MSC. Accounting and Finance CF : Session 7

CAPITAL ASSET PRICING MODEL (CAPM)

Session three summary

- The CAPM definition and formula

- Types of risk

- How to navigate risks

- Calculation of betas

- Validity of CAPM assumptions

- Testing and use of CAPM

- CAPM and portfolio

- Arbitrage pricing model

Estimating the cost of equity using the Capital Asset pricing model (CAPM)

- The dividend discount model or the dividend valuation model(DVM) we saw earlier assumes that an investor's current required rate of return will remain unchanged for future projects. For projects with different risk profiles, this assumption of the DVM may not hold true.

- Using the DVM we saw, implies that we are effectively assuming that all future investment projects will be subjected to same risk as those currently undertaken which may not always be true

Estimating the cost of equity using the Capital Asset pricing model (CAPM) contd

If an investor's required rate of return reflects the risk they face , and if the investment project is in different business area, then there is need to use a method of calculating the cost of equity that involves looking more closely at the nature of risk itself. This method is called the Capital Assets Pricing Model (CAPM)

Definition of CAPM

- The **CAPM** is a model that describes the relationship between risk and the expected / required rate of return. It is used for pricing an individual security (asset) or a portfolio (combination of assets or collection of investments).

- The **Capital Asset Pricing Model (CAPM)** is used to determine a theoretically appropriate required rate of return of an asset if that asset is to be added to an already well-diversified portfolio; given that assets non-diversifiable risk. The model takes into account the asset's sensitivity to non-diversifiable risk (also known as systematic risk or market risk), often represented by the quantity beta (β) in the financial industry, as well as the expected return of the market and the expected return of a theoretical risk-free asset.

CAPM formula

Thus CAPM formula is as follows:

$$E(R_i) = R_f + \beta_i\left(E(R_m) - R_f\right)$$

Where:

$E(R_i)$ *is the expected return on the capital asset i*

R_f *is the risk-free rate of interest such as   interest arising from government bonds*

β_i *(the beta coefficient) is the sensitivity of the asset returns to market returns*

E (R_m) is expected return of the market.

Assumptions of the Capital Asset Pricing Model

It assumes that all investors;

- Aim to maximize economic utilities.

- Are rational and risk-averse.

- Are broadly diversified across a range of investments.

- Are price takers, i.e., they cannot influence prices.

- Can lend and borrow unlimited amounts under the risk free rate of interest.

- Trade without transaction or taxation costs.

- Deal with securities that are all highly divisible into small parcels.

- Assumes all information is available at the same time to all investors

Types of risks

Risk is a potential threat in investment decisions and therefore it must be measured and is also categorized as:

Systematic risk and non-systematic

1. Systematic Risk also called non-diversifiable risk

This is a result of factors common to and affecting all securities. The impact of these factors on a portfolio cannot be avoided. This type of risk is also called **market risk.** Once an investor is in the market he cannot avoid it. Systematic risk is the extent to which the company's expected returns are affected by macro –economic factors.

Causes of systematic risk

Systematic risk is caused by market wide factors such as the following:

- Movement in exchange rate

- Consumer demand level

- Rate of growth of the economy

- Rate of inflation

- War

- etc

Causes of systematic risk in the agricultural sector

- **Market Fluctuations:** Changes in global agricultural markets, including shifts in supply and demand for agricultural products, can impact the demand for agrochemicals.
- **Economic Downturns:** Economic recessions or downturns can lead to reduced agricultural spending, affecting the sales of agrochemical products.
- **Natural Disasters and Climate Events**: Events like droughts, floods, hurricanes, or unseasonable temperatures can disrupt agricultural operations and lead to reduced demand for agrochemicals.
- **Regulatory Changes:** Alterations in government policies and regulations related to agriculture and chemical usage can directly impact agrochemical production and sales.
- **Trade Disputes or Tariffs:** Changes in international trade agreements, tariffs, or export restrictions can affect the import/export dynamics of agrochemicals, potentially impacting the factory's operations.

