


ROBERT C. MERTON

WHODUNNIT?

Few are so well placed to delve into the mysteries of the markets as Robert C. Merton, writes **Dan Tudball**

A legacy called into question, the markets scattered like chalk outlines at the scene of a mass murder, a state of paranoia as speculation leads to accusations of avarice, hubris, and neglect. All the makings of a bloody thriller, demanding molecule's-eye views of atrophying economies as credit spectacularly hemorrhages in a world that looks familiar but is, in fact, an opiate fantasy. 

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CONTINUOUS

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In the January 2008 issue of *Wilmott* magazine, we published Espen Haug and Nassim Nicholas Taleb's article "Why We Have Never Used the Black-Scholes-Merton Option Pricing Formula." It'd be an understatement to say that the article was anything less than scathing; more accurately, it was a bludgeoning.

Haug and Taleb's major points of attack were that "Black, Scholes, and Merton did not invent any formula, just found an argument to make a well-known (and used) formula compatible with the economics establishment, by removing the 'risk' parameter through 'dynamic hedging'." That what Black, Scholes, and Merton did was "marketing," "finding a way to make a well-known formula palatable to the economics establishment of the time ... and in fact distorting its essence". That the primary claim to fame of the formula as presented by Black, Scholes, and Merton was to make the trade "risk neutral" via the introduction of dynamic hedging – but that this removal of the necessity of the risk-based drift from the underlying security could be achieved without dynamic hedging, simple put-call parity would suffice, and that the dynamic hedging argument is "dangerous in practice as it subjects you to blowups; it makes no sense unless you are concerned with neoclassical economic theory."

Where the Black-Scholes-Merton approach relies on the Gaussian and bans probability distributions that are not Gaussian, the authors argued that precisely the same formula less the dynamic hedging component (utilizing put-call parity, and allowing for a wide choice of probability



distributions) has been used by option traders at least since the early 20th century and that this formula found its most exemplary expression in the work of Louis Bachelier and, later, Edward O. Thorp. The mythologizing of the Black-Scholes-Merton 'formula would have us believe that, prior to its publication, options were not viable. The authors contend that the Black-Scholes-Merton view has in fact increased risk and set back risk management.

Michael Lewis, of *Liar's Poker* fame, picked up the still-warm cudgels and took the argument off the practitioner/academic circuit to a more general audience – an audience, in March 2008, baying for blood. His *Portfolio* article, "Inside Wall Street's Black Hole," hinged largely on an interview with Taleb, and though initially a critique of portfolio insurance, the piece swiftly shifted the focus of its attack squarely onto the Black-Scholes-Merton paradigm. Taleb was rolled out as an instigator of a nascent

revolution against a dangerous dominant world view. Where Taleb's previous two papers had, at least, followed each body blow with the precise incision of informed critique, the Lewis article eschewed the rapier entirely in favor of the blunt instrument.

Punches were not pulled. Scholes and Merton should have their Nobel prize retracted. Taleb was quoted as calling the pair "parasites," bringing nothing useful to the market. The intimation is that the sole notion upon which the Black-Scholes-Merton model rests is that shorting the market takes all risk away. That the model leads investors to think they understand risk, when in fact it makes things more precipitous. That the Black-Scholes-Merton model gave ordinary homeowners the excuse, and the financial markets the means, to jeopardize the roof over their heads. Lewis paints a picture of an industry that, in part, has suddenly grown wise to the shortcomings of an esoteric yet fundamental for-

mula, a formula which only a select few could adequately criticize while the rest of the industry had, prior to the emergence of latter-day Lollards like Taleb, muttered the catechism out of blind faith.

Neatly and tidily, the subprime, credit, and world economic crises – like the prey of a crazed serial killer – are quickly explained away as the victims of Black, Scholes, and Merton, and swift on the heels of that judgment the model and its makers are executed in the most excoriating fashion.

And so the arguments are repeated in increasingly dilute form with ever-greater levels of hysteria, and in a world that looks for neat answers to complex problems, the irony couldn't be more palpable.

No one in their right mind has ever claimed that Black, Scholes, and Merton begat modern options markets; it was nothing more than a very happy coincidence that 1973 saw not only the publication of the two papers on which so many accusations have been leveled, but also the opening of the Chicago Board Options Exchange, an institution that sought to expand the market for instruments that were still very much seen as the realm of specialists practicing a very imprecise art.

From *The Financial Modelers' Manifesto* by Emanuel Derman and Paul Wilmott:

"All models sweep dirt under the rug. A good model makes the absence of the dirt visible. In this regard, we believe that the Black-Scholes model of options valuation, now often unjustly maligned, is a model for models; it is clear and robust. Clear, because it is based on true engineering; it tells you how to manufacture an option out of stocks and bonds and what that

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will cost you, under ideal dirt-free circumstances that it defines. Its method of valuation is analogous to figuring out the price of a can of fruit salad from the cost of fruit, sugar, labor, and transportation. The world of markets doesn't exactly match the ideal circumstances Black-Scholes requires, but the model is robust because it allows an intelligent trader to qualitatively adjust for those mismatches. You know what you are assuming when you use the model, and you know exactly what has been swept out of view."

Rational choices

Robert C. Merton is on the phone. He is in expansive mood and willing to take a fairly sketchy discussion plan revolving around ethics in the markets and root out the more interesting cues along a chronological course taking in the highlights of his career. Beginning, then, at the beginning, Merton recalls how, during his teenage years, he had already developed a consuming interest in trading. He was introduced to the stock market by his father, the preeminent sociologist and founder of the Sociology of Science, Robert K. Merton. Merton Senior, also an accomplished magician, had also attempted to spark an interest in his son for prestidigitiation but that particular diversion did not hold the same allure as the sleight of hand of the financial markets. The young Merton was enamored of mathematics and money from an early age, investing in his first stock ("ironically, it was GM") at 10 years old.

By his teenage years, his favorite after-school activity was to sit in at board rooms with trading stockbrokers, who filled him in on market

lore as it stood in the early 1960s. Merton got a micro-education in the markets, learning to read the ticker tapes, observing specialists as they picked off people from the tape. He was introduced to convertible bonds and, later, warrants. The hobby, for he did not see it as a fledgling career, continued through college, where he found himself gravitating toward an academic career in applied math, but even with a move to Caltech for his Masters in Applied Math, the call of the market would find him, more often than not, at a brokerage house at 6.30 a.m. to catch the 9.30 a.m. opening bell back east in New York.

