

AQ061-3-M-ODL-TSF Time Series Analysis and Forecasting

Topic 1 – Characteristic of Time Series (Part I)

TOPIC LEARNING OUTCOMES

At the end of this topic, you should be able to:

1. have a broad understanding of time series characteristics, correlogram, autocorrelation, and stationary time series.
2. explain the characteristics of time series.
3. solve the model using computer software and interpret the results.

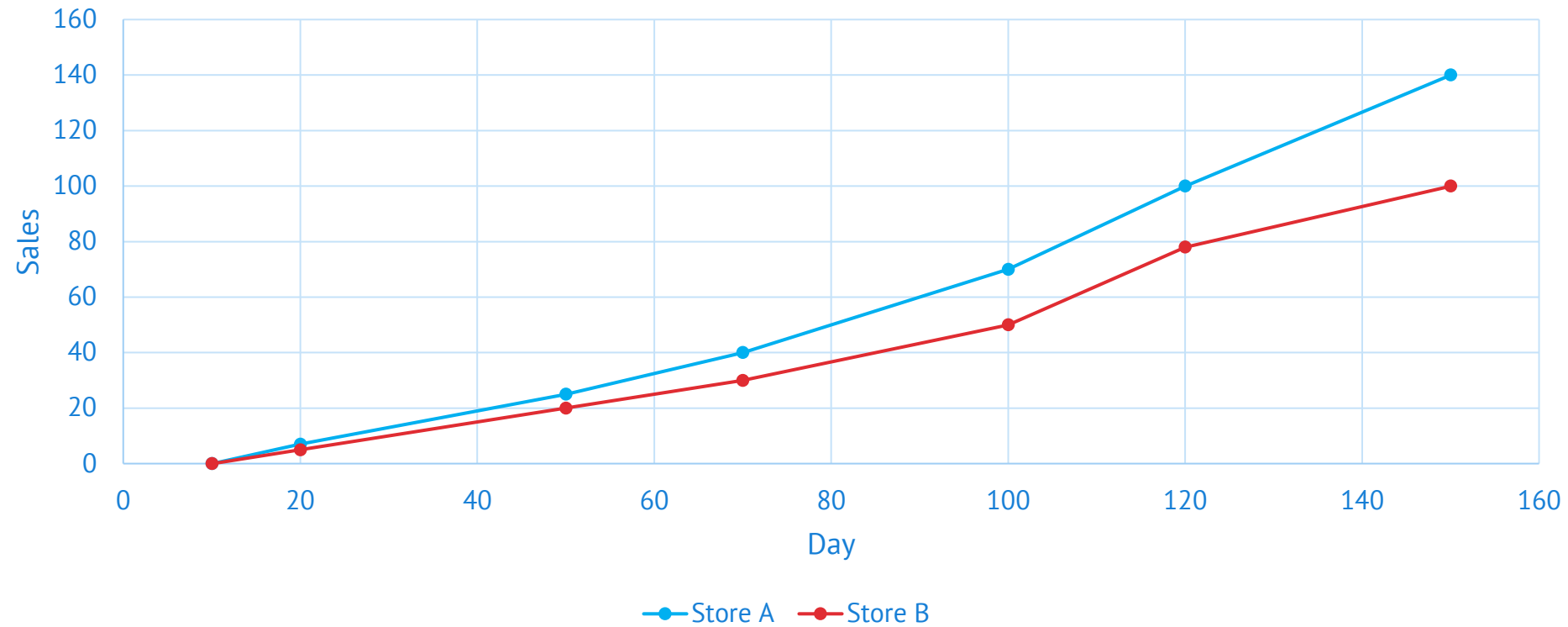
Contents & Structure

- Introduction
- Features of Time Series Data
- Time Series Plots
- Stationary Time Series