Types of systematic risks

Systematic risk may include the following:-

i. A government change in the interest rates policy

ii. The corporation tax rate is changed (increased)

iii. The government decided to resort to massive deficit financing

iv. The rate of inflation increases (changes)

v. The central bank constitutes a restrictive credit policy

vi. The government relaxes the foreign exchange controls and announces full convertibility

2. Non- systematic risk

Non- systematic risk is also called diversifiable risk

This is the unsystemic risk, which is unique to an individual security. It arises out of uncertainty surrounding a particular firm or industry. Like a long strike in a factory, this would affect its earnings and profitability. This risk can be avoided by diversifying the portfolio of securities. By holding a portfolio of 10-12 different stocks, an investor can diversify away all un systemic risk. In this situation of a well-diversified portfolio the only risk is the non-diversifiable or market risk (which in any case cannot be avoided when an investor enters the market). An investment manager must therefore make a tradeoff between Risk and return so as to be able to maximize wealth. All investment projects should be assessed in light of the expected return and risk.

Causes of non- systematic risk

The causes of non - systematic risk are basically company/industry specific factors which include:

- Quality of Management

- State of labour relations with management and owners

- Level of advertising

- Effectiveness of research and development

- Level of corporate governance

Causes of non- systematic risk

- **Product Contamination or Recall:** Contamination of products due to manufacturing errors or issues in the supply chain can lead to recalls, lawsuits, and reputational damage.
- **Supply Chain Disruptions:** This can include issues with the sourcing of raw materials, disruptions in production, or difficulties in transportation and distribution.
- **Workplace Accidents and Safety Incidents:** Occupational hazards and accidents can result in injuries, property damage, legal liabilities and potentially lead to the shutdown of operations.
- **Technological Failures:** Malfunctions or failures in critical machinery, automation systems, or IT infrastructure can lead to production delays and financial losses.

Causes of non- systematic risk

- **Regulatory Compliance Violations:** Failure to comply with industry-specific regulations, environmental standards, or health and safety requirements can lead to fines, legal actions, and potential shutdowns.
- **Labour Disputes and Strikes:** Labor-related conflicts, strikes, or disputes with employees or labour unions can disrupt operations and lead to financial losses.
- **Intellectual Property and Patent Infringements:** Legal issues related to intellectual property, such as patent disputes or allegations of infringement, can lead to legal expenses and potential damages.
- **Market Competition:** Intense competition within the agrochemical industry, particularly from larger, more established companies, can pose a risk to smaller or newer factories.
- **Geopolitical Events:** Political instability, conflicts, or changes in government policies in regions where the factory operates can lead to disruptions in operations.

Examples of non- systematic risks

Examples of unsystematic risk include:

i. The company workers declare a strike

ii. The R and D expert leaves the company

iii. The company loses out on a big contract in a bid

iv. A formidable competitor-enters the market

v. The company is unable to obtain adequate quality of raw materials

vi. Government increases custom duty on the material used by the company

How can Systematic risk be navigated?

i. Diversification

By spreading investments across different asset classes, industries, and geographic regions, investors can reduce their exposure to market-wide systematic risks.

ii. Hedging

Using financial instruments like **options** (a type of contract that gives the buyer the right to buy or sell a security at a specified price at some point in the future. An option holder is essentially paying a premium for the right to buy or sell the security within a certain time frame, **futures** (A future is a contract to buy or sell an underlying stock or other assets at a pre-determined price on a specific date), and **derivatives** (financial contracts, set between two or more parties, that derive their value from an underlying asset, a group of assets, or a benchmark) can help mitigate the impact of specific systematic risks such as interest rate fluctuations or currency movements.

ii. Risk Management Strategies

Implementing risk management strategies like stop-loss orders, setting asset allocation limits, and rebalancing portfolios regularly can help investors navigate systematic risks.

How can un systematic risk be navigated

i. Research and Due Diligence

Conducting thorough research and due diligence on individual companies or investments can help identify and assess potential unsystematic risks such as business, financial, operational, or legal risks.

ii. Diversification

Building a well diversified portfolio with investments across different industries, sectors, and companies can reduce exposure to company-specific unsystematic risks.

iii. Risk Mitigation Techniques

Implementing risk mitigation techniques such as insurance coverage, contractual agreements, internal controls, and disaster recovery plans can help manage and reduce unsystematic risks.

iv. Active Management:

Taking an active approach to managing investments, monitoring market conditions, staying informed about industry trends, and making timely adjustments to the portfolio can help navigate unsystematic risks effectively.

