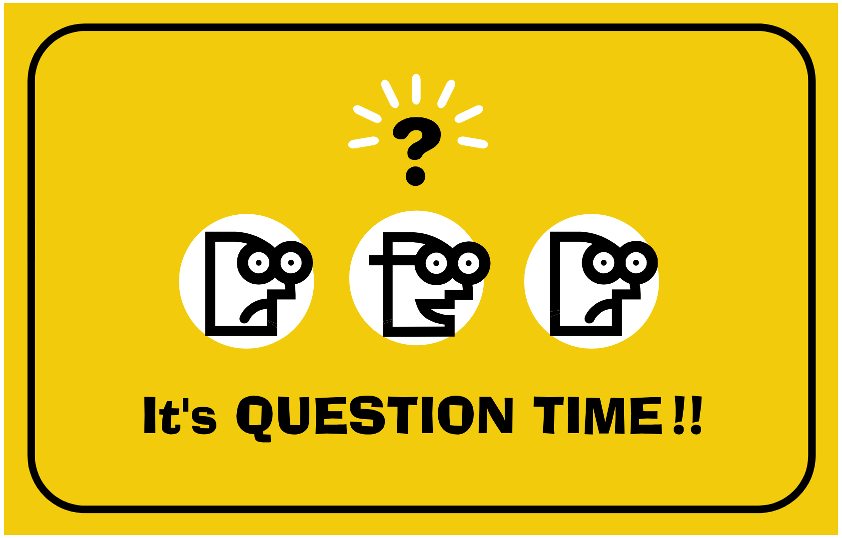
Time series

Time series and Trend analysis

A time series consists of a set of observations measured at specified, usually equal, time interval.

Time series analysis attempts to identify those factors that exert influence on the values in the series.



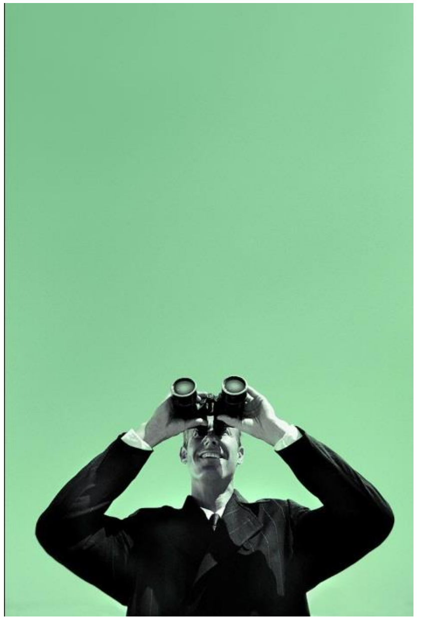
Time series analysis is a basic tool for forecasting. Industry and government must forecast future activity to make decisions and plans to meet projected changes.

An analysis of the trend of the observations is needed to acquire an understanding of the progress of events leading to prevailing conditions.

The trend is defined as the long term underlying growth movement in a time series.

Accurate trend spotting can only be determined if the data are available for a sufficient length of time.

Forecasting does not produce definitive results. Forecasters can and do get things wrong from election results and football scores to the weather.



Time series examples

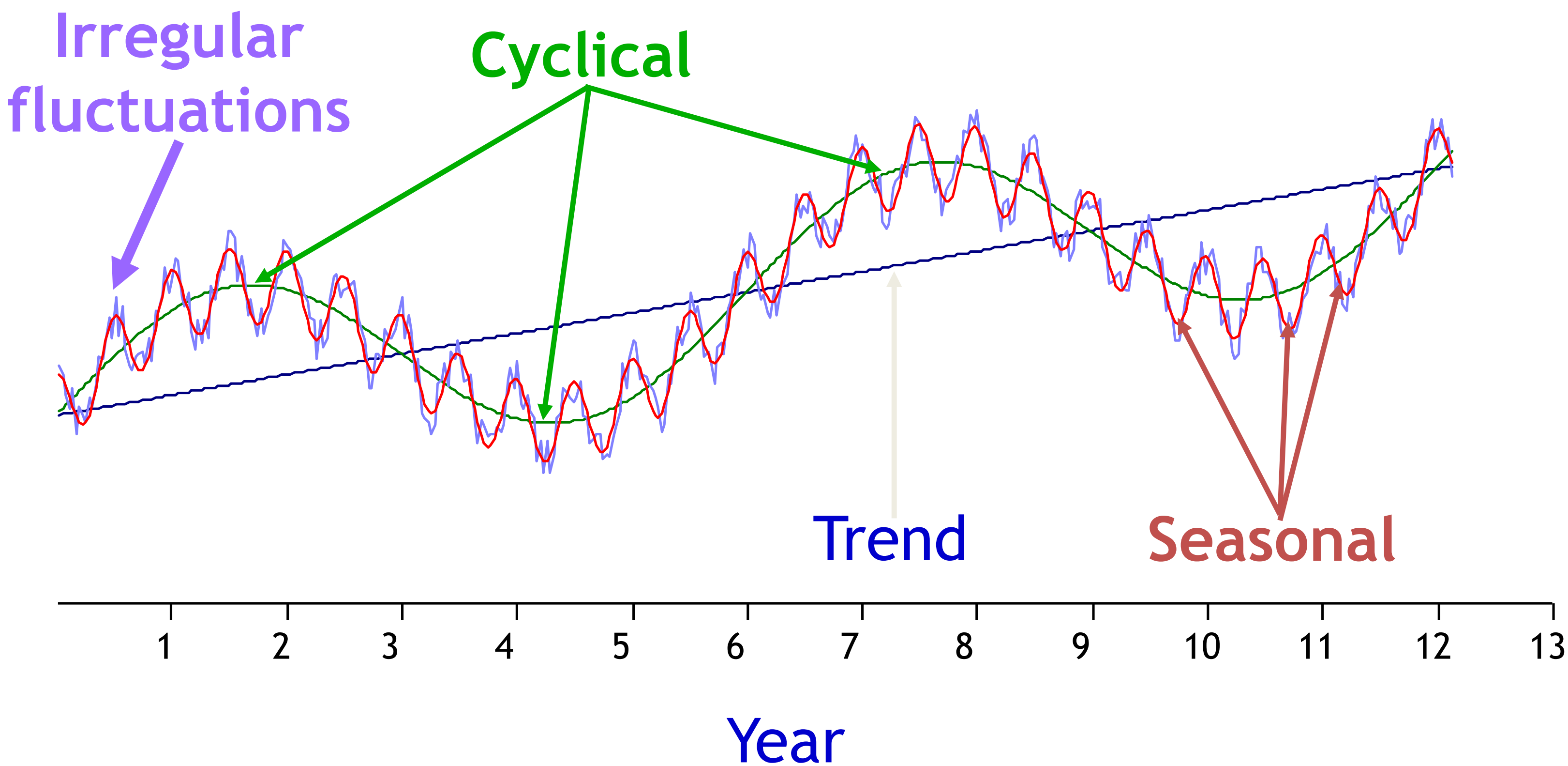
- Sales data
- Gross national product
- Share prices
- $A Exchange rate
- Unemployment rates
- Population
- Foreign debt
- Interest rates

