

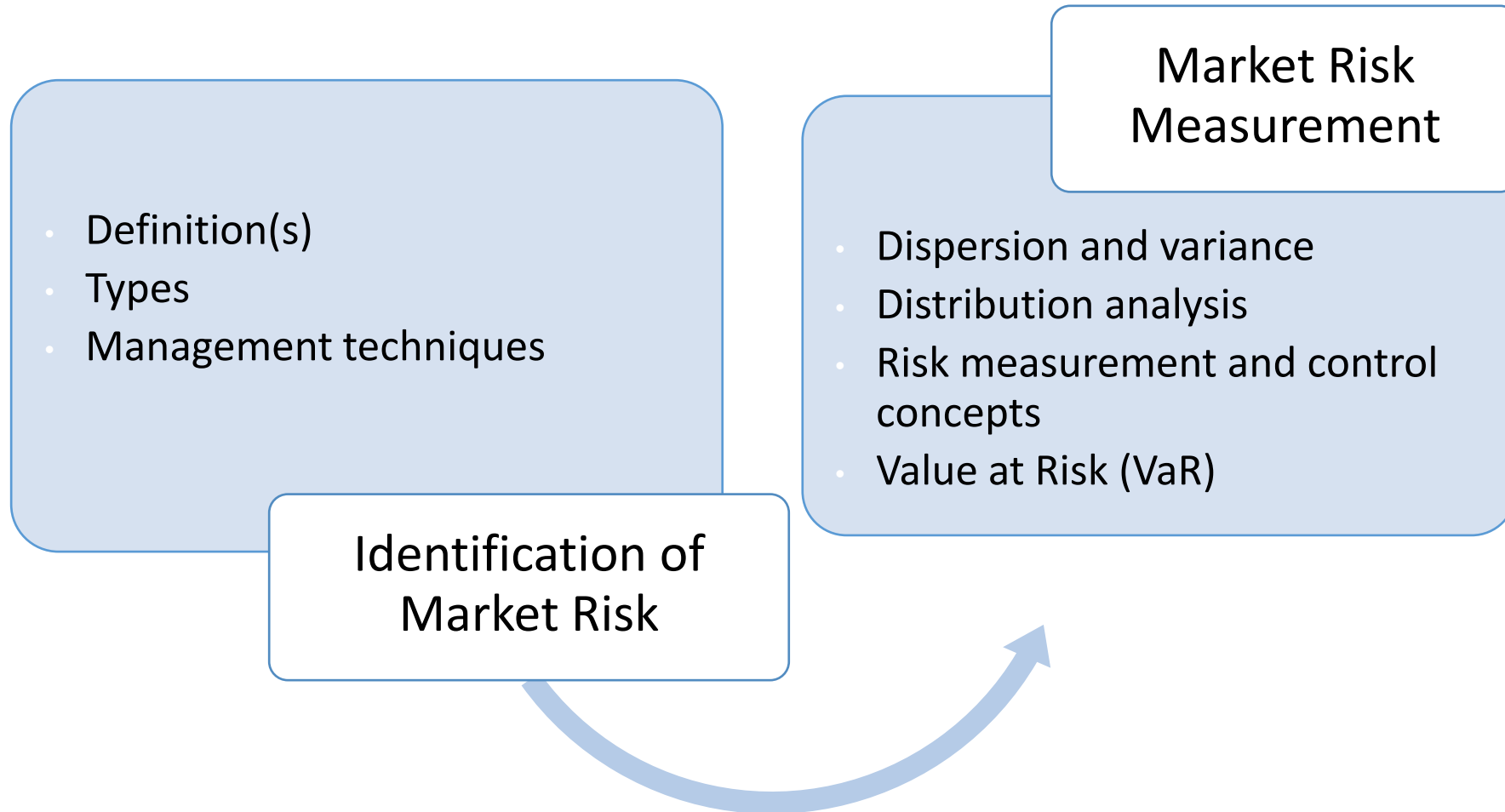


## Chapter 5

# Market Risk

Questions - 15





## Market Risk

**Price uncertainty** is the mechanism that allows **profits or losses** to be made and the risk of loss associated with it is known as market risk



# Identification of Market Risk

## Volatility Risk

- The risk of **price movements** that are more uncertain than usual affecting the pricing of products.

## Market Liquidity Risk

- The risk of loss through not being able to **trade in a market** or obtain a price on a desired product when required.

## Foreign Exchange Risk (FX)

- The risk caused by adverse **movements in exchange rates**

## Basis Risk

- When one **risk exposure** is hedged with an offsetting exposure in another instrument that behaves in a similar, but not identical, manner.