Applying the CAPM formula to calculate cost of equity

Using CAPM the Required Rate of Return of a rational risk-averse well diversified investor can therefore be found from

Required return = Risk free return + Risk premium

Risk premium is relative level of systematic risk x market risk premium for specific investment

Required Rate of Return = Rf + β (Rm-Rf), where

➢ Where Rf = risk free rate

➢ Rm = average return on the market

➢(Rm- Rf) = average market risk premium or the equity risk premium

➢ β (Beta) = systematic risk of the investment compared to the market and therefore amount of the premium needed

Applying the CAPM formula to calculate cost of equity

Understanding Beta (β)

- If an investment is riskier than the average,(i.e. the returns are more volatile than average market returns) then the β (beta) > 1

- If an investment is less risky than the average (i.e. the returns are less volatile than the average market returns) then the β (beta) < 1

- If an investment is risk free then β (Beta) = 1

Applying the CAPM formula to calculate cost of equity

- From the assumptions of **CAPM,** it is deduced that all investors will hold a well diversified portfolio of shares , known as market portfolio, which is really a slice of the whole market .

- The attractiveness of any individual security is therefore judged in relation to its effect when combined with the market portfolio.

Applying the CAPM formula to calculate cost of equity

- A security whose returns are highly correlated with fluctuations in the market is said to have a high level of systematic risk . It does not have much risk-reducing potential on the investor's portfolio and therefore a high required rate of return is expected of it.

- On the other hand , a security which has a low correlation with the market (low systematic risk) is valuable as a risk reducer and hence its required rate of return will be lower. Remember that the higher the risk the higher the return and vice vasa.

Applying the CAPM formula to calculate cost of equity

- The measure of systematic risk of a security relative to that of the market portfolio is referred to as its *beta factor*. In practice industries such as construction are far more volatile than others such as food retailing and would have corresponding higher betas (β).

- The CAPM shows the linear relationship between the risk premium of the security and the risk premium of the market portfolio.

- Hence Required Rate of Return of a share =

    Rf + market premium x β

Application of CAPM

- The Required Rate of Return specified by CAPM helps in valuing an asset, one can also compare the expected (estimated) rate of return on an asset with its required rate of return and determine whether the asset is fairly valued.

- Under CAPM, the security market line (SML) exemplifies the relationship between an asset's risk and its required rate of return.

