Harry M. Markowitz, Merton H. Miller, William F. Sharpe, Robert C. Merton and Myron S. Scholes

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PIONEERING PAPERS OF THE NOBEL MEMORIAL LAUREATES IN ECONOMICS

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Introduction to Part IV: Robert C. Merton (b. 1944)

Robert Merton was born in New York City, New York, USA in 1944 and grew up in Hastings-on-Hudson (Nobel Foundation, 2008). Merton's father was a renowned professor of sociology at Columbia University, while his mother kept the family home; both parents were important positive influences in his formative years. One thing he got from his father that had a profound effect on Merton's later career was a fascination with the stock market. He remembers:

> As early as 8 or 9 years of age, I developed an interest in money and finance, even at play. I created fictitious banks ... At 10 or 11, I drew up an 'A' list of stocks, and bought my first one, General Motors. In college, I spent time doing some trading, learning tape watching, and hearing the lore of the market from retail traders in brokerage houses (Nobel Foundation, 2008).

Merton's high school was small but offered a good curriculum and he divided his time there between academic work and sports. His own view is that he was a good rather than exceptional student and an athlete of no great distinction. Outside school and in addition to the stock market, Merton's other interests were initially baseball and then cars. As a teenager he bought and built 'street hot rods' and raced them at drag strips. For a time a place in the automobile industry seemed to be Merton's vocation: he spent his college summers working for the Ford motor company and a career in engineering greatly appealed to him (Nobel Foundation, 2008).

Merton attended Columbia University and studied engineering. He particularly relished his mathematics classes, having since school found the discipline 'fun'. At Columbia he took one introductory economics course, using Samuelson's textbook, little knowing that he would find himself working for Samuelson just a few years later. Merton was awarded a BS (engineering mathematics) by Columbia in 1966.

After graduation, Merton began to study for a PhD in applied mathematics at the California Institute of Technology (Cal Tech) but, despite finding his work rewarding, he elected to leave Cal Tech and drop mathematics in favour of economics. In his Nobel autobiography, Merton offers three reasons for this abrupt switch. First, like other Nobel Laureates in economics, he felt drawn to a discipline that appeared to be a force for social progress. This was particularly so in the late 1960s, when the sustained growth and full employment fruits of the postwar boom were widely credited to macroeconomic policy making. Second, Merton's training in mathematics would, he thought (presciently enough), provide him with some advantage in economics. Finally, and, he says, most tellingly, Merton felt that he had an intuitive connection with economics that was stronger than that with the physical sciences. At Cal Tech he had continued to trade in stocks – even rising in the early morning to get to a local brokerage house to put in a couple of hours before attending classes. In the end, in the battle between his youthful passions, the stock market won out over automobile engineering.

With the support of members of the faculty at Cal Tech, Merton applied to a number of economics departments but was accepted only by the Massachusetts Institute of Technology (MIT). After taking a mathematics course at MIT offered by Samuelson, he was subsequently recruited by Samuelson as a research assistant. Sharing an interest in the stock market, the two began to work together, producing a paper – part of Merton's PhD thesis – on the theory of warrant pricing in 1969 (see Merton and Samuelson, 1969a). Merton was awarded a PhD in economics by MIT in 1970.

After spending the 1968–70 period as Samuelson's research assistant, and 1969–70 as an instructor in economics at MIT, Merton took up the post of Assistant Professor of Finance at the A.P. Sloan School of Management at MIT from 1970 to 1973. Subsequently, Merton became associate professor (1973–74) and professor (1974–80), before his appointment in 1980 at the Sloan School as J.C. Penney Professor of Management. After spending 1987 on sabbatical as Visiting Professor of Finance at Harvard University, Merton moved to Harvard in 1988 as the George Fisher Baker Professor of Business Administration. He spent June 1993 as Invited Professor of Finance in France at the University of Nantes. In 1998 Merton was appointed to his current post as the John and Natty McArthur University Professor at Harvard.

Merton's professional appointments include directorships and advisory roles associated with a variety of academic and financial institutions. For example, since 1979 he has been a research associate of the National Bureau of Economic Research; from 1988 to 1996 he was a trustee of the College Retirement Equities Fund; and from 1988 to 1992 he was senior advisor at Salomon Inc. In 1994, Merton, together with Myron Scholes and others, was a co-founder of Long-Term Capital Management, the hedge fund subject to an infamous rescue organised by the Federal Reserve in 1998 (see Edwards, 1999).

Merton has a significant accumulation of offices and honours among which are honorary degrees from the universities of: Harvard, Chicago, Lausanne, Paris-Dauphine, the National Sun Yat-sen University in Taiwan and the Athens University of Economics and Business. In 1971–72 Merton received the Salgo-Noren Award for Excellence in Teaching at MIT. He was director of the American Finance Association in 1982–84 and 1987–88. He has been a fellow of the Econometric Society since 1983, and a fellow of the American Academy of Arts and Sciences since 1986. Also in 1986, Merton was president of the American Finance Association, and in 1993 vice president of the Society for Financial Studies. He has also been a member of the Honorary Board of the International Raoul Wallenberg Foundation since 1993.[1] In 1993 he received the Financial Engineer of the Year Award from the International Association of Financial Engineers. In 1997 Merton was awarded the Nobel Memorial Prize in Economics jointly with Myron Scholes 'for a new method to determine the value of derivatives' (Nobel Foundation, 2008).