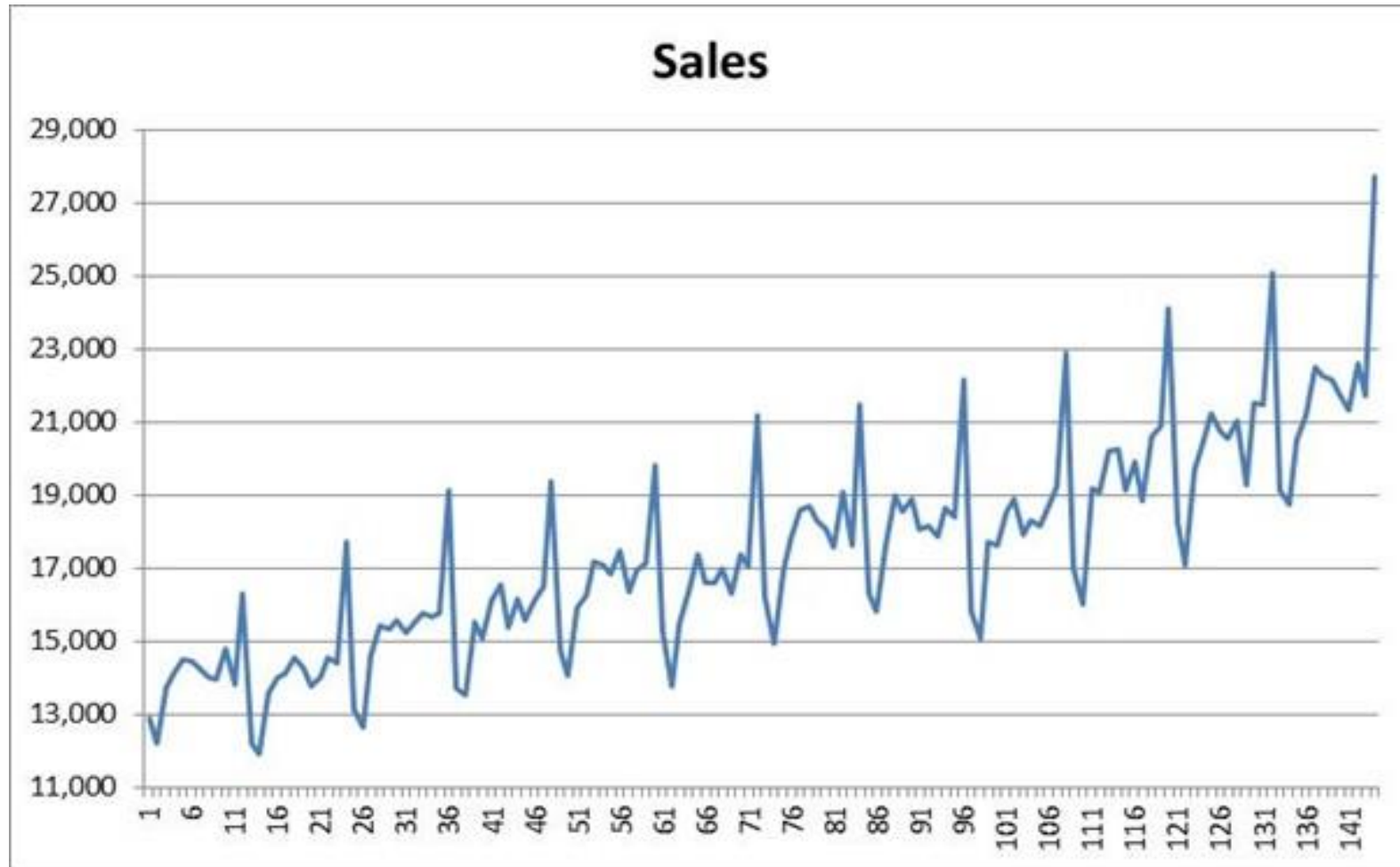
Recap From Last Lesson

- Questions to ask to trigger last week's key learning points

Time Series?



Time Series?



Time Series Data?

	id	countryname	year2	trade
1	1	Australia	1	16.44
2	1	Australia	2	18.63
3	1	Australia	3	19.526
4	1	Australia	4	19.895
5	2	Austria	1	34.71
6	2	Austria	2	38.502
7	2	Austria	3	48.538
8	2	Austria	4	55.46
9	3	Belgium	1	64.186
10	3	Belgium	2	68.086
11	3	Belgium	3	76.51
12	3	Belgium	4	79.7883
13	4	Canada	1	28.446
14	4	Canada	2	39.964
15	4	Canada	3	41.444
16	4	Canada	4	33.7
17	5	Czech Republic	1	46.262
18	5	Czech Republic	2	49.988
19	5	Czech Republic	3	60.652
20	5	Czech Republic	4	65.275
21	6	Denmark	1	37.72
22	6	Denmark	2	38.584
23	6	Denmark	3	46.302
24	6	Denmark	4	50.9883
25	7	Estonia	1	.
26	7	Estonia	2	69.338
27	7	Estonia	3	75.522
28	7	Estonia	4	72.08