Time series components

Time series data can be broken into these four components:

1. Secular trend
2. Seasonal variation
3. Cyclical variation
4. Irregular variation

Components of Time-Series Data



Predicting long term trends without smoothing?
What could go wrong?
Where do you commence your prediction from the bottom of a variation going up or the peak of a variation going down……….

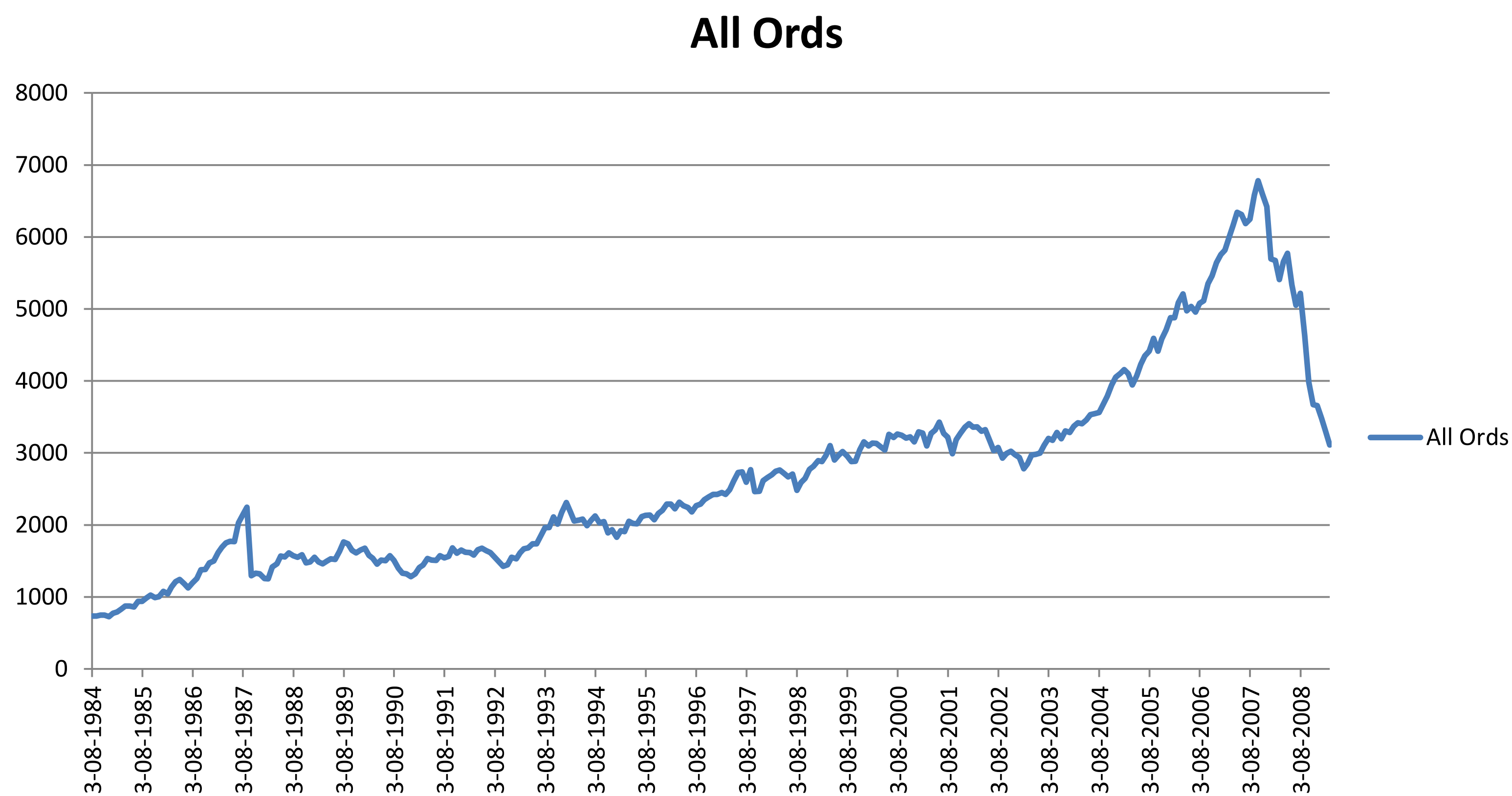
1. Secular Trend

This is the long term growth or decline of the series.

- In economic terms, long term may mean >10 years
- Describes the history of the time series
- Uses past trends to make prediction about the future
- Where the analyst can isolate the effect of a secular trend, changes due to other causes become clearer

Secular Trend

A secular trend identifies the underlying trend (direction) of the data: – increasing, decreasing or remaining constant. It is the long term direction of the data, usually described by the "line of best fit". And is deduced over a large number of periods. The following chart is a long term graph of the ASX200.

