

A BRIEF HISTORY OF THE CAPITAL ASSET PRICING MODEL

Edward J. Sullivan, Lebanon Valley College

ABSTRACT

This paper explores the near-simultaneous development of the capital asset pricing model by four men: Jack Treynor, William Sharpe, John Lintner, and Jan Mossin. Further, it identifies the key ideas that inspired the research of these men. Lastly, it considers why the work of only one of them resulted in a Noble Prize in economic science.

INTRODUCTION

The history of scientific thought is replete with examples of individuals who independently and simultaneously discover the same concept. Undoubtedly, the most famous example of such a coincidence is the development of calculus by both Isaac Newton and Gottfried Leibniz in the seventeenth century. Such examples are considerably less common in the history of economic thought. However, during the early 1960s, four economists -- John Lintner (1965a, b), Jan Mossin (1966), William Sharpe (1964), and Jack Treynor (1962) -- developed essentially the same model for describing security returns. The capital asset pricing model (CAPM), as it later became known, revolutionized the theory and practice of investments by simplifying the portfolio selection problem. Interestingly, only one of these men, William Sharpe, received the 1990 Nobel Prize in economic science for this work. Further, Jack Treynor, who arguably wrote the earliest draft of this model, never had his work published until recently. This paper defines the intellectual milieu that inspired these men to develop this remarkable model at the same time and explains why only Sharpe's work was recognized by the Nobel Committee.

THE BEGINNINGS OF A MODEL

In tracing the origins of the CAPM, two papers appear to have been the primary inspirations. In 1952, Harry Markowitz provided the first truly rigorous justification for selecting and diversifying a portfolio with the publication of his paper "Portfolio Selection." Later, he would expand his mean-variance analysis to a book-length study (1959) which firmly established portfolio theory as one of the pillars of financial economics. Markowitz's work presents a direct and obvious root to the CAPM. After publishing his initial paper, Markowitz became interested in simplifying the portfolio selection problem. His original mean-variance analysis presented difficulties in implementation: to find a

mean-variance efficient portfolio, one needs to calculate the variance-covariance matrix with $N(N-1)/2$ elements. Thus, a reasonably sized portfolio of 100 securities requires the daunting task calculating 4,950 variances or covariances. Markowitz suggested a possible solution to this problem by proposing a "single index model" (now referred to in the literature as a one-factor model). Indeed, it was this idea that involved William Sharpe with Markowitz and put Sharpe on a line of research that culminated in his version of CAPM.

The other paper which motivated researchers is Franco Modigliani and Merton Miller's classic 1958 analysis, "The Cost of Capital, Corporation Finance, and the Theory of Investment." In their original analysis, they explore the connections between a firm's capital structure and its cost of capital or discount rate. The absence of a theory for determining the correct discount rate provided the impetus for Jack Treynor to develop the first truly theoretical analysis for determining the discount rate.

FOUR ECONOMISTS IN SEARCH OF A MODEL

In reviewing the literature, it appears that Jack Treynor developed the earliest version of the CAPM. Jack Treynor attended Haverford College in the early 1950s. He notes that his "real love was physics."^{vi} Unfortunately, the physics department consisted of only two professors, one of whom was blind and the other one about to retire. Rethinking his choice of majors, he chose mathematics. After completing his undergraduate studies, Treynor attended Harvard Business School where he was awarded an MBA in 1955. "At Harvard Business School I hadn't begun to think about the CAPM problem except that I was dissatisfied with the answers of finance guys, especially the corporate finance guys, were giving me for the choice of discount rate for evaluating long-term corporate

projects". In 1958, during a summer vacation, Treynor read Modigliani and Miller's paper. He returned from the vacation with 44 pages of mathematical notes – notes which eventually evolved into a paper entitled "Market Value, Time, and Risk," which he never published. Treynor believes he first showed his paper to John Lintner at Harvard. "He was the only economist I knew, which is why I gave him the paper. He didn't give much encouragement. I suppose my paper seemed like a bunch of gobbledygook to John." Interestingly, Lintner then published his version of the CAPM several years later.