Introduction

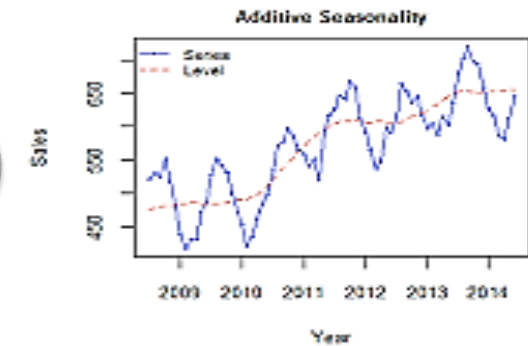
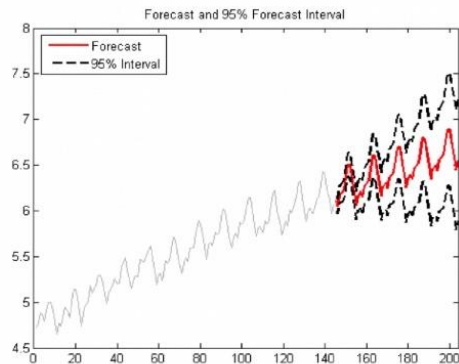
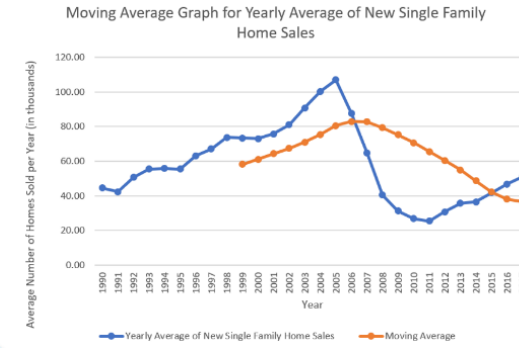
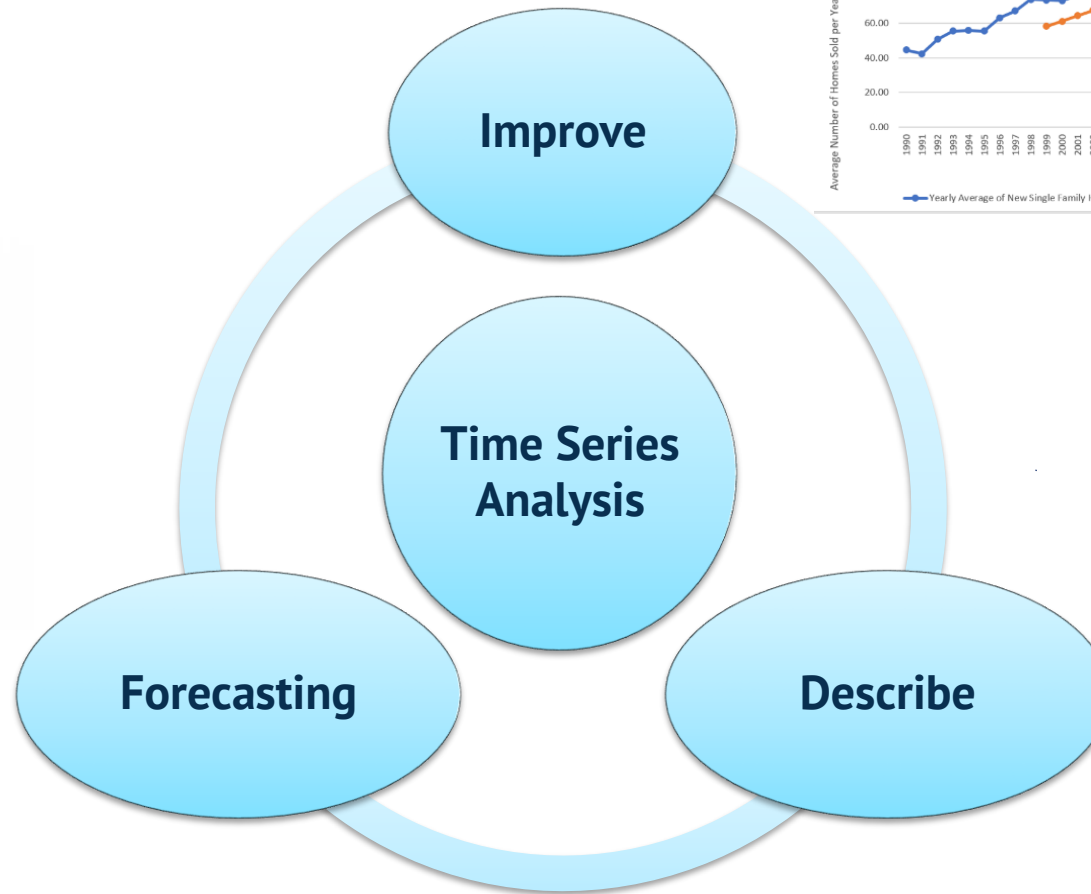
- Time series is a set of values which occurs sequentially in time.
- Numerical data obtained at regular time intervals.
- The time intervals can be **annually, quarterly, daily, hourly**, etc.
- **Example:**

Year:	2010	2011	2012	2013	2014
Sales:	75.3	74.2	78.5	79.7	80.2

Introduction

- Time series can be used as an aid to business decision.
- Time series plot is the graph of time series.
- It is a two-dimensional plot.
- Time series analysis is used to detect pattern of change in statistical information over regular intervals of time.