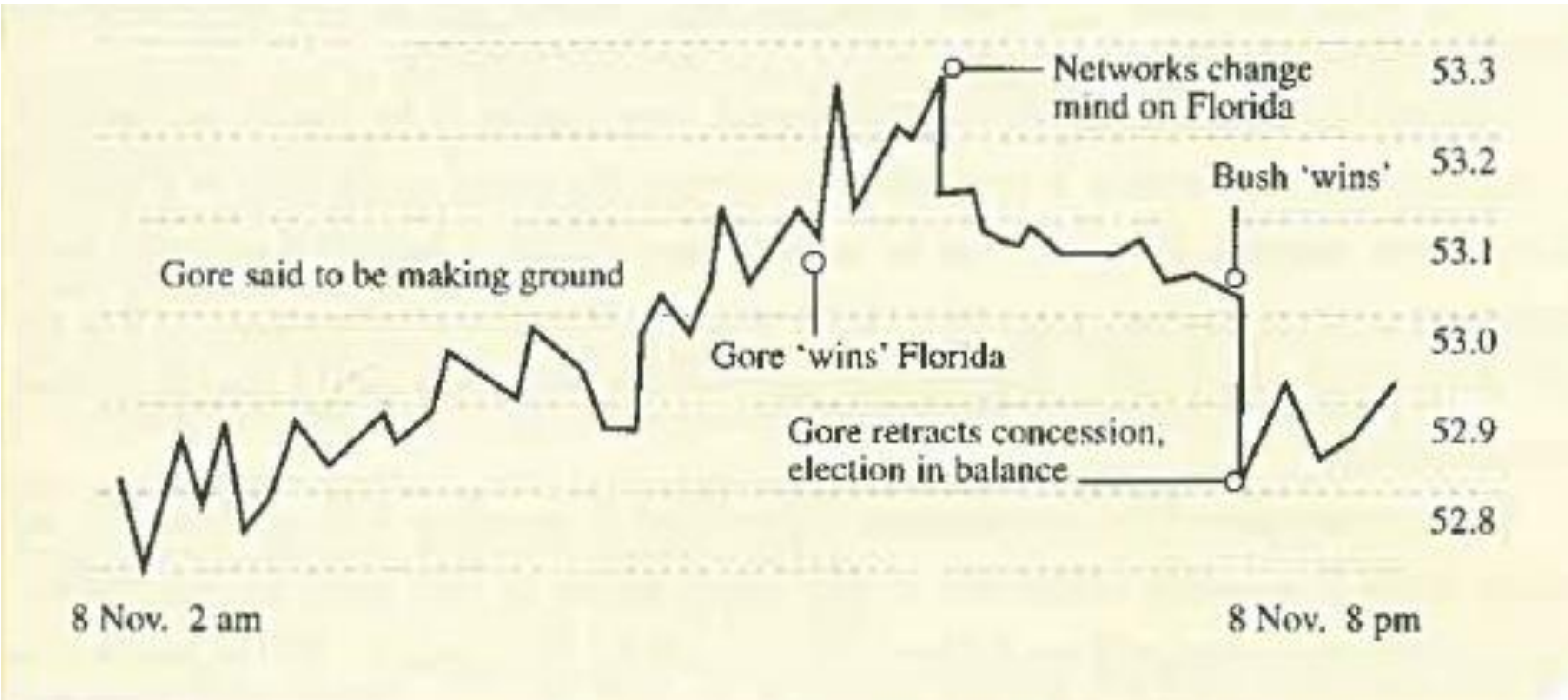


Look out

While trend estimates are often reliable, in some instances the usefulness of estimates is reduced by:

- by a high degree of irregularity in original or seasonally adjusted series or
- by abrupt change in the time series characteristics of the original data

$A vs $US
during day 1 vote count 2000 US Presidential election



This graph shows the amazing trend of the $A vs $UA during an 18 hour period on November 8, 2000

