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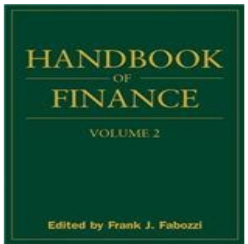

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Excerpt

Handbook of Finance

Investment Management and Financial Management, Volume II

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Chapter One

Portfolio Selection

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Abstract: The goal of portfolio selection is the construction of portfolios that maximize expected returns consistent with individually acceptable levels of risk. Using both historical data and investor expectations of future returns, portfolio selection uses modeling techniques to quantify "expected portfolio returns" and "acceptable levels of portfolio risk," and provides methods to select an optimal portfolio. It would not be an overstatement to say that modern portfolio theory has revolutionized the world of investment management. Allowing managers to quantify the investment risk and expected return of a portfolio has provided the scientific and objective complement to the subjective art of investment management. More importantly, whereas at one time the focus of portfolio management used to be the risk of individual assets, the theory of portfolio selection has shifted the focus to the risk of the entire portfolio. This theory shows that it is possible to combine risky assets and produce a portfolio whose expected return reflects its components, but with considerably lower risk. In other words, it is possible to construct a portfolio whose risk is smaller than the sum of all its individual parts.

Keywords: portfolio selection, modern portfolio theory, mean-variance analysis, utility function, efficient portfolio, optimal portfolio, covariance, correlation, portfolio diversification, beta, portfolio variance, feasible portfolio

In this chapter, we present the theory of portfolio selection as formulated by Markowitz (1952). This theory is also referred to as mean-variance portfolio analysis or simply *mean-variance analysis*.

SOME BASIC CONCEPTS

Portfolio theory draws on concepts from two fields: financial economic theory and probability and statistical theory. This section presents the concepts from financial economic theory used in portfolio theory. While many of the concepts presented here have a more technical or rigorous definition, the purpose is to keep the explanations simple and intuitive so the reader can appreciate the importance and contribution of these concepts to the development of modern portfolio theory.

Utility Function and Indifference Curves

In life there are many situations where entities (that is, individuals and firms) face two or more choices. The economic "theory of choice" uses the concept of a utility function developed by von Neuman and Morgenstern (1944), to describe the way entities make decisions when faced with a set of choices. A *utility function* assigns a (numeric) value to all possible choices faced by the entity. The higher the value of a particular choice, the greater the utility derived from that choice. The choice that is selected is the one that results in the maximum utility given a set of (budget) constraints faced by the entity.

In portfolio theory too, entities are faced with a set of choices. Different portfolios have different levels of expected return and risk. Also, the higher the level of expected return, the larger the risk. Entities are faced with the decision of choosing a portfolio from the set of all possible risk/return combinations: where return is a desirable which increases the level of utility, and risk is an undesirable which decreases the level of utility. Therefore, entities obtain different levels of utility from different risk/return combinations. The utility obtained from any possible risk/return combination is expressed by the utility function. Put simply, the utility function expresses the preferences of entities over perceived risk and expected return combinations.

A utility function can be expressed in graphical form by a set of indifference curves. Figure 1.1 shows indifference curves labeled [*u*.sub.1], [*u*.sub.2], and [*u*.sub.3]. By convention, the horizontal axis measures risk and the vertical axis measures expected return. Each curve represents a set of portfolios with different combinations of risk and return. All the points on a given indifference curve indicate combinations of risk and expected return that will give the same level of utility to a given investor. For example, on utility curve [*u*.sub.1], there are two points *u* and *u*', with *u* having a higher expected return than *u*', but also having a higher risk. Because the two points lie on the same indifference curve, the investor has an equal preference for (or is indifferent to) the two points, or, for that matter, any point on the curve. The (positive) slope of an indifference curve reflects the fact that, to obtain the same level of utility, the investor requires a higher expected return in order to accept higher risk.

For the three indifference curves shown in Figure 1.1, the utility the investor receives is greater the further the indifference curve is from the horizontal axis, because that curve represents a higher level of return at every level of risk. Thus, for the three indifference curves shown in the exhibit, [*u*.sub.3] has the highest utility and [*u*.sub.1] the lowest.

The Set of Efficient Portfolios and the Optimal Portfolio

Portfolios that provide the largest possible expected return for given levels of risk are called *efficient portfolios*. To construct an efficient portfolio, it is necessary to make some assumption about how investors behave when making investment decisions. One reasonable assumption is that investors are risk averse. A risk-averse investor is an investor who, when faced with choosing between two investments with the same expected return but two different risks, prefers the one with the lower risk.

In selecting portfolios, an investor seeks to maximize the expected portfolio return given his tolerance for risk. Alternatively stated, an investor seeks to minimize the risk that he is exposed to given some target expected return. Given a choice from the set of efficient portfolios, an *optimal portfolio* is the one that is most preferred by the investor.

Risky Assets versus Risk-Free Assets

A risky asset is one for which the return that will be realized in the future is uncertain. For example, an investor who purchases the stock of Pfizer Corporation today with the intention of holding it for some finite time does not know what return will be realized at the end of the holding period. The return will depend on the price of Pfizer's stock at the time of sale and on the dividends that the company pays during the holding period. Thus, Pfizer stock, and indeed the stock of all companies, is a risky asset.

Securities issued by the U.S. government are also risky. For example, an investor who purchases a U.S. government bond that matures in 30 years does not know the return that will be realized if this bond is held for only one year. This is because changes in interest rates in that year will affect the price of the bond one year from now and that will impact the return on the bond over that year.