Objectives of a time series



Example

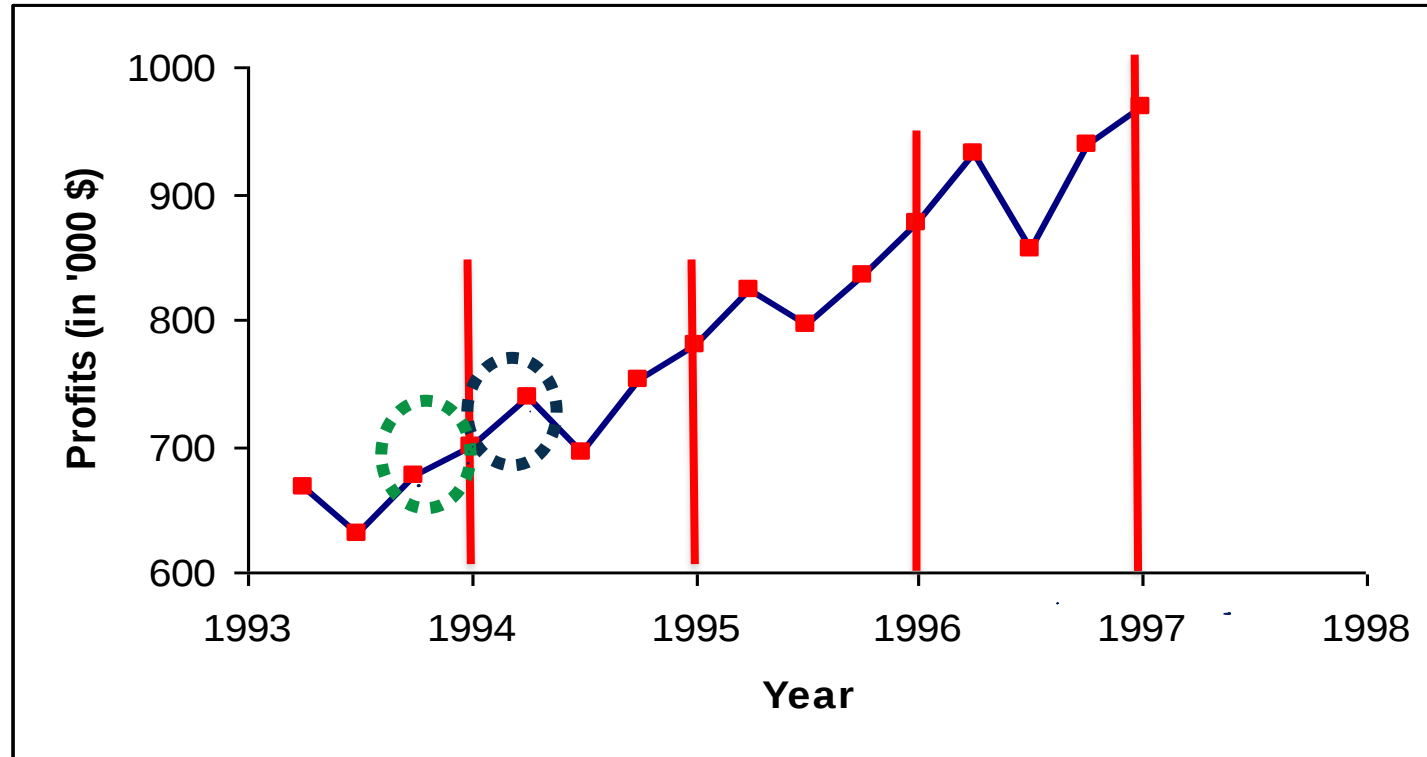
Data (interval-scale): Company profits ('000 dollars)

Objective: To study changes in profit figures over consecutive quarters

Year	Quarter 1	Quarter 2	Quarter 3	Quarter 4
1	667	631	675	699
2	739	695	751	779
3	823	795	835	875
4	931	855	939	967

The 4th quarter is always higher than the 1st quarter.

Take a look again ...



You will notice that the activity in the first quarter (**difference between the last quarter of the year and the first quarter**) shows considerable more activity than a similar **difference between the 3rd and 4th quarters** , which reflects the activity in the 4th quarter

Coding Exercises

You are required to construct a time series plot using R for the following data file:

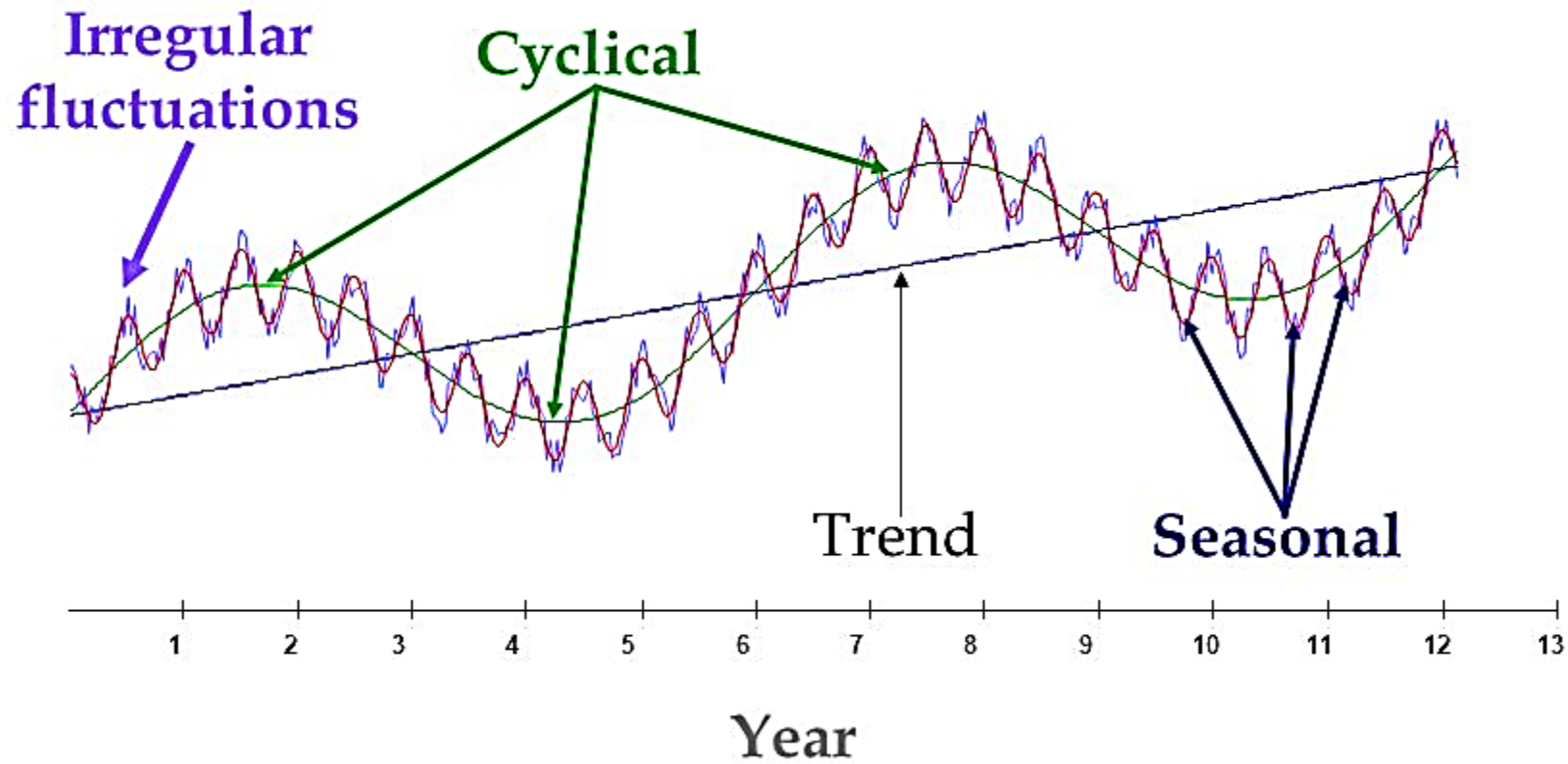
1. quakes.dat – **annual** number of earthquakes worldwide with a magnitude greater than 7.0 on the seismic scale.
2. sales.dat – **quarterly** sales data (in \$'000), starting **01-01-2007**.

Use **ts(x, start, end, frequency = 1 (annual), 4 (quarterly), 12 (monthly))** in R.