I felt like I had some intuition in economics and I also thought it would be pretty neat if you could go into a field where if you did something, even a small thing, it could affect millions of people, favorably of course!

He'd then go to classes and do his research at night. In a world without quotrons, Merton was furthering his education learning about OTC options, trading convertibles, and stocks.

Thanks to excellent mathematics training at Columbia for his Bachelors in Engineering Mathematics, the 23-year-old Merton managed to get all of his Caltech coursework completed within a year, after which he turned his mind to his doctoral thesis. Water waves in the tank and plasma physics just didn't excite Merton at all. He recalls the period as being one of supreme confidence

in the power of economic theory; Walter Heller, and the Council of Economics Advisors, had "solved the macro problem of big dislocations." "I can see you're smiling," Merton chuckles, "but that was a reasonable belief. They said 'We've started to cut off major depression, we cut off major inflations, we know how to deal with them;' of course, this would be relevant later in life." Merton's own practical experience at brokerages and board rooms and the seemingly boundless optimism in the potential of economic theory combined to decide the path he would take. "I felt like I had some intuition in economics

said, 'Look, they've already done it.' But, I read a bad one!" Everyone in his circle "thought I was crazy - my advisor, everyone at Caltech." Undaunted, Merton applied to economics departments the length and breadth of the country, and, because he had no training in economics, was swiftly rejected by all. All, that is, except MIT, "which was probably the best department in the country and they gave me a full fellowship," Merton relates with satisfaction. "There's a story in there about Harold Freeman, who happened to be on the selection committee; it's like these little rare events that cause us to marry peo-

ple or go into careers. So, I ended up at MIT; I was very contrite, 'I don't know any economics,' I said, 'tell me what to take.' Freeman told me to sign up for Samuelson's mathematical course right at the beginning."

Having signed up with the great Paul Samuelson, Merton acquired his economics "a little backwards because I had the mathematics," and performed satisfactorily in class. "I actually wrote my first economics paper to be published as a term paper. So, Samuelson asks me if I could read one of his papers he was writing and later he hired me as his research assistant." Once

and I also thought it would be pretty neat if you could go into a field where if you did something, even a small thing, it could affect millions of people, favorably of course!" A poor choice of reading material also helped nudge things in that direction.

"I read a very bad mathematical economics book," Merton recalls, although the title and authors elude him, "I didn't know anything about it. I read it and I said to myself, 'Gee, with what I know about I might be able to do something!' Maybe if I had read Ken Arrow or Paul Samuelson, I would have been intimidated and

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he got to know him, Merton was practically living in Samuelson's office. It wasn't long before Merton discovered his mentor's interest in warrants; he had already written a paper on option and warrant pricing. Merton saw a hook from which to hang his proverbial hat. "I said, 'Well, gee, I know a lot about those – at least I traded them.' At least I thought I knew a lot about them! In retrospect, I realized I didn't know very much at all."

Unlike most graduate students

and it gave me a confidence that I think somebody who's never been in the markets might be missing.

"Don't hear this as me saying I was brilliant," Merton interrupts himself to note. "I don't know if I made or lost money, that's not the point; I may have paid for a few TV sets! The main thing was I had this experience at an early age; I was fascinated by applied mathematics, the idea of uncertainty and optimization, and intertemporal optimization, particularly in uncertainty,

warrant pricing paper. His first paper was just a first moment ad hoc theory; he wanted to derive pricing using preference functions or something where there would be a grounding for where the numbers came from. "I was off and running because I found out that my night job could become a day job; that it was okay to do research on the stock market and the pricing of complex securities. I was really interested in solving the lifetime consumption portfolio, which was

tion problem, although I didn't start with the tools, I started with the problems. Through various things, I found stochastic dynamic programming, which helped me solve initially the intertemporal problem, but I wanted more: I wanted to actually be able to characterize the so-called sample paths, not just expected paths. So, I eventually came across the Ito calculus, and that was the perfect tool for doing that. I used it then to write some of my more favorite, better papers on lifetime consumption. It was all about being able to characterize the actual paths of portfolios under uncertainty, and so I was also interested in warrant prices. I did the paper with Samuelson, so it was natural then to step in and say, how do I bring the two together, which kind of brings me up to meeting Myron Scholes."

Abandoned and malignant hearts

This period in history couldn't be in greater contrast to the juncture we find ourselves at now. In the late 1960s, finance was taking its first steps toward being accepted as a serious area for research. Nearly half a century on, these theories, which have formed the bedrock of the massive growth in the efficiency and influence of the financial markets, are under attack. The sense of paranoia about who has their finger on the world's financial self-destruct button couldn't be greater.

"I don't know how to respond sometimes," says Merton later in our conversation. "I'm not talking about academic squabbles, but people who are saying that people in the industry and risk management are naïve people who don't understand this, and the press helps

They call up someone at Goldman and ask, if you have a normal distribution with the standard deviation of x , what's the likelihood that you observe y , and it's like 10 standard deviations. The Goldman guy says one in a billion years, that's what gets quoted, and it's reported that y happened four times in the last six months and he's made to look absurd

in their early 20s who started to think about research, Merton had acquired a lot of experience in the market, even if he had yet to develop a level of comfort with good analytical modeling. "That helped me a lot when I was thinking about the abstractions to make to the models. I always felt that when someone queries that, 'how do you make those assumptions? That doesn't make sense in the real world.' I thought I could defend it by saying, here's how it works, here's what I think is a valid assumption, a valid approximation to complex reality,

and that was the age of growth theory and optimization, but it was all done with certainty models. You either had the static, Markowitz–Tobin type, one-period models of uncertainty, or you had intertemporal models that used Pontryagin principles optimized over time – but it was a certainty world. I was just fascinated in trying to bring the two of them together but didn't know how to do it."

Samuelson hired Merton in the spring of 1968, right through into the summer, with the purpose of working on the next version of his

both uncertainty and time and still fascinates me. So, it was a wonderful set of mathematical challenges, but the substance was what excited me too. That got me into my research; then I did the portfolio selection problem, and at that time I had a lot of mathematics. Although I later realized I didn't have all the mathematics I needed." Merton had reached a level of mathematical maturity to be able to root out the material he required to teach himself new things, however.