Application of CAPM
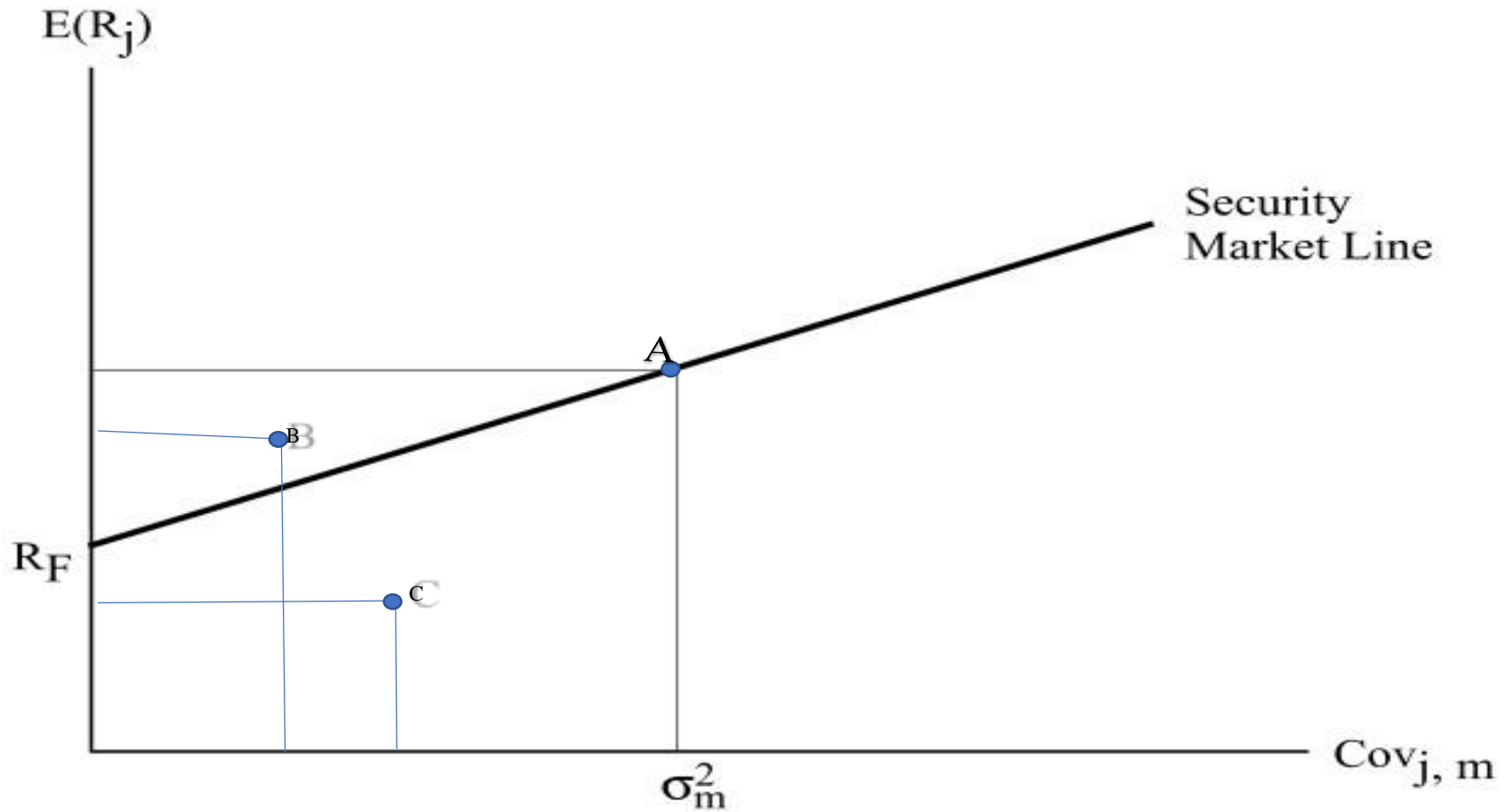
Application of CAPM

•The security (C) that is below the security market line is considered to be overpriced, since it commands a high risk and low return.

•Security (B), has a higher return and a lower risk an implication that it is under priced

•A security (A) on the security market line is considered to be fairly priced.

Illustration of CAPM

The current average market return being paid on risky investments is 12%, compared to 5% on treasury bills .Global company ltd company has a beta of 1.2. what is the cost of equity for Global ltd. company

Solution:

Required return = Rf + β (Rm-Rf)

Ke = 5 + 1.2 (12-5) = **13.4%**

Class Exercise on CAPM

Let's assume that the risk free rate is 5%, and the overall stock market will produce a Rate of return of 12.5% next year. You see that XYZ Company has a beta of 1.7. Calculate the cost of equity for XYZ company

Solution;

What rate of return should you get from this company in order to be rewarded for the risk you are taking? Remember investing in XYZ company (beta =1.7) is more risky than investing in the overall stock market (beta = 1.0). So you want to get more than 12.5% market rate of return.

Solution for exercise on CAPM

$$E(R_i) = R_f + \beta_i(E(R_m) - R_f)$$

- Ks = 5% + 1.7 (12.5% - 5%)
- Ks = 5% + 1.7 (7.5%)
- Ks = 5% + 12.75%
- **Ks = 17.75%**

So, if you invest in XYZ Company, you should get at least 17.75% return from your investment. If you don't think that XYZ Company will produce those kinds of returns for you, then you would probably consider investing in a different stock

Class exercise

Bell breweries ltd is currently paying a return of 9% on equity investment. If the return on treasury bills is currently 5.5% and the average return on the market is 10.5%, what is the beta of Bell breweries ltd and what does it tell us about the volatility of Bell breweries returns compared to those of the market on average?

Revision exercises on CAPM

Given the following information about an asset Beta=1.5, Expected return on the market portfolio=16%, Risk free rate of return=10%.Using the capital asset pricing model (CAPM) calculate the expected return on the asset and portfolio beta

Exercise 2:

Given the following data on an asset, beta=1.5, expected return on a market portfolio=18%, risk free rate of return=10%.