# Identification of Market Risk

## Interest Rate Risk

- The risk caused by adverse **movements in interest rates**

## Commodity Price Risk

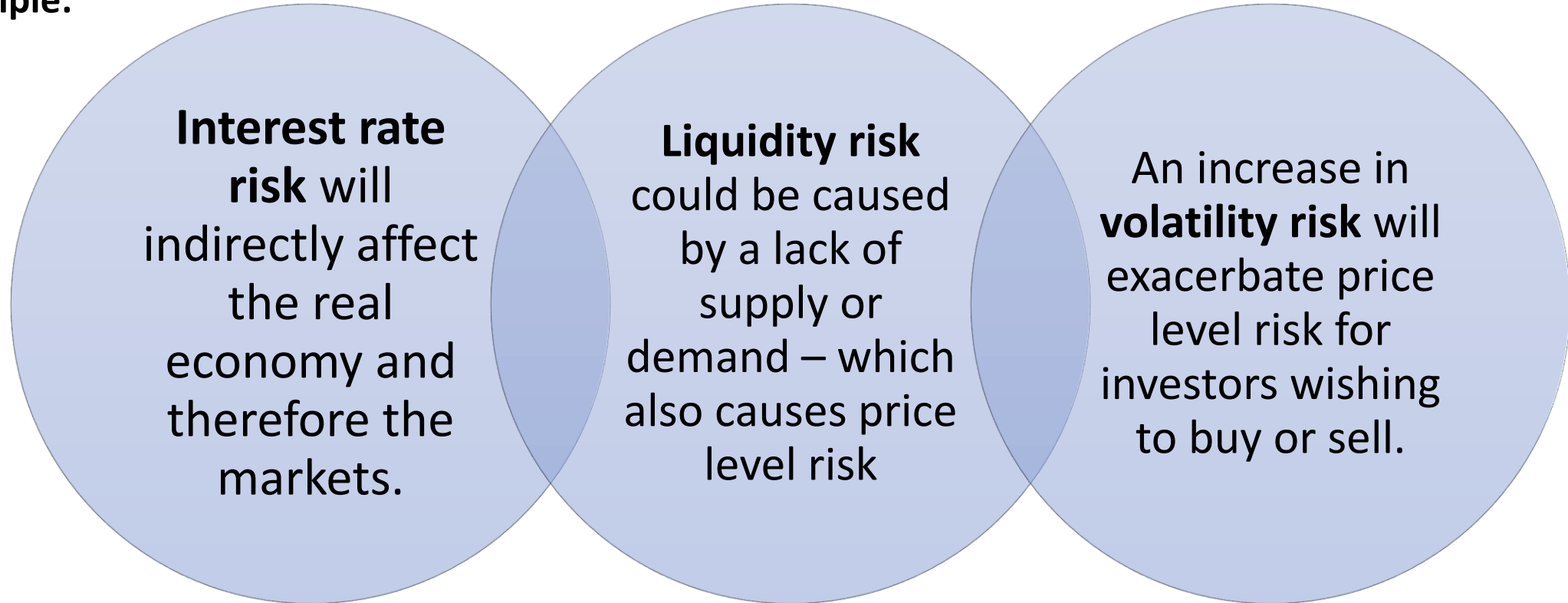
- This is the risk of an **adverse price movement** in the value of a **commodity**.

## Equity Price Risk

- **Capital growth** – if a company does well, the price of its shares should go up
- **Income** – through the distribution by the company of its profits as dividends



Many of the constituent market risk elements described above are related to each other. For example:



These boundary issues mean that it is not straightforward to analyse exactly which factors are causing which movements



# Market Risk Examples

## Currency Risk

- A UK investor purchases an equity portfolio in the US. The investment itself, in dollars, provides a positive return of 10% but because the dollar loses 8% of its value against the pound, the investor's return is only 2%.

## Interest Rate Risk

- An investor purchases a long-term bond in the UK hoping to sell it at a profit in the future. Bond prices move inversely to interest rate moves, if interest rates increase, the price of bonds will fall. For short term bonds the change in prices will be relatively minor compared to the change in price for a long-term bond .

## Liquidity Risk

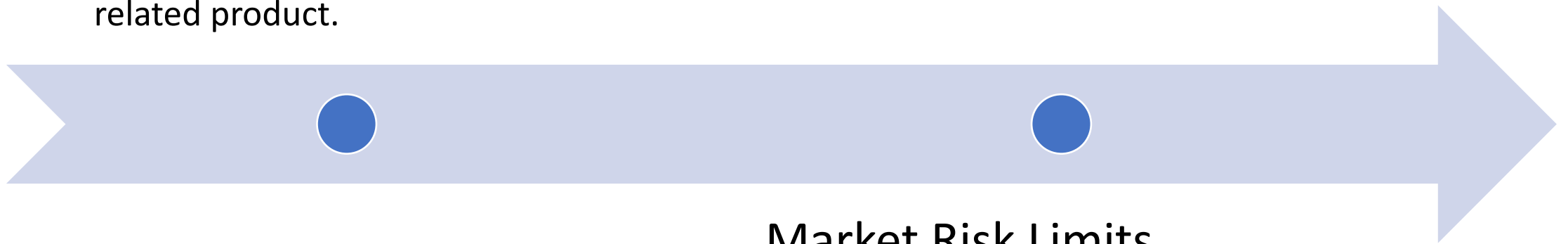
- An investor purchases a commercial property to rent out. Because of liquidity issues in the property market, it takes much longer to sell again – even reducing the price may not help if no-one else wants to own the property, or if it becomes difficult to obtain credit for a mortgage.



## Techniques and their Application

### Hedging

- Hedging is a means of **reducing the risk** of adverse price movements by taking an offsetting position in a related product.



### Market Risk Limits

- When an organisation takes a risk, it will specify the **maximum loss** that it is prepared to make on a portfolio or transaction. This is called the market risk limit or stop-loss limit

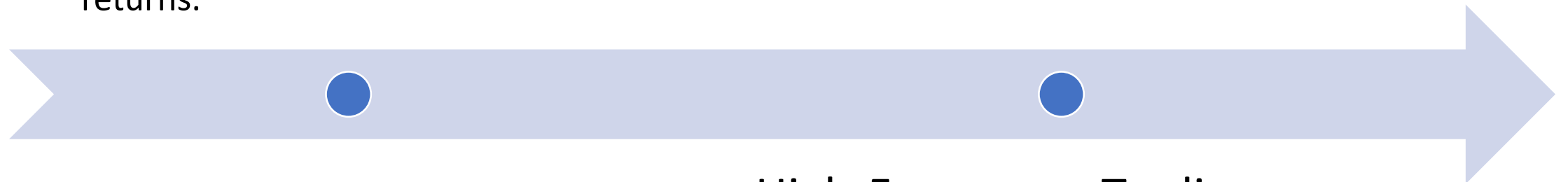




## Techniques and their Application

### Diversification

- The market risk of **holding two securities** in isolation is given by their respective standard deviation of returns.



### High-Frequency Trading (HFT)

- HFT firms pursue speed above all else, rather than developing **economic price prediction models**.