"I went searching for the tools I needed to solve the portfolio selec-

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sometimes; they call up someone at Goldman and ask, if you have a normal distribution with the standard deviation of x , what's the likelihood that you observe y , and it's like 10 standard deviations. The Goldman guy says one in a billion years, that's what gets quoted, and it's reported that y happened four times in the last six months and he's made to look absurd. The real question is, does anyone believe that? Is anyone using that model in that way? Sure, you could find anyone doing things like that somewhere, just like you can get any forecast you want, after the fact. Millions of people are saying all kinds of bizarre things; by chance, someone is going to have to be right.

"This other business, and I don't want to point out anyone's name because I don't even want to get into names, that keeps being repeated, people repeat it as if it's true. This feeds back eventually to the prices itself, which is just exemplifying it. I think it's important at some point, and preferably not for me because I would be viewed, of course, as having a great vested interest in defending the strangest things, that the fact is stated that there is a rich set of models out there, that they had these things. Does that mean the models are right? No. Does that mean they have errors in them? Of course. Does that mean we have missed things? Yes. Can we improve on them? Of course. It does not come out that this is a house of cards; this is not the island of Laputa! The motionless motion of Swift's flying island!

"I think the problem at this point is less theory and more execution," says Merton, drilling down to what will largely be the subject of our discussion. "It's not even clear



to me if we will ever get the whole pathology from the crisis, where we will find the problems and what they were. First, I should tell you on the crisis, if you were sitting here with me now, we notice there's a body lying on the floor – you and I looked at it. I say to you 'heart attack,' that's pretty plausible, or maybe someone knocks on the door, comes in, looks, and says, 'poisoning' – that's plausible too. The point is there are a lot of things being said which are plausible explanations, but until you really do the real pathology, you wouldn't know what did it. There's an awful lot of speculation because we don't have all the knowledge. To take something as complex and big as what's happened in this crisis and try to boil it down to one or two things, other than fools and knaves, who are both there, and, as always, we want to

get rid of them and try to protect against getting them."

Part of that pathology often points to the instruments being used; that blame must be apportioned to those who have created these financial weapons of mass destruction. Merton rapidly answers, "Have derivatives made us safer? I always say that's a very complicated and subtle answer. Let me give you an analogy; here, in New England, we get snow and slush, and just suppose 4WD was introduced 15 years ago widely in all kinds of vehicles. Everyone would agree that a 4WD is safer in snow and slush than a 2WD. Has the 4WD made it safer? Now if you go and look at the data 15 years later, it isn't clear that you have that many fewer accidents per passenger mile than you did before, but what's wrong? It's clearly safer! The

level of risk we take is endogenous; we choose it, it's not given as a physical constant. Let's say we were more or less comfortable with the risk we were taking driving a 2WD. Now give me a safer 4WD – how do I use it? Here, when I have my 2WD, if I see four inches of snow, I call up my family and say, 'I'm sorry I can't drive up, it's too dangerous.' With my 4WD, I say I can do it; it's an acceptable risk with the 4WD. Or if I'm caught in the snow driving a 2WD, I'll drive at four miles an hour; with a 4WD, I'll drive at 15 miles an hour.

"What we tend to do when we get something that could make us safer if we didn't change, is we tend to adjust what we do, we take risks that were imprudent before but are now prudent because of the greater safety afforded. We could end up at the margin, even though we have a safer set of tools. We have the same risk we had before because we have chosen not to use the new tool to make us safer because we were comfortable with the risk we had. We use the new tool for other benefits. We can go places under conditions we couldn't before, faster. If you think about that, you know that no matter what safety tools we put in, we're not going to use them just to make ourselves safer; therefore, ultimately, at the margin we're going to be facing the prospect of crisis, of risk. I point that out to say we will always have them. We always will say we wish we had done this."

What about the ethical vagaries of the financial industry? "Firstly, I don't believe that people are unethical; I think they find themselves in situations where they have no control or little control, or they delude themselves. If you tell me

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that if I do one thing, I'm going to get crucified, lose everything I have, and then another person tells me that if I do another thing I may succeed, who do you think I'm going to hope to believe? It's natural. If someone says, 'I think these prices out there are fire sale prices; they are artificially low, therefore the right thing is not to have mark to market,' maybe that's true but it probably isn't; but I want to believe that because if I believe, it allows me to take the easier path."

Merton believes there is a lack of knowledge, which seems to be diametrically opposed to all the public announcements. "People are saying we should get these freaking financial engineers out, fire them! Actually, I think this is not a takeover of financial engineers of the major institutions and the regulatory agencies. I think the problem is that senior management were not well enough educated; they don't have to be engineers themselves, but they have to understand the principles.

"These are not one-liners; these are not 30-second sound bites. These are complex things that need to be analyzed and have the pathology done. They need to write regulation, on risk measurement and risk management and so forth, and try to deal with structural issues, not just have these broad platitudes of 'get the scoundrels out' or 'we just have to be more ethical.' Please don't hear this as if I'm poo-pooing ethical. I like to think that I live my life that way; like everyone, I'm not always as good as I'd like to be! I like to think of people I work with are that way; people who are not, we run away from or fire them. I think that the people in our profession are working hard and they are basically honest people – they're no

different in that respect from any other industry: policemen, firemen, clergymen, government officials – we know that all of those have their bad apples and they all have their incompetent members. I think it's too simple an answer to say we just have to behave better. I want to use the tools we've been given, which is the not the whole answer – certainly not for the economic element – but at least with respect to the financial system, to try to really do a serious job, making it better all the way through. I think it's not an impossible thing; I think we really can do it."

Symbolic interactions

The late 1960s saw a lot of work in economics on growth theory and intertemporal optimization, to which Merton took "like a duck to water." When working on the warrant paper with Samuelson, Merton had used optimization of demand functions for portfolios to derive the pricing – the main focus of his work was solving the lifetime consumption portfolio problem. This in some way provided a bridge between classical economics and the upstart theories of finance. "That could be viewed in the economics profession as not so much 'finance' finance – like the capital asset pricing models or even the Markowitz–Tobin portfolio model – because it was really finding life cycle solutions for people; people saved, they invested, and they consumed, and this was very acceptable in mainstream economics." Merton was very much focused on questions posed by Modigliani's life cycles savings or Friedman's permanent income hypothesis.

On the other hand, Paul Samuelson's horizons seemed

boundless, and blurred the boundaries between finance and economics. Despite this, when it came to getting back on the job market at the end of his degree, Merton only interviewed with economics departments – and not at MIT, as there was a rule against staying in the department. Merton had received a number of offers and was about to make his choice when Franco Modigliani interceded. "I want you to come to the Sloane School, just downstairs," he said to Merton, "teach and be there, and that's legal."