There are assets, however, for which the return that will be realized in the future is known with certainty today. Such assets are referred to as risk-free or riskless assets. The risk-free asset is commonly defined as a short-term obligation of the U.S. government. For example, if an investor buys a U.S. government security that matures in one year and plans to hold that security for one year, then there is no uncertainty about the return that will be realized. (Note: Here "return" refers to the nominal return. The "real" return, which adjusts for inflation, is uncertain.) The investor knows that in one year, the maturity date of the security, the government will pay a specific amount to retire the debt. Notice how this situation differs for the U.S. government security that matures in 30 years. While the 1-year and the 30-year securities are obligations of the U.S. government, the former matures in one year so that there is no uncertainty about the return that will be realized. In contrast, while the investor knows what the government will pay at the end of 30 years for the 30-year bond, he does not know what the price of the bond will be one year from now.

MEASURING A PORTFOLIO'S EXPECTED RETURN

We are now ready to define the actual and expected return of a risky asset and a portfolio of risky assets.

Measuring Single-Period Portfolio Return

The actual return on a portfolio of assets over some specific time period is straightforward to calculate using the following:

[R.sub.p] = [*w*.sub.1] [*R*.sub.1] + [*w*.sub.2] [*R*.sub.2] + ... + *[w.sub.G] [R.sub.G]* (1.1)

where

[R.sub.p] = rate of return on the portfolio over the period

[R.sub.g] = rate of return on asset g over the period

[w.sub.g] = weight of asset g in the portfolio (that is, market value of asset g as a proportion of the market value of the total portfolio) at the beginning of the period

G = number of assets in the portfolio

In shorthand notation, equation (1.1) can be expressed as follows:

[R.sub.p] = *[G*.summation over (*g*=1)] *[w.sub.g] [R.sub.g]* (1.2)

Equation (1.2) states that the return on a portfolio (*[R.sub.p]*) of *G* assets is equal to the sum over all individual assets' weights in the portfolio times their respective return. The portfolio return *[R.sub.p]* is sometimes called the holding period return or the ex post return.

For example, consider the following portfolio consisting of three assets:

Market Value at the Beginning of Rate of Return Over Asset Holding Period Holding Period

1 $6 million 12% 2 8 million 10% 3 11 million 5%

The portfolio's total market value at the beginning of the holding period is $25 million. Therefore,

[*w*.sub.1] = $6 million/$25 million = 0.24, or 24% and [*R*.sub.1] = 12%

[*w*.sub.2] = $8 million/$25 million = 0.32, or 32% and [*R*.sub.2] = 10%

[*w*.sub.3] = $11 million/$25 million = 0.44, or 44% and [*R*.sub.3] = 5%

Notice that the sum of the weights is equal to 1. Substituting into equation (1.1), we get the holding period portfolio return,

[R.sub.p] = 0.24(12%) + 0.32(10%) + 0.44(5%) = 8.28%

Note that since the holding period portfolio return is 8.28%, the growth in the portfolio's value over the holding period is given by ($25 million) × 0.0828 = $2.07 million.

The Expected Return of a Portfolio of Risky Assets

Equation (1.1) shows how to calculate the actual return of a portfolio over some specific time period. In portfolio management, the investor also wants to know the expected (or anticipated) return from a portfolio of risky assets. The expected portfolio return is the weighted average of the expected return of each asset in the portfolio. The weight assigned to the expected return of each asset is the percentage of the market value of the asset to the total market value of the portfolio. That is,

E([R.sub.p]) = [*w*.sub.1] *E([R*.sub.1]) + [*w*.sub.2] *E([R*.sub.2]) + ... + *[w.sub.G]E([R.sub.G]*) (1.3)

The *E*() signifies expectations, and *E([R.sub.P]*) is sometimes called the *ex ante* return, or the expected portfolio return over some specific time period.

The expected return, *E([R.sub.i]*), on a risky asset *i* is calculated as follows. First, a probability distribution for the possible rates of return that can be realized must be specified. A probability distribution is a function that assigns a probability of occurrence to all possible outcomes for a random variable. Given the probability distribution, the expected value of a random variable is simply the weighted average of the possible outcomes, where the weight is the probability associated with the possible outcome.

In our case, the random variable is the uncertain return of asset *i*. Having specified a probability distribution for the possible rates of return, the expected value of the rate of return for asset *i* is the weighted average of the possible outcomes. Finally, rather than use the term "expected value of the return of an asset," we simply use the term "expected return." Mathematically, the expected return of asset *i* is expressed as:

E([R.sub.i]) = *[p*.sub.1] [*R*.sub.1] + [*p*.sub.2] [*R*.sub.2] + ⋯ + *[p.sub.N] [R.sub.N]* (1.4)

where,

[R.sub.n] = the nth possible rate of return for asset *i*

[p.sub.n] = the probability of attaining the rate of return *n* for asset *i*

N = the number of possible outcomes for the rate of return

How do we specify the probability distribution of returns for an asset? We shall see later on in this chapter that in most cases the probability distribution of returns is based on historical returns. Probabilities assigned to different return outcomes that are based on the past performance of an uncertain investment act as a good estimate of the probability distribution. However, for purpose of illustration, assume that an investor is considering an investment, stock XYZ, which has a probability distribution for the rate of return for some time period as given in Table 1.1. The stock has five possible rates of return and the probability distribution specifies the likelihood of occurrence (in a probabilistic sense) for each of the possible outcomes.

Substituting into equation (1.4) we get

E([R.sub.XYZ]) = 0.18(12%) + 0.24(10%) + 0.29(8%) + 0.16(4%) + 0.13(-4%) = 7%

Thus, 7% is the expected return or mean of the probability distribution for the rate of return on stock XYZ.

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