Calculate the expected rate of return on the asset and portfolio beta

Question 3

You are given the following information regarding an asset. Beta =1.8%, expected Return on the market portfolio =20%, risk free rate of return=11%.calculate the expected rate of return on the asset.

CALCULATION/ESTIMATION OF BETA (β)

- Using historical returns
- Using forecast returns
- Using average returns

Using historical returns (empirical CAPM)

We use regression analysis with historical returns to determine β which is then used for future estimates of return

$$r_s = r_f + (r_m - r_f)\,\beta + \alpha$$

Where ,

- r_s is return on a security
- α (alpha value) is the excess, abnormal return due to variations in actual return; it may be positive or negative and should disappear over time, given the assumptions of CAPM.
- $(r_s - r_f)$ $= \alpha + \beta(r_m - r_f)$

CALCULATION/ESTIMATION OF (β)

Reducing this to Y = a + bx (a straight line equation)

$$Y = (r_s - r_f)$$
$$X = (r_m - r_f)$$
$$a = \alpha$$
$$b = \beta$$

Using regression analysis formula:

$$b = \frac{n\sum XY - \sum X \sum Y}{n\sum X^2 - (\sum X)^2}$$

Illustration

The following data relates to the actual returns on a share (s) and the market portfolio (m) over the last 8 months. The risk free rate of interest throughout the period was 6% p.a

Month	Return on security (r_s)	Return on market (r_m)
1	2%	2%
2	4%	3%
3	-1%	-0.5%
4	0%	0.5%
5	6%	4%
6	1.5%	1.0%
7	-3%	0.5%
8	4%	1.5%

You are required to Calculate the Beta:

Solution on calculation of Beta

r_f = 6% p.a = 6% x 1/12 = 0.5% per month

Month	Y = ($r_s - r_f$)	X= ($r_m - r_f$)	XY	X^2
1	2-0.5 = 1.5	2-0.5 = 1.5	2.25	2.25
2	4-0.5 = 3.5	3-0.5 = 2.5	8.75	6.25
3	-1-0.5 = -1.5	-0.5- 0.5 = -1.0	1.5	1.00
4	0-0.5 = -0.5	0.5-0.5 = 0	0	0
5	6-0.5 = 5.5	4-0.5 = 3.5	19.25	12.25
6	1.5-0.5 = 1.0	1-0.5 = 0.5	0.5	0.25
7	-3 – 0.5 = -3.5	0.5 -0.5 = 0	0	0
8	4-0.5 = 3.5	1.5-0.5 = 1.0	3.5	1.00
	∑Y = 9.5	**∑X = 8**	**∑XY =35.75**	**∑X^2= 23**

Solution on calculation of Beta

b = β $= \dfrac{n\;\sum XY - \sum X \sum Y}{n\sum x^2 - (\sum x)^2}$;   n = 8.

$= \dfrac{(8(\,(35.75) - (8)\,(9.5)}{(8)\,(23) - (8)^2}$ $= \dfrac{210}{120}$

Beta (β) = 1.75

Interpretation

Since Beta (β) is greater than 1, it indicates that The shares are more volatile than the market. This suggests that these shares tend to move more than the market in response to market fluctuations. Therefore, investors should expect higher returns but also higher risks when investing in such a company's shares compared to the overall market simply because, the higher the risk the higher the return and vice versa.

Class Exercise 1 on computation of Beta

The following data relates to the actual returns on a share (u) of Uganda Clays ltd and the market portfolio (m) over the last 4 months for the year 2024. The risk free rate of interest throughout the period was 4% p.a

Month	Return on security (ru)	Return on market (rm)
1	6%	4%
2	4%	3%
3	-3%	0.5%
4	4%	1.5%

You are required to calculate and interpret the Beta of this share.