When he started teaching finance, Merton was, in his own words "one page ahead of the students in terms of figuring it all out in order to teach it." Merton's recollection illustrates how embryonic things still were in finance research. Despite Modigliani being at MIT, the Modigliani–Miller theorem was taught "nowhere in the entire department." Markowitz was taught as a special case of portfolio theories. "One was an example of maximized expected utility because the Markowitz model – while very intuitively appealing if you think of it as a practitioner – could be shown to be inconsistent with expected utility maxims. This was because the only time the two matched up was with normal distributions, which made no sense because they have negative prices and negative wealth, which were not meaningful or did not possess quadratic utility. But even then, you have to bound it to keep the quadratic from going over the top so you get more wealth as you are unhappier.

"The bottom line was that Markowitz looked very pretty and it was a great intuitive example to show something that you can solve

because it has a quadratic solution, but it was literally just an example because there was no consistency with expected utility theory, so why spend time on it?" But this early work on the intertemporal problem proved valuable for Merton. "As you went to continuous trading that for any concave utility, there was no special utility for log-normal processes, which were specialized, prototypical, and certainly had limited liability. So, although there was a particular case, it was a very prototypical one and it didn't have the problem of normal distributions, which give you these silly negative prices. For mathematicians, that's the equivalent of allowing you to divide by zero – it doesn't prove anything. Negative wealth allows the weirdest theorems in the world. So, I was able to show in one special, but prototypically interesting case that if it can happen that all the securities you can invest in are log-normally distributed, if that opportunity set doesn't change over time, constant volatility, and so on, then the demand functions, the optimal portfolios for anyone, any kind of utility, would be an instantaneously mean-variance efficient portfolio. So, the formulas looked exactly like Markowitz, and that became the bridge between the simplicity and intuitive understanding of Markowitz and consistency with the theory of choice in terms of utility maxims.

"And what was nice about that was that it was a bridge that allowed me, when I did the more general cases, to categorize the nature of why people held portfolios by starting with an instantaneous mean-variance efficient portfolio. And then you had the incremental

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demands to hedge risks that never appeared in a one-period problem, but appeared in multiperiod problems. You hedge against interest rate changes, against changes in volatility, against changes in relative prices of consumption, against human capital, so you get a much richer theory of why people hold securities and you don't get everyone holding the same risky portfolio as in Markowitz."

This early work is exemplary of the typical Merton approach. The *modus operandi* is one whereby "the idea is to give people things that I never have to unteach them, but only have to enhance. If you look at my papers on portfolio theory, that's how it turns out."

As soon as it was recognized that Markowitz-Tobin holds with some case, then the capital asset pricing model was also shown to hold. "You know that's going to happen and then you get a special case, again which is consistent with utility theory and log-normal, which is a nice specialized prototype. But the key is, in Sharpe and in Markowitz, the period is left open – it can be a day or 100 years." Common sense dictates that you can't have a model where, whether you change your decision every day or once every 100 years, you're going to get the same result. The cost of the continuous time model was that it pinned down the time period between trades but the rationalization for the continuous time model was, well, rational. "If the trading interval's small relative to other things, then it's going to be approximated by a continuous solution. It's not a bad mindset, and in fact the modeling has gotten better over the last 40 years because we have round-the-clock trading,



futures, and all kinds of things we didn't have then. In some ways, the assumptions are getting better, in terms of the market structures being able to trade.

"I was having a great time at MIT," says Merton. "It was very productive and the idea of not even having to move was pretty attractive to me. I wasn't unusually young for a Ph.D., I was 25, but if you're going to teach Master's [level], you tend to be older in business and finance. But I had this confidence from being in the market; I could look them in the eye when I talked about my models, I could quote real world – put some flesh around those foundational bones, if you will. That's when I first met Myron Scholes, who had been hired a couple of years previously from Chicago."

After he met Scholes, Merton was "trying to price some other stuff that came to be called derivatives. Fischer Black had his own consulting business; he was always hanging out at MIT, writing little research pieces, and he and Myron knew each other. I met Fischer, but Myron was the main one I had inter-

actions with and then we became colleagues.

"When Fischer and Myron got together, Fischer came from one place, Myron from another. At that time, they were setting up these zero-beta portfolios. Instead of trying to test the capital asset pricing models, they would measure the beta, put the portfolio in, and take the beta out to create a zero-beta portfolio; then they would just test the hypothesis of whether the average return was close to the risk-free rate, to test the Sharpe model. You could see it was a kind of natural thought to say, 'well, if we're going to do something, maybe if we use the stock to get rid of the beta of the warrant or the option,' then the resulting portfolio would be zero-beta. Therefore, if it didn't have any expected return of the risk-free rate, maybe we'd get somewhere; that's indeed how they derived the model."

There were two different derivations; what Black and Scholes did involved short intervals, it was discreet. "With no disrespect at all, they had the insight," Merton

explains. "But, they'd never heard of Ito; they just didn't have that kind of mathematics training. Fischer had an applied mathematics degree; he applied it to doing psychological modeling or something. The reason they got the right answer is that when they did the expansion of the variables, there's this funny term, which is the square of the return on the underlying stock. That's still random – if I take a random variable and square it, generally that's still uncertain! It was a term that they felt was still nonlinear. When they took the expectation of the square of the stock return with the market return – because that's going to be the co-variance term – and because they were approximating it mathematically as if things were normal, there's a theorem that says the expectation of the square of a normal with any other normal is always zero, because normal is always symmetric so it's always zero, so it dropped out for them. That's the reason it worked, but don't take it as a criticism! The important insight they had is the idea of setting up that kind of dynamic hedging portfolio, and they found the mechanism. What happened when I did it the way I did, not only did all the risk go away, but you didn't have to do any of those things. This is more of a heuristic; I'm not talking about rigor here, I'm just saying theirs was not a sample path based on expectations."