2. Seasonal Variation

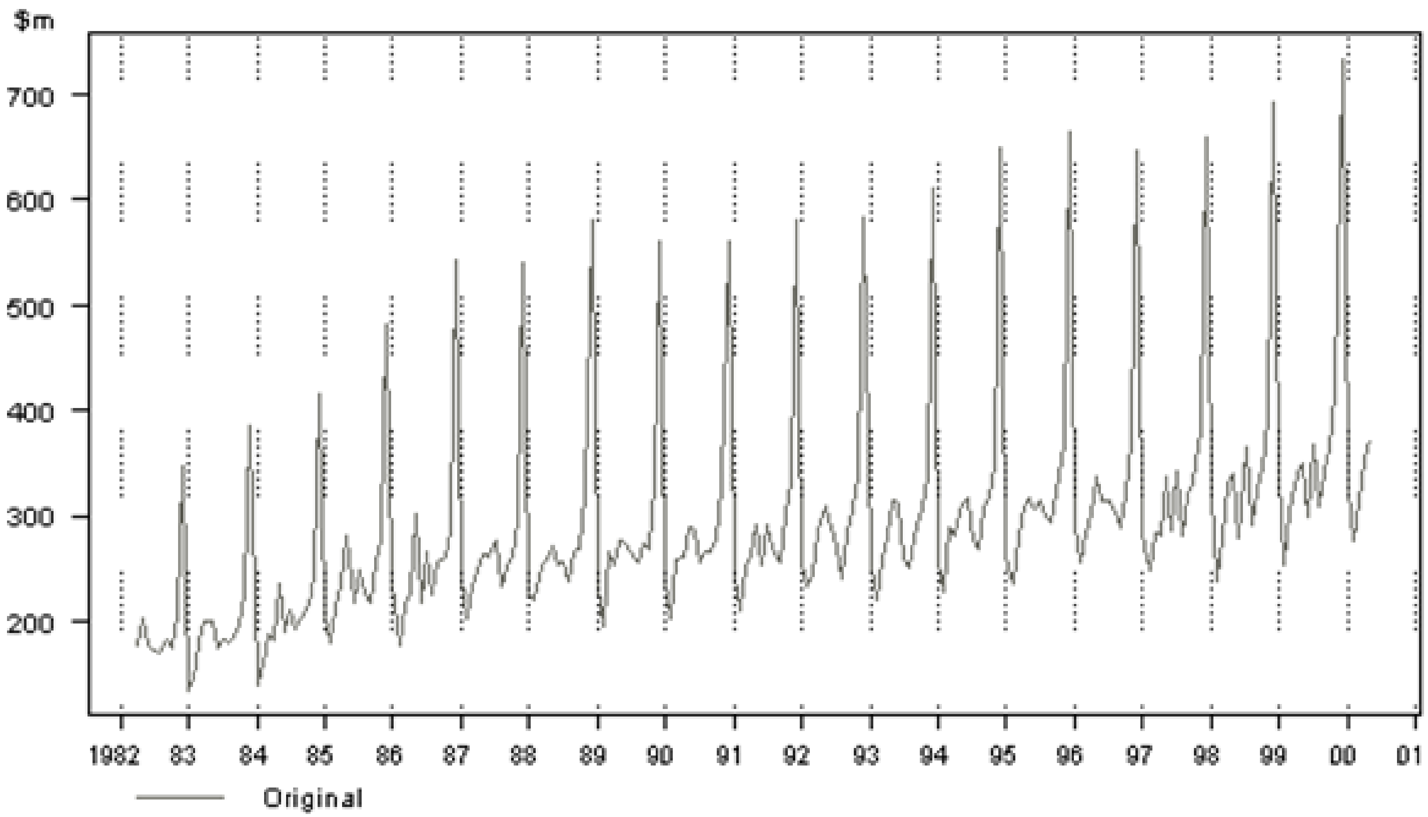
The seasonal variation of a time series is a pattern of change that **recurs** regularly over time.

Seasonal variations are usually due to the differences between seasons and to festive occasions such as Easter and Christmas.

Examples include:

- Air conditioner sales in Summer
- Heater sales in Winter
- Flu cases in Winter
- Airline tickets for flights during school vacations

Monthly Retail Sales in NSW Retail Department Stores



Seasonal Movement

Seasonal movement refers to regular periodic fluctuations that occur in each time period – yearly, monthly, daily. Some examples are speciality cards for Valentine's Day, monthly travel passes and off-peak heating.

Seasonal variations greatly impact on the outcomes of recorded data and often belie the underlying trend. Businesses need to identify the seasonal impact:

- So that a measurement (index) can be used to adjust the expected outcome.

- In order to recognise the direction of the underlying trend.

3. Cyclical variation

Cyclical variations also have recurring patterns but with a longer and more **erratic time scale** compared to Seasonal variations.

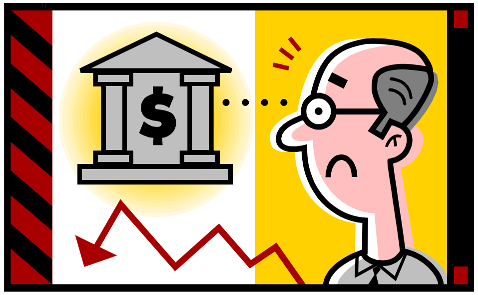
The name is quite misleading because these cycles can be far from regular and it is usually impossible to predict just how long periods of expansion or contraction will be.

There is no guarantee of a regularly returning pattern.

Cyclical variation

Example include:

- Floods
- Wars
- Changes in interest rates
- Economic depressions or recessions
- Changes in consumer spending

