the new entity? What were the right analogies? They shaped

Then why did it work? Perhaps, suggested Beunza, because the way traders use their quantitative models is also "a reflexive model"—a way of forcing themselves to look over their shoulders, to see if the market is with them. However, said Beunza, "Just as this use of models for reflexive purposes has advantages, it has disadvantages." He has traced the use of models in "arbitrage disasters" that generated implied collective losses on the trading community of over half a billion dollars, and these disasters were "fueled by the use of reflexive models." For example, in the failed GE-Honeywell merger, reflexive modeling led arbitrageurs to increase exposures and to suffer greater losses:

"Everyone expected the merger to succeed, but the E.U. Commission opposed it. Our specific traders [described above] lost \$6 million. The loss was one reasonable person could expect, but these were reasonable people, and they still suffered losses. [Why? Because] they were using the spread to see if they were in line with the market and the rest of the market was just as wrong. So they increased their exposure and suffered losses."

Beunza was suggesting that in practice, *the key use of models by traders is not to lead or break with the market, but*

¹³ *The New Market Wizards: Conversations with America's Top Traders*, Harper Paperbacks, 1994.



A conference guest read over the conference materials.

to confirm that they are following its collective judgment. If the market contradicts their own judgment and experience, traders will typically override those personal concerns. Certainly, not *all* players give in to the desire to conform. Kent Daniel of Goldman Sachs stressed “the importance of empirical validation, and the extent to which disasters come about because of over-reliance” on models—and by extension, others who are using similar models. In particular, he said, the presence of too many players can be a danger sign: “You really have to pay attention to the amount of crowding in your positions—to what you see,” as opposed to only “what the model tells you.”

However, Daniel implicitly framed the issue as a matter of individual prudence. At one level, it is exactly that. But Beunza was making a different point that the problem is that in practice, individual prudence succumbs to the market’s collective wisdom or folly. Floyd Norris, of the *New York Times*, argued that the fear of loss involved is powerfully seconded, if not surpassed, by the fear of losing one’s job on Wall Street:

“If the people running Merrill Lynch had woken up one day in 2005 and said, ‘This market in mortgages is weird; let’s get out,’ they would have underperformed their competition [up to the subprime crash] and lost their jobs. Kent Daniel said that people weren’t thinking about risks. I disagree, people were aware of them, and those people were discredited. There is a Wall Street proverb: ‘The graves are filled with people who were right too soon.’ Discrediting bears is a requirement of any bubble.”

Adam Parker also noted that sometimes, doing the same as *selected* competitors pays: “There are people who model based on the actions of people they know are good managers... It can be a successful strategy.” Implicit in his remark was that good managers do not always follow the market; if they did, they could not outperform it.

It comes down, suggested Beunza, to whether “too many people take the same position [on] trades that were deemed

to be legitimate, safe and sound.” The first problem is that when too many people take the same position, it may become none of the above. The second is that it is very hard to tell in advance when the crowd becomes too many, and in the current state of the art, most models can bring you to that point, but cannot tell you when it has been passed.

C. Will More and Better Quants Solve the Problems?

One implication of Derman’s and Daniel’s contributions was that models are not going away, whether or not they are quants. Daniel put it very clearly:

“Every model is replacing another model. To the extent it does a better job of explaining the world, it will make money for people. That’s why quant finance has come to be so important on Wall Street. Thirty years ago there were no quantitative models. People were using casual models, instead of theoretical models that had been validated.”

He observed that “demand for quantitative practices is growing,” and not just in the markets. “It’s even made a difference in deciding what baseball players to hire,” he said. The reason for that growth, he believes, is that quantitative models provide a level of verification that was previously missing. “Before, people used casual models based on rules of thumb that were never empirically validated,” he said. “It’s building something you can test that matters.” It matters particularly in fields like aircraft safety, where “people built models of how pilots should be trained and aircraft designed. We have detailed data on what can go wrong, and by applying these techniques, we’ve made air travel safe.”