# The Market Risk Management Function

An effective market risk function will include the following features:

Ownership of the firm's market risk **management policy**

**Defined escalation procedures** to deal with rising levels of trading loss, and market risk limit breaches

**Ensuring that VaR** is not used alone, but is combined with stress testing and scenario analysis

Accounts and review of front-office **closing prices**

Proactive management involvement in **market risk issues**

Independent validation of market pricing and adequacy of **VaR models**

**Independent daily monitoring** of risk utilisation through the daily production of profit and loss (P&L)



## What is Hedging ?

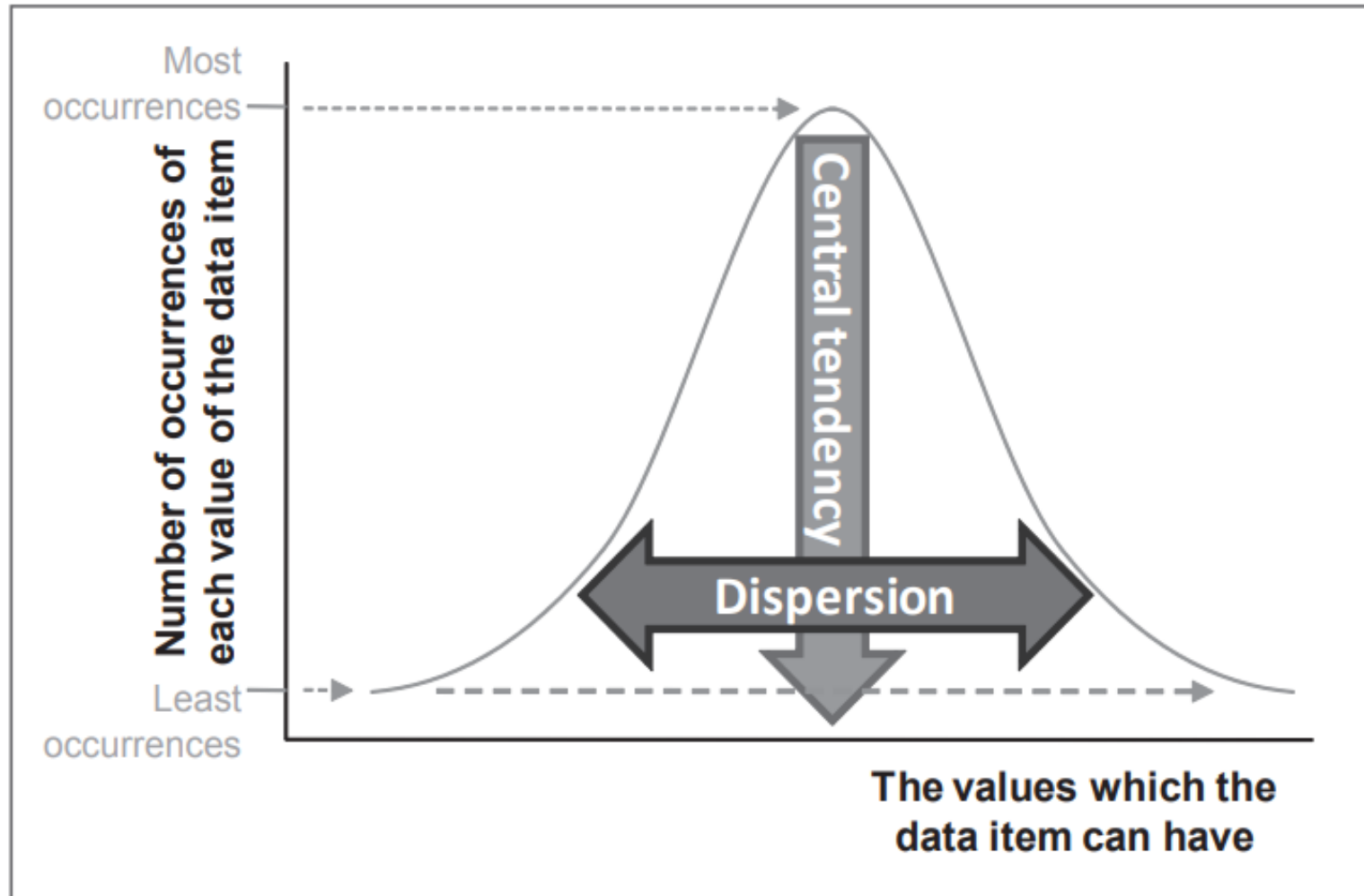
- A. The risk of price movements that are more uncertain than usual, affecting the pricing of products
- B. The risk caused by adverse movements in exchange rates
- C. Reducing the risk of adverse price movements by taking an offsetting position in a related product.
- D. Risk due to an uneven distribution of exposures