In time, Treynor's paper found its way to Merton Miller who then sent it along to Franco Modigliani at the Massachusetts Institute of Technology (MIT). Eventually, Modigliani called Treynor and invited him to lunch. Treynor recalls that Modigliani said, "Merton gave me your paper, I've read it and frankly you need to study economics." Treynor then took a sabbatical from Arthur D. Little, where he was working at the time, and studied economics at MIT. While at MIT, Modigliani suggested that Treynor split his paper into two parts. The first paper, written in 1962 and published in 1999, became "Toward a Theory of Market Value of Risky Assets." The second paper, written in 1963 and never published, was called "Implications for the Theory of Finance". Treynor observes, "The second paper was a failure. It wasn't right. But the first paper was the CAPM. So basically Franco rescued the part of paper that was valid from the rest." Interestingly, the second paper was later reworked with Fischer Black and published in 1976 as "Corporate Investment Decisions."

After leaving MIT and returning to Arthur D. Little, Treynor received a call from Modigliani telling him that William Sharpe was working on a capital asset pricing model. Modigliani suggested that Treynor and Sharpe exchange papers, which they did. At this point, Treynor made a fateful decision that cost him the Noble Prize. He recalls, "I thought that if Sharpe was going to publish, what's the point of my publishing my paper?"

William Sharpe was born June 16, 1934 in Boston. He attended the University of California at Los Angeles where he earned three degrees in economics: Bachelor of Arts in 1955, a Masters of Arts in 1956 and a doctorate in 1961. After completing his master's degree and a tour in the army, Sharpe took a job as an economist at the RAND Corporation and began his Ph.D. studies. Sharpe took finance as one of his fields of

specialization. Here, he first studied the work of Harry Markowitz. Fortunately, Markowitz was working at RAND when Sharpe joined the think tank. At the suggestion of one of his professors, Sharpe asked Markowitz if he had any ideas for a dissertation topic. In his Noble Prize autobiography, Sharpe recalls, "He had, and I proceeded to work closely with him on the topic *Portfolio Analysis Based on a Simplified Model of the Relationships Among Securities*. Although Harry was not on my committee, he filled a role similar to that of dissertation advisor. My debt to him is truly enormous. The dissertation was approved in 1961, at which time I received the PhD degree."^{lvii} In the final chapter of his dissertation, Sharpe developed the first draft of his capital asset pricing model which features the now famous security market line – a positively sloped straight line depicting the relationship between expected return and beta. In 1961, Sharpe began teaching finance at the University of Washington. While there, he began reworking the final chapter of his dissertation. He attempted to publish his analysis in the *Journal of Finance*. Initially, the paper was rejected. A referee deemed the assumptions of his analysis too restrictive and the results "uninteresting" (French, 2003, p.68). Eventually, the *Journal* changed editors and published his paper in 1964.

The third individual credited with developing CAPM was John Lintner. Born in 1916, Lintner received his undergraduate degree from the University of Kansas. He started his graduate work at Harvard in 1940 at the age of 24 after spending two years in a sanatorium recuperating from tuberculosis. In 1945, he completed a dissertation entitled "Tax Restrictions on Financing Business Expansion." In his book, *Fischer Black and the Revolutionary Idea of Finance* (2005), Perry Mehrling argues that Lintner's analysis was inspired by the Modigliani and Miller paper, just like Treynor had been. Clearly, an examination of Lintner's earlier research reveals an interest in corporate finance. For example, after CAPM research, Lintner's most famous paper is arguably his 1956 empirical study of corporate dividend policies. Indeed, Mehrling argues that Lintner believed that Modigliani and Miller's analysis was wrong. Specifically, Lintner hoped to refute their theory of an optimal capital structure by developing a theory for valuing risky assets – a capital asset pricing model (Mehrling, 2005, ch.3). While Mehrling makes a plausible case for Lintner's independent development of CAPM, it is important to remember that Lintner saw Treynor's earliest draft of CAPM in 1960 or 1961—at least four years before Lintner's