Routine activity

"In terms of scientific priority, I think that the following is true: one has to deal with what's published," says Merton down the line. We are now talking about Stigler's law of eponymy. Well, no, we're not really



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talking about that at all. We're talking about Bachelier-Thorp. "What I mean by published is, it has to be circulated. This goes back to the Royal Society and the creation of the modern system of science. The rules of the game are that Gauss can't write down a proof of a theorem, put it in a drawer with a time stamp, and share it with no one, and then, 10 years later, when someone else, through independent discovery, proves the theorem, pull it out of the drawer and say that's not original, I did it first.

to reveal to the world quickly. If you didn't have the time pressure, you might say, 'Hey, I'll put it in a drawer and pull it out when someone else has done it, say that I did it, and get all the credit anyway.' Those have been the rules of the game in science since the 17th century, so if you want to change the rules, you might be changing a lot of incentive systems, so you make a choice. In fact, many people asked Fischer, Myron, and me why we did publish it; the answer is, we never considered doing anything other than that. They said, 'why, if

later discoveries, they then go back and say 'I had this formula,' 'Gauss had this formula.' The second point is that, particularly with people who are just talking a lot, rather than doing serious research, they always talk to you about the formula. They say two things about the formula: that they have very specialized assumptions that are not true or that they can show you a dozen places where the formula appears, but just have different parameters. Of course, I knew that because as soon as I saw it in Samuelson's

clear theorem; that's Black-Scholes – you cannot extract expectations or preferences out of an option model in a Black-Scholes world. But if it's almost singular, it can explode in your computer at the slightest little mistake in your numbers, so it's not a reliable model for extracting anything.

"The more important point is that the formula is not what's important," Merton confides. "Look at the popular jive that floats around, it's all this big discussion of the same formula. The formula is not what matters; what matters is the methodology."

The conceptual idea that you set up a dynamic trading portfolio; that you can do replication because that has the richer effect of saying that where an option or derivative does not exist it can be synthesized; that this was more than hedging because where replication could be achieved exactly, then risk could be gotten rid of. That is the key to the success of the methodology. Where the formula just wouldn't apply at all, say in fixed income, the methodology did – and paid off massively.

"Now, the formula is a *special* case; we all know that, with the exception of certain standardizations, the VIX out of the CBOE was computed out of the Black-Scholes formula, as a device for transforming one set of numbers which are option prices into another standardized number that's useful, which they call implied volatility. Mercator Minerals 30 years ago would deal with the fact that gold traded on a discontinuous basis, yet they wanted to trade options with their customers before the fixing, so what they did was negotiate a price for the option based on a sigma. The rule was that, after the market

The point is that lots of people write down formulas, but they don't understand their implications and what it's all about. In the light of later discoveries, they then go back and say 'I had this formula'

"That's not part of the rules; there's good reason for designing it that way." Merton continues, "Prior to the Royal Society, people kept all the things they did secret because they used to have competitions like jousts; but it was mental jousting. If you found a solution to a cubic equation, you would never tell anyone because if you go to the tournaments, you can challenge people to a cubic solution. The Royal Society said that if you do the work and you give it to us, we will publish it, share it with the world, and certify you as the first to do it. The beauty of that is that it creates incentives to share your knowledge with the world. Secondly, because you only get the credit if you are the first, it puts a time pressure on you

you had patents back then?' Well, maybe, but if we had kept it a secret or had a big price on the patent, maybe it wouldn't have been used.

"There's a thing called *post facto*; someone makes a discovery, and people go back in time to the 13th century and see if they can find if someone wrote a similar model. It's very common; this is no new idea. While there may be some cases, most of the cases are about the same as saying at the extreme that Shakespeare did nothing original – because every word he used is in the dictionary, by looking and piecing them all together, I can get all of everything he wrote!

"The point is that lots of people write down formulas, but they don't understand their implications and what it's all about. In the light of

paper, which I cut my teeth on, I knew he had the differential equation in there already; he had a thing called alpha and beta, which were just arbitrary, they were just exogenous numbers for the means of the two things. As soon as you get the Black-Scholes formula, it's mathematically equivalent to the expected value, discounted at the risk-free rate and so forth.

"It doesn't matter if Black-Scholes is accurate or the best description of the real world; it's a reasonable model, it's not a crazy model. If, in a reasonable model, preferences don't enter and expected returns don't enter, any models where they do have got to be precarious to use. We all know you cannot invert a singular matrix, that's a

opened, instead of fixing prices, you take the fixing price, plug it into the Black-Scholes formula with the sigma you had negotiated with each other, and that would be the price you paid for the options.”

Black-Scholes-Merton provided a way of dealing with asymmetric information. “Black-Scholes was used in the accounting profession and in all kinds of places where there’s standardization, but I don’t think anyone used Black-Scholes for actual trading or actual valuation. If you are making markets, and particularly if you are doing options or other derivatives, you can’t use the formula. Everyone knows we have stochastic volatility; in fact, we trade it – it’s patently obvious that that formula doesn’t hold. In 1973, when Black and Scholes got a dealers book, they got 10,000 trades from a dealer of actual trades, where they then tried to test their models. If you go back and look at their paper, what did they conclude? ‘The models had information that the market didn’t, the market had information that the model didn’t.’ That’s pretty much true of anything today, so it’s not like these are new discoveries.

“Then, people, naturally, do all this generalization; they generalize stochastic interest rate, they generalize stochastic volatility, introduce discontinuous jump processes to deal with jump events or for gaps of information. Despite all the popular talk that no one looks at tails, as you know in your own magazine, people have built models on options prices and so on, based on Levy and Mandelbrot distributions. It’s kind of hard to take seriously unless you want to play games; people are standing up in 2007 and 2009, saying that all these people in this



industry are using standard normal distributions with constant volatility, and don’t know about tails or jumps. My first jump paper was published in 1976, 33 years ago, and if we went through *Wilmott* or any risk-related publications, you’ll find lots of formulas in there, but no one likes this. No one just goes out and says that’s nonsense; people make these speeches, announce to the world that this industry is filled with idiots and knaves who don’t understand the data, who are so naïve to believe that. I don’t know how one responds to that, what are you going to do? This is no secret.”

Merton points to the record, the reason why this methodology has had legs, why it’s still the same basic methodology being used, not the formula, the methodology. “You are faced with new problems that drove innovation. It made it possible to take a new instrument, call it a ‘squiggle,’ for instance; it had some funny payoffs, yet you can use that methodology to come up with the production cost – I don’t think

of it as a price, I call it a production cost. You sell it for a price; under special conditions, the price equals production cost, and the replicating process is just the production process. Like anything else, production processes are different for different people; for instance, Sony’s process for producing a TV set would be different from mine, if I tried to produce it, and the whole reason we have an industry, options, and everything else is because not everyone can produce at the lowest prices. Saying that Bob Merton can’t trade at those prices and that efficiency is totally irrelevant. If you say that Bob Merton cannot produce a TV set for less than \$3 million – and it probably wouldn’t work if I did! – that price is off the market and totally irrelevant. You look at the lowest-cost producers and that’s where the prices come from, not any one producer. Every other business does that, except, for some reason, in finance, people use it in strange ways.”