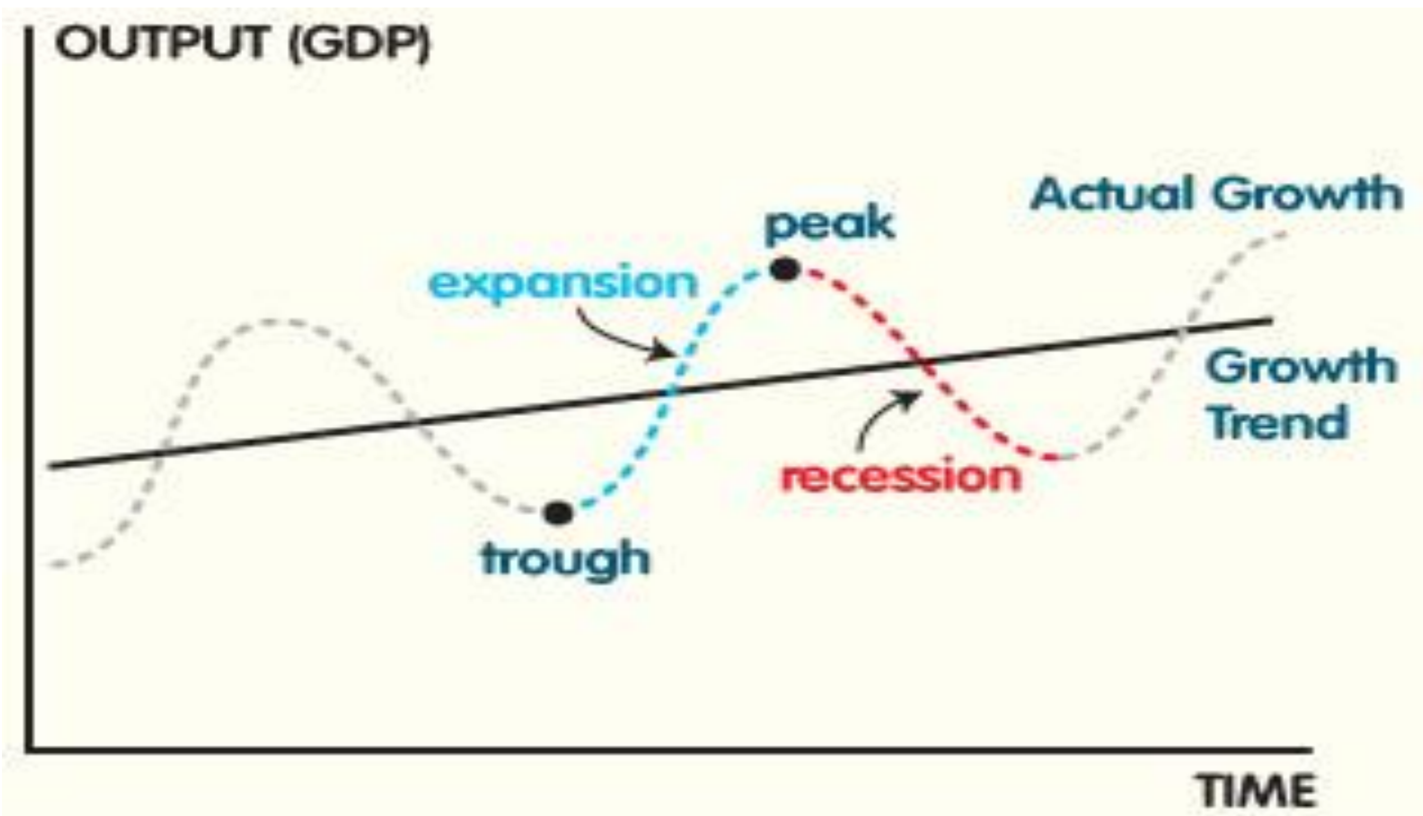


Cyclical Movement

This reflects the level of business activity and economic movement over time by fluctuating patterns, known as the economic cycle. These variations measure periods of expansion and contraction in industry and the economy. Their regularity and intensity are not predictable, however certain economic indicators contribute to their existence – level of investment, confidence in the economy, GDP, trade indexes and government policy.

Cyclical variation

This chart represents an economic cycle, but we know it doesn't always go like this. The timing and length of each phase is not predictable.



4. Irregular variation

An irregular (or random) variation in a time series occurs over varying (usually short) periods.

It follows no pattern and is by nature unpredictable.

It usually occurs randomly and may be linked to events that also occur randomly.

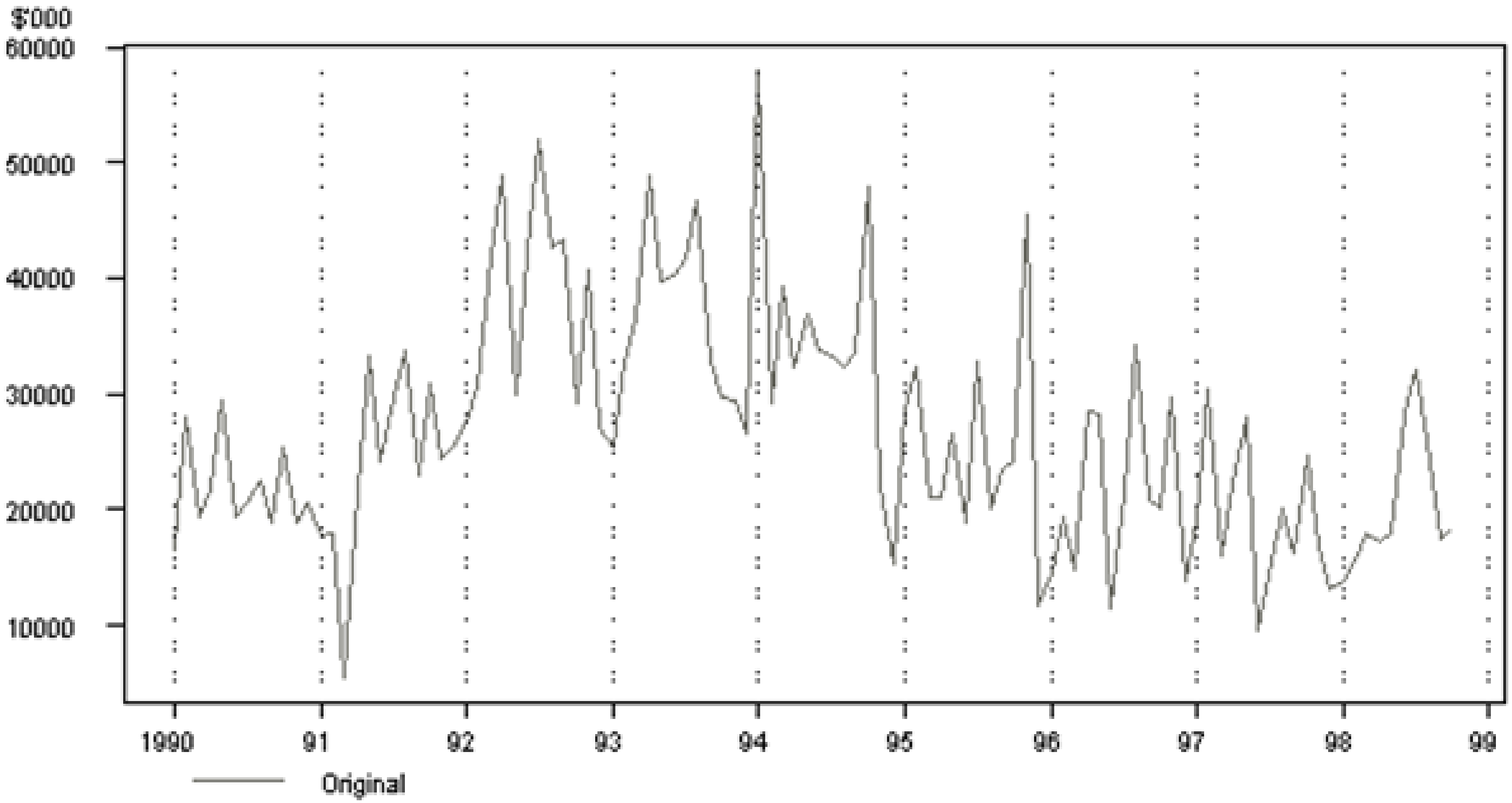
Irregular variation cannot be explained mathematically.