Can quantitative models do for finance what they did for air travel? Perhaps, but only if people get better at them, suggested Daniel:

“My sense is that the financial crisis was not caused by the presence of these sophisticated models, but by

Adam Parker, chief investment strategist and director of quantitative research at Sanford C. Bernstein & Co. LLC, and Kent Daniel, director of research at Goldman Sachs, spoke on the panel "Does the Practice of Quantitative Finance Need to Be Changed?"



not enough good quantitative finance. If you look at estimates of risk, from 2002 many fell dramatically... There was a perception in the broader economy that risk had moved to a much, much lower level. It was a period where volatility in the market became lower because people believed it would be lower, a self-fulfilling prophecy. A lot of money flowed in. People were willing to take bigger positions because risk went so low. Was this a result of the sophisticated models? I think it was the underlying parameter, but also that people didn't think risk was going to pop up again. They were looking at too short a history and adopted a new paradigm that risk had disappeared."

Thus better models, based on longer term data, could have counteracted the narrative that "risk is dead" and the consequent catastrophe, according to Daniel. Adam Parker at Sanford C. Bernstein & Co. agreed: "When people build models, they have to prove they worked historically before they can implement them. Maybe recent things aren't in your models." That was clearly the case with CDOs, because they burgeoned only a few years before the crisis. Like Daniel, Parker underlined the importance of empirical validation:

"We think you have to combine quantitative work with bottom-up work. At Sanford Bernstein we can get access to the buy sides of fundamental recommendations. We took 11 years of data from the buy side, and we asked, 'When these guys agree with the models, what is the result?' Strong performance. When they don't agree, performance is weak. They have to be used in conjunction."

However, at least four caveats to the argument that better quantitative models, better used, will resolve current problems surfaced at the conference:

1. Not all quants know what they're doing very well

Adam Parker noted that a great many practitioners do not have a clear idea of what, exactly, ought to be in their models:

"We do a quant conference every year. In 2008 there were 400 people, and 25 percent did not know what a risk model is. Thinking about practical consequences is not something every quant on the buy side is charged with."

The image that emerged from successive details reinforced the impression that in areas of the industry with lower standards than Parker's, a number of people who rely on quantitative models do so in a relatively lazy way. For example, he noted that "building different models for different kinds of stock can be valuable, but it's not systematically done on the buy side." He added, "I hear a lot that people treat quantitative models like a black box [as in], 'It's telling me to do this; turn it on or off.'" Parker's team deliberately tries to do the opposite through a technique he calls *decomposition*—"We take this thing that looks like a black box and break it down, [look for] factors that contributed to performance, are they operative today or not." But not everyone in the market goes that far. Parker also suggested that industry standard practice and best practice are not yet identical:

"Somebody asked me a year ago, 'Most alpha equity models¹⁴ forecast 12 month returns—why?' I don't know if it's because we get paid once a year, but what we do is try to solve this problem of 12 month return when it's not what we're best at—we're best at 4.2 months. So one thing we can do is look at different time windows for each stock. We can work at different horizons as a way for differentiating yourself."

2. Some quants don't have enough data

At many medium- and small-sized firms, quants are looking at histories that are not only too short, but too narrow, suggested Jacques Longerstae of State Street Global Advisors:

"One thing that characterizes these models is that for business losses, they rely on historical data that's largely

¹⁴ Alpha is the return on an investment that exceeds compensation for the risk assumed by investing in a given asset. It matters greatly on Wall Street, because it is a common measure of how well an asset manager performs.



Conference guests conversed during a coffee break.

internal. If you move from pricing models to operational risk, you get tiny samples, and samples that are smaller if you know what you're doing. So you get small numbers, and [up till now] you may have been good, lucky or both. It may be a pretty long time before you figure out if there are significant weaknesses in your operational model, and by then it's too late."