Locus delicti

“I’m much more interested in the structural element of it, not because fools and knaves aren’t there, not because it’s not important, but because it leaves us off the hook too much.” Merton turns his attention to the current crisis. He feels that if the whole story ever gets written, a number of causes will be found; it’s not going to be ‘the’ thing that caused it, but a number of things that may not have been, by themselves, bad or dysfunctional. “I can give you an example of potentially what kinds of things were happening. If you look at any one of them, by itself you can say there’s nothing wrong with it, but if you put the three events [described below]

together, you can get the equivalent of resonance. The three together can cause something that makes – in this case – the mortgage market very vulnerable.” He’s not, he points out, trying to excuse bad behavior, poor regulation, greediness, etc. “I don’t think any one of them were under a single person’s control.

“I don’t know if it will turn out to be empirically true or important, but take the following three events that happened.” Merton begins, “Because of the dotcom and 9/11, *ex-post* the Fed cut interest rates through that period, up until about 2005 – that’s just a fact. People have criticized this and said that maybe this led to part of the bubble, but – for whatever reason – the Fed cut. We didn’t know they were going to be cutting every time, we didn’t know what was going to happen to the world – that was the time path. At the same time, housing prices kept rising; even during the 2000–2002 period, when equities fell; you can say that’s due to low interest rates, maybe – maybe not, but it’s not that simple. In any case, it’s a fact that residential housing prices kept rising. Third thing that happened is the extraordinary increase in the efficiency of refinancing.

“I had a mortgage refinance on my apartment,” Merton illustrates. “The guy who’d done my original mortgage called me up a couple of years later, and told me he could save me \$500 a month. I asked him how much was the closing cost, and he said, ‘zero, and we’ll pick everything up.’ I bet that I could refinance without penalty, and he said, ‘that’s true’ – so what about the new one? ‘No penalty.’ So, he wasn’t stripping options out on me. I went through the whole list and I couldn’t find any hidden cost. ☐

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So, I said, sure – I’ll send my lawyer to the closing; he told me that he could come to my office at Harvard and take care of everything for me, that, ‘you don’t even need to have your lawyer come, save the lawyer fees,’ so I did that. Everything went fine. I started saving \$400 to \$500 a month. At the time he came to me, I couldn’t remember what my interest rate was; I can’t tell you today what my new interest rate is. Normally, someone like me is a dream to every bank because I don’t even know what my interest rates are; I’m unlikely to prepay! But because of the efficiency of the system, I ended up prepaying. Maybe I could have got a better deal if I had investigated and spent time on it. I’m sure it exemplifies the efficien-

they say, ‘we’ll refinance and give you a check for \$25,000 and you’re still making the same payment.’”

The combination of housing prices going up and interest rates falling – which didn’t have to happen but happened to coincide – sets up a rich environment not only for refinancing, but also for deleveraging. “Now, you create this efficient machine, so that even guys like me, who didn’t know their interest rates, get refinanced. I didn’t take money out, I just took the saving, but you can imagine people thinking, ‘I can make the same payment I was committed to make, and treat the \$25,000 as free money;’ they don’t think they are hollowing out their house, they don’t think they are leveraging up because they are

ket; if I bought it this year, I’m at full leverage, so all of us end up at pretty high leverage. In 2006, prices started to come down, and you see systemically that the mortgage market was much more vulnerable than it would have been otherwise; it’s as if we all purchased at the peak of the market. On the upside, I can incrementally do that quite easily; on the downside, I can’t act as if I’ve got a margin loan, sell off shares and keep the leverage the same – in a house, you cannot sell off a room. When you start going down, it’s asymmetric, you are just stuck – you either have to sell a whole house or you just let the leverage rise. I’m not saying that’s the important descriptor, although I’m trying to look and see how important that might be.

of major disruptions through fiscal policy back in the 1960s;’ in the next decade, we had stagflation and discovered that we hadn’t solved this. I was already tuned to this on the fiscal side and saying to people, ‘this is crazy, to think that you can rely on the Fed; no one can expect that to be true.’

“But it’s always easy after the fact. The nature of a crisis, in my mind, is something that’s outside your model, your whole mindset; if it’s within your model, it’s maybe a big move but it’s not a crisis. There’s always something you didn’t think of; the hubris is to think that somehow we can solve it and never have a crisis. We can’t, there will always be crisis; part of the reason for that is that, even if you made better models, better tools that would make us safer, we tend to do this not to make ourselves safer but to get other benefits. So, we’re always going to be in a margin.

“One thing I was naïve about in recent times – I had not been involved in the markets for some time – I had thought, without checking, that standard procedures now among firms of any substance, including hedge funds, were independent of rating, that it was two-way mark-to-market collateral on OTC derivatives. That’s one of the things that gave me faith when people would come to me four or five years ago and say that there are four banks representing 60 percent of this derivative market. I’d say that’s pretty concentrated, but they are two-way mark-to-market collateral; while it’s not perfect, it takes an enormous amount of the risk off, as we saw with Lehman, by the way. In spite of the entire knock-on negatives of Lehman, all that stuff cleared because of collateral.

Each of those three things, taken by themselves, is hardly something you would say was a crazy thing to do, was ‘crooked,’ ‘greedy,’ or ‘unethical.’ You can’t call rising prices or cutting rates for the reasons they did

cy of the system; the same guy who did my first mortgage was redoing it with me and I paid nothing.”

Merton proposes that if interest rates fall, that creates a natural reason for refinancing; if interest rates hadn’t fallen, then no one would have done that. “If housing prices rise when you refinance, you can pull out more money because interest rates are lower and you can keep your payment the same. Instead of taking a \$500 saving, the bank asks if you can support the payment you are making now; you say, ‘sure,’ and

the same payment as before.

