

[Academic Script]

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PORTFOLIO THEORY

Part 2

Topics: Modern portfolio theory, Markowitz Mean Variance Model, Capital Asset Pricing Model, Arbitrage Pricing Model, Capital Market line, Security Market line

INTRODUCTION

Portfolio management is the new and modern method of risk management. The attempt to optimize returns by minimizing risk has led to development of theories that help build various models that suit the varied risk aptitudes. The concept of diversification is practiced by intelligent investors to bring a tradeoff between risk and return. The following session describes various theories which help build an effective portfolio spread across various assets that would not only balance out risk and return but also focus on long term goals of the investor as well as safety and liquidity.

Markowitz Mean Variance Model

Harry Markowitz is regarded as the father of modern portfolio theory. The essence of this theory is that risk of an individual asset hardly matters to an investor. What really matters is the overall contribution it makes to total risk. By turning his principle into a useful technique for selecting the right portfolio from a range of different assets, he developed 'Mean Variance Analysis' in 1952. The thrust has been on balancing safety, liquidity and returns depending on the risk bearing capacity of an investor. The first step is finding the mean variance efficient portfolios and secondly selecting one such portfolio. Investors are generally risk averse and in case of risky investments, the returns expected are higher.

Assumptions

1. The return on an investment adequately summarizes the outcome of the investment.

2. The investors can visualize a probability distribution of rates of return.

3. The investors' risk estimated are proportional to the variance of return they perceive for a security or portfolio.

4. Investors base their investment decisions on two criteria i.e. expected return and variance of return.

5. All investors are risk averse.

6. For a given expected return he prefers to take minimum risk, obviously for a given level of risk the investor prefers to get maximum expected return.

7. Investors are assumed to be rational in so far as they would prefer greater returns to lesser ones given equal or smaller risk and risk averse.

8. Risk aversion in this context means merely that, as between two investments with equal expected returns, the investment with the smaller risk would be preferred.

9. Return could be any suitable measure of monetary inflows such as NPV, but yield has been the most commonly used measure of return, in this context, so that where the standard deviation of returns is referred to the standard deviation of yield about its expected value.

Efficient frontier

Markowitz has formulized the risk return relationship and developed the concept of efficient frontier. For selection of a portfolio, comparison between a combinations of portfolios is essential. As a rule, a portfolio is not efficient if there is another portfolio with:

- A higher expected value of return and a lower standard deviation (risk),
- A higher expected value of return and the same standard deviation (risk),
- The same expected value but a lower standard deviation (risk)

As explained in the previous session, where investments with less than perfect correlation will reduce portfolio risk, diversification would be gainful for the investor. If his portfolio is not efficient he may;

- Increase the expected value of return without increasing the risk
- Decrease the risk without decreasing the expected value of return
- Obtain some combination of increase of expected return and decreased risk

This is possible by switching the portfolio on an *efficient frontier*.

If all the investments are plotted on the risk return sphere, individual securities would be dominated by portfolios and the efficient frontier would be taken shape indicating investments which yield maximum return given the level of risk bearable or minimize risk for the given level of return.



INSERT FIGURE 30.1

In the above figure among investments B and D lie on the efficient frontier. This dark line on which the securities B and D lie represents the efficient combinations i.e. the efficient frontier.

The optimal investment achieved at a point where the indifference curve is at a tangent to the efficient frontier. This concept of efficient frontier, and the optimal point location is explained as follows;



- At point R, risk and return are at optimal level.
- Point W represents highest risk as well as return
- Point P represents lowest risk and return.
- The shaded area represents all attainable portfolios.

Thus the investor has to select among these attainable portfolios based on his individual risk return preference.

Capital Market Line

The Markowitz mean variance model is modified by using the concept of risk free asset. If the option of investing in completely risk free securities is available to the investor, them he can construct a portfolio R_fM . the point R_f is the point of holding all risk free securities whereas M represents all equity portfolio. Investment in points between these two points is termed as lending portfolio.



