A.D. Roy: THE FORGOTTEN FATHER OF PORTFOLIO THEORY

Edward J. Sullivan, Lebanon Valley College

ABSTRACT

In 1952, Harry Markowitz published a ground-breaking paper on portfolio selection. In that article, he proposes that optimal portfolios could be constructed using expected return and the variance of the return. About three months later, A. D. Roy also published a paper that argues for portfolio selection using the mean-variance criterion. In essence, these economists developed the same theory of portfolio selection at the same point in time, independently of each other. Yet, in 1990, Harry Markowitz was awarded the Nobel Prize in Economics for his development of portfolio theory, while Roy received no such honor. This paper explores the contributions of Roy in detail and compares them to the Markowitz analysis. Although Roy's work still remains a footnote in the development of portfolio theory, this paper offers a new appreciation for the forefather of portfolio theory.

Introduction

In 1952, Harry Markowitz published a ground-breaking paper on portfolio selection. In that article, he proposes that optimal portfolios could be constructed using expected return and the variance of the return. About three months later, A. D. Roy also published a paper that argues for portfolio selection using the mean-variance criterion. In essence, these economists developed the same theory of portfolio selection at the same point in time, independently of each other. Yet, in 1990, Harry Markowitz was awarded the Nobel Prize in Economics for his development of portfolio theory, while Roy received no such honor. This paper explores the contributions of Roy in detail and compares them to the Markowitz analysis. Although Roy's work still remains a footnote in the development of portfolio theory, this paper offers a new appreciation for the forefather of portfolio theory.

The Early Beginnings Of Portfolio Theory

The notion that asset diversification reduces risk is ancient and can be traced as far back as the Talmud which states, "A man should always keep his wealth in three forms: one third in real estate, another in merchandise, and the remainder in liquid assets."[1] Somewhat more recently, in 1738, Daniel Bernoulli observed "it is advisable to divide goods which are exposed to some small danger into several small portions rather than to risk them all together."[2] Arguably, however, it was not until 1935 that the future Nobel laureate J.R. Hicks offered some early direction for modern portfolio theory. Although his research was more concerned with explaining the demand for money, he points out two important considerations for modeling risk. Hicks writes, "The risk-factor comes into our problem in two ways: First, as affecting the expected period of investment, and second, as affecting the expected net yield of investment."[3] Regarding Hick's first point, both Markowitz (1952) and Roy (1952) emplace their analyses in a one-period investment horizon. Second, and even more relevant to modern portfolio theory, is Hicks's suggestion of using an expected value calculated with subjective probabilities. Hicks continues, "It is convenient to represent these probabilities to oneself, in statistical fashion, by a mean value, and some measure of dispersion."[4] Clearly, Hicks comes very close to articulating a mean-variance solution. Crucially, and unlike Roy or Markowitz, Hicks does not develop this line of reasoning nor does he suggest the particular use of variance or standard deviation as that measure of risk. Nonetheless, Hicks's suggestion anticipates the work of Markowitz and Roy.[5]

Like Hicks, and later James Tobin (1958), Jacob Marschak (1938) was interested in the demand for money and how it related to the demand for other assets. In developing his analysis, Marschak makes a significant conceptual leap: he employs mean and standard deviations for modeling risk. In this

instance, however, the analysis centers upon modeling uncertainty in production and consumption but not, however, portfolio selection. Curiously, Markowitz does not cite Marschak in his original work. Since Marschak was Markowitz's dissertation advisor, it is very likely he knew of his mentor's approach. However, Markowitz attributes his insight to the reading of Williams's book (1938) *The Theory of Investment Value*.[6] In that book, Williams presents the now well-known dividend discount model which states that the price of a stock is equal to the present value of a firm's expected dividends. While Williams advocates selecting assets with the highest expected returns and reducing risk by diversifying among those assets, he implicitly assumes that returns are independent. Markowitz (1952), of course, clearly recognizes that the returns on securities are highly correlated, and this fact is the entrée for his analysis. Roy, on the other hand, does cite Marschak's later paper (1950) which deals with the problem of choice under uncertainty. Roy is critical of Marschak's approach because, while it explains the phenomenon of diversification, it ignores an objective function that maximizes expected return. Thus, Roy and Markowitz set out to build a model that maximizes expected return subject to a risk measure which both economists define as the variance or standard deviation of returns.