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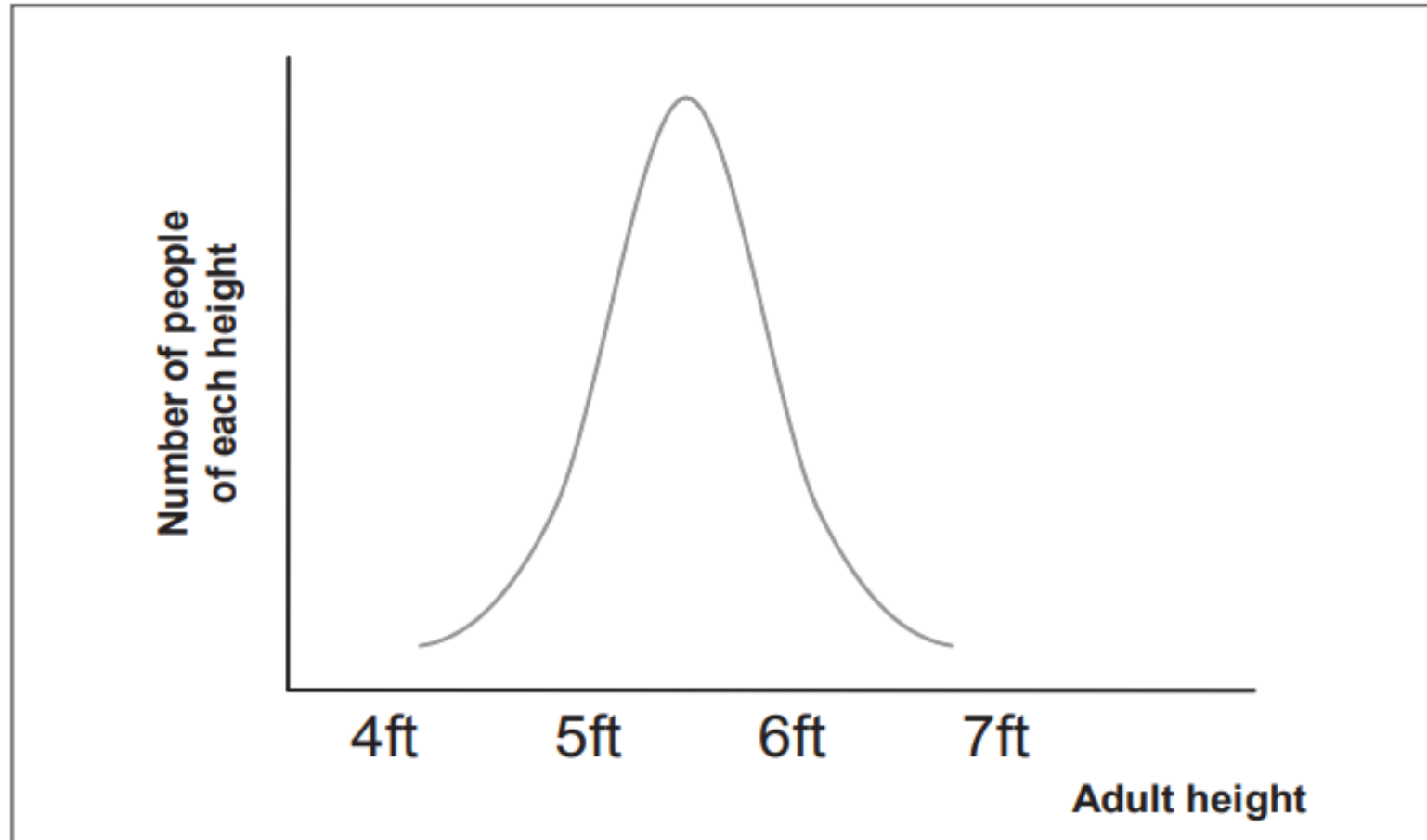


# Market Risk Measurement

## Calculating Dispersion and Variance - Illustrating Normal Distribution



# Calculating Dispersion and Variance – Example



# Measures of Central Tendency

## Mean

Mean = the sum of all of the observed values ÷ the number of observations

Example :  $(7\%+8\%+9\%+10\%+11\%+12\%) \div 6$   
 $= 9.5\%$

The mean or average  $\longrightarrow \bar{x} = \frac{\sum x}{n}$

The sum of all observed values  $\longleftarrow$

The number of observed values  $\longleftarrow$



# Measures of Central Tendency

## Median

The median is the value of the **middle item** in a set of data arranged in ascending order.

2	5	8	9	12	13	15	16	18		
Four numbers				Median	Four numbers				→	<b>ODD</b>

2	5	8	9	12	13	15	16	18	19		
				Median = 12.5 $\frac{(12 + 13)}{2}$						→	<b>EVEN</b>



## Mode

The most **frequently occurring** number in a set of data.

## Example

£100k, £125k, £100k, £115k, £135k, £95k, £100k

Mode = 100k



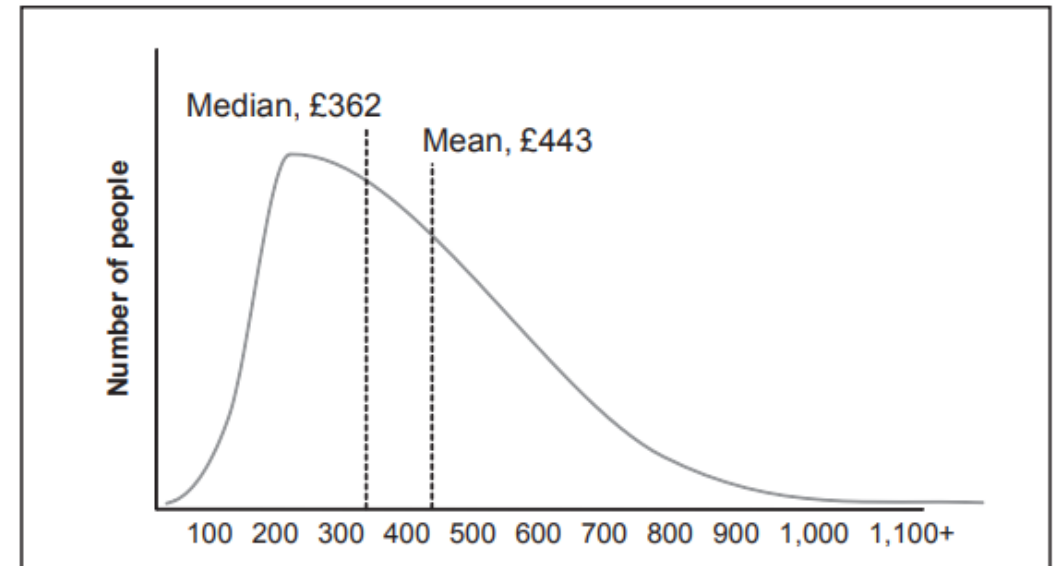
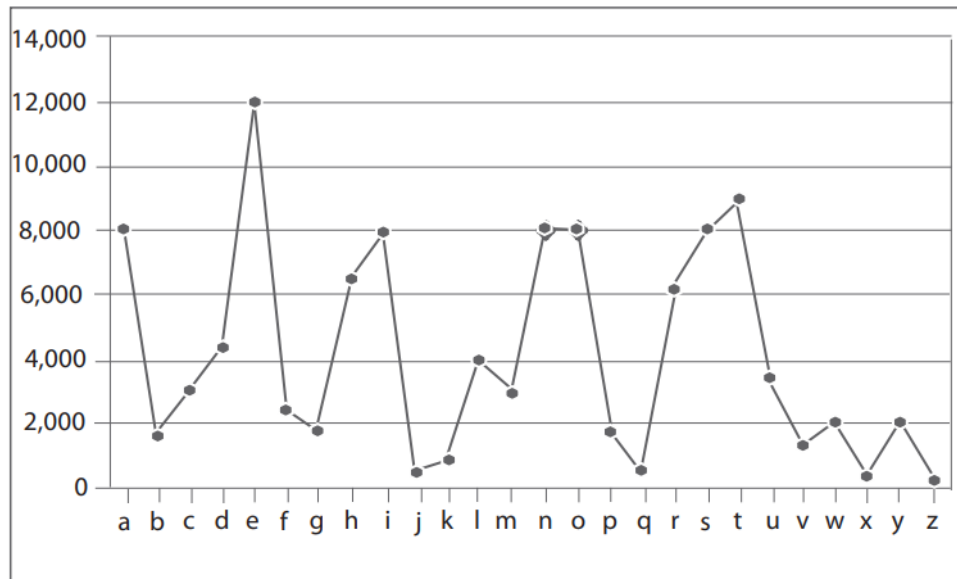


