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August 15, 2006

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Interdisciplinary Perspectives on Risk

Excerpts from a presentation given to the Greenwich Roundtable, July 26, 2006

Good evening. These roundtable meetings always encourage me to organize my thoughts on an important theme. This evening's topic, an interdisciplinary perspective on risk, is particularly fascinating and we could spend days on it without doing it full justice. I only hope my comments serve to provoke thought and add some perspective.

I'd like to break my comments into three parts:

- First, I'd like to underscore the classic Knightian distinction between risk and uncertainty. I believe this distinction remains useful, especially when we think about how to manage risk.

- Second, I'll discuss some of the *mechanisms* behind risk and uncertainty. I will place a particular emphasis on differentiating between complex systems where risk or uncertainty is *endogenous,* or internal, versus situations where risk or uncertainty is due to *exogenous*, or external, factors.

- Finally, I'll share some thoughts about managing risk, including a brief look at probability assessment.

I.

In our day-to-day language, and even in finance, people tend to use the terms risk and uncertainty interchangeably. But in the 1920s economist Frank Knight made a distinction that I find quite useful.[1] He argued that risk describes a system where we don't know the outcome, but we *do* know what the underlying probability distribution of outcomes looks like. So think of a roulette wheel—when the croupier spins the wheel, you don't know where the ball will land, but you do know all the possibilities and their associated probabilities. Risk also incorporates the notion of harm—that is, you can lose.

In contrast, uncertainty reflects a situation where you don't know the outcome, but you also *don't know* what the distribution of the underlying systems looks like. Uncertainty also doesn't necessarily imply harm, although it often does. So it's not hard to see that most systems we deal with in the real world are really uncertain, not risky. Uncertainty better describes issues like terrorism or the avian flu, or even markets.

Here's why I'm stressing this distinction: we can model risk using probability calculus. In fact, the statistics of risk are relatively straightforward. In contrast, we can't model uncertainty easily. And real trouble arises when we model *uncertain* systems using the mathematical tools of risk. Yet this is precisely what many people do in financial markets and in other domains as well. We'll come back to this issue of risk or uncertainty quantification in a moment.

II.

Let me now turn to the second topic. Over the past decade or so, I've had the pleasure of being affiliated with the Santa Fe Institute, a multidisciplinary research institute dedicated to the study of complex systems. [2] My interaction with the scientists there—including physicists, biologists, and network theorists—has encouraged me to think much more about the *mechanisms* behind risk and uncertainty. To be frank, today these mechanisms can really only help *describe* what's going on, and are of limited *predictive* value. [3] But I believe these mechanisms provide insights into how complex systems work, and a first step in how we might deal with them.

But let me first be clear about a point: when we discuss risk or uncertainty, we're not so much interested in the boring events—a small move in the stock market or a rain storm. We're interested in the extreme events—a market crash or a devastating hurricane. How do these extreme events come about?

A distinction I find useful is between *endogenous* and *exogenous* sources of risk (notwithstanding the prior distinction, I will use the terms risk and uncertainty interchangeably for discussion purposes). As the word implies, endogenous risk arises *within* the system. Endogenous risk is inherent in a complex system, yet remains poorly understood. We'll try to shed some light on that.

Exogenous risk, of course, comes from *outside* the system. It's basically a condition imposed on a system.

I'd like to start with endogenous risk, which is by its nature interdisciplinary. Don't worry, I'll offer some concrete examples to link these ideas to the real world. But to do this approach justice, I need to sketch out three frameworks.

The first framework is the *wisdom of crowds*, which writer Jim Surowiecki laid out well a couple of years ago in his book of the same title. [4] The basic idea is simple and somewhat counterintuitive: if you get a diverse group of people together to solve a problem, the group's answer will typically be better than that of any individual, even an expert. The wisdom of crowds is a more common way of describing a type of complex adaptive system—the heart of the Santa Fe Institute's work—and is an apt description of the stock market. [5]

The key is that the crowd is only wise under certain conditions. You need agent diversity, an aggregation mechanism, and some sort of incentives. When one or more of these conditions is violated, all bets are off. In human systems, diversity is the most likely condition to be violated. When you take away diversity, the complex system can become fragile and in some cases will lead to large-scale changes. Booms and crashes are good examples of diversity breakdowns in markets. Fads and fashions also illustrate the concept. And that leads to the second framework: diffusion theory.