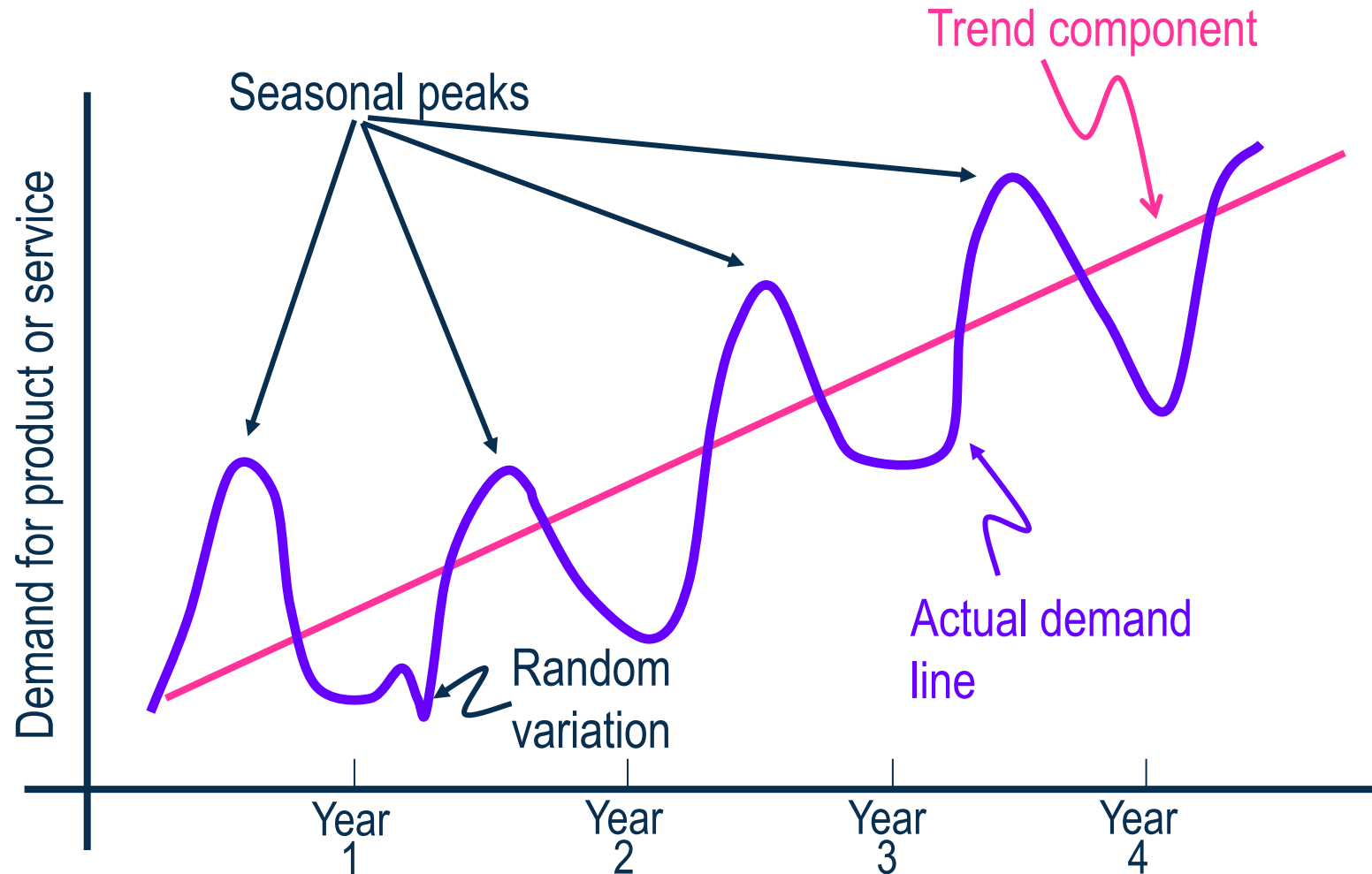
Important Questions to Consider

- Is there a trend? Increase (or decrease) over time?
- Is there seasonality? Regular repeating pattern of highs and lows over time.
- Are there outliers? Far away from your data.
- Is there constant variance over time?
- Is there any abrupt/unexpected/sudden changes to either the level of the series or the variance?