If the investor can lend and borrow funds at the same risk free interest rate. In such circumstances the efficiency boundary simply becomes the straight line drawn from R_f which is a tangent to the original risky boundary. The boundary that arises between the assumption of risk free lending and borrowing rates leads to some very important conclusions and is termed as *'Capital Market Line' (CML)*.

The slope of CML is the rate of exchange between expected return and risk and is explained by;

$$\frac{R_m - R_f}{\sigma_m}$$

Where $R_m = Return$ on market portfolio

 $R_{\rm f} = Return on risk free investments$

 $\sigma_{\rm m}$ = Standard deviation of the portfolio

The slope of the CML gives the market price of risk for fully diversified portfolios. The CML, using standard deviation as its risk measure, shows graphically the total risk of the individual securities and portfolio in the risk return sphere. Individual securities do not lie on the CML because they bear same nonsystematic risk, which does not contribute to expected returns.

Separation theorem

Investors can lend and borrow unlimited amounts at the risk free interest rate of Rf. It is important because of the fact that in such circumstances all risk averse investors will be interested in only one portfolio of risky investments i.e. portfolio M

They will either put all their investment funds into this portfolio or only part of their funds and lend the rest at the risk-free interest rate, or borrow additional funds and place all their own funds plus the borrowed funds into portfolio M.

Whatever investment portfolio is constructed by an investor, he will only be interested in one portfolio of purely risky assets. This will be portfolio M.

As a result we are now in a position of being able to identify the portfolio of risky assets that an investor would wish to hold i.e. M, without any knowledge of his set of indifference curves assuming that the investor is generally risk averse. This is called

separation theorem.

Market portfolio

If an investor holds an all equity portfolio, it is called Market portfolio.

An investor who wishes to hold a market portfolio would hold shares of companies quoted on stock exchanges, in amounts proportionate to their market values.

The concept of market portfolio produces a definition of equilibrium market prices.

Share prices are at equilibrium when they produce and expected return that is just sufficient compensation for the risk that they involve.

Capital asset pricing model

William Sharpe and John Linter developed the capital asset pricing model. This model is based on the portfolio theory developed by Harry Markowitz.

The capital market line does not take into account the unsystematic risk. This model emphasizes both on systematic and unsystematic risk. This is the concept of total risk. This model suggests that a security's return is directly related to its systematic risk, which cannot be neutralized through diversification. The total variance of returns is equal to market related variance plus company's specific variance. CAPM explains the behavior of security prices and provides a mechanism whereby investors could assess the impact of a proposed security investment on the overall portfolio risk and return. CAPM suggests that the prices of securities are determined in such a way that the risk premium or excess returns are proportional to systematic risk, which is indicated by beta coefficient.

Thus CAPM provides a conceptual framework for evaluating any investment decision where capital is committed to achieve objective of producing future returns. The return on security is taken as a dependent variable and the return on market is the independent variable.

$$\mathbf{R}_{j} = \mathbf{R}_{f} + \beta \ (\mathbf{R}_{m} - \mathbf{R}_{f})$$

 β Represents the slope of the above regression relationship and measures the responsiveness of security returns to general market returns.

Beta of a portfolio is the total of the weighted average beta factors of each security in the portfolio. If there is a rise or fall in the return of market portfolio. There should be a corresponding rise or fall in individual returns from a security.

CAPM is based on certain assumptions:

1. Efficient capital market exists.

2. Investors base their portfolio on security, expected returns and standard deviation criteria.

3. Investors may borrow or lend without limit at risk free rate of interest.

4. Investors have identical expectations in one particular time period.

5. There are no transaction costs involved in buying and selling of securities.

6. Investors desire higher return for any acceptable level of risk or lowest risk for any desired level of return.

7. Investors are risk averse and expect maximum utility if wealth.

8. The goals of investors are rational.

9. Capital market is not dominated by any individual investor.

10. Securities have no issue of insolvency or bankruptcy.

Three aspects that need to be considered are;

- Stock market is not concerned with diversifiable risk.
- It is not concerned with investor having a diversified portfolio.
- Compensation paid is restricted to diversifiable risk.