Technologies, ideas, and illnesses tend to diffuse following an S-curve pattern. [6] So, for example, a new technology will start with only a few adopters, and will grow at a relatively slow rate early on. The rate then accelerates, and the technology takes off. This field has been studied in detail, and is of prime interest to epidemiologists and technologists, just to name two groups. The key point is the growth rate is not stable: it's low to start, rises, and then slows down again. Also important is that most technologies or ideas *don't* diffuse—they simply sputter out. [7]

The final framework is network theory, or how the individual nodes in a network are connected. Network theory bears on a wide variety of phenomena, including your network of friends, transmitters on the power grid, or the spread of disease. In recent years, scientists have made major advances in understanding the nature of networks. We now know that the structure of the network is important in understanding how things get transmitted over the network. [8]

There are two features of these frameworks worth emphasizing. First, they are non-linear. For example, in the case of the wisdom of crowds you can reduce diversity, reduce diversity, and nothing happens. Then you reduce it a bit more and the system reacts violently—the proverbial straw that broke the camel's back. [9] Many of you know this idea as the tipping point. [10]

That leads to the second feature: lack of proportionality. The *size* of the perturbation and the *outcome* are not always linked. Sometimes small perturbations lead to large outcomes, and vice versa. [11] When you combine a lack of linearity with a lack of proportionality, it's not hard to see that predictions are difficult and cause and effect thinking is often futile.

Let me discuss two examples to make this more tangible.

The first is a market example, and deals with Long Term Capital Management (LTCM). LTCM used statistical arbitrage to "vacuum up nickels", as one of the founders, Myron Scholes, described it. One essential component of their portfolio was that it was highly diversified: the correlations between the positions were historically quite low—10 percent or less. To be conservative, in their value at risk models LTCM assumed correlations could jump to 30 percent, vastly higher than anything they saw in their historical data.

However, the summer of 1998 saw a real contagion—a diversity breakdown of epic proportions. Notwithstanding the substantial arbitrage opportunities, there were no arbitrageurs to be found, and correlations rocketed higher, to about 70 percent. Add high correlations, leverage, and declining asset prices, and you have the story. [12]

The second example is the large East Coast blackout in August 2003. That blackout started with a fairly routine power problem in Ohio—a problem that happens relatively frequently all over the country. Since our national power grid is a network, a failure in one spot is typically absorbed by a neighboring area. In 2003, Ohio demanded power from Michigan, which couldn't handle it so it demanded power from Canada, which couldn't handle it so it demanded power from New York. All along the chain things got worse until we ended up with a widespread blackout. It was a classic example of a cascading failure. [13]

There are a couple of points worth underscoring in these examples. First, the outcomes were grossly out of proportion with the perturbation. In both cases, there were real issues that triggered the ultimate events, but those catalysts were not at all out of the ordinary—only the outcomes were.

Second, after the events—and this is true of the crash of 1987 as well—people automatically seek to understand the cause and effect and to fix the problem. [14] As I mentioned a moment ago, there's no way to understand cause and effect simply, and these behaviors are part-and-parcel of complex systems. As long as these systems exist, we will suffer periodic, catastrophic failures. On the flip side, these systems bring a lot of good to society, and are a useful way to solve problems.

The other kind of risk a system faces is exogenous. Examples today include the threat of the avian flu, terrorism, and hurricanes. While each of these threats, viewed individually, can be treated as a complex system, we often think of events *happening to us* rather than arising from our day-to-day activities. So when we think about disaster preparedness, we're often thinking of exogenous risks.

III.

Let me wrap up with the third part of my comments by asking the question, what should we do about all of this? Here are some thoughts—some constructive, some concerning.

On the constructive side, it's useful to note that the outcomes of complex systems often have a signature—a power law distribution. A power law—colloquially known as the 80/20 rule—says that large events happen infrequently and small events happen frequently. What's elegant about power laws is there is a specific mathematical formula that can express this relationship. Power laws describe a wide range of phenomena, from deaths in wars, to earthquake sizes, to the size of blackouts, to stock price changes, to city sizes, to the metabolic rate of animals. [15] Awareness of the statistical properties, even with limited specific predictive ability, is very useful.