Irregular variation

If the variation cannot be accounted for by secular trend, season or cyclical variation, then it is usually attributed to irregular variation. Example include:

- Sudden changes in interest rates
- Collapse of companies
- Natural disasters
- Sudden shift s in government policy
- Dramatic changes to the stock market
- Effect of Middle East unrest on petrol prices

Monthly Value of Building Approvals ACT)



Irregular Movements

These patterns refer to random variations that impact greatly on the level of business activity, often called natural variation. Some examples are extreme weather patterns (flood, fire, cyclone), extreme business variation (stock market crash, drop in $A), political climate (sudden elections, wars, death of a leader), and industry changes (pilot strikes, waterside strikes.). The resulting patterns will exert a great pressure on the predicted underlying trends and for this reason must be accounted for when planning for the future. However, the irregular movements are unpredictable.

Now we have considered the 4 time series components:

1. Secular trend
2. Seasonal variation
3. Cyclical variation
4. Irregular variation

We now take a closer look at secular trends and 5 techniques available to measure the underlying trend.

Measurement of the Underlying (secular) Trend

The essential aim of time series analysis is to use past information to establish and plan for the next time period(s). This is achieved effectively by measuring the underlying or secular trend which depicts the general direction of the trend line over time.

The secular trend is influenced by:

- Population changes.
- Productivity improvement.
- Technological changes.
- Market changes.

Why examine the trend?

When a past trend can be reasonably expected to continue on, it can be used as the basis of future planning:

- Capacity planning for increased population
- Utility loads
- Market progress

The most common methods for depicting the secular trends are:

- Freehand drawing (graphing).
- Semi-average.
- Moving average.
- Least- squares method.
- Exponential smoothing.

Measure underlying trend freehand graph (plot)

Example: Plot and Estimate

Let us look at these individually using the following data:

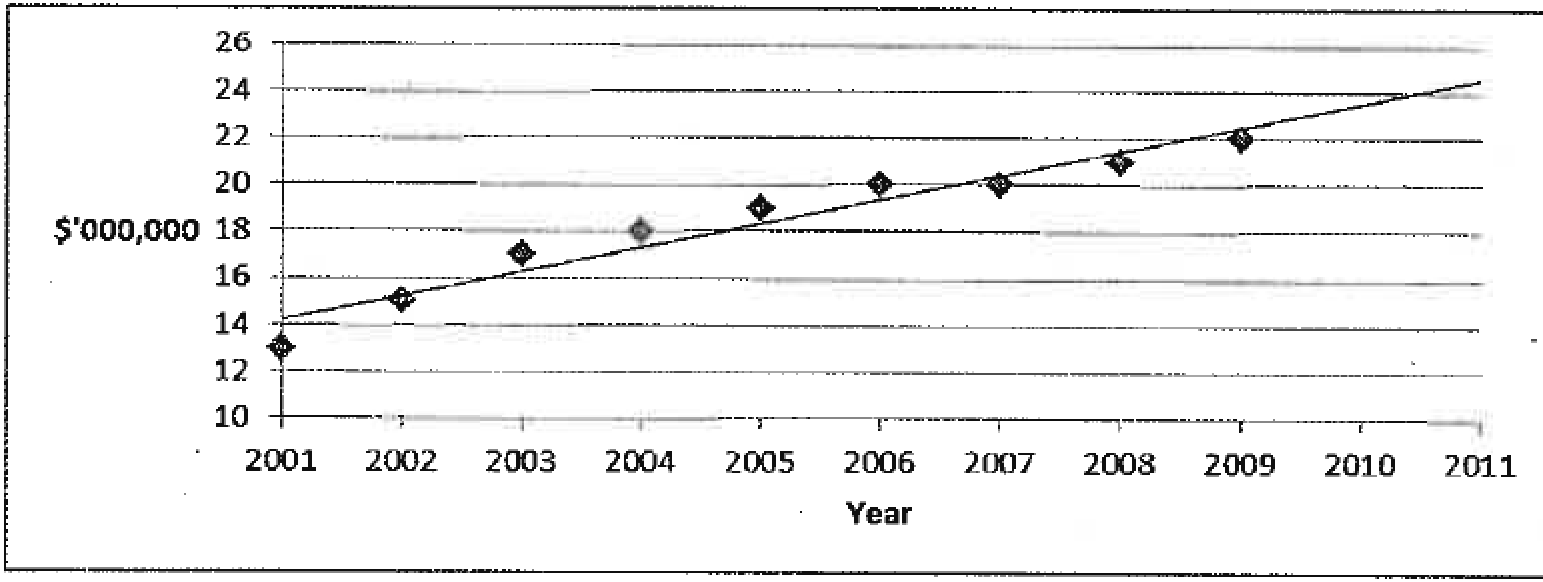
Annual Soft Drink	2001	2002	2003	2004	2005	2006	2007	2008	2009
($'000,000)	13	15	17	18	19	20	20	21	22

Required:
(a) Plot the data freehand and estimate sales for 2011
(b) Derive a trend line using the Semi-average method
(c) Derive a trend line using the Moving-average method Three year , Five year and Four year

Solution

(a) **Freehand:**

This requires the data to be plotted like a scatter diagram with time on the horizontal and information represented vertically.



A line of best fit is plotted through the data.

For predictive purposes, the line is extended and the respective year's data is read from the graph. Therefore 2011 – Sales estimate: $24,000,000.

