A MODEL Mind

Robert C. Merton on putting theory into practice

BY ROGER MITCHELL

A young, relatively unknown MIT professor applied continuous-time analysis to the capital asset pricing model and published it as a working paper in 1970. As a result, the evolution of financial theory and practice would be profoundly altered.

The rise of the derivatives markets, the decomposition of risk, the growing use of equity pricing information to evaluate credit risk, the valuation of insurance contracts and pension guarantees — all these and more have depended heavily on a body of theory that derived, to a significant degree, from the insights described in that working paper.

When asked about his achievements, the now internationally renowned professor, Robert C. Merton, finds particular satisfaction in the practical application of his ideas. "It's just been wonderful to be a part of this and have a sense that what you're doing is not only interesting, perhaps helping people to understand things, but also that you're having some impact on the way the financial world has evolved," he says.

For his seminal contributions to option-pricing theory, he shared the 1997 Nobel Prize in economics with Myron Scholes (who collaborated with the late Fisher Black in formulating the Black–Scholes model). Famously, the Black–Scholes model and Merton's refinement of it were widely incorporated into practice within two years of publication in 1973. But another of Merton's innovations went much longer before finding broad practical use. In 1974, Merton published what has come to be known as "the Merton model" for predicting debt pricing from equity pricing ("On the Pricing of Corporate Debt: The Risk Structure of Interest Rates," *Journal of Finance*; also included as Chapter 12 in Merton's book *Continuous-Time Finance*). Only within the past several years have greater numbers of practitioners begun to appreciate the power of this model.

Can you explain the Merton debt model in layman's terms?

The base case is a firm that has a single class of debt and equity, which is the simplest nontrivial capital structure. In some way or another, according to the contractual arrangements for each, they share in whatever happens to the assets, good or bad. Recognizing that, what we did was to consider the assets as having a certain market value. For publicly traded companies, one could get that market value by adding up the market prices of all the liabilities plus equity, which has to equal, definitionally, the market value of the assets.

If you plot the payoff to equity at the maturity of the debt, say in five years, against the value of the firm's assets, you would see that the payoff structure looks identical to the structure for a call option, except the call option is not on just the stock. The call option is on the whole firm, or the market value of the assets of the firm. From these terms, you recognize that you can value the leveraged equity of the firm as if it were a call option on the assets of the firm.

If we have a way to value equities as an option, then we can value the debt by subtraction. We take the total market value of assets, subtract from it the value of the option (the option-type structure that equity represents), and end up with the value of the debt. So, that's how you arrive at the valuation of the debt. Once you have a value function for the debt and a value function for the equity using an option-pricing-type structure, then you can also figure out the risk of the debt and all the Greeks of traditional option pricing. You can say: What's the delta (that is, what is the sensitivity of debt value and equity value to a change in asset value) or the sensitivity of debt value and equity value to a change in the risk-free interest rate, asset value volatility, and so forth? And what is the effect of the changes in the volatility of the value of assets?

So, it's an analogous structure. ("Isomorphic" is the mathematical term — there's an isomorphism between leveraged equity and a call option.) It was really recognizing Modigliani and Miller's observation that the right side of the balance sheet, liabilities plus equity, is always equal to the total assets on the left side of the balance sheet and then recognizing that the payoff structure to equity was just like an option.

Why has the Merton model become so important to practitioners? It seems to be central to what many people are trying to do right now.