The Contributions Of A Forgotten Founder

Andrew Donald Roy was born June 28, 1920, the elder son of Donald Whatley Roy, a physician. Shortly before the outbreak of World War II, he studied mathematics at Cambridge University, England. With the outbreak of World War II in Europe, Roy volunteered for military service in October, 1939. During the war, he served overseas in the Royal Artillery and fought in the Burma campaign at the Battle of Imphal. His military service took its toll: Roy contracted epidemic jaundice and suffered a nervous breakdown which resulted in depression and mild schizophrenia.[7] After the war, a healthier Roy returned to Cambridge to study economics. He completed his bachelor's degree in 1948 and married Katherine Juliet Grove-White (b. September 15, 1922, d. July 24, 2001). They had one son, Donald James Roy. In 1950, Roy completed his master's degree. In the following year, Roy obtained a Lectureship in Economics and Politics at Sidney Sussex College in Cambridge University – a position he held until 1964. While teaching there, Roy (1952) made his key contribution to portfolio theory by writing "Safety First and the Holding of Assets." In 1964, he left the academy and became a civil servant. Roy held variety of positions in the Treasury, the Department of Trade & Industry, Ministry of Defense (where he was the Assistant Under-Secretary of State), and, finally, he moved to the Department of Health & Social Security. This change of careers steered his research interests into largely macroeconomic issues, such as labor productivity, and away from portfolio theory.[8] Roy died March 12, 2003 of heart disease.

The history of scientific thought reveals a number of instances when individuals, working independently, developed the same ideas or theories. Clearly, the most famous case involves the development of calculus by Isaac Newton and Wilfred Leibniz. Within financial economics, the derivation of the capital asset pricing model (CAPM) by John Lintner, Jan Mossin, William Sharpe and Jack Treynor is a similar tale. What motivated Roy and Markowitz to consider the portfolio selection problem at the same time? Not surprisingly, both men were dissatisfied with the simple rule of maximizing expected return. Instead, they both sought to reconcile maximizing return with asset diversification. While portfolio diversification, as a practice, can be traced back at least to the mid 19th century, when it was practiced by British investment trusts, no rigorous argument had been put forth to explain it. Instead, diversification was seen as a useful rule of thumb to be applied in an *ad hoc* manner. Markowitz writes, "Diversification is both observed and sensible; a rule which does not imply the superiority of diversification must be rejected both as a hypothesis and as a maxim."[9] Along similar lines, Roy notes, "the principle of maximising expected return does not explain the well-known phenomenon of the diversification of resources among a wide range of assets."[10]

In comparing the papers of Markowitz and Roy, the similarities are, at times, striking. For example, the first three numbered equations are virtually the same, save for their choice of letters, to denote expected return. More importantly, however, is the key difference between them: Roy uses the Safety First principle as the guiding notion for his analysis. In formulating his model, he specifies that the expected return on an investment, *m*, should not fall below some disaster level, *d*. In turn, this leads him to develop his equations in order to estimate the probability of a disaster, i.e., the failure of an investment to yield some minimum rate of return. In essence, then, Roy's statement of the problem can be restated as maximizing:

$$(m - d)/\sigma$$

where σ denotes the standard deviation of return.[11] Roy's use of the Safety First principle was, at that time, unusual for an economist and probably influenced by his unfortunate military experience. In employing this principle, he writes about "avoiding the known rocks of uncertain position or with deploying forces so that, if there is an ambush round the next corner, total disaster is avoided. If economic survival is always taken for granted, the rules of behaviour applicable in an uncertain and ruthless world cannot be discovered."[12]