A derivative is a financial instrument that has its price conditioned by the value of some other underlying asset such as a stock or currency. Merton and Scholes, together with their colleague Fischer Black who died in 1995,[2] refined a formula for the valuation of a particular form of derivative: the stock option. In the late 1960s and early 1970s, when Black, Merton and Scholes were conducting their research, stock options were rarely used in the financial service industry; shortly after the publication of their findings they became so widespread as to be internationally – now globally – commonplace (see Duffie, 1998; Jarrow, 1999; Nobel Foundation, 2008). As Schaefer (1998, p. 425) notes,

> Many economic theories have affected economic life but most often through their influence on a relatively small group of macro-economic policymakers. But it is surely rare for an advance in the economic sciences to influence the details of the way literally thousands of individuals engaged in financial transactions carry out their analysis and make their decisions.

For a more modest reading of the impact of the Black, Merton and Scholes option-pricing formula that emphasises the need for new financial instruments in the context of the riskier post-Bretton Woods, inflationary and oil-price sensitive economic environment, see Merton (1998).

An option is a contract that provides its owner with the right but not the obligation to purchase or sell a specified quantity of a particular underlying asset – such as stock in a firm – at a specified 'strike' price on a predetermined date in the future. If the right can only be exercised on a given date, the option is known as a European option; if this right can be exercised at any point up to and including the date of maturity, the option is known as an American option. Options are commonly used for risk-management purposes and to facilitate speculative activity. For example, a stockholder who wishes to insure against the possibility of a fall in the value of his or her stock can take out an option to sell it at a given price some time in the future. If the stock does fall in value, the option may be exercised thus insuring its owner against losses. To illustrate the opportunities for speculation provided by options consider the position of an investor who anticipates that a particular stock will increase in value. Rather than taking the straightforward step of buying a given amount of the stock, he/she could use an equivalent sum to purchase options to buy significantly more stock at a set price in the future. This highly leveraged position both offers the possibility of much greater profit and insures against the possibility that the stock falls in price – if it does the options are simply not exercised and the only cost incurred is their purchase price.

Prior to the work of Black, Merton and Scholes the development of option-pricing theory had been limited. The major obstacle to progress was an assumed implication of the fact that the price of an option, for example to buy stock, depended upon what happened to the price of the stock up to the maturity of the option (Nobel Foundation, 2008). The supposition was that this meant that the option price had to incorporate a risk premium covering the vagaries of the stock price. Unfortunately, risk premia reflect the subjectivities of individual investors, as well as wider economic fundamentals which are themselves subject to change (Jarrow, 1999). This made the determination of appropriate risk premia difficult and options hard to price.

Black, Merton and Scholes overcame the problems associated with risk-premia decisions by incorporating the risk premium in the stock price. Their widely acclaimed insight into option valuation was to propose that the risk exposure of a call option (the option to buy stock) could be hedged by taking short positions in the stock. Following Jarrow (1999), this meant in practice borrowing the stock from a broker, selling it to a third party, and undertaking to repay the stock at its spot price at a specified time in the future. In these circumstances if the stock price rises, the value of the call option will increase as the stock price is more likely to be above the strike price when the option matures. However, any gain here is offset because repaying the borrowed stock will cost more. Conversely, if the stock price falls, the decrease in the value of the call option is offset by the fall in the cost of repaying the borrowed stock. The option-stock portfolio thus created – and if perfectly hedged – identifies the option's price. As the portfolio is riskless it must pay the same rate as the risk-free market interest rate, otherwise profits could be made through arbitrage: selling the hedged portfolio and buying the

risk-free asset or vice versa. The price of an option can thus be expressed in terms of the underlying stock price and the riskless interest rate. Although the option-pricing formula that emerged from this analysis first appeared in a paper by Black and Scholes (1973), both authors credit Merton with the insight that the hedged position can be managed so that it is riskless (see Duffie, 1998; Schaefer, 1998; Scholes, 1998; also Merton, 1998). Indeed, Black once stated that his paper with Scholes 'should probably be called the Black–Merton–Scholes paper' (quoted in Duffie, 1998, p. 417). In the event, it was Merton (1973a – paper 17) who elaborated upon several aspects of the option-pricing formula, including proof that the hedged position was riskless, and an extension to allow for the American (early exercise) form of an option (see also Merton, 1998). Merton (1977 – paper 20) is now thought to be the standard version of his analysis (Duffie, 1998).

One of the more immediate applications of the Black, Merton and Scholes breakthrough in option pricing was in the area of corporate finance. Both Black and Scholes (1973) and Merton (1974 – paper 19) recognised that corporate liabilities can be understood as options. For example, the holders of a firm's debt can accept payment on maturity but if the debt cannot be repaid, they have the equivalent of a European call option on the firm's assets (Jarrow, 1999). As Merton (1998, p. 336) argues, this kind of approach to valuation allows a wide variety of instruments for corporate finance to be interpreted as derivative securities and provides 'a unified theory for pricing these liabilities'.

Additional research contributions to financial economics by Merton highlighted in his Nobel citation include the development of a new method for analysing consumption and investment choices over time (Merton, 1969b – paper 15; 1971 – paper 16), and the generalisation of the capital asset pricing model (for which William Sharpe was awarded the Nobel Prize in 1990) (Merton, 1973b – paper 18). Many of Merton's earlier papers, including those central to his Nobel award have been drawn together in his 1992 book *Continuous-Time Finance*, which he regards as 'the crowning synthesis of my earlier work' (Nobel Foundation, 2008).

Notes

1. Raoul Wallenberg was a Swedish diplomat credited with saving tens of thousands of Hungarian Jewish lives during the Second Word War.
2. The Nobel citation for Merton and Scholes specifically acknowledged Black's contribution to the Prize-winning work. In his Nobel Banquet speech at the award ceremony, Merton reflected on Scholes and his friend's absence: 'for us this is also a bittersweet moment for we greatly miss our friend and collaborator, Fischer Black – especially so this special day. We are gratified that the Academy made it quite clear that, were Fischer alive, he too would now be honoured'.

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