# Which Measure to Use

**Mean** is what people often refer to as the average and is the most used measure of central tendency

**Median** it is a more robust measure of central tendency.

**Mode** is useful when working with qualitative not quantitative data



## Range

The difference between the **highest and lowest** values in a set of data.

Let us assume that the following numbers represent the returns from an investment fund over ten years. Using the range measure would indicate that the average returns from the fund had a range of 11 ( $13-2=11$ ).

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Return	7	6	5	2	3	3	6	9	11	13

The main drawback in using range as a measure of dispersion is that it is distorted by extreme values and ignores the numbers in between.



# Measures of Dispersion

## Inter-Quartile Range

It ranks data against each other and presents the data as a **series of quartiles**.

Fund	A	B	C	D	E	F	G	H	I	J	K	L
Return	3.5%	4%	4.75%	5%	5%	5.75%	6%	6.5%	7%	7.5%	8%	9%
Median 5.875%												
Quartile	1st quartile			2nd quartile			3rd quartile			4th quartile		
				Inter-quartile range								



# Quartile Deviation

Formula

- Quartile deviation =  $\frac{1}{2} (Q3 - Q1)$

Step one

- **Find the median** of the data set and call this median Q2

Step two

- Use Q2 to divide the original data set into two parts.
- The **lower 50%** consists of those values less than Q2.
- The **upper 50%** consists of values greater than Q2.

Step three

- Calculate Q1 as the median of the **lower data set**
- Calculate Q3 as the median of the **upper data set**

Step four

- $(Q3 - Q1)/2$  is the quartile deviation



# Question Time

What is the mean from these daily volume numbers:  
100, 200, 150, 175, 230?

- A. 175
- B. 167
- C. 171
- D. 200

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## Variance

- Variance is a measure of **dispersion** and shows the spread of data around the mean.



## Standard Deviation

- A set of data is simply the square root of the variance and is the most commonly used **measure of dispersion**.



# Examples of Variance

Assume , Mean can be simply computed as:  $(13\%+11\%+2\%+6\%+5\%+8\%+7\%+9\%+7\%+6\%) \div 10 = 7.4\%$

Row two - The difference in the return each year from the mean

Row three - shows this difference squared

Row four - shows the average variance for the data

	Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
1	Return	13	11	2	6	5	8	7	9	7	6	
2	Difference from the mean	5.6	3.6	-5.4	-1.4	-2.4	0.6	-0.4	1.6	-0.4	-1.4	
3	Difference squared	31.36	12.96	29.16	1.96	5.76	0.36	0.16	2.56	0.16	1.96	86.4
4	Average variance (86.4/10)											8.64



# Standard Deviation

The steps you should take in making these calculations manually are as follows:

Obtain the mean

Square each deviation

Take the square root of the variance to obtain the standard deviation

Obtain the set of deviations from the mean

Divide the sum of the squared deviations by the number of observations to obtain the population variance

Population standard deviation =

$$\sqrt{\frac{\sum (x - \bar{x})^2}{n}}$$

Sample standard deviation =

$$\sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}}$$





# Application of Dispersion and Variance Measures

The variance of a set of stock returns provides a measure of the returns' dispersion and is used to calculate the beta of the stock

The variability of returns generated by an asset or portfolio

Knowing the standard deviation can help us to know the range of different values of return we might expect from an investment.



