Agenda

Capital Market Theory

● Basics
  – Return and risk
  – Diversification
  – Modern portfolio theory (MPT)
  – Capital asset pricing model (CAPM)

● Practical applications
  – Portfolio optimization
  – Risk and return attribution
Role of Capital Market Theory

- Capital market theory attempts to explain the relationship between investment returns and risks.
- Addresses both individual investments and portfolios of multiple investments.
- Uses:
  - *Portfolio construction*: How should a portfolio of assets be constructed given the variety of different assets available for investment?
  - *Asset valuation*: How much is an asset worth given the characteristics of the other assets in market?
  - *Performance measurement*: How did an asset perform historically relative to the other assets in similar markets? How are risk and return attributed?
Returns According to Modern Portfolio Theory

● First, modern portfolio theory (MPT) defined:
  – A theory on how risk-averse investors can construct portfolios to maximize expected return based on a given level of market risk.

● MPT focuses on total return (income + realized gain + unrealized gain).
  – Income includes stock dividends and bond coupons.
  – Realized gain occurs when a security is sold for a profit.
  – Unrealized gain is a gain on paper only.

● MPT assumes that returns are normally distributed.
  – While return distributions can be asymmetrical (commodities and hedge funds for example), well-diversified portfolios (of securities or of asset classes) are approximately normally distributed.
Risk According to Modern Portfolio Theory

- Risk is measured by the standard deviation of returns which can be thought of as the average difference from the average return.
  - If there are large deviations from the average, the standard deviation is high meaning the returns are very volatile or uncertain.
- Calculation of standard deviation includes returns both above and below the average.

Example Using Broad Domestic Equity
Range of Returns

![Diagram showing the range of returns and standard deviation with examples of projected return and standard deviation values.]
Modern portfolio theory assumes investors are risk averse.

- Given a choice between two assets with the same level of return, an investor will select the asset with a lower level of risk.
- The risk premium demanded by investors provides evidence of risk aversion.
  - *For example, investors demand a greater return from private equity over public equity for the increased risk they are assuming.*
Diversification

- Diversification is an age-old concept.
  - "Don’t put all of your eggs in one basket."

- The goal is risk control.
  - If one outcome is bad, all is not lost.

- The key is to diversify across risky assets that react differently to various macroeconomic scenarios.
Correlation is One Measure of Diversification

● Correlation measures the degree to which two variables, such as asset classes, move in relation to each other. Correlations range from -1 to +1.

● -1 correlation:
  – Returns are completely unsynchronized.
  – Good and bad returns exactly cancel out, leaving no volatility.

● 0 correlation:
  – The relationship between the returns of two investments is completely random.
  – Substantial, but not complete, reduction in volatility.

● +1 correlation:
  – Returns are completely synchronized.
  – Said to be “perfectly correlated.”
  – No diversification/volatility reduction.
Modern Portfolio Theory (MPT)

- Harry Markowitz authored in 1952.
  - Nobel Prize winning theory.

- MPT quantifies the idea of diversified investment portfolios through the use of correlation.
  - Previously a subjective judgment.
  - Makes use of the correlations of investment returns for the first time.

- Quantification allows ranking diversification opportunities.
  - Given two otherwise identical investments, choose the one that diversifies the portfolio most.

- Quantification allows the measurement of total portfolio diversification.
  - Can now measure the probability of losing a given amount of money.
  - Can compare the relative diversification of different portfolios.

---

PORTFOLIO SELECTION*

HARRY MARKOWITZ
The Rand Corporation

The process of selecting a portfolio may be divided into two stages. The first stage starts with observation and experience and ends with beliefs about the future performances of available securities. The second stage starts with the relevant beliefs about future performances and ends with the choice of portfolio. This paper is concerned with the second stage. We first consider the rule that the investor does (or should) maximize discounted expected, or anticipated, returns. This rule is rejected both as a hypothesis to explain, and as a maximum to guide investment behavior. We next consider the rule that the investor does (or should) consider expected return a desirable thing and variance of return an undesirable thing. This rule has many sound points, both as a maxim for, and hypothesis about, investment behavior. We illustrate geometrically relations between beliefs and choice of portfolio according to the “expected return—variance of returns” rule.

One type of rule concerning choice of portfolio is that the investor does (or should) maximize the discounted (or capitalized) value of future returns. Since the future is not known with certainty, it must be “expected” or “anticipated” returns which we discount. Variations of this type of rule can be suggested. Following Hicks, we could let “anticipated” returns include an allowance for risk. Or, we could let the rate at which we capitalize the returns from particular securities vary with risk.

The hypothesis (or maxim) that the investor does (or should) maximize discounted return must be rejected. If we ignore market imperfections the foregoing rule never implies that there is a diversified portfolio which is preferable to all non-diversified portfolios. Diversification is both observed and sensible; a rule of behavior which does not imply the superiority of diversification must be rejected both as a hypothesis and as a maxim.

* This paper is based on work done by the author while at the Cowles Commission for Research in Economics and with the financial assistance of the Social Sciences Research Council. It will be reprinted as Cowles Commission Paper, New Series, No. 60.

MPT and “Optimal” Portfolios

● Investment allocations determine portfolio return and risk.
  – Multiple portfolios can be constructed with the same expected returns but different levels of risk.
  – Multiple portfolios can be constructed with the same risks but different levels of expected return.

● Definition of optimal portfolios:
  – For a given level of return, the portfolio with the lowest risk level.
  – For a given level of risk, the portfolio with the highest return level.