own version of the model was published. (In the Mehta interview, Treynor says he believes this paper was typed in 1960, but he is not certain.) Did Treynor feel that Lintner stole his work? If so, he has never stated so publicly. How closely do the two papers resemble each other? In fairness to Lintner, his 1965 papers are the most mathematically impressive of all the models published. In them, he provides numerous proofs and analyzes a variety of special cases where his model still applies.

While Treynor never felt compelled to compare his model with Lintner, Lintner did not hesitate to compare his own work with the then only published competitor William Sharpe. Lintner felt that his model was different and more general than Sharpe's model. For a short time, at least, he convinced Sharpe also. In his *Journal of Finance* "Reply," Sharpe agrees that conflicts exist between their models and that Lintner's analysis "supercedes" his model (Fama, 1968, p. 29). A closer examination of the two models by Eugene Fama (1968), however, reveals that "their general models represent equivalent approaches to the problem of capital asset pricing under uncertainty" (Fama, 1968, p.40). Fama notes, "Unfortunately, Sharpe puts the major results of his paper in his footnote 22" (Fama (1968), p.37). Like Treynor, it seems, Sharpe failed to fully appreciate the significance of his analysis. In the Mehta interview, Treynor notes, "We can look back now and talk about the significance of the CAPM, but if it has any real significance, it wasn't evident at the time to anybody..."

The last to publish the CAPM was Jan Mossin in 1966. Born in Oslo, Norway in 1936, Mossin graduated from the Norwegian School of Economics and Business in 1959. He did his graduate studies in economics at the Carnegie Institute of Technology (now Carnegie Mellon University) in Pittsburgh. In his studies, he gravitated toward the study of risk in financial markets. In the last chapter of his dissertation, "Studies in the Theory of Risk Bearing," contains a chapter that is the basis of his CAPM analysis. Mossin was quick to realize the importance of his work because he published his paper two years before completing his thesis in 1968. Once again, it is difficult to pin down exactly when he began work on CAPM and what he knew about the other three men's work. As noted on the first page of his paper, the revised manuscript was received by *Econometrica* in December, 1965. Assuming, at minimum, a one year's lag between originally submitting the paper to the journal and writing his first draft of the model, we can safely conclude that

Mossin began work on CAPM no later than 1964 -- the year Sharpe published his first paper. In fact, Mossin cites Sharpe's 1964 paper and critiques "his lack of precision in the specification of equilibrium conditions" (Mossin, 1966, p. 769.)^{lviii}

In comparing the Treynor, Lintner, Sharpe and Mossin models, it takes some time before it is apparent that they are all talking about the same issue. Indeed, the equivalence of Mossin's model to the three other's work was not demonstrated until 1970 (Stone, 1970). One simple reason for this difficulty is that the mathematical notation in the papers are inconsistent; only a very close reading of the texts reveals that the key equations are essentially the same. At a more profound level, each paper reveals a different point of view. For example, Treynor was originally interested in capital budgeting/ cost-of-capital issues. Hence, his emphasis on Modigliani and Miller's famous Proposition I -- that the capital structure of a firm is irrelevant to its value. Lintner's approach appears to be motivated by the concern of a firm issuing equities. Unlike Modigliani and Miller, Lintner remained convinced that a firm's financial policy mattered a great deal. Sharpe approached the problem via optimum portfolio selection, inspired, no doubt, by the work of his mentor Harry Markowitz. Similarly, Mossin's work was grounded in portfolio theory but with a greater interest and emphasis on specifying equilibrium conditions in the asset market.