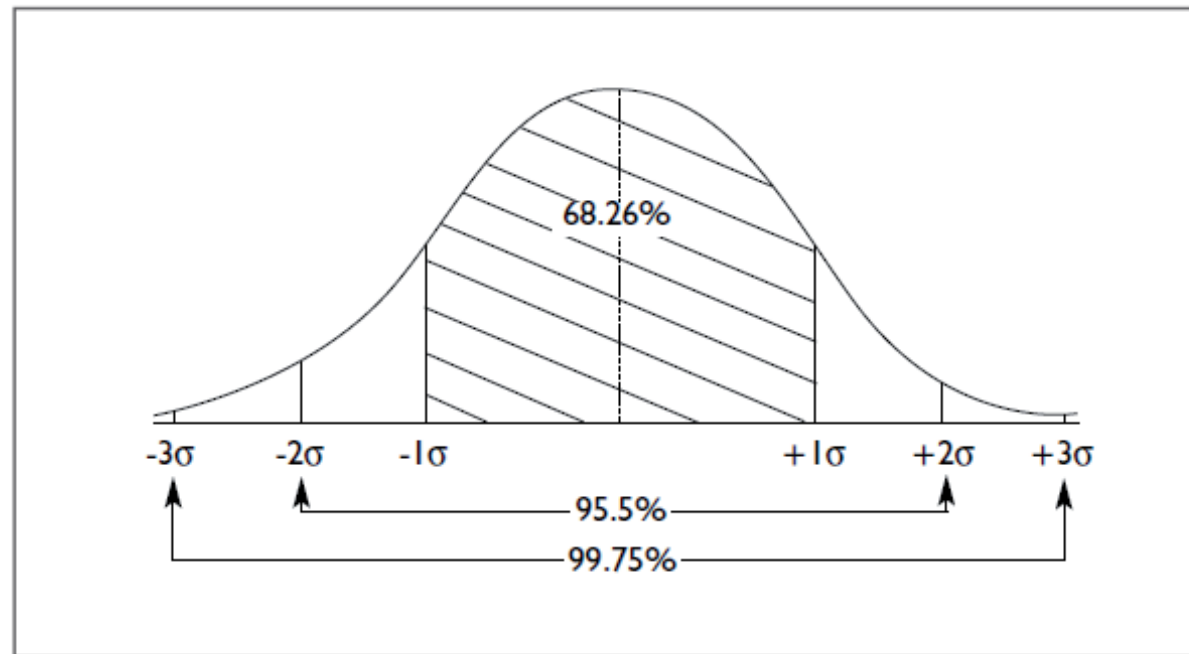
# Understanding the Terminology

## Distribution Analysis

- Distribution analysis is a statistical means of using **historical data to predict future events** and relies on an understanding of probability distributions

## A normal distribution curve has the following attributes:


- It is symmetrical about its mean
- It is defined by its mean and its standard deviation (represented by the Greek letter sigma,  $\sigma$ ).



# Confidence Intervals

**Investment returns** from primary instruments based on market factors, are assumed to be normally distributed.

This probability is also known as the '**confidence interval**'.

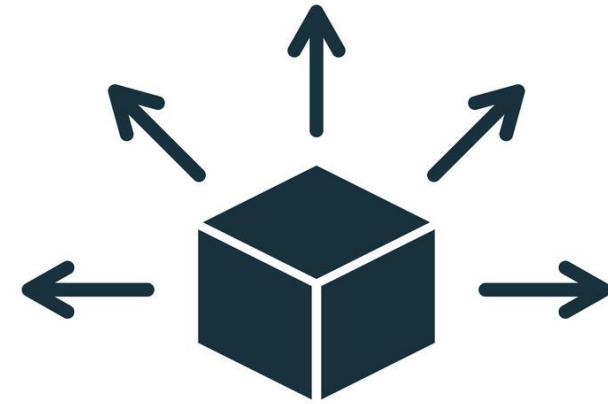


It is possible to create a model that will predict the future performance of the instrument to a given level of probability



# Fat-Tailed Distribution

- This means that using a **normal distribution** for simplicity when the distribution is fat-tailed will result in periodically very large deviations from our expected returns.



**DISTRIBUTION**



## Probability

$$\frac{\text{The number of ways the event can occur}}{\text{The total number of possible outcomes}}$$

## Volatility

- The volatility is a description of how variable they are

## Regression

- Regression analysis is a statistical tool for the investigation of relationships between variables



## How do you calculate the Probability ?

A.  $\frac{\text{The number of ways the event can occur}}{\text{The total number of possible outcomes}}$

B.  $\sqrt{\frac{\sum (x - \bar{x})^2}{n}}$

C.  $\sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}}$

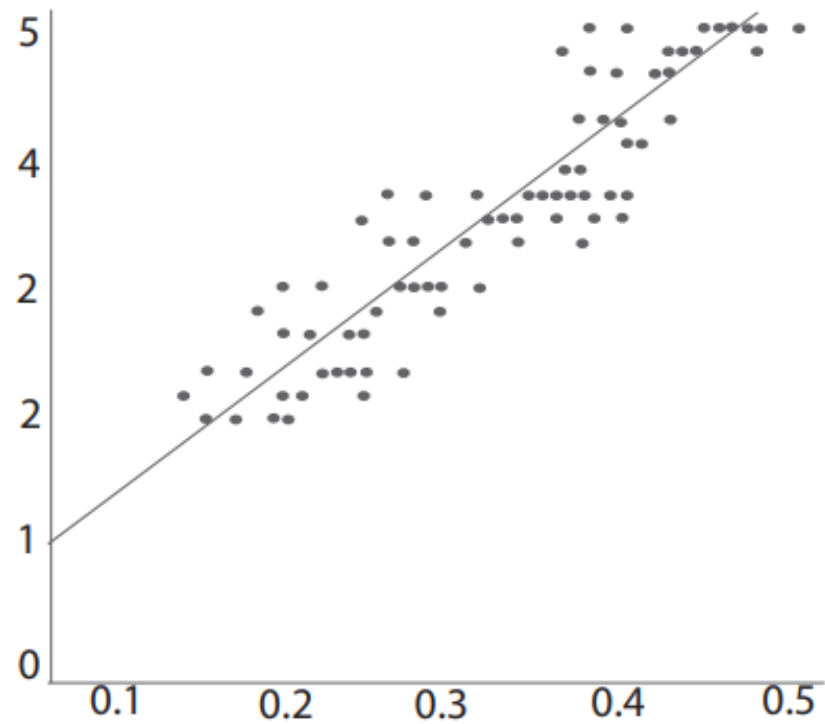
D. The sum of all the observed values \* the number of observations

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# Regression Line

## Regression Line



## The Correlation Coefficients: Alpha and Beta

- Positive correlation describes a Positive relationship
- Negative correlation describes a Negative relationship
- Beta - Correlation with the market
- Alpha -The performance of a fund or portfolio above a benchmark