In short, Longerstaeay suggested that when it comes to building reliable quantitative models, "Not all firms have those resources." But that does not prevent them from doing so.

3. Models are as much sales tools as they are science

In some cases quantitative models, whether or not they were well-designed, were employed precisely to legitimize and sell the "risk is dead" narrative. The first and most influential targets of that pitch were the credit rating agencies. Takatoshi Ito said:

"Ratings agencies [create] an appraisal of how secure investments are. You can't expect buyers to understand the underlying assets. That's the function of credit ratings agencies. They failed. Not just in calculating the assumptions. They were in consultation with the issuers, who asked, 'How many diversified assets do we need to put in to get such and such a rating?' We need more separation between the agencies and the sell side."

Where equities are concerned, said Adam Parker, the main role of quants "is to try to generate buy ideas, help portfolio managers fish from an advantage sea." A second major role of his people resides in attribution and construction of portfolios. Parker noted that buy decisions take more time and thought than sell decisions, because "quants can think about sell signals more accurately." Jacques Longerstaeay noticed the same issue: "There is an information and skill-set asymmetry between the sell side and the buy side." In the crisis, he sees "a large number of investors not knowing at all what they bought, and a lack of process in what were eligible securities to buy." Norris agreed: "My impression is that some of the firms in their

own risk models assumed that if you had a triple A security that was floating, nothing could go wrong."

The use of quantitative models to sell products to ratings agencies, regulators and the public poses significant issues. Suppose that we could limit such use to responsible practitioners. If we can, who defines, approves or licenses such practitioners? The argument that the financial industry's self-serving use of badly made models, and not models in and of themselves, fed the crisis is also an excellent argument for situating such decisions outside the industry.

4. Quants are not always the people in charge of quantitative models

"Should we say nothing to our students of financial engineering, of the possible consequences of what they're doing?" asked Kogut. For example, should the creator of a model have a right of approval over and responsibility for the way it is sold to clients? The question is both cruel and quite pertinent. Three weeks after this conference, Goldman Sachs was accused of reaping profits at the expense of its own customers in 2007–2008, by shorting the firm's own mortgage-backed CDOs. If true, this was like "buying fire insurance on someone else's house and then committing arson."¹⁵ Whether or not Goldman *did* do such a thing, two issues at least remain: Do quants approve of such uses of their work? If not, what can they do about it? In many cases, suggested Emanuel Derman, the current answer is often *not much*:

"One thing the crisis taught firms is that they really need to pay attention to their risk managers. There were a lot of situations where the people in charge of risk management didn't have the power they should have, because others had made a lot of money over a few years, and that gives them a lot of power... You have to look at the models [to] see if there's a flaw."

¹⁵ Gretchen Morgenson and Louise Story, "Banks Bundled Bad Debt, Bet Against It and Won," *New York Times*, December 24, 2009.

Ronald Gilson, the Marc and Eva Stern Professor of Law and Business at Columbia Law School, and Takatoshi Ito, visiting professor at Columbia University and professor of economics at the University of Tokyo, spoke on the panel “Why Was the Financial Crisis Less Enduring in Japan and Other Countries... This Time Around?”



In practice, those who are looking closely at the models and those who are deciding on their use are not the same people. Beunza confirmed the point from another angle: “There’s a lot of analysis that goes into the decision to use a model or not, but when it goes to the superior or the superior’s superior, there’s a lot of simplification, which gets the go-ahead.” Floyd Norris of the *New York Times* observed that the same applies to regulators:

“Tied to the regulatory sector was a willingness to assume that models were reliable. A lot of people came to accept models without the caveats that the model makers knew were in them. Maybe this had something to do with the fact that senior managers had not learned quantitative finance when they were young. At Columbia Business School 30 years ago, if they were teaching quant finance, I managed to avoid it.”