● MPT identifies optimal portfolios using return, risk, and correlation expectations.
  – Optimal portfolios maximize diversification.
Diversification and the Efficient Frontier

- An efficient portfolio is the combination of available assets that provides the highest level of return for a given level of risk.
  - C’s return ≥ A’s return
- Alternatively, it is the portfolio that provides the lowest level of risk for a given level of return.
  - B’s risk ≤ A’s risk
- The efficient frontier comprises all efficient portfolios in risk and return space.
Limits of Diversification

- Market risk cannot be diversified away.
- MPT distinguishes between risks inherent in the market and risks that can be diversified.
  - **Systematic Risk** (*market risk*) is inherent in every security and cannot be avoided.
  - **Unsystematic Risk** (*company specific risk*) can be reduced through diversification.

![Total Risk = Systematic Risk + Unsystematic Risk](chart.png)

<table>
<thead>
<tr>
<th>Number of Stocks in Portfolio</th>
<th>Total Risk (Standard Deviation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Few</td>
<td>High</td>
</tr>
<tr>
<td>Many</td>
<td>Low</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Few</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Many</td>
<td>Low</td>
</tr>
</tbody>
</table>
Capital Asset Pricing Model (CAPM)

- Markowitz’s model required covariance (correlation x standard deviation) calculations between all assets leading to immense computational complexity.
  - For example a 1,000 stock portfolio results in 499,500 covariance pairs.

- William Sharpe replaced Markowitz’s reliance on covariance with each security’s relationship to the overall market.

- CAPM assumes that markets are “efficient” – all information is freely available and reflected instantaneously in asset prices.
  - Academics have proposed several levels of market efficiency: strong, semi-strong, and weak.

- Sharpe’s approach greatly simplified the computational requirements of defining an efficient portfolio.
  - He was recognized with a Nobel prize for these achievements in 1990.
The Capital Asset Pricing Model (CAPM) is a framework for modeling the relationship between expected return and market risk for assets.

The model is expressed as the following equation:

\[ r_p - r_f = \alpha_p + \beta_p (r_m - r_f) + \epsilon_p \]

Where:
- \( r_p - r_f \) is the Portfolio Excess Return (return on the portfolio in excess of the risk-free rate).
- \( r_m - r_f \) is the Market Excess Return (return on the market portfolio in excess of the risk-free rate).
- \( \alpha_p \) is the Alpha (the intercept, representing the return on a security or portfolio in excess of what would be predicted by an equilibrium model such as CAPM).
- \( \beta_p \) is the Beta (the slope of the line, representing market risk).
- \( \epsilon_p \) is the Residual Risk.

The narrower the band around the line, the higher the correlation.

* Alpha represents the return on a security or portfolio in excess of what would be predicted by an equilibrium model such as CAPM.
Applications of Capital Market Theory

- Standard deviation encompasses many foreseeable risks at the major (publicly traded) asset class level.
- Annual asset returns, over meaningful time periods, are approximately normally distributed.
- As a consequence, mean-variance optimization (MVO) is one useful approach to formulating asset allocation policy.
- The mean-variance framework and capital asset pricing model (CAPM) also work well when measuring and evaluating performance.
Measuring Return and Risk

- **Absolute measures:**
  - Total return vs. standard deviation of return

- **Risk-adjusted measures**
  - Sharpe Ratio
  - Treynor Ratio

- **Measures based on regression analysis:**
  - Alpha
  - Beta
  - Residual risk
  - Information ratio (alpha / residual risk)
  - R-squared ($R^2$)

- **Relative measures:**
  - Excess return
  - Tracking error
The Sharpe and Treynor Ratio

- Sharpe Ratio = Return – Risk-Free Rate / Risk (standard deviation).
  - The Sharpe ratio represents a risk premium (reward) earned per unit of risk.
  - Commonly used measure of risk-adjusted return.

- If the denominator of the Sharpe ratio is replaced with Beta (systematic risk) we obtain another measure of risk-adjusted performance called the Treynor Ratio.
  - For well-diversified portfolios, the measures will be very close.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>Risk-Free Rate</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Return</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Sharpe Ratio</td>
<td>0.5</td>
<td>0.4</td>
</tr>
</tbody>
</table>
**Alpha and Beta**

- **Alpha** is a measure of a manager’s added value above the benchmark.
  - Alpha is characterized as active management skill, since passive exposure to “the market” is captured in beta. Alpha is used as a measure of a manager's contribution to performance due to security or sector selection.

- **Beta** is a measure of the portfolio’s sensitivity to the benchmark return (“the market”).
  - Beta quantifies the expected change in return per unit on the market. A portfolio with a beta of 1.5 would move 50% more than the market.
  - Beta represents market risk. No manager skill is required to earn beta as it is cheaply and readily available through passive index exposure.
Excess Return and Tracking Error

Rolling 12 Quarter Tracking Error Relative To S&P:500 for 10 Years Ended March 31, 2014

- **Excess return** measures a portfolio’s return relative to a specified benchmark.
  - Excess return = portfolio return less benchmark return.

- **Tracking error** is the standard deviation of a portfolio's excess returns.
  - Tracking error measures the volatility of the return differences between the portfolio and the benchmark over time.
  - A portfolio that is actively managed in an aggressive manner would have a large amount of tracking error versus its index. A portfolio which tightly hugs the benchmark would have smaller amounts of tracking error.