There are a couple of answers. But first let me say that although it is called "the Merton model," Black and Scholes also applied the option-pricing methodology to the pricing of corporate debt. Furthermore, the versions used today are far more sophisticated than the one I published in 1974 and reflect nearly three decades of fundamental contributions by several researchers, including Brennan, Cox, Duffie, Geske, Jarrow, Kealhofer, Leland, Longstaff, Schaefer, Schwartz, Singleton, Sundaresan, and Vasicek. You can ask the question: What's the history of the relationship between this model developed in academe and its evolution into practice? The original option-pricing model, both Black–Scholes and my papers, came out in 1973 at the same time that the Chicago Board Options Exchange was started. It's well documented that within two years, nearly everyone on the floor of the exchange was using some version of the Black–Scholes model and there was even a specialized calculator sold. In the case of option pricing, the model was very rapidly adopted into practice in a broad way, and it's continued in that fashion for the last 30 years. In contrast, the debt-valuation model really did not get much attention in the practicing community after it was initially out there. There were a number of proprietary trading desks in investment banks and commercial banks who used that kind of model for pricing junk bonds and so forth. Eventually, a firm called KMV — which was in the business of providing advice and assessment, principally to banks but also to anyone who was willing to buy their services on the valuation of risky debt — used this model as the basis for valuing and assessing the risk of, initially, bank loans, which of course is just debt that is not traded, but also applied it to junk bonds.

But absent the proprietary trading desks of financial firms, some hedge funds, and KMV, I am not familiar with widespread use of the model. Sometime around 1999, maybe 2000, several firms, JP Morgan, Goldman Sachs, Deutsche Bank, Credit Suisse First Boston, which had been using the model internally for proprietary valuations, attempted to establish a standard for such valuations by publishing a simplified version of their proprietary models. Subsequently, Riskmetrics entered with CreditGrades, and BARRA recently announced its version of the model.

The question one might ask is: Why then? The simple answer, in my view, is "need." The first version of the need was that in this past period a number of companies, such as Xerox, went from being not highly rated but also household names to being junk. Some of the traded Xerox bonds went from a market price of 100 cents on the dollar to 33 cents on the dollar, and not because interest rates rose. You also had Polaroid and, of course, WorldCom and Enron, but a whole host of pretty highly rated bonds very rapidly deteriorated in terms of their value and rating to junk or, in some cases, outright default.

And the traditional models didn't capture these until it was too late. In contrast, the so-called Merton model picked them all up. So, just as a simple practical matter, it was recognized that the other models being used had a flaw in terms of capturing the credit-influencing events that occurred. That was the incentive to stimulate the adoption and use of the model. Of course, KMV was acquired a few years ago by Moody's for more than $200 million, which is a pretty strong statement of belief in using this kind of model from a major rating agency. The large Japanese ratings agency, R&I, offers an advice service for its clients based on the Merton model.

The other incentive for using this kind of model came from the development of credit derivatives. A model that fundamentally, methodologically evolved out of the original derivatives/option-pricing model would be a very natural type of model to apply to credit derivatives, because, again, it does more than give a price — it also gives a risk structure for understanding how the risk is changing, how you might try to hedge the risk with other instruments.

In a sense, is the divide between debt and equity markets almost analogous to the split in physics between quantum mechanics and Newtonian mechanics? Do we need a unified field theory of securities markets?

I think it goes back to the original insight of Modigliani and Miller. Prior to Modigliani and Miller, debt was valued as debt, the firm's debt ratio, and equity was valued at some equity rate, and then the cost of capital of the firm was some blend of the two — one came from one place and one came from another and they came together here. In the limited case when debt is risk-free, that's not too totally unreasonable. However, if one just looks at the firm, when you take all those right-hand-side liabilities plus equity instruments, they add up to the assets. So, the value of all those claims is inherently linked to the value of the assets.

The convergence of recognition that debt and equity are actually linked and need to be looked at as a whole is well on its way, and as I mentioned, it's done by many firms now in the context of credit analysis. Also, there are hedge funds that do so-called capital-structure arbitrage, in which they attempt to use these models to buy the underpriced part of a firm's capital structure, be it debt or equity, and sell the overpriced part. To the extent that debt and equity have been looked at completely separately, there might be prospects for making money, but in the process of doing this, of course, you're setting up the mechanism for economic convergence in the sense that debt and equity will be priced off one another and a common pool of knowledge.

Credit derivatives have become a very effective means in the marketplace of transmitting this information because now equity people do look at credit, where the pricing and changes give them information, and credit derivatives people certainly look at what's happening in the stock market. Going back to what I said about Xerox, Polaroid, WorldCom, and so forth, what really happened was the equity markets picked up really quickly that things weren't going so well for those firms and their share price changes reflected that. They didn't know for sure default was going to happen. In the case of Xerox, it has since rebounded; in the case of Polaroid, it didn't; and WorldCom and Enron certainly didn't.