The practitioners agreed that the price of success in using models is continual refinement. The scholars suggested that the practical danger of using models is that many people keep using them, unchanged and without deep understanding of their features, once they have gained some success with them. Adam Parker and Kent Daniel are surely right in saying that a more sophisticated approach is a competitive advantage, for a firm and for its clients. But the question remains: How many users of quantitative models are that sophisticated, or care to be?

A question from the floor raised the issue of management oversight: “To what extent does the widespread prevalence of Nobel Prize-endorsed models create moral hazard, taking more risk? To what extent does top management understand the health warnings of the models?” Emanuel Derman replied:

“At some firms they understand, at others they don’t. If you look at the people who got hurt the most—[those at] Merrill—the people at the top don’t blame the modelers. I don’t think any banks went bankrupt because they used Black-Scholes-Merton. *It’s more a question of incentives.*”

Were and are the incentives to continually make quantitative models better and to use them more responsibly, or merely to sell financial products in a convincing way? Ronald Gilson, the Marc and Eva Stern Professor of Law and Business at Columbia Law School, observed that disincentives for irresponsible use of models are trivial: “Serious liability concerns for people who devise models, and for senior managers who either followed the herd or didn’t see that conditions had changed [are] not a serious concern in our system.”

A second set of incentives has to do with pleasing the markets. Existing incentives are clearly against breaking with market wisdom (which might be taken as another example of counterperformativity). Commented Norris, “If Moody’s had discovered in 2005 that the results behind the CDOs were baloney, Fitch would have got the [ratings] job and Moody’s would lose buckets of money.” Thierry Porte, operating partner at J.C. Flowers & Co. and former CEO of Shinsei Bank, agreed: “If Chuck Prince [when he was CEO at Citi] had said, ‘I’m going to the sidelines [during the subprime frenzy],’ in two quarters, a year, he’d be gone.”

Can we, then, create market rules that will dependably lead to better models and better use of them? Derman suggested that regulation would not suffice. The “greatest danger,” he concluded, resided in “idolatry” of models and “hubris” in their use. “The right way to engage with a model is, like a fiction reader, to temporarily suspend disbelief and then push it as far as you can,” he said. “But then you must look over your shoulder... catastrophes strike when hubris evolves into idolatry.” In other words, the problem is not inherent in models, but in the people who use them. Will the catastrophe we are living through change those people? The next panel suggested firmly that the answer is “no.”



Thierry Porte, operating partner at J.C. Flowers & Co., LLC, and former president and CEO of Shinsei Bank, Limited, spoke about Japan and the financial crisis.

IV. Other Paths: The Example of Japan

A. Why the Crisis Hit Less Hard in Japan

There were two key reasons for taking time to consider the example of Japan in this conference, one contemporary and the other historical. First, Japan has suffered less from the current crisis than the United States or Europe. Second, from a longer term perspective, it is “the country where the world’s first futures market was born in 1730,” noted Takatoshi Ito. One of the five lessons Japan drew from that long experience is that a futures exchange “was socially productive if used properly,” said Ito. When it began, the samurai were the highest rank of Japan’s four castes; the others, in descending order, were peasants, artisans and commercial and financial actors. Ito said wryly, “Japan knew that finance creates no social value; that’s why they’re on the bottom.” Rice collected from the peasantry by the samurai led to the creation of a spot market in Osaka, and then to a forward market based on anticipated cargoes of rice. Then, said Ito, “They traded the rights, standardized the different kinds of rice, and created margin calls and maturity dates. The market was born as rice certificate futures.” Japan’s ruler, the Shogun, approved the exchange. In 2005, however, the government denied permission to the Tokyo commodity futures market to create a rice futures exchange. The decision was “wiser in 1730,” said Ito.

What can explain these contradictory decisions? Hugh Patrick evoked the Japanese concern with adapting business practices to social outcomes, which may change over time:

“Japanese and Americans share the same values and ethics in terms of business behavior, but...America has a highly individualistic society, focused on equality of opportunity, and Japan is more a group society, where equality of outcome is the focus. That also shows in how financial institutions organize themselves and reward their staff. Americans think Japanese don’t reward quickly enough. Japanese think the differences in salary between American executives and theirs is immense—

they think the system of large bonuses is inefficient, exorbitant and maybe immoral.”