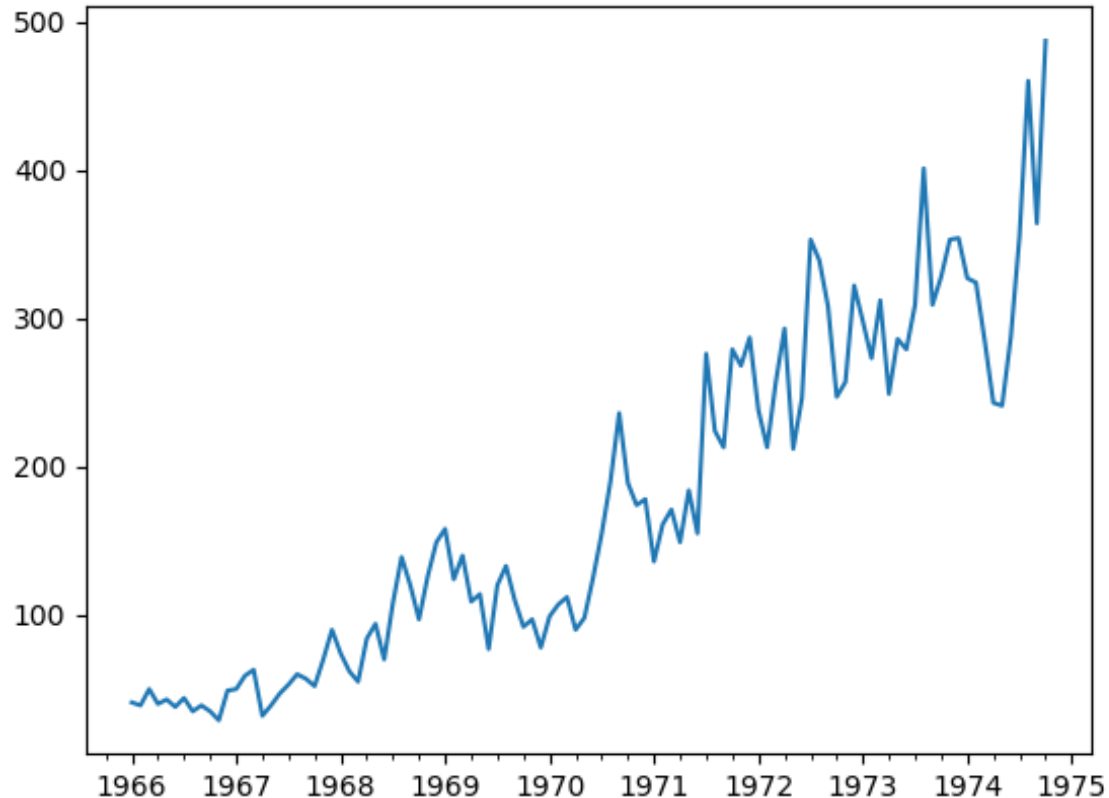
Time Series Components



Product Demand over Time



Example 1



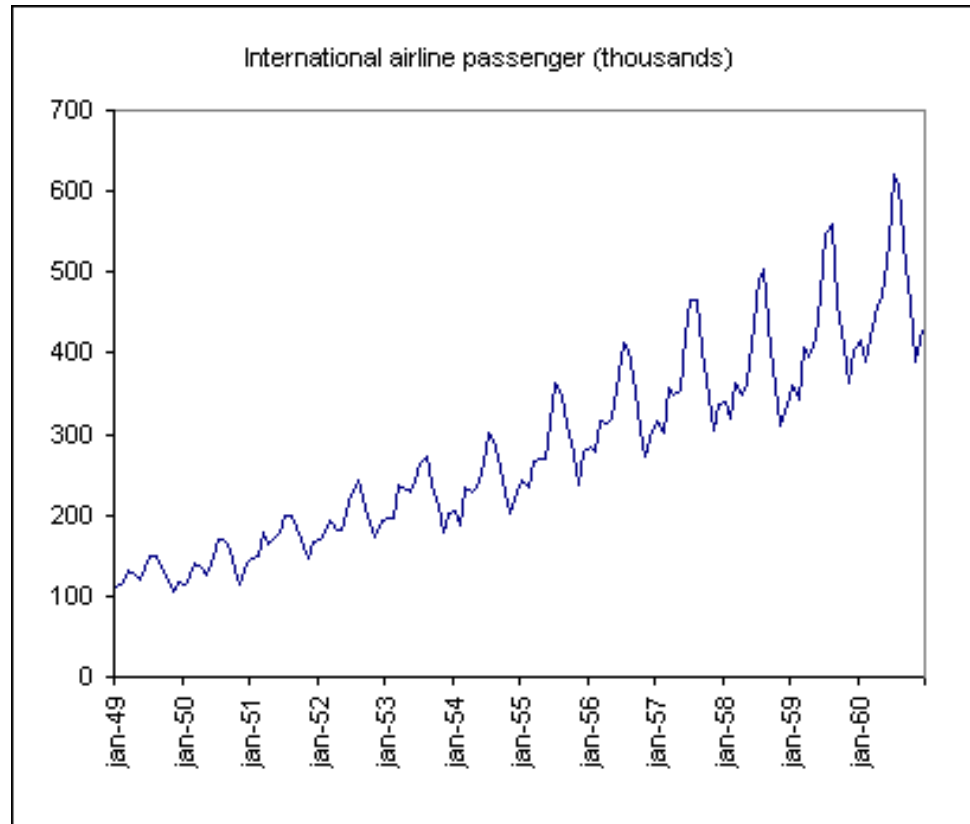
- **Trend**

Variations that move up or down in a reasonably predictable. Long-term movement or tendency of the data. Fluctuation is due to the factors such as change slowly over a long period of time.

- **Irregular variation**

Unpredictable movement or change in the series. Random variations other than trend, seasonal and cyclical. Duration is short and may occur at any time of the day.