Now, you ask if we need a unified theory for pricing securities. In fact, I wrote a working paper in 1970, "A Dynamic General Equilibrium Model of the Asset Market and Its Application to the Pricing of the Capital Structure of the Firm," [MIT Sloan School of Management Working Paper Series, No. 497-70; also included as Chapter 11 in *Continuous-Time Finance*], which became the basis for three of my published papers [on the intertemporal capital asset pricing model, Merton's version of the option-pricing model, and a theory for pricing term-structure bonds], in which I talked about using this approach not just for debt and equity but more generally as a unified theory for pricing the entire capital structure of the firm.

Given that theoretical framework, have you been surprised by the persistence of the divide between equity analysis and debt analysis at the investment firm level?

I've always been involved in practice as I have been in research and academia. My research has been helped by my experience in practice and vice versa. From that experience, I've come to recognize that the speed at which ideas are adapted and change takes place varies considerably. As I indicated earlier, one of the factors is "need." It's not a matter of practitioners not having good insights, but instead they have to look at the most important things on their list to act on because they don't have the luxury of considering everything. Things don't get up high enough on the list unless there's a material need.

So, I'm not surprised by that. Also, with organizations, they are geared to looking at data and looking at things in a way that is not easily adaptable to this unified approach. It will change; it is changing. It's much more rapid now because competition forces that.

I'd even go further to say an area that is not being, as far as I know, done at all but that actually I think should be done — and I'm trying to see if I can help to do it on my practitioner side at IFL [Integrated Finance Ltd.] — is to have corporations and other issuers begin to think in terms of understanding what they're issuing (whether it be straight debt, convertibles, and so forth), understanding what they're giving up, understanding the value of what they're giving up, understanding how it might apply to the risk of their own equityholders and the firm as a whole.

And I haven't seen that. I've seen analysts, banks, and even rating agencies doing it, but it hasn't happened yet with corporations and I think it's going to be a while. Even within the rating agencies, if you look at the models that they tend to use to do ratings, probably the ones that are closest to using versions of this kind of model would be those that rate special-purpose structures, CDOs [collateralized debt obligations] and things like that. The traditional parts of the rating agencies rate corporations, and I think they still are pretty far behind on doing this.

But it's going to come, it is coming, and one just has to be reasonably patient. And the other side of it is if one finds delay frustrating at one level, it also creates opportunities at another. One could make their mark by bringing this market-proven technology into this area perhaps ahead of some of the other firms.

What is your view of the rise of the credit derivatives market over the past decade, a market that depends heavily on a body of theory you helped create?

The rise is again a manifestation of what's been going on for the last three decades — namely, that you have a decomposition of risk characteristics of assets and specialization. If you think of what a piece of debt is, one way to understand it is this: Take a risky piece of debt (by risky debt, I mean not risk in terms of interest rate but risk in terms of default). Attach to that risky debt a full-faith-and-credit US government guarantee of the debt. What do you end up with? Risk-free debt.

So, therefore, risky debt with a highly rated guarantee is the same as risk-free debt. What's risky debt? Risky debt is like having risk-free debt minus a guarantee. So, everyone who buys debt, other than risk-free debt, is really performing two functions — they're lending money in the strict sense of lending money, time-value money, but they're also writing a guarantee. And what's the guarantee? The guarantee really is an asset guarantee. The need to pay off on the guarantee of the debt in case the assets are insufficient in value is really an asset guarantee. It's like a put on the assets.

So, structurally, every piece of debt that's bought really has two components. One component is risk-free, time-value lending, and the other component is a put option on the assets of the underlying credit of the debtor. Those are both honorable businesses, but they really are quite different. And credit derivatives

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Robert C. Merton is the John and Natty McArthur University Professor at Harvard Business School. In 1997, he and Myron Scholes were awarded the Nobel Prize in Economic Sciences for contributions in the area of option pricing.