Is there a link between this difference in values and the fact that Japan “held up well in the financial markets” in the current crisis, as Ito said? He evoked two popular hypotheses: “Japan was so advanced that they understood the risk and didn’t touch it, or they were so far behind that they *couldn’t* touch it.” Thierry Porte commented that “Japan was the first major country to adopt Basel II. You can’t argue they were backward.” The Japanese also use quantitative models. “But they were *not* on the leading edge of innovation, in trading securities or novel assets,” said Porte. He believes the chief reason was that Japanese banks operate in a system based on seniority, which results in the best young talent going to “foreign financial institutions where they get faster promotion and bigger innovation.” This generation gap may be not be an advantage for growth in a globalized banking system. Ito agreed that “Japan is not the model for innovation in institutions.” However, that conservatism may have helped protect the country during the financial crisis.

1. The advantages of painful memories

The people running the Japanese system, said Ito, “still remember what horrible things they went through in the 1990s.” He referred to the asset price bubble collapse that led to Japan’s “lost decade.” Porte noted that at the height of Japan’s speculative frenzy, “Japanese banks in the 1980s participated in every global extravaganza [including] junk bonds and derivative related securities of huge complexity.” The lingering aftereffects remain present in the minds of experienced Japanese investors. Ito noted:

“One Japanese institution that held the toxic assets [of the U.S. subprime crisis] got rid of them in a very early stage. I talked to the guy responsible. He smelled something fishy in subprimes in 2006, and he immediately told the staff, ‘Sell it at any price!’ By September 2007 they got rid of them all at fire sale prices, 70 cents on the dollar. I said, ‘How did you make

Takatoshi Ito, visiting professor at Columbia University and professor of economics at the University of Tokyo, gave his perspective on why Japan survived the financial crisis.



the decision?’ He said, ‘I remember the nonperforming loans problem [in Japan in the early and mid 1990s].’

One safeguard against crisis, said Ito, is to keep such employees around as long as possible, “telling crisis stories. Institutional memory is an important thing.” People will not learn from crises they didn’t live through. He suggested that “traders’ lives are too short, so the next generation makes the same mistakes.” Floyd Norris agreed: “It helps if a country went through a recent crisis. The Asian countries learned something from 1998, and the answers they came up with proved valuable this time around.” Specifically, he said, “The countries that did the best job of staying away from the conventional wisdom of Wall Street did the best.” Conversely, Porte offered the example of the Norinchukin Bank in Japan (for agricultural associations), which escaped the first banking crisis, then used its liquidity prior to the current crisis to create “an enormous portfolio of hedge funds.” Losses were enormous, and would have been avoided, said Porte, if managers had “felt the trauma” of the earlier crisis.

2. Regulating after a crisis may soften the next one

Before the crisis, Wall Street’s conventional wisdom, shared by the Bush Administration, was that less regulation means a better market. Japan went the other way during the Lost Decade. The new Financial Services Agency, an integrated regulator, “took five years to shape up examination and enforcement, but they succeeded. This is one thing Japan did right,” said Ito. Porte detailed the process, which also entailed a cultural shift:

“They ripped away financial oversight from the Ministry of Finance and created a new system within a period of two years. We are having a lack of discussion in Washington, because we say it would be too hard and too long. Japan did it in the middle of a financial crisis. That reform was hugely successful in creating transparency in Japanese banks. In 1992 Japanese banks were not required to disclose nonperforming loans, and inspection was nonexistent. By 2006, we had rigorous, well-trained

inspectors and deep disclosure. Japan is not a Christian society that believes in sin and redemption, but in shame. If you have to disclose, you’re *shamed*. But now transparency is the standard.”