Next, on the constructive side, we now have so-called prediction markets that can at least help us assess probabilities of various events. These are real-money markets that have proven quite accurate in predicting economic and political outcomes. [16] Let me read off some of the probabilities I found in the markets this morning (July 26, 2006): [17]

<u>**Event**</u>	<u>**Probability of Happening (%)**</u>	
	as of July 26, 2006	*as of August 15, 2006*
Confirmed case of avian flu in U.S. by 12/31/06	33	39
Confirmed case of avian flu in E.U. before U.S.	88	85
Avian flu vaccine by 12/31/06	33	31
Islamic terrorists hit U.S. while Bush is president	54	48
Terrorists attack E.U. before U.S.	69	70
More than nine Atlantic hurricanes in 2006	43	39

Naturally, some understanding of the distributions and probabilities allows for forms of insurance, or preparedness, that can protect against one or more of these events.

But that leads to my final thought, which is not optimistic. Psychologists have demonstrated that events that are not vivid in our minds get assigned very low probabilities—much lower than the facts warrant. [18] I suspect for us to mobilize, as a society, to address risks like global warming or energy constraints we will need one or more 9/11-type events—a tragic incident that reveals what's really going on.

In summary, I want to leave you with the notion that we humans are still not very good at dealing with risk or uncertainty. We are still linear thinkers, we have a nearly-insatiable need to link cause and effect, and we assess probabilities poorly. However, we do now better understand some of the mechanisms that underlie complex systems, and that knowledge can be very helpful in preparation for future catastrophic events.

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The Greenwich Roundtable is a non-profit research and educational organization for investors who allocate capital to alternative investments.

Endnotes

[1] Frank H. Knight, *Risk, Uncertainty, and Profit* (Boston: Houghton and Mifflin, 1921).
[2] See www.santafe.edu.
[3] For some thoughts about prediction in complex systems, see Didier Sornette, *Why Stock Markets Crash: Critical Events in Complex Financial Systems* (Princeton, N.J.: Princeton University Press, 2003).
[4] James Surowiecki, *The Wisdom of Crowds: Why the Many Are Smarter Than the Few and How Collective Wisdom Shapes Business, Economies, and Nations* (New York: Random House, 2004).
[5] Michael J. Mauboussin, "Capital Ideas Revisited," *Mauboussin on Strategy*, March 30, 2005.
[6] Everett M. Rogers, 5th ed., *Diffusion of Innovations* (New York: Free Press, 2003).
[7] Geoffrey A. Moore, *Crossing the Chasm: Marketing and Selling Technology Products to Mainstream Customers* (New York: HarperCollins, 1991).
[8] Duncan J. Watts, *Six Degrees: The Science of a Connected Age* (New York: W.W. Norton, 2003).
[9] Steven Strogatz, *Sync: The Emerging Science of Spontaneous Order* (New York: Hyperion Books, 2003).
[10] Malcolm Gladwell, *The Tipping Point: How Little Things Can Make a Big Difference* (New York: Little, Brown, 2000).
[11] John H. Holland, *Hidden Order: How Adaptation Builds Complexity* (Reading, MA: Helix Books, 1995).
[12] Donald MacKenzie, *An Engine, Not a Camera: How Financial Models Shape Markets* (Cambridge, MA: MIT Press, 2006), 218-236.
[13] Michael J. Mauboussin and Kristen Bartholdson, "Watts on Watts (and Much More)," *The Consilient Observer*, vol. 2, 16, September 9, 2003.
[14] David M. Cutler, James M. Poterba, and Lawrence H. Summers, "What Moves Stock Prices?" *The Journal of Portfolio Management*, Spring 1989, 4-12.
[15] Mark Buchanan, *Ubiquity: The Science of History . . . Or Why the World is Simpler Than We Think* (New York: Crown Publishers, 2000).
[16] See Justin Wolfers and Eric Zitzewitz, "Prediction Markets," *NBER Working Paper 10504*, May 2004. Also Justin Wolfers and Eric Zitzewitz, "Interpreting Prediction Market Prices as Probabilities," *Working Paper*, February 2005.
[17] See www.tradesports.com; www.newsfutures.com.
[18] Paul Slovic, Melissa Finucane, Ellen Peters, and Donald G. MacGregor, "The Affect Heuristic," in *Heuristics and Biases: The Psychology of Intuitive Judgment*, ed. Thomas Gilovich, Dale Griffin, and Daniel Kahneman (Cambridge: Cambridge University Press, 2002), 397-420.

06-0376 (08/06)