Solution to exercise 1

Using regression analysis: rf = 4% p.a =4% x 1/12 = 0.3% per month

Month	$Y = (r_s - r_f)$	$X = (r_m - r_f)$	XY	X^2
1	6-0.3=5.7	4-0.3=3.7	21.09	13.69
2	4-0.3=3.7	3-0.3=2.7	9.99	7.29
3	-3-0.3=-3.3	0.5-0.3= 0.2	-0.66	0.04
4	4-0.3=3.7	1.5-0.3=1.2	4.44	1.44
	$\sum Y = 9.8$	$\sum X = 7.8$	$\sum XY = 34.86$	$\sum X^2 = 22.46$

Solution to exercise 1

Formula for regression Analysis:

$b = \beta = \dfrac{n \sum XY - \sum X \sum Y}{n \sum x2 - (\sum x)2}$;   n = 4.

$= \dfrac{4\,(34.86) - (7.8)\,(9.8)}{(4)\,(22.46) - (7.8)^2} \quad = \quad \dfrac{139.44 - 76.44}{89.84 - 60.84}$

$= \quad \dfrac{63}{29} \qquad\qquad = \ 2.17$

Beta (β) = 2.2

Interpretation

Since Beta (β) of 2.2 is greater than 1, it indicates that The shares are more volatile than the market. This suggests that these shares tend to move more than the market in response to market fluctuations. Therefore, investors should expect higher returns but also higher risks when investing in such a company's shares compared to the overall market.

Class Exercise 2 on computation of Beta

Lawrence Enterprise ltd (LEL) is currently paying a return of 8% on equity investment. If the return on treasury bills is currently 4.5% and the average return on the market is 9.5%, what is the beta of LEL and what does it tell us about the volatility of LEL returns compared to those of the market on average?
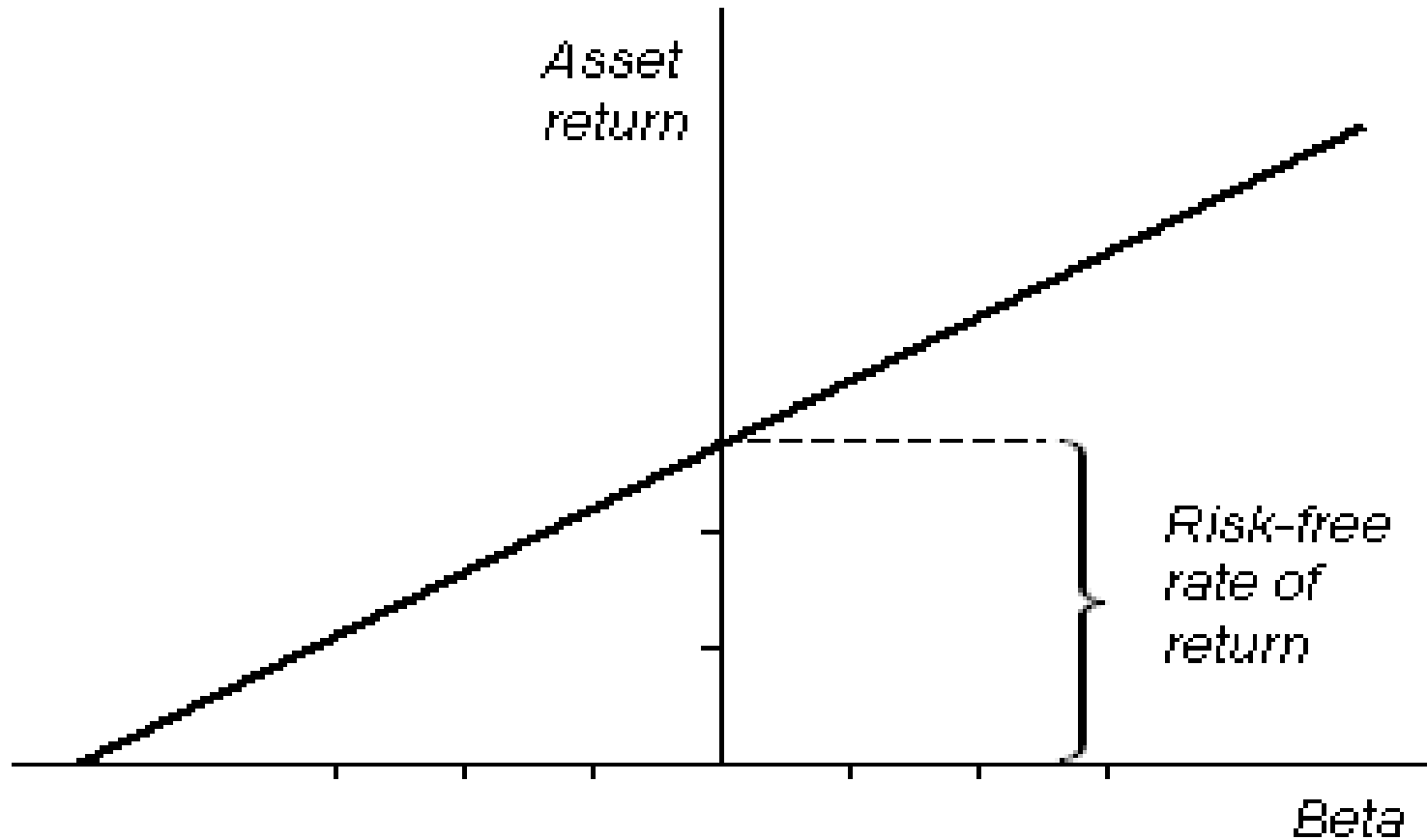
Implications and relevance of CAPM