Measure underlying trend
Semi-averages

This technique attempts to fit a straight line to describe the secular trend:

i. Divide data into 2 equal time ranges
ii. Calculate the average of the observations in each of the 2 time ranges
iii. Draw a straight line between the 2 points
iv. Extend line slightly past the end of the original observation to make predictions for future years

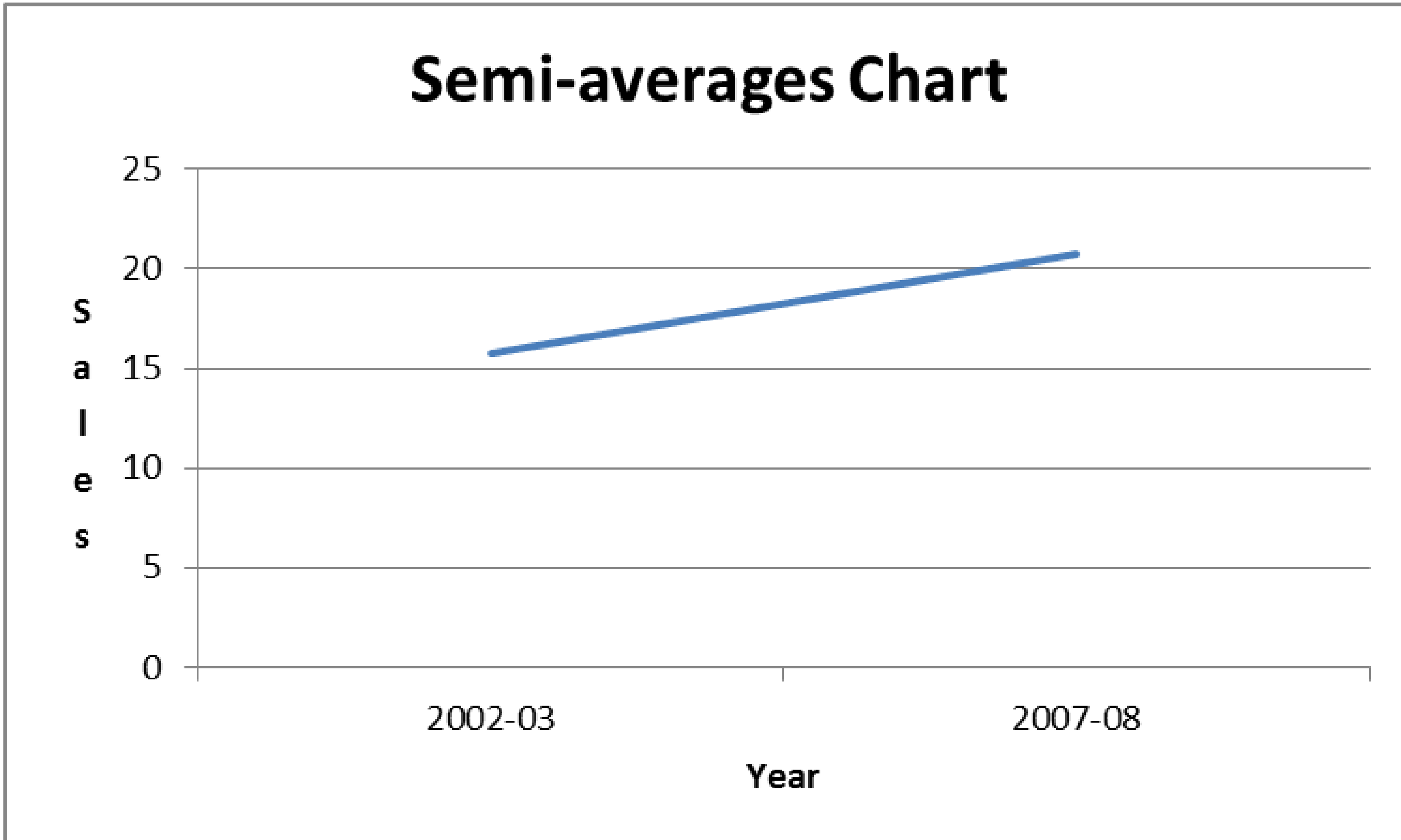
(b) Semi-Averaging Method

In this instance the series of data is divided into two halves. Each half is then averaged, then each of the two averages is plotted half way within its series.

In the given data there is an uneven number of years. To divide the data in half, ignore the middle piece of data.

	($'000,000)		($'000,000)
2001	13	**2006**	20
2002	15	**2007**	20
2003	17	**2008**	21
2004	18	**2009**	22
	$\frac{63}{4}$		$\frac{83}{4}$
	= 15.75		= 20.75

The score $15.75 ('000,000) is positioned over 2002/03 and $20.75 ('000,000) is positioned over 2007/08, then a line extended between these two points.


Semi-averages Chart
Sales
25
20
15
10
5
0
2002-03
2007-08
Year

Measure underlying trend
Moving averages

This method is based on the premise that if values in a time series are averaged over a sufficient period, the effect of short term variations will be reduced.

That is, short term, cyclical, seasonal and irregular variations will be smoothed out resulting in an apparently smooth graph depicting the overall trend.

The degree of smoothing can be controlled by selecting the number of cases to be included in an average.

The technique for finding a moving average for a particular observation is to find the average of the *m* observations before and after the observation itself.

That is, a total of ($2m + 1$) observations must be averaged each time a moving average is calculated.

Find:
both 3 and 5 year moving averages (or mean smoothing) for this time series:

Year	Sales
2001	13
2002	15
2003	17
2004	18
2005	19
2006	20
2007	20
2008	21
2009	22

Solution - Continued

Three Year Moving Average:

Year	Annual Sales $('000,000)	3yr Moving Total	3yr Moving Avg.
2001	13		
2002	15	45	15.00
2003	17	50	16.67
2004	18	54	18.00
2005	19	57	19.00
2006	20	59	19.67
2007	20	61	20.33
2008	21	63	21.00
2009	22		

These figures are plotted onto the graph and the line extended for predictive purposes → 2011 = $23,500,000.