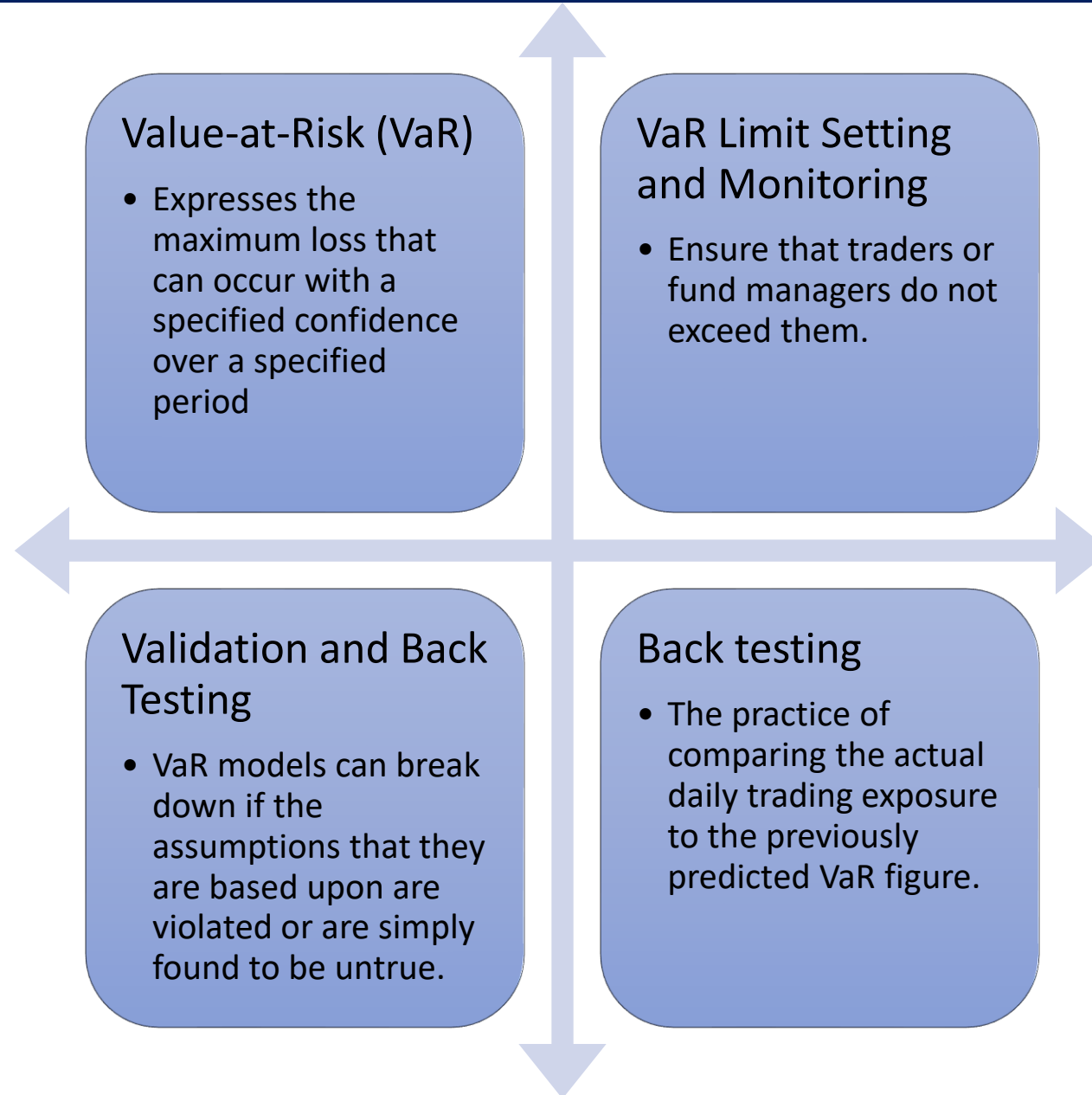
## Optimisation

- Portfolio construction techniques that obtain the best expected returns from the right mix of correlations and variances





# Value-at-Risk (VaR) Approach



# The Three Different Approaches to VaR

## Historical simulation

This involves looking back at what actually happened in the past and basing our view of the future on that analysis.

## Monte Carlo simulation

This involves generating a random set of results based on the actual underlying risk factors and again 'reading off' the graph

## The parametric approach

This assumes that the distribution of possible returns can be plotted, based on a small number of factors, so that the required confidence level can be 'read off' the graph.



# Historical simulation

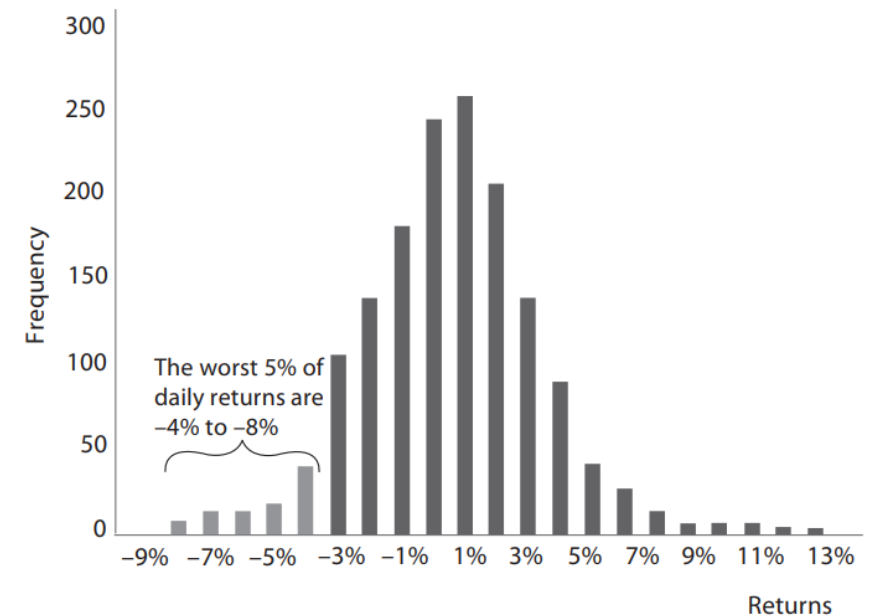
## Advantages

- It is conceptually simple enough to communicate easily to **non-specialists**
- There is no need to make any assumption about the distribution of the **portfolio's returns**.
- There is also no need to estimate the volatilities and correlations between the **various assets** in the portfolio.

