The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 1990
Harry M. Markowitz, Merton H. Miller, William F. Sharpe

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THIS YEAR'S LAUREATES ARE PIONEERS IN THE THEORY OF FINANCIAL ECONOMICS AND CORPORATE FINANCE

The Royal Swedish Academy of Sciences has decided to award the 1990 Alfred Nobel Memorial Prize in Economic Sciences with one third each, to

Professor **Harry Markowitz**, City University of New York, USA,
Professor **Merton Miller**, University of Chicago, USA,
Professor **William Sharpe**, Stanford University, USA,

for their pioneering work in the theory of financial economics.

Harry Markowitz is awarded the Prize for having developed the theory of portfolio choice;
William Sharpe, for his contributions to the theory of price formation for financial assets, the so-called, *Capital Asset Pricing Model* (CAPM); and
Merton Miller, for his fundamental contributions to the theory of corporate finance.

Summary
Financial markets serve a key purpose in a modern market economy by allocating productive resources among various areas of production. It is to a large extent through financial markets that saving in different sectors of the economy is transferred to firms for investments in buildings and machines. Financial markets also reflect firms' expected prospects and risks, which implies that risks can be spread and that savers and investors can acquire valuable information for their investment decisions.

The first pioneering contribution in the field of financial economics was made in the 1950s by Harry Markowitz who developed a theory for households' and firms' allocation of financial assets under uncertainty, the so-called theory of portfolio choice. This theory analyzes how wealth can be optimally invested in assets which differ in regard to their expected return and risk, and thereby also how risks can be reduced.

A second significant contribution to the theory of financial economics occurred during the 1960s when a number of researchers, among whom William Sharpe was the leading figure, used Markowitz's portfolio theory as a basis for developing a theory of price formation for financial assets, the so-called Capital Asset Pricing Model, or CAPM.

A third pioneering contribution to financial economics concerns the theory of corporate finance and the evaluation of firms on markets. The most important achievements in this field were made by Merton Miller, initially in collaboration with **Franco Modigliani** (who received the Alfred Nobel Memorial Prize in Economic Sciences in 1985 mainly for other contributions). This theory explains the relation (or lack of one) between firms' capital asset structure and dividend policy on one hand and their market value on the other.

Harry M. Markowitz

The contribution for which Harry Markowitz now receives his award was first published in an essay entitled "Portfolio Selection" (1952), and later, more extensively, in his book, *Portfolio Selection: Efficient Diversification* (1959). The so-called theory of portfolio selection that was developed in this early work was originally a normative theory for investment managers, *i.e.*, a theory for optimal investment of wealth in assets which differ in regard to their expected return and risk. On a general level, of course, investment managers and academic economists have long been aware of the necessity of taking returns as well as risk into account: "all the eggs should not be placed in the same basket". Markowitz's primary contribution consisted of developing a rigorously formulated, operational theory for portfolio selection under uncertainty - a theory which evolved into a foundation for further research in financial economics.

Markowitz showed that under certain given conditions, an investor's portfolio choice can be reduced to balancing two dimensions, *i.e.*, the expected return on the portfolio and its variance. Due to the possibility of reducing risk through diversification, the risk of the portfolio, measured as its variance, will depend not only on the individual variances of the return on different assets, but also on the pairwise covariances of all assets.

Hence, the essential aspect pertaining to the risk of an asset is not the risk of each asset in isolation, but the contribution of each asset to the risk of the aggregate portfolio. However, the "law of large numbers" is not wholly applicable to the diversification of risks in portfolio choice because the returns on different assets are correlated in practice. Thus, in general, risk cannot be totally eliminated, regardless of how many types of securities are represented in a portfolio.

In this way, the complicated and multidimensional problem of portfolio choice with respect to a large number of different assets, each with varying properties, is reduced to a conceptually simple two-dimensional problem - known as mean-variance analysis. In an essay in 1956, Markowitz also showed how the problem of actually calculating the optimal portfolio could be solved. (In technical terms, this means that the analysis is formulated as a quadratic programming problem; the building blocks are a quadratic utility function, expected returns on the different assets, the variance and covariance of the assets and the investor's budget restrictions.) The model has won wide acclaim due to its algebraic simplicity and suitability for empirical applications.

Generally speaking, Markowitz's work on portfolio theory may be regarded as having established financial micro analysis as a respectable research area in economic analysis.

William F. Sharpe

With the formulation of the so-called Capital Asset Pricing Model, or CAPM, which used Markowitz's model as a

"positive" (explanatory) theory, the step was taken from micro analysis to market analysis of price formation for financial assets. In the mid-1960s, several researchers - independently of one another - contributed to this development. William Sharpe's pioneering achievement in this field was contained in his essay entitled, *Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk* (1964).

The basis of the CAPM is that an individual investor can choose exposure to risk through a combination of lending-borrowing and a suitably composed (optimal) portfolio of risky securities. According to the CAPM, the composition of this optimal risk portfolio depends on the investor's assessment of the future prospects of different securities, and not on the investors' own attitudes towards risk. The latter is reflected solely in the choice of a combination of a risk portfolio and risk-free investment (for instance treasury bills) or borrowing. In the case of an investor who does not have any special information, *i.e.*, better information than other investors, there is no reason to hold a different portfolio of shares than other investors, *i.e.*, a so-called market portfolio of shares.