In deriving his model, Roy, like Markowitz, graphically depicts the now-familiar mean-variance frontier, which identifies the risk-return combinations available from holding different portions (weights) of assets. Interestingly, Roy does not emphasize the obvious implication of his diagram: that a higher expected return can be obtained only by assuming more risk (a higher variance). Instead, he chooses to demonstrate how an investor could derive an upper-bound estimate for the probability of a disaster occurring (a return lower than some value *d*). Also of note is that Roy anticipates the commonly adopted form of mapping the frontier by putting the expected return on the *y*-axis and variance (or standard deviation) on the *x*-axis. In his original and subsequent papers, Markowitz reverses the variables on the axes.

In a section of the paper entitled, "The optimum distribution of resources among n-assets," Roy tackles the diversification problem. Specifically, Roy sets out to determine the optimal amounts to invest in each asset (the portfolio weights). Hence, his "optimal portfolio" differs from the Markowitz model for several reasons. First, by "optimal", Roy means any portfolio that offers an expected return above some level *d*, given some level of risk. Second, his optimal portfolio is one which provides an upper-bound probability of disaster. For Markowitz, any portfolio that offers the highest expected return for a given level of risk (one that lies on the efficient frontier) is judged optimal. In reading the papers of Roy and Markowitz, their divergence in analysis is one born of emphasis. For Markowitz, diversification is shown to reduce the variance of a portfolio's return. For Roy, diversification is a tool for reducing the probability of disaster.

Perhaps the most crucial insight of mean-variance analysis is its demonstration of the importance of return covariances. Through his equations, Markowitz conveys the impact of covariances on a portfolio's variance: the lower their values, the lower the variance. Because of his emphasis on determining a probability for disaster, Roy downplays this role for covariance. Nonetheless, in a section of the paper entitled, "A detailed examination of the particular case of two assets," Roy develops another argument familiar to portfolio theorists – that the position of the mean-variance frontier varies with correlation coefficient values. Although he does not develop this argument, his Figure 3 demonstrates that the efficient frontier becomes linear when the correlation value is negative one.[13]

When comparing the original analyses of Markowitz and Roy, can one be judged "better" than the other? In this context, better can be construed as a more general analysis; specifically, an analysis with fewer

constraints or assumptions. An argument could be forged that Roy's analysis is broader in scope because he allows an investor to short sell securities. Markowitz, on the other hand, allows only non-

negative positions in investments. Offsetting this degree-of-freedom is Roy's requirement that a portfolio satisfy a minimum expected disaster return. In one sense, this slightly complicates the analysis and sends Roy off in search of disaster probabilities. Aesthetically, Markowitz serves us with a pristine version of the mean-variance model. Although the import of their papers are the same, history pronounces Markowitz the clear winner. Today, Markowitz's name is synonymous with portfolio theory.

Conclusions

Like Markowitz, Roy understood that maximizing expected return was an incomplete or unsatisfactory way to model portfolio choice. He recognized that a better theory was needed to provide a convincing explanation for diversification. In his conclusion, Roy writes, "We have shown why it is a good thing for the property owner to disperse widely both his assets and liabilities, a principle that is always accepted in practice but rarely explained satisfactorily on relatively simple theoretical assumptions."[14] Curiously, Roy was unimpressed by his own paper and that of Markowitz. In a private communication with me, Professor Richard Brealey of the London Business School recalls a luncheon with Roy. Brealey writes, "The interesting thing is how little regard Roy had for his paper. I wonder whether things would have been different if he had worked on it at Chicago and [the] Rand Corp." In other words, Brealey believes that Markowitz received quite a bit of encouragement while writing his dissertation at the University of Chicago and, later, while working at the Rand Corporation; Roy labored in obscurity.