“I’m talking about true, honest, pure vanilla changes as a result of housing prices going up and interest rates going down. But what would be the effects of that, if it was really efficient and it happened for everyone? Instead of the old days without refinance, where you and I bought our houses at different times, the amount of leverage is different because we have different price points. If you’ve owned your house for six years, you’re probably quite deleveraged in an up mar-

“Each of those three things, taken by themselves, is hardly something you would say was a crazy thing to do, was ‘crooked,’ ‘greedy,’ or ‘unethical.’ You can’t call rising prices or cutting rates for the reasons they did, ‘unethical’ or ‘foolish’ – although maybe a mistake. It’s not unrelated to the foolishness that, even in the professional investor market, people believe the Fed can do anything to solve any problem. Recall I told you way back, when I went into economics, that we’d, ‘solved the problem

“What I didn’t really know or think about was the AIG situation, where there were firms who were doing enormous positions based solely on their credit rating. I just didn’t know that – although it’s not my job to be an overseer of securities firms. Sometime way back, during Long Term days, a lawyer asked me, ‘Do you think you are the President of the USA?’ No. ‘Have you told them everything you know?’ Yes. ‘Okay, you did your job, you don’t have to figure out how to solve this.’ I confess that I didn’t realize that big financial firms that were doing large OTC derivatives were able to get away with effectively no two-way mark-to-market.

“I don’t know how many of the things we’re going to find are old finance; they have nothing to do with fancy mathematical models or financial engineering. It’s the same thing with complexity; you mentioned before how people are more comfortable with familiar than unfamiliar things. Let me ask you this. You hear about all this complexity in all the structured products; I agree with some of these extreme cases, for instance 32 tranches, CDO3, etc. If you were to write down on a piece of paper three T accounts: assets and liabilities. Let’s go through the assets of CDOs; on the left side, there are 100 mortgages – I don’t care if they’re subprime or whatever; on the right side, there are senior mezzanine and equity – that’s just the basics. What are the terms of the assets of this thing? They never change, do they? The core they never change, no matter how risky the assets. You know exactly what the assets are on the right hand side, you know exactly what the liabilities are, and you know the sharing rule. Now,



let’s take a CDO2. Take 100 of the CDOs; out of each one of those, you take the mezzanine; you put it into a new structure on the left side; again, you have 100 securities, but, of course, 100 mezzanine debt; underlying those are 10,000 mortgages – sounds pretty complicated, right? And on the right side, you have senior, junior, etc., and once again you know precisely what the assets are on the left side of the CDO2 – they’re never going to change, it’s the same thing with the liabilities.

“Let’s take a garden variety, non-financial corporation. Let’s write down the economic balance sheet because we’re not here dealing with what GAAP’s telling you to put in the balance sheet, it’s as if you were looking at it as an economic entity. So, what is typical for the left side: cash and accounts receivable, plant and equipment, patents and trademarks, subsidiaries – foreign and domestic, deferred tax, cash, inventory, good will, pension assets, etc. If you are Coca Cola, that goodwill

or intangible is a big number, so these are not small. What about on the right side? You have short-term debt, senior secured debt, senior debt, pension liabilities, subordinated debt, deferred comp., deferred tax liabilities, convertible debt, employee stock option, preferred stock, common stock, warrants, targeted stock, etc. By the way, can you change the left side? You bet – you could be in the storm window industry, and next you could sell those assets and buy airlines. Nothing on the left side is stable over any long period of time; it can all change. What about the liabilities conditions? If you compare them at a complexity level, I think you’ll find that a financial institution is extremely complicated compared to a CDO, certainly, or even a CDO2.

“I understand there are a lot of very complicated contracts, but I find it a little too simple or too quick to say that this is far more complicated to do, but we’re fine buying shares or stocks of companies. I’m not making fun of anybody; I’m not saying, ‘what idiots.’ I’m trying to convey that people are looking for simplifications, they just accept that this is much more complex and that we created these monsters and we can’t even figure them out. I agree that if you have issued securities versus bank loans or if you have bonds versus bank loans, renegotiation is always harder with bondholders than with banks because with banks you have a built-in in advance that you can renegotiate. With bonds, you need to get the trustee, etc., so everybody understands *a priori* that the nature of having securities versus bonds, or the equivalent versus loans, gives up flexibility on

renegotiation. That’s a complexity understood beforehand. So, if you ex out that – which can be very big but not new – to say, in some cold hard rational sense, one is more complex than the others is not immediate to me.”

Merton does think, on the positive side, that we could learn a lot from derivatives specialists, financial engineers, or quants in understanding how certain things happened, without any one-off theories or conspiracy theory, or resorting to the notion of people running wild. “The question is, if you look at the banks, they clearly don’t seem to be consciously adding more risk to their portfolio, they’re not doing anything as far as I know – that’s one of the complaints. So, someone might reasonably ask, how is it that a bank or AIG lost \$6 or \$12 billion in a quarter, and in the next quarter, even though they hadn’t changed anything, lost another \$60 billion. They continue to lose and they lose more; it sounds like they must not be reporting the numbers. If you think of what any loan is – mortgage, corporate loan, or bond – if you expose the loan to some possibility, that the issuer may not pay, it is a risky loan.”

Causa mortis

“No. I’ll give you a concrete example.” The discussion has turned to long-term capital management; to the idea that it was some sort of Manhattan Project in finance that went horribly wrong. “We made many mistakes. I was one of the founders and partners and I’m responsible, along with everybody. Let’s stipulate that. We’re running this big thing; we knew darn well it took us a long time to put the positions together and to get the financ-



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ing done. Just physically doing it, when you're that size, efficiently. There were no illusions; we were in a liquid market where we could sell these things out in any size, in any quick period of time. Our financing was all term financing; it's not an overnight thing, we weren't playing the liquidity game, where you hold highly liquid big positions and finance them overnight, and you could sell them out like a futures contract. We were long term; all the traders, everybody, was incentivized to keep rolling out the financing, both swaps and the actual cash financing. So, there was as much time spent on working capital; on worrying about things like futures

boss say to him, 'cut your exposure;' and he had to say back to the boss, 'I can't.' That's not a good thing.