A former senior advisor to Salomon Inc. and JP Morgan and a co-founder and principal of Long-Term Capital Management, Professor Merton is currently chief science officer of Integrated Finance, Ltd. As he explains, he co-founded IFL in 2002 "to implement into practice some of the research concepts that modern finance science has developed," such as the personal finance products and advice he described in his 2003 *Financial Analysts Journal* article "Thoughts on the Future," which earned this year's Graham and Dodd Award for the "Best Perspectives" article.

Prior to joining the Harvard faculty in 1988, Professor Merton served on the finance faculty of MIT's Sloan School of Management. He holds a BS from Columbia University, an MS from California Institute of Technology, and a PhD in economics from Massachusetts Institute of Technology.

make debt clear, because if you have a risky piece of debt and you buy a credit derivative, it becomes risk free.

With the decomposition of risk, you can get rid of interest rate risk using swaps and swaptions and options and futures. Using the financial engineering of decomposing asset positions, you can strip asset securities into their component risk parts, hedging out or stripping out the ones you don't like, getting rid of those, adding ones you do like, and then recomposing them. So, the development of credit derivatives is a very natural development that's in line with innovations we've been seeing for 30 years.

In the past few years, there's been much debate between the "stocks for the long run" school, championed by Jeremy Siegel among others, and those such as Peter Bernstein and Robert Arnott who think the equity risk premium is insufficient and thus bonds, notably TIPS, are potentially more attractive. What's your view on this debate, especially given your description of TIPS as a standard-of-living hedge?

In terms of a strict standard-of-living hedge, I mean what you or I should buy to try to lock in our current standard of living. As a practical matter, as a US-based person, probably the best hedge of your standard of living is a life annuity based on TIPS combined with ownership of your own home in a place where you plan to live for the indefinite future. The reason I focus on local real estate ownership is that if you look at most of our standard of living, a big chunk of it's our housing.

If the question is whether stocks are a better buy or not, I don't think it has anything at all particularly to do with the risk premium. If you're asking about the risk–reward trade-off between locking in a standard rate and using TIPS and residential real estate and taking risks and investing some of that in stock to try to get a higher standard of living, that risk–return rate offers the function of classic portfolio analysis. And people can disagree. If one person thinks the risk premium is 6 percent and someone else thinks it's 1 percent, obviously, they are going to see the risk–return trade-off differently.

Now, the other argument for stocks in the long run, which I believe is a misleading one (and a number of people have written about that, myself included, but in particular, Zvi Bodie had an article on this in the *Financial Analyst Journal* some years ago ["On the Risk of Stocks in the Long Run," May/June 1995]), is that over a long-enough horizon, stocks will outperform bonds almost certainly and, therefore, if you have a long-enough horizon, you can be sure of getting a higher standard of living by holding stocks long enough. That's not what Jeremy Siegel has said, but I believe this particular argument is fundamentally misleading.

Pick a horizon — 10, 20, 30, or 40 years — and ask, "What does it mean that stocks will certainly outperform bonds over that very long horizon?" It really means that at the end, the cost of having a shortfall between the performance of stocks and TIPS is negligible.

If that's the case, if the risk of a shortfall is so trivial, it should be that for a 20-, 30-, or 40-year horizon, the cost of buying insurance against that shortfall should be smaller and smaller. What is that insurance? It is, in fact, a put option at the forward price. And when you value that, instead of going down, it actually goes up. So, to insure against the US stock market underperforming a long-term bond over 40 years, my guess is the number that you would have to pay would be somewhere around $45–$50 per $100. To insure $100, you'd have to pay $50. That's hardly "no risk." But the key is you don't have to use any particular model. Go to any of the investment-banking firms and ask for a quote, and if they provide one, it will be a very big number. So, the one thing I can say with great conviction is that the notion that just because the probability of stocks outperforming bonds over a long horizon is approaching almost surely 95–96 percent, that doesn't mean that you can treat it as virtually no risk and therefore the only question is if I have a long enough horizon, I can get the higher standard of living with no risk.

Roger Mitchell is associate editor of CFA Magazine.