Still, the question remains: why did Roy view his work as unimpressive? Excluding the problem of calculating the variance-covariance matrix, which at the dawn of the computer age seemed daunting, both men were troubled by the notion of incorporating subjective probabilities into the analysis.[15] Probabilities play a crucial role in their theory: this is how expected returns and variances are calculated. Roy proposes that these probabilities come from "both introspection and observation".[16] Similarly, Markowitz suggests that they are derived by "observation and experience."[17] Probability formulation weighed on the minds of both men. Markowitz acknowledges that, "This paper does not consider the difficult question of how investors do (or should) form their probability beliefs."[18] Roy's misgivings are revealed in his review of Markowitz's 1959 book *Portfolio Selection*. Roy writes,

> Before probability concepts can help us with the selection of our investments, we must be able to translate our expectations about future yields and process into subjective joint probability distributions. While Dr. Markowitz emphasizes that past experience is unlikely to be a very good guide to future performance, he gives no clear indication of how either we, or our investment advisors, can provide ourselves with sufficiently precise or generally agreed expectations to merit their processing in an elaborate way… Dr. Markowitz presses for a precision in the specification both of motives and of expectations which it seems unlikely that any existing investor can reasonably be expected to possess or to express coherently.[19]

Roy's commentary reveals a skepticism regarding the implementation of their theory. Perhaps this explains why he chose not to pursue portfolio theory much further.

In 1990, Harry Markowitz was awarded the Nobel Prize in economics; Roy received no such acclaim. Toward the end of his life, Markowitz offered this final assessment:

> Comparing the two articles, one might wonder why I got a Nobel Prize for mine and Roy did not for his… the more likely reason was visibility to the Nobel Committee in 1990. Roy's 1952 article was his first and last article in finance. He made this one tremendous contribution and then disappeared from the field, whereas I wrote two books and an assortment of articles in the field. Thus, by 1990 I was still active and Roy may have vanished from the Nobel Committee's radar screen.[20]

Markowitz's observation is well-taken. After the publication of his 1952 paper, Roy's research slowly drifted away from the portfolio selection problem. In hindsight, another avenue of research leading to greater acclaim now appears obvious. By employing a safety-first criterion in his analysis, Roy anticipated the value-at-risk approach to portfolio selection used today. Had he chosen to pursue his safety-first analysis, it seems unlikely that the Nobel Committee would have missed his contribution to financial economics. Today, Markowitz is still largely credited with developing the mean-variance model. Yet, as this analysis reveals, Roy deserves equal credit for establishing the foundations of modern portfolio theory.

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[1] Talmud, Baba Metzia ("Middle Gate"), 42a.
[2] Bernoulli (1954), p.30.
[3] Hicks (1935), 7.
[4] Hicks (1935), 8.
[5] Neither Roy nor Markowitz cites the Hick's 1938 paper. However, Markowitz (1952) does cite *Value and Capital* (1939), where Hicks applies the notion of expected profit to a firm rather than a portfolio. Roy does cite Marschak's 1950 paper but not his earlier work.
[6] For more on Markowitz, please see his autobiography at www.nobelprize.org.
[7] The author thanks the Sidney Sussex College Archivist Nicholas Rogers who made provided these details from the College register. Regarding the diagnosis Roy received at that time, one wonders if it now be categorized as post-traumatic distress disorder.
[8] See, for example, Roy (1982) and (1983).
[9] Markowitz (1952), 77.
[10] Roy (1952), 431.
[11] Students of portfolio theory will notice that this ratio is reminiscent of the Sharpe ratio which measures performance as the ratio of the portfolio

risk premium, defined as the difference between the portfolio return and the risk-free rate, over the portfolio return's standard deviation.

[12] Roy (1952), 432.

[13] This graph is now standard in investment textbooks. See for example, Jordan and Miller (2008), 374, Figure 11.5.

[14] Roy (1952), 447.

[15] 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.

[16] Roy (1952), 432.

[17] Markowitz (1952), 77.

[18] Markowitz (1952), 81, fn. 7.

[19] Roy (1961), 99-100.

[20] Markowitz (1999), 6. Roy (1956) did produce one more paper involving decision making under uncertainty. However, the paper does not address the portfolio selection problem.

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.