13 + 15 +17 = 45

15 + 17 + 18 = 50…. Or 45 +18 - 13 = 50 (pick up the new drop off the old)

(c) (ii) **Five Year Moving Average:**

Year	Annual Sales $('000,000)	5 yr Moving Total	5 yr Moving Avg
2001	13		
2002	15		
2003	17	82	16.4
2004	18	89	17.8
2005	19	94	18.8
2006	20	98	19.6
2007	20	102	20.4
2008	21		
2009	22		

(iii) **Four Year Moving Average:**

A four year moving average requires an extra step in order to align trend values with a given year (or period).

Year		Moving Total	Moving Avg 1	Moving Avg 2	Trend Line
2001	13				
2002	15			15.75	
2003	17	63	15.75	17.25	16.50
2004	18	69	17.25	18.50	17.88
2005	19	74	18.50	19.25	18.88
2006	20	77	19.25	20.00	19.63
2007	20	80	20.00	20.75	20.38
2008	21	83	20.75		
2009	22				

13 + 15 + 17 + 18 = 63, 63 / 4 = 15.75

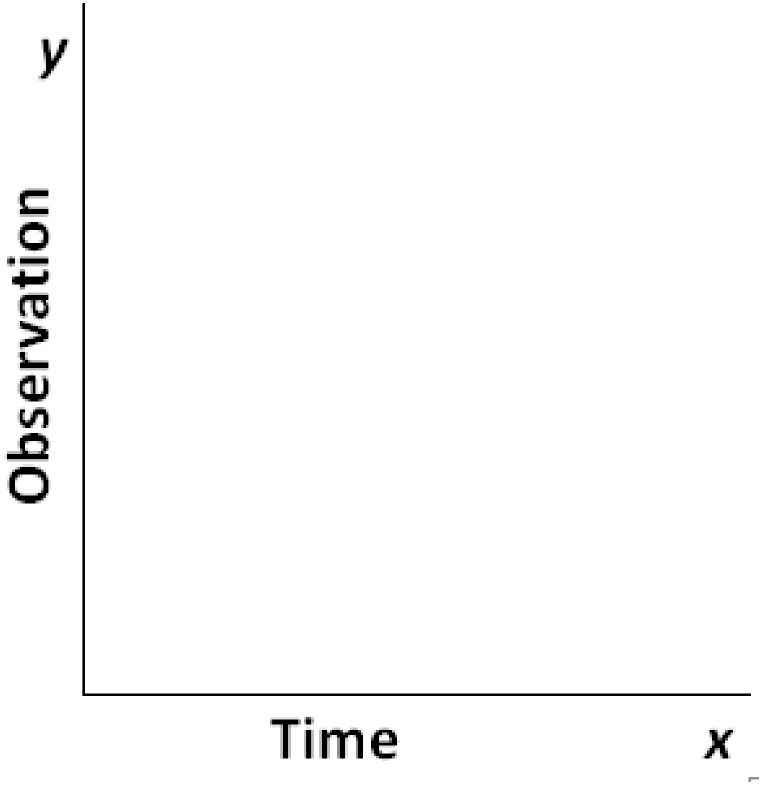
15.75 + 17.25 = 33 ...... 33 / 2 = 16.5

Measure underlying trend
Least squares linear regression

A more sophisticated way to of fitting a straight line to a time series is to use the method of least squares regression.

Sound familiar?

The observations are the dependant *y* variables and time is the independent *x* variable.



Least-Squares Method

This method uses a mathematical formula to develop a trend line for predictive purposes. Each year is given a numerical value to satisfy the formula. The middle year's value is 0 with each preceding year reducing by 1 and each subsequent year increasing by 1. The least-squares method establishes a trend line formula:

$$Yt = a + bx \qquad \text{where } a = \frac{\sum y}{n} \qquad b = \frac{\sum xy}{\sum x^2}$$

Please note that this procedure differs from least squares for regression analysis. Both provide a "line of best fit", however with regression, only interpolation is permitted. With trend series the line is extended for future time periods (extrapolation).

Least squares regression example

Soft Drink Sales $'000 for Carbonated Pty Ltd

Year	Y	x	x^2	xy
2003	13			
2004	15			
2005	17			
2006	18			
2007	19			
2008	20			
2009	20			
2010	21			
2011	22			
	165			

In developing the least squares formula for secular trend the following steps are used:

- Determine the number of years of data. (n)
- Allocate midpoint in time and give the years their respective x values by increasing and decreasing one unit from the midpoint accordingly.
- The given data (net profit) is "y"
- Proceed to develop columns "x^2" and "xy".
- Complete y = a + bx where $b = \dfrac{\sum xy}{\sum x^2}$, $a = \dfrac{\sum y}{n}$

To predict the given value, x is determined by the number of years after the last year of detailed figures, e.g. in 2009; x = 2, therefore in 2010; x = 3.

Calculation for least squares regression example

Year	Y	x	x^2	xy
2003	13	-4	16	-52
2004	15	-3	9	-45
2005	17	-2	4	-34
2006	18	-1	1	-18
2007	19	0	0	0
2008	20	1	1	20
2009	20	2	4	40
2010	21	3	9	63
2011	22	4	16	88
	165		60	62

Least squares regression line

a $= \frac{\sum y}{n} = \frac{165}{9} = 18.3$ *And b* $= \frac{\sum xy}{\sum x^2} = \frac{62}{60} = 1.03$

Yt = a + bx

Yt = 18.3 + 1.03 x

What is the predicted Sales figure for 2013?

Hint: what value is x in 2013?

$$a = \frac{\sum y}{n} = \frac{165}{9} = 18.3 \quad And\ b = \frac{\sum xy}{\sum x^2} = \frac{62}{60} = 1.03$$

$$Yt = a + bx$$

$$Yt = 18.3 + 1.03\ x$$

What is the predicted Sales figure for 2013?

Hint: what value is x in 2013?

If 2011 = 4, then 2013 = 6, so 6 2nd f (= 24.53