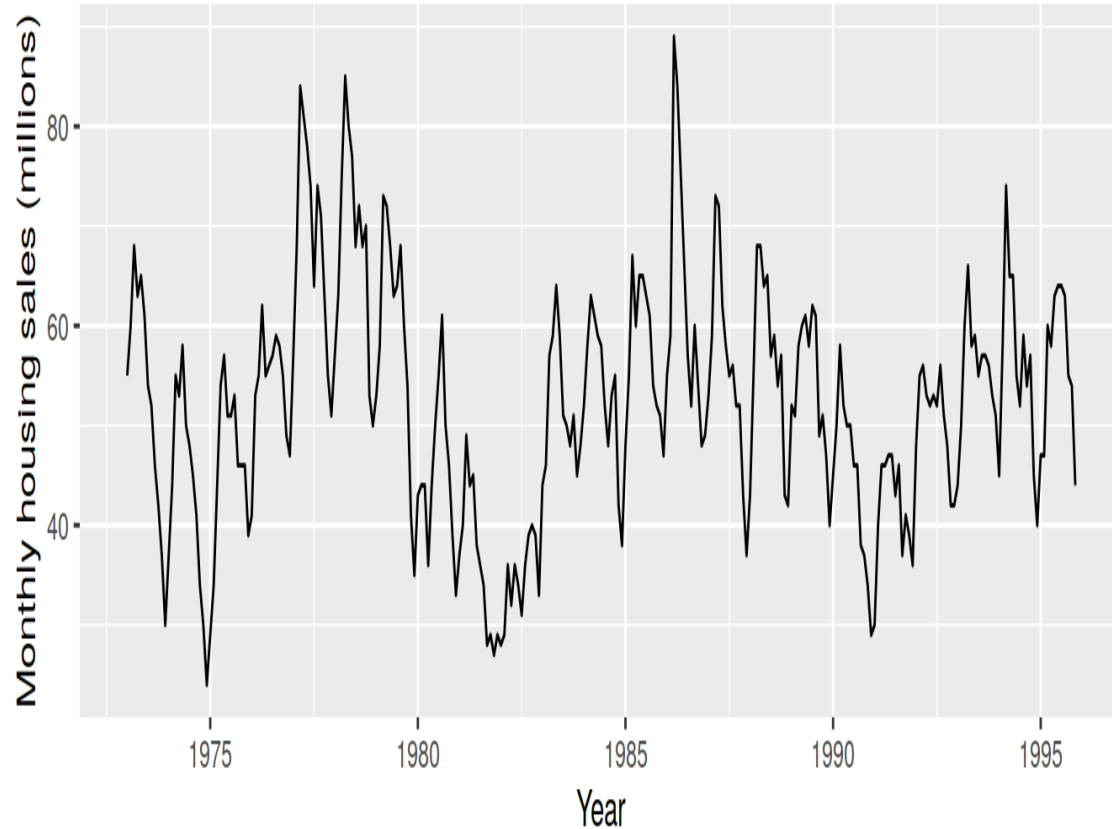
Example 2



- **Seasonal variation**

Short term movement due to the seasonal factor such as temperature and weather. Patterns of change that recur over short period of time. Also known as short-term cyclical movement. The duration (repeated pattern) is usually less than a year.

Example 3



- **Cyclical variation**

Repeated up and down swing or movement through 4 phases, such as from peak to recession, to depression, and to expansion. The cycle may repeat within 2-10 years with different intensities.

Example of Time Series Components

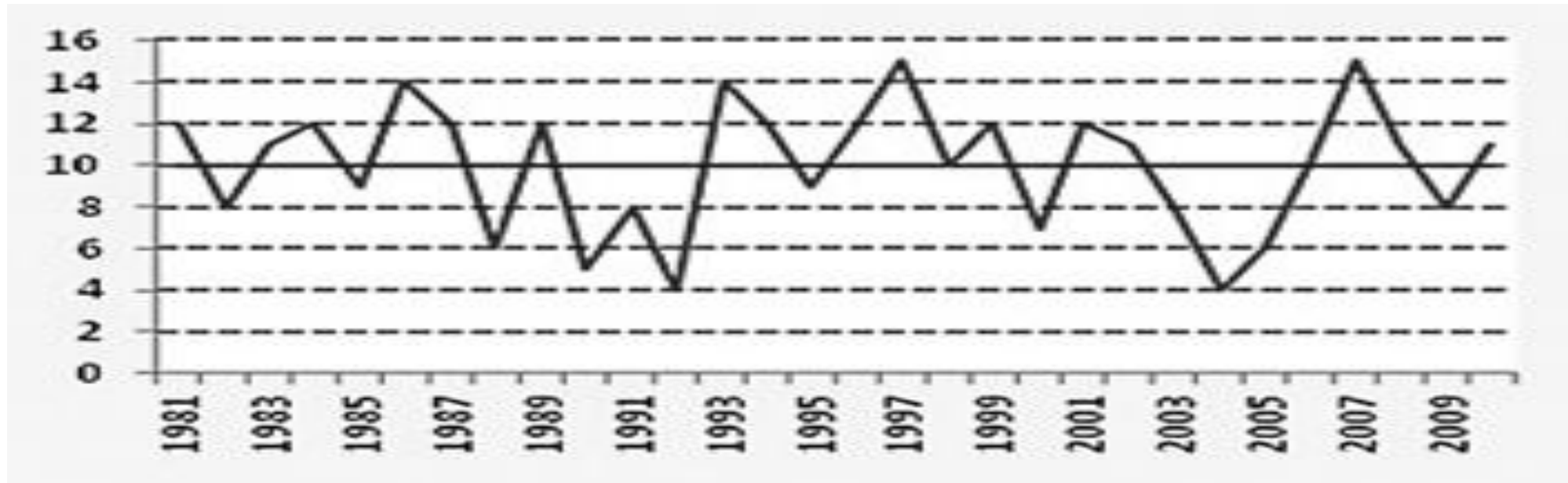
Time Series Components	Properties / Descriptions	Example
Trend	- Variations that move up or down in a reasonably predictable. - Long-term movement or tendency of the data - Fluctuation is due to the factors such as change slowly over a long period of time	- World population increases in the recent years - Sales / demand of a product increases - upward trend
Seasonal variation	- Short term movement due to the seasonal factor such as temperature and weather - Patterns of change that recur over short period of time - Also known as short-term cyclical movement - The duration (repeated pattern) is usually less than a year	- Sales of pullovers is relatively higher in winter than in summer. - Traffic is the highest during the working hours, such as 7am, 12pm etc.

Example of Time Series Components

Time Series Components	Properties / Descriptions	Example
Cyclical variation	- Repeated up and down swing or movement through 4 phases, such as from peak to recession, to depression, and to expansion - The cycle may repeat within 2-10 years with different intensities	- Business cycle - Inflation rate
Irregular variation	- Unpredictable movement or change in the series - Random variations other than trend, seasonal and cyclical - Duration is short and may occur at any time of the day	- Rise in the steel due the strike in the factory - Sales decreases due to natural disasters such as flood etc.