What is known as the "beta value" of a specific share indicates its marginal contribution to the risk of the entire market portfolio of risky securities. Shares with a beta coefficient greater than 1 have an above-average effect on the risk of the aggregate portfolio, whereas shares with a beta coefficient of less than 1 have a lower than average effect on the risk of the aggregate portfolio. According to the CAPM, in an efficient capital market, the risk premium and thus also the expected return on an asset, will vary in direct proportion to the beta value. These relations are generated by equilibrium price formation on efficient capital markets.

An important result is that the expected return on an asset is determined by the beta coefficient on the asset, which also measures the covariance between the return on the asset and the return on the market portfolio. The CAPM shows that risks can be shifted to the capital market, where risks can be bought, sold and evaluated. In this way, the prices of risky assets are adjusted so that portfolio decisions become consistent.

The CAPM is considered the backbone of modern price theory for financial markets. It is also widely used in empirical analysis, so that the abundance of financial statistical data can be utilized systematically and efficiently. Moreover, the model is applied extensively in practical research and has thus become an important basis for decision-making in different areas. This is related to the fact that such studies require information about firms' costs of capital, where the risk premium is an essential component. Risk premiums which are specific to an industry can thus be determined using information on the beta value of the industry in question.

Important examples of areas where the CAPM and its beta coefficients are used routinely, include calculations of costs of capital associated with investment and takeover decisions (in order to arrive at a discount factor); estimates of costs of capital as a basis for pricing in regulated public utilities; and judicial inquiries related to court decisions regarding compensation to expropriated firms whose shares are not listed on the stock market. The CAPM is also applied in comparative analyses of the success of different investors.

Along with Markowitz' portfolio model, the CAPM has also become the framework in textbooks on financial economics throughout the world.

Merton Miller
While the model of portfolio choice and the CAPM focus on financial investors, Merton Miller - initially in collaboration with Franco Modigliani - established a theory for the relation, via the capital market, between the capital asset structure and dividend policy of production firms on one hand and firms' market value and costs of

capital on the other.

The theory is based on the assumption that stockholders themselves have access to the same capital market as firms. This implies that within the limits of their asset portfolios, investors themselves can find their own balance between returns and risk. As a result, firms do not have to adjust their decisions to different stockholders' risk preferences. Corporate managers can best safeguard the interests of stockholders simply by maximizing the firm's net wealth. In other words, it is not in the investors' interest that firms reduce risks through diversification, as the stockholders can accomplish this themselves through their own portfolio choice.

The basic model was formulated in Miller's and Modigliani's essay entitled "The Cost of Capital, Corporation Finance and the Theory of Investment" (1958); it was followed by two other important essays in 1963 and 1966. Using this basic model, Miller and Modigliani derived two so-called invariance theorems, now known as the MM theorems.

The first invariance theorem states that (i) the choice between equity financing and borrowing does not affect a firm's market value and average costs of capital, and (ii) the expected return on a firm's shares (and hence the cost of equity capital) increases linearly with the ratio between the firm's liabilities and equity, *i.e.*, the well-known leverage effect. The second invariance theorem states that under the same assumptions, a firm's dividend policy does not affect its market value.

In retrospect, the intuition underlying the MM theorems appears simple. The effects of every change in a firm's financial asset structure on the stockholders' portfolios can be "counteracted" by changes in the stockholders' own portfolios. Investors are quite simply not prepared to "pay extra" for an "indirect" loan from a firm which increases its borrowing when the investor himself can borrow on equal terms on the market.

The intuition behind MM's second invariance theorem, i.e., that dividend policy does not affect the market value of the firm in equilibrium, is also apparent in retrospect. An additional dollar in dividends lowers the net wealth of the firm by one dollar which, in efficient stock markets, implies that the stockholders' units are worth one dollar less. This relation is not quite as simple as it seems. As in the case of the first invariance theorem, the mechanism which generates this conclusion is that investors in the capital market can "counteract" changes in firms' financial structure.

Both of the invariance theorems were originally derived under highly simplified assumptions. Therefore, subsequent research has to a large extent dealt with the consequences of various deviations from the conditions on which the MM theorems were based. This research has been in progress since the mid-1960s, with Merton Miller as its leading figure.

Miller thus showed how the design of different tax structures affects the relation between firms' capital asset structure and market value, after taking into account the indirect market effects of taxes through equilibrium price formation on financial markets. Similarly, Miller analyzed the importance of bankruptcy costs for the relation between a firm's financial asset structure and dividend policy on one hand and its stock-market value on the other.

The main message of the MM theorems may be expressed as follows: if there is an optimal capital asset structure and dividend policy for firms, *i.e.*, if the asset structure and dividend policy affect a firm's market value, then this reflects the consequences of taxes or other explicitly identified market imperfections. The MM theorems have therefore become the natural basis, or norm of comparison for theoretical and empirical analysis in corporate finance. Merton Miller is the researcher who has dominated this analysis during the last two decades. He has thus made a unique contribution to modern theory of corporate finance.
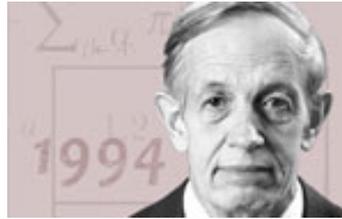
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