"Everything we did was two-way mark-to-market collateral, and so what they began doing was marking the positions so that they got the maximum collateral that they could. I don't think they did that to try to hurt us, but I think they were doing it to protect themselves to get the maximum collateral they could gather. The unintended consequences of that were that, since we were a mark-to-market entity, that would hit our NAV. I watched both sides, the long and short swaps, and both sides went down; that's not random! I can tell you

hadn't thought through was this idea of pushing the prices, specifically to get more collateral. Our specific positions would always be negatively hit. It wasn't like what they talk about in crises; where all assets move together. That happens too, but this was far more concentrated – it was literally our positions. Because there was a specific entity on the other side, specifically doing this – again, not to hurt us I think – there may have been some who were front-running us going down; there always are. But I tend to think that most people out there don't do this; I don't attribute nastiness to people at the first pass. I can understand that the

made a bid for Long Term for \$4 billion; contrary to what is sometimes reported, we did not turn him down. This is in the new biography on Warren. The contract couldn't be fulfilled, as what was offered had to be structured in a different way because we had 26,000 lines of bilateral contracts; they wanted us just to transfer all the assets rather than financing everything they wanted to do without, instead of just putting money in the fund and taking it all. But if you go in the first way, there's no way you can do it because you need to get approval from all those bilateral contracts. It sounds pretty boring, but it isn't doable. Warren did call before the fax came in and said, 'I just want to tell all you guys this is coming from me.' Then he disappears on his 1998 cell phone; he was up in Alaska, cruising with Bill Gates, and we couldn't get back to him. In the middle of everything, it doesn't happen; then the consortium gets hit for \$3.6 billion. I think there's some evidence it was not a bailout. If you can buy at the same price or cheaper than Warren Buffet, who was under no pressure to buy at all, I think that is fair. The consortium did a wind down, they made about a billion dollars; had Warren bought – he was planning to hold it, he wasn't planning to liquidate it – he would have made \$4 billion. But if he had gotten it, we would not be talking about it."

Felo de se

How do you explain, to Main Street, in terms that won't scare unintentionally, what happened? "When a bank makes a mortgage loan, time value of money, what does it write a put option on? On the house, if you're writing a corporate loan,

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calls at 11 a.m. on an unusually volatile day; not getting the collateral back on swaps until 3.30 p.m. It was things like that, it was all termed out, and that sounds very prudent right?

"Let me tell you one dynamic that happened. When the problems at Long Term became known, every bank, each counterparty tells their trading desks to cut their exposures to Long Term. That shouldn't be a surprise. Guess what they got back as an answer? 'We can't because we're termed out and they have a contract; eventually we can but not now.' So, the guy at the desk has his

exactly why, each side, wherever the counterparty was, they marked it. Theoretically, we could ask two competing bids and challenge the marks. But in the middle of a crisis, you can't do that.

"What I watched, day after day, was how every position on both sides was just going down. If you were in a normal market, things wouldn't happen, but in a period where markets were very fragile, lots of things were going on, those kinds of things happened. And those were things I hadn't anticipated, that was the only covenant we had on our financing; what I

guy's trying to get more collateral, he isn't trying to hurt us. That's one example of something I didn't anticipate, that I did learn, and it was fairly important. Is that the reason it happened? No. It's one of them; it's a dynamic that entered in. There was a lot of that sort of thing; there's an old saying, 'For want of a nail, the shoe was lost on the horse, the horse was lost, the leader was fallen, the battle was lost, the war was lost as a result of all that.'"

What of the bailout? Didn't it set an unhealthy precedent? "Warren Buffet, you may recall,

you are writing a put option on the assets. Now you show them a curve of the put option, a price versus asset value, the underlying, and, of course, when assets go up the put goes down. It's nonlinear, it's a curve. If you think of a curve, it has the feature that, as the assets go down, not only does the value of the put go up, the slope of that curve gets steeper; we call that the delta. This is convex; you have a gamma on this thing – as the thing goes down, delta gets bigger, and so forth. Any one running a derivative book understands that. I can say that because if they didn't understand that, they're long gone. But the insight you can show people is that even if the portfolio is being marked, and you are marking its guarantee, it goes up in value. What loan holders, mortgage holders, regulators are typically not doing is that they don't explicitly recognize that, without changing any of the mortgage book, it's a completely static portfolio of mortgages; as the assets go down, not only does the guarantee of the put go up, but the value of the mortgage also goes down because it's short a put, although the risk goes up. So, what happens is that the first time you get a shock in asset value, which is the housing prices, you get one response of loss; if you get the same shock again, the response is much bigger. That's the convexity; it's insidious in that, even if you are marking to market, what you are not taking into account is that the risk is going up in a nonlinear way and getting bigger. You can have an enormous build-up of risk without realizing that risk is building up until you are exposed. This insight is really Derivatives 101; it helps to

explain to people that what we're observing is not some new particle or some unexplained phenomenon of a world we don't understand, it's a way of explaining – yes, it's exactly what we predict, even for vanillas.

“Very few people think that when they buy a mortgage or

assets. “What are the government positions? Governments are a put on a put, of either corporate or housing assets. That's superconvex. It starts out very insensitive, and it can very quickly become very risky; it's like a put on a put, it's doubling gamma. So, it's a great way to show people. It's a worry going forward,

green, black, or any other kind of swans, just garden variety – apply derivative analysis in looking at the convexity that a government has. It's exacerbated even more when you have government that's not 100 percent best credit. Because a lot of the banks held government debts too and the government was

Very few people think that when they buy a mortgage or standard loan, they're writing put options and taking all sorts of gamma risk. The regulators don't think of it that way. This is one insight that modern finance at the very basic level can give to people to help them understand what they observe

standard loan, they're writing put options and taking all sorts of gamma risk. The regulators don't think of it that way. This is one insight that modern finance at the very basic level can give to people to help them understand what they observe. To tell them this is not out of control, this isn't some weird, 'where are these losses coming from?' – the good thing is, when things turn around, convexity works the other way.”

With the same analysis, of course, we're not stopping there with the banks because governments guarantee the bank liabilities and deposits; we know from the same structure that they're writing the puts on the assets of the banks, but what are the assets of the banks? The interesting part is that they are short puts on the

by the way, when you see all these guarantees being written left and right by governments. Ironically, they don't put those on their books; they don't expense them. Congress doesn't tell you that it is appropriating a certain amount to pay for the guarantees it's giving away; it does it off balance sheet. Don't you think that's rather ironic? Because the very thing it's shouting at banks for doing off balance sheet, it's doing in massive size.

“If you go back to the 1987 Asian crisis, you look at Thailand who seems to be getting along fine; but overnight the government was in trouble with the degree of convexity plus the currency convexity – because all the loans were done in hard currency. I'm not saying that this is the whole explanation; you don't need any understandable

guaranteeing the banks, and banks were guaranteeing the government because they're holding the bonds, you get a hell of a feedback from that.

“The people in the industry, the people who read your magazine, they have a lot to contribute here, in terms of helping people to understand the phenomenon we observe, or at least parts of it. We could help people understand that. Although it may not solve anything, it does help us to understand what we are seeing. That also explains the so-called fat tails; if we underestimate the delta because we don't realize that risk is going up, when we observe something, we underestimate what the real standard deviation really is. It looks like it's more standard deviation than it actually is.”