## Disadvantages

- It assumes that history will repeat itself

VaR: The Historical Simulation Approach



# The Parametric Approach

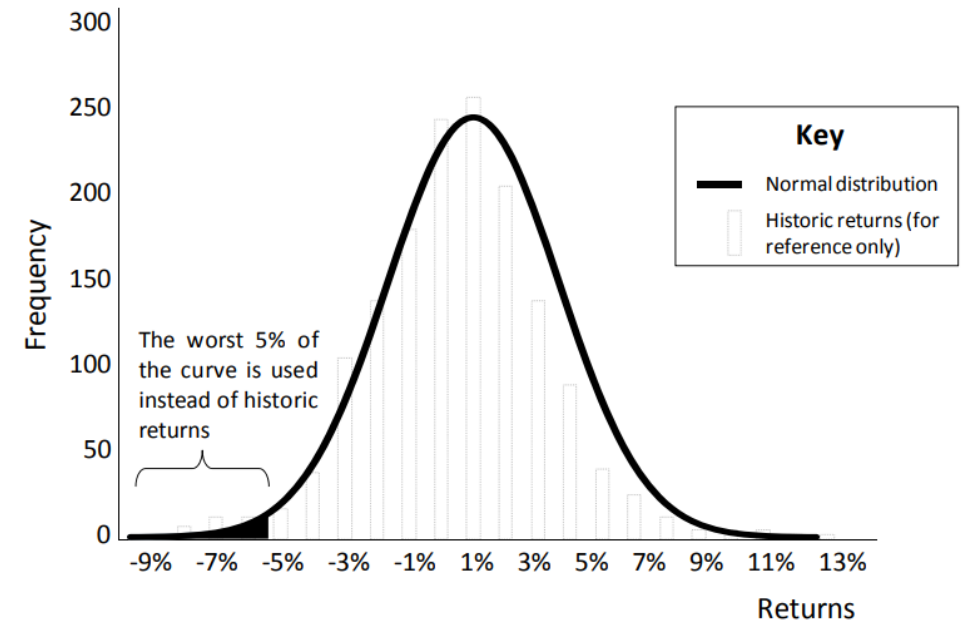
## Advantage

- The **parametric approach** is the simplest methodology used to compute VaR
- A limited amount of input data is required
- **Minimal computation** time is required

## Disadvantages

- Too simple
- The **actual returns** are not actually normally distributed, the results will be inaccurate.
- Does not work for derivatives such as options.

VaR: The Parametric or Analytical Approach



# Monte Carlo Simulation Method

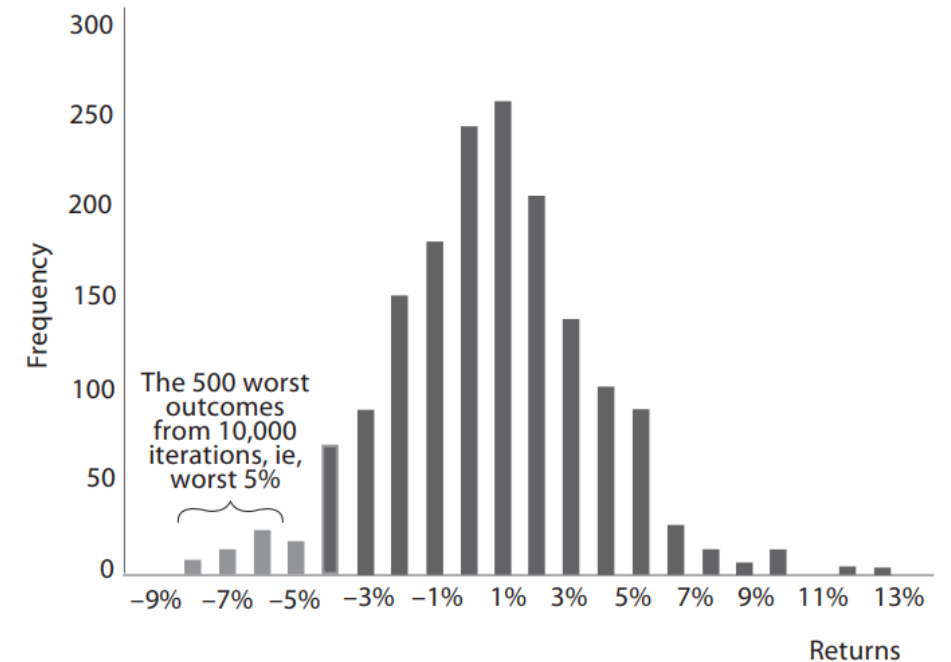
## Advantages

- It can be used to produce VaR for **non-normally distributed** instruments such as options.

## Disadvantages

- Computing power required and time taken to run the simulations

VaR: Monte Carlo Simulation Approach



## What is Historical Simulation?

- A. Generating a random set of results based on the actual underlying risk factors
- B. Looking back at what actually happened in the past
- C. Assuming that the distribution of possible returns can be plotted, based on a small number of factors
- D. Looking at actual returns based on the underlying risks

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VaR does not suggest how bad a situation can get. Scenario analysis and stress testing provides this:

- A stress test alters **one variable at a time** to analyse its effect on the rest of the portfolio.
- Scenario analysis looks at **how the portfolio behaves** under conditions of multiple changes.