Thus an investor has look into the non-diversifiable portion of risk on one side and returns from the other side. For this, the concept of security market line is used.

Security Market Line:

Security market line (**SML**) is the representation of the capital asset pricing model. It displays the expected rate of return of an individual security as a function of systematic, non-diversifiable risk.

The Y-intercept of the SML is equal to the risk free interest rate. The slope of the SML is equal to the market risk premium and reflects the risk return trade off at a given time:

SML: E (R_i) = R_f + β_i [E(R_m) - R_f]

where:

 $E(R_i)$ is an expected return on security $E(R_M)$ is an expected return on market portfolio M β is a non-diversifiable or systematic risk R_m is a market rate of return

 R_f is a risk-free rate



When used in portfolio management, the SML represents the investment's opportunity cost (investing in a combination of the market portfolio and the risk-free asset). All the correctly priced securities are plotted on the SML. The assets above the line are undervalued because for a given amount of risk (beta), they yield a higher return. The assets below the line are overvalued because for a given amount of risk, they yield a lower return.

There is a question about what the SML looks like when beta is negative. A rational investor will accept these assets even though they yield sub-risk-free returns, because they will provide a cushion during recession as part of a well-diversified portfolio. Therefore, the SML continues in a straight line whether beta is positive or negative. A different way of thinking about this is that the absolute values of beta represent the amount of risk associated with the asset, while the sign explains when the risk occurs or not.

Thus the CAPM model can be used to sell, buy or hold stocks. It considers the required return on a stock with reference to the risk involved. One can quantify the expected returns based on some benchmark or current scenario and then take a decision as follows;

CAPM < ERR=undervalued stocks = buy

CAPM > ERR=overvalued stocks = sell

CAPM = ERR= correct valuation=hold

If the current market price is taken as the base, then the decision can be based on the following;

Actual market price < CAPM= undervalued stocks = buy

Actual market price > CAPM= overvalued stocks = sell

Actual market price = CAPM= correct valuation=hold

Advantages of CAPM

1. It considers only systematic risk, reflecting a reality in which most investors have diversified portfolios from which unsystematic risk has been essentially eliminated.

2. It generates a theoretically derived relationship between required return and systematic risk, which has been subject to frequent empirical research and testing.

3. It is generally seen as a much better method of calculating the cost of equity than the dividend growth model (DGM) in that it explicitly takes into account a company's level of systematic risk relative to the stock market as a whole.

Limitations of CAPM

1. Reliable beta may not exist for all firms.

2. Unsystematic risks also hold importance along with systematic risks.

3. The information on risk free rate and expected return on market portfolio due to multiple rates available in the market. Also they fluctuate very often.

Characteristic line

A characteristic line is a line formed using regression analysis that summarizes a particular security or portfolio's systematic risk and rate of return. The rate of return is dependent on the standard deviation of the asset's returns and the slope of the characteristic line, which is represented by the asset's beta.

A characteristic line of a stock is the same as the security market line, and is very useful when employing the capital asset pricing model, or when using modern portfolio formation techniques. The slope of the line, which is a measure of systematic risk, determines the risk-return tradeoff. According to this metric, the more risk you take on - as measured by variability in returns - the higher the returns you can expect to earn.



It can be observed from the graph that greater the expected return from the market, the greater the expected excess for the stock. (Ri - Rf) and (Rm - Rf) are pairs of

observations of return in the security over risk free rate and expected return on market portfolio over risk free rate. This can be used to evaluate stock market investments.

Alpha Coefficient

The alpha coefficient (α) gives the vertical intercept point of the regression line.

The investing term alpha coefficient refers to a measure of an asset's risk-adjusted performance. Alpha is a measure of "excess" returns and is frequently used along with beta values to judge the performance of an individual stock or mutual fund manager.