CONCLUSIONS

The 1990 Noble Prize in economic science was awarded to Harry Markowitz, Merton Miller, and William Sharpe for their contributions in financial theory. Until that moment, finance received little respect as a valid area of economic research. Sadly, the Noble Prize is not awarded posthumously. If it were, John Lintner, who died in 1983, and Jan Mossin, who died in 1987, would have been considered, most certainly, for the Noble Prize. Sadly, the first man to truly write down the capital asset pricing model failed to appreciate the significance of his model. By not publishing his work, Treynor effectively took himself out of contention for the award. Recently, his work was finally published (Korajczyk, 1999) and is now being acknowledged by scholars in the field. It remains to be seen if his momentous contribution will be acknowledged by a wider audience.

REFERENCES

- Fama, E. (1968). Risk, Return, and Equilibrium: Some Clarifying Comments. *Journal of Finance*, 23, 29-40.
- French, C.W. (2003). The Treynor Capital Asset Pricing Model. *Journal of Investment Management*, 1(2), 60-72.
- Lintner, J. (1956). Distribution of Incomes of Corporations among Dividends, Retained Earnings, and Taxes. *American Economic Review*, 46(2), 97-113.
- Lintner, J. (1965a). The Valuation of Risk Assets and the Selection of Risky Investments in Stock Portfolios and Capital Budgets. *Review of Economics and Statistics*, 73, 13-37.
- Lintner, J. (1965b). Security Prices, Risk and Maximal Gains from Diversification. *Journal of Finance*, 20, 587-615.
- Markowitz, H. (1952). Portfolio Selection. *Journal of Finance*, 12, 71-91.
- Markowitz, H. (1959). *Portfolio Selection: Efficient Diversification of Investments*. New York: John Wiley & Sons.
- Mehrling, P. (2005) *Fischer Black and the Revolutionary Idea of Finance*. Hoboken: John Wiley & Sons.
- Mehta, N. (2005). Jack Treynor: The FEN Interview. Retrieved November 26, 2006, from http://www.fenews.com/fen49/one_on_one.html.
- Modigliani, F. & Miller, M. (1958). The Cost of Capital, Corporation Finance, and the Theory of Investment. *American Economic Review*, 48 (3), 261-297.
- Mossin, J. (1966). Equilibrium in a Capital Asset Market. *Econometrica*, 34 (4), 768-83.
- Sharpe, W.F. (1964). Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk. *Journal of Finance*, 19(3), 425-42.
- Sharpe, W.F. (1966). Reply. *Journal of Finance*, 20(4), 743-744.
- Stone, B. K. (1970). *Risk, Return, and Equilibrium: A General Single-Period Theory of Asset Selection and Capital Market Equilibrium*. Cambridge: MIT Press.
- Tobin, J. (1958). Liquidity Preference as Behavior toward Risk. *Review of Economic Studies*, 67, 65-86.
- Treynor, J. L. (1999). Toward a Theory of Market Value of Risky Assets. Robert Korajczyk (Ed.), *Asset Pricing and Portfolio Performance*. London: Risk Books.
- Treynor, J. L. & Black, F. (1976). Corporate Investment Decisions. *Modern Developments in Financial Management*. Stewart C. Myers (Ed.), New York, Praeger.

^{lvi} All quotes by Treynor are from the Mehta (2005) interview.

^{lvii} Sharpe's dissertation advisor was Armen Alchian. His autobiography is available online at: http://nobelprize.org/nobel_prizes/economics/laureates/1990/sharpe-autobio.html.

^{lviii} It is interesting to note that the title of Mossin's dissertation chapter is exactly the same as his *Econometrica* paper. Further, there are only eight references in that chapter including Markowitz's book, Sharpe's 1964 paper, and Tobin's Liquidity Preference paper.

Edward J. Sullivan is an associate professor of business and economics at Lebanon Valley College. He earned his Ph.D. in Economics at The Pennsylvania State University. His research interests include monetary and financial economics.