Porte concluded that “we need to increase transparency [in the United States], and that means more rigorous, tough-minded regulation.” However, Gilson warned that in the current climate, the kind of regulation that may be handed down may hurt the economy more than it helps:

“We’re having a one-sided debate about the future of regulation. Conservatism, the Burke view, restrains excess and prevents unexpected consequences—it avoids systemic risk. There’s another kind of risk: a systematic reduction in innovation brings another set of pain. That’s Schumpeter. If you think our government is loss averse, like their electorates, we run a significant risk of building that into our regulatory structure.”

B. American Culture and the Global Crisis

For the financial crisis to gather such momentum from the subprime crash, “you needed an environment where a significant loosening of underwriting standards had to take place,” commented Jacques Longestaey. “That didn’t happen everywhere.” Longestaey is Belgian, and in his country, “if you walked into a bank and said, ‘I can’t document my income and I want 100 cents on the dollar [of the value of a house in loans],’ they’d call in the white coats.” The link with quantitative models was indirect but substantive, he argued:

“To tie this to models, you have to look at the movement from issuer to holder to financial market intermediary. It was symptomatic in the U.S. that a large number of banks became underwriters and lost the sense of fiduciary responsibility. No one here ever said a lender has a fiduciary responsibility to the borrower, but it works that way in a number of countries. That change had a very significant impact.”



Conference guests spoke with each other during a break in the day.

How did the change occur? Besides the usual suspects of lax regulators and regulation, Longerstaey argued that the quantitative models that he saw employed played a major role. In one case at his firm, he said, a capital allocation model led to an investment decision in “a business with a risk-adjusted return of 50 percent.” To Longerstaey, it looked too good to be possible, let alone true: “I said, ‘Here’s the next blowup. Any number that high means that you haven’t captured the risk.’”

“Is it over?” asked Longerstaey rhetorically. After listening to him, one might reply: not while key actors in the U.S. financial markets continue to see themselves as a world apart, and to live in a world where the same questions from the same people generate the same answers, over and over.

All of these factors point to an underlying cultural assumption that things will work out fine, because they always have. This conclusion can be drawn from models that overlook sufficient history and risk. It can also emerge, said Longerstaey, among “people from the same backgrounds, the same culture and the same schools who have the same answers whatever problems emerge. The same comes up [within firms and] with regulators. One’s staffed with lawyers, one with economists. So I’d advise taking people who don’t fit the model very well and asking different questions.” The remark highlighted a missing element of the current quant world: diversity. That absence may contribute to enabling the phenomenon of many people doing the same thing at once, with disastrous consequences.

Longerstaey emphasized that more is at stake than the profits or losses of market actors. Loose monetary policy and weak underwriting standards meant that the models helped shape reality in ways that went far beyond financial markets (like the ownership of homes): “In the case of the United States, there was more connection between what happened in the real economy and financial services.” Because institutions in countries that had stricter standards were buying financial products in the United States, the effect was exported:

“Before the crisis, in Belgium there were three large banks: KBS, Fortis and Dexia. They had trading arms that bought U.S. financial products, CDOs and the like. You come out of the crisis and Fortis has disappeared, and KBS and Dexia would have disappeared without government intervention.”

Donald MacKenzie, professor of sociology at the University of Edinburgh, delivered the keynote presentation on "Models, Markets and Crises."



V. Conclusions

Should the analysis of the use of quantitative models be explicitly incorporated with the regulatory process? This "Quantitative Revolution and the Crisis: How Have Quantitative Financial Models Been Used and Misused?" conference indicated that the short answer is yes. Quantitative models appear to be implicated as a causal factor in more than one market catastrophe, and the risk of individual ruin has not sufficiently mitigated that phenomenon. Nor has it deterred or reduced wider social consequences. In short, society has a major interest in how these technologies are applied.