Alpha = Return of Asset - (Risk Free Rate + (Benchmark Return - Risk Free Rate) x Beta)

Where:

• Return of Asset = total return of an asset such as an individual stock or portfolio of stocks

• Risk Free Rate = total return of an investment which is thought to be risk free. The return on Treasury Bills is often used as a proxy for the risk-free rate.

• Benchmark Return = in the case of common stocks this is the return provided by the entire market. The S&P 500 Index is often used as a proxy for the benchmark return.

• Beta = also known as beta coefficient, this is a measure of the relative volatility of the asset.

Alpha is a measure of an investment's return relative to its risk. The calculation compares the investment's return to that of a risk-free security such as Treasury Bills, and relative to a benchmark such as the S&P 500 Index.

Interpreting alpha is fairly straightforward, and requires the knowledge of only three rules:

• Alpha < 0: the investment has provided a return that is low relative to its risk; in the case of a mutual fund, the manager has destroyed value.

• Alpha = 0: the investment has provided a return that is aligned with its risk; in the case of a mutual fund, the manager has neither created nor destroyed value.

• Alpha > 0: the investment has provided a return that is high relative to its risk; in the case of a mutual fund, the manager has created value.

• Limitations:

It is useful generally among securities of the same asset class.

The choice of benchmark needs to be properly thought of.

Beta Coefficient

It describes the slope of the characteristic line and so indicates the degree to which the individual security's risk premium reacts to changes in market portfolio's risk premium. The greater the beta, greater is the systematic risk for an individual stock. (Explained in part 1)

The Arbitrage Pricing Model

In 1976, Stephen Ross suggested a theory based on the idea that asset's returns can be predicted using the relationship between that asset and many common risk factors. It forecasts a relationship between the returns of a portfolio and returns of a single asset through linear combination of many independent macro-economic variables. It is generally used as an alternative to CAPM. When CAPM uses markets expected return, APM uses the risky assets' expected return and the risk premium of a number of macro-economic factors. Some of them identified are;

Inflation, changes in the level of industrial production, changes in real interest rate, level of consumption, level of money supply in the economy

Arbitrage is the practice of taking positive expected return from overvalued or undervalued securities in the inefficient market without any incremental risk and zero additional investments.

In the APT context, arbitrage consists of trading in two assets – with at least one being mispriced. The arbitrageur sells the asset which is relatively too expensive and uses the proceeds to buy one which is relatively too cheap.

Under the APT, an asset is mispriced if its current price diverges from the price predicted by the model. The asset price today should equal the sum of all future cash flows discounted at the APT rate, where the expected return of the asset is a linear function of various factors, and sensitivity to changes in each factor is represented by a factor-specific beta coefficient.

SUMMARY:

The session explained various models of portfolio management. The main aim is risk minimization so as to maximize returns. Such models help the investor build an efficient portfolio by spreading the investment across various assets. The Markowitz model presents the efficient frontier explaining most efficient combinations. The same is modified by the concept of capital market line. The slope of CML is the rate of exchange between expected risk and return. The separation theorem also supports the risk appetite of the investor and identify market portfolio. Market portfolio defines an investor who would prefer all equity portfolio. The capital asset pricing model is based on the portfolio theory of harry Markowitz. It does not take into account the unsystematic risk. A characteristic line of a stock is the same as the security market line and is very useful when employing the capital asset pricing model, or when using modern portfolio formation techniques. The slope of the line, which is a measure of systematic risk, determines the risk-return tradeoff. Alpha is a measure of "excess" returns and is frequently used along with beta values to judge the performance of an individual stock or mutual fund manager. The Arbitrage Pricing Model forecasts a relationship between the returns of a portfolio and returns of a single asset through linear combination of many independent macro-economic variables. It is generally used as an alternative to CAPM. When CAPM uses markets expected return, APM uses the risky assets' expected return and the risk premium of a number of macro-economic factors. The understanding of models of portfolio management theory helps investors and portfolio managers take calculated risk while accomplishing short term and long term goals. Both the parties can calculate the market movements and revise the portfolio for enhanced returns.