 CAPM is based on a number of assumptions. Given those assumptions, it provides a logical basis for measuring risk and linking risk and return.

Implications

1. Investors will always combine a risk-free asset with a market portfolio of risky assets. They will invest in risky assets in proportion to their market value.

2. Investors will be compensated only for that risk which they cannot diversify. This is the market related (systematic) risk.

3. Investors can expect returns from their investment according to the risk. This implies a linear relationship between the asset's expected return and its beta.

Relationship between Risk and Return

Implications & relevance of CAPM

4. Beta is the ratio of the covariance between the asset returns and the market returns divided by the market variance. It is the most appropriate measure of an asset's risk.

5. The concepts of risk and return as developed under CAPM have intuitive appeal and they are quite simple to understand.

6. Financial managers use these concepts in a number of financial decisions-making such as valuation of securities, cost of capital measurement and investment risk analysis.

Uses of CAPM

i) To calculate the risk attached to an asset given the discount rate

ii) To calculate the discounting factor.

iii) Enables investors to know which assets are undervalued (i.e. those assets plotting above the SML).

iv) It is used in deriving the required return on a security

v) It is used in determining the fair price of an investment

vi) It is used as a benchmark for assets performance by comparing expected return and actual return of a security

Advantages of CAPM

1.Works well in practice since it gives due consideration to risk that is real. It thus provides a market-based relationship between risk and return and an assessment of security risk and rates of return given that risk.

2. It is one of the best methods of estimating a quoted company's cost of equity

3. It Focuses on systematic Risk and shows why systematic risk is important in this relationship

4. Is useful for appraising specific projects as it provides a basis for establishing risk-adjusted discount rates for capital investment projects

Disadvantages of CAPM

1. **It is Less useful if investors are undiversified** . By concentrating only on systematic risk, other aspects for risk are excluded. These unsystematic elements of risk will be a major importance to those shareholders who do not hold well-diversified portfolios, as well as being of importance to managers and employees . Hence it takes an investor oriented view of risk.

2. It Ignores tax situation of investors yet in real life taxation cannot easily be dodged.

Disadvantages of CAPM

3. **Actual Data inputs are estimates and may be hard to obtain** e.g. Estimation of beta , market return and, market risk premium etc.…

4. **It considers Beta as the only measure of systematic risk** thus disregarding other measures

5. It is difficult to test the validity of CAPM. Most of the assumptions of CAPM may not be very critical for its practical validity. We therefore need to know the empirical validity of CAPM.

Disadvantages / Limitations of CAPM

6. **It takes an investor –oriented view of risk**. Other aspects of risk are exchanged since CAPM concentrates on systematic risk. The unsystematic elements of risk would be of great importance to shareholders who do not hold well-diversified portfolio, as well as being of importance to managers and employees.

7. **The model considers only the level of return to be important to investors and neglects the way in which that return is received.** Hence dividends and capital gains are equally desirable yet with different tax rates, the packaging of returns between dividends and capital gains may be important.