The question of *how* they might be regulated, however, was not resolved. It is worth recalling MacKenzie's warning: "If you build models into regulatory structures, expect people to game those models." Financial innovation is one thing, regulatory arbitrage is another. If there are incentives to "game" regulation, there will be gaming. That is assuming that reform will be enacted in the first place. Public pressure for some kind of reform remains remarkably intense at this current time, but the outcome is nonetheless hardly certain. The public cannot be expected to demand regulation of innovations whose existence it only vaguely divines, much less understands.

Certain actions that might reduce the risks of model counterperformativity will not require regulatory reform. Changing the culture of Wall Street to ensure that wiser heads are present when risks are discussed, on boards or as risk counselors, does not depend on an act of Congress or the Securities and Exchange Commission. The same can be said for diversifying the culture of Wall Street to include contrarian viewpoints.

The market does have a role to play. Implicit in the discussion was the clear message that incentives, responsibilities and sanctions are misaligned in the financial industry where quants and their models are concerned. On the one hand, innovators are separated from responsibility for the application of their innovations. On the other, those who are responsible, and who

gain the greatest rewards from their use, point to the models as justification for risktaking that on occasion far exceeds what judgment and experience would indicate. Every incentive evoked pushes them to do so.

Likewise, few sanctions push them away from doing so. An acid remark from Charles Calomiris, the Henry Kaufman Professor of Financial Institutions at Columbia Business School, at the Bernstein Center's previous conference on the financial crisis in December 2008 illustrates the resultant dilemma: "You may feel sorry for those CEOs, but they are rich and will stay rich. They won't go to jail, because they can show you models to prove they acted prudently."¹⁶

The market did not resolve this dilemma before the crisis, and the current state of regulatory reform does not point to a resolution soon. What can be affirmed, on the basis of these two conferences, is that the underlying problems will not resolve themselves. The power of financial innovations, and of quantitative models in particular, is unprecedented. In wise hands they enable a deeper, more farseeing grasp of how complex realities will evolve. The poor use or misuse of quantitative models can have catastrophic results for the mass of investors, as our recent history attests. Safeguards against this eventuality must be built into the use of quantitative models and into the environments where these models are used.

One of the faces of ethics is responsible behavior and accountability. Indeed, economics recognizes the disastrous results when behavior and accountability are divorced, under the rubric of moral hazard. Arguably, a core problem of financial innovations is this division between private and social value, in which risk is passed to society and gain is kept by private actors. For this reason, regulation is required, with the minimal charge that financial innovations are moved to organized markets which provide greater transparency over the volume trades, the private provisioning for counterparty risk and implicit (e.g., capital reserves) or explicit taxing (e.g.

16 Op. cit., "Preventing the Next Financial Crisis," p. 24.

Conference attendees listened as Donald Mackenzie, professor of sociology at the University of Edinburgh, delivered the keynote presentation.



capital charges) of *all* financial players in the anticipation of the bearing of the costs of financial stress by society.

Closer to home, there are important implications for the design and content of professional education. All professional schools, such as law, journalism, medicine and business, have ethics as an integral part of their education. The growing importance of financial engineering also deserves recognition as a profession and thus concomitantly an assumption of ethical acceptance of accountability. Banks can be analogized as nuclear reactors (as suggested in the Bernstein Center's 2008 Preventing the Next Financial Crisis: Lessons for a New Framework of Financial Market Stabilization conference), in which the systemic risk is mitigated by intelligent design to lower the interactions among components. Apart from design, another part of the mitigation of nuclear energy risk is regulatory oversight over the professional training of employees and managers working at these plants. Programs in financial engineering should include education in the ethical accountability for innovations that have proven to be, by nature or by misuse, contributory to financial crises. As Donald MacKenzie explained, the historical events of the short-lived 1987 and long-lived 2008 crises provide a fascinating and sobering introduction to the potential counterperformativity of financial innovation, and a reminder of the danger when action and accountability are separated in volatile systems.

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