8. **It is strictly a one- period model** and should be used with caution if carrying out the appraisal of multi-period projects

Arbitrage Pricing Theory (APT)

Arbitrage Pricing Theory (APT) is an alternative asset pricing model that extends beyond the limitations of the Capital Asset Pricing Model (CAPM) by incorporating multiple factors that influence asset returns. It was **developed by Stephen Ross in the 1970s.** APT provides a framework for pricing assets based on their exposure to various systematic risk factors. Here is a detailed summary of APT, including its formula, assumptions, and limitations:

APT Formula

The APT formula for the expected return ($E(R_i)E(R_i)$) of an asset ii is given by:

$E(R_i)=R_f+\beta_{i1}\times(E(R_1)-R_f)+\beta_{i2}\times(E(R_2)-R_f)+\ldots+\beta_{ik}\times(E(R_k)-R_f)+\epsilon_i E(R_i)=R_f+\beta_{i1}\times(E(R_1)-R_f)+\beta_{i2}\times(E(R_2)-R_f)+\ldots+\beta_{ik}\times(E(R_k)-R_f)+\epsilon_i$

Where:

- $E(R_i)E(R_i)$ is the expected return on asset ii.

- $R_f R$ is the risk-free rate.

- $\beta_{ij}\beta_{ij}$ represents the sensitivity of asset ii to factor jj.

- $E(R_j)E(R_j)$ is the expected return on factor jj.

- $\epsilon_i\epsilon_i$ is the asset-specific random error term.

Arbitrage Pricing Theory (APT) continued

•APT is a multi-factor asset pricing model that is based on the idea that an asset's returns can be predicted using the linear relationship between the asset's expected return and a number of macroeconomic variables that capture systematic risk.

•Unlike the CAPM, which assume markets are perfectly efficient, APT assumes markets sometimes misprice securities, before the market eventually corrects and securities move back to fair value.

•Using APT, arbitrageurs hope to take advantage of any deviations from fair market value.

Arbitrage Pricing Theory (APT) continued

The macro-economic factors that have proven most reliable as price predictors include unexpected changes in inflation, Gross National Product (GNP), corporate bond spreads and shifts in the yield curve. Other commonly used factors are Gross Domestic Product (GDP), commodities prices, market indices, and exchange rates.

Assumptions OF APT

1. **Factor Model**: APT assumes that asset returns are determined by multiple systematic risk factors rather than a single market factor as in CAPM.
2. **No Arbitrage Opportunities**: APT assumes that investors are rational and competitive, and there are no arbitrage (the simultaneous buying and selling of securities, currency, or commodities in different markets or in derivative forms in order to take advantage of differing prices for the same asset) opportunities available in the market.
3. **Factor Sensitivity**: APT assumes that asset returns are linearly related to their sensitivities to various factors, as captured by the beta coefficients.
4. **Factor Uniqueness**: APT assumes that factors are unique and cannot be diversified away. Each factor represents a distinct source of risk in the market.
5. **Factor Independence**: APT assumes that factors are independent of each other, meaning that changes in one factor do not affect the behavior of other factors.

Limitations of APT

1. Factor Identification

One of the main challenges of APT is identifying the relevant systematic risk factors to include in the model. Determining the appropriate factors and estimating their expected returns can be subjective and may vary depending on the researcher or practitioner.

2. Factor Sensitivity Estimation

Estimating the beta coefficients ($\beta_{ij}\beta_{ij}$) accurately can be difficult, especially when dealing with a large number of factors. Small changes in these coefficients can significantly impact the model's output.

3. Model Complexity

APT can become computationally intensive and complex, particularly when incorporating numerous factors. Managing and interpreting the results of such a model can be challenging for investors and practitioners.

Limitations of APT continuation

4. Data Requirements
APT requires extensive historical data on asset returns and factor exposures, which may not always be available or reliable, especially for less liquid or newly emerging markets.

5. Market Efficiency Assumption
 APT relies on the efficient market hypothesis, which assumes that all relevant information is reflected in asset prices. However, in reality, markets may not always be perfectly efficient, leading to deviations from APT predictions.

Despite these limitations, APT remains a valuable tool for asset pricing and risk management, providing insights into the underlying factors driving asset returns and helping investors make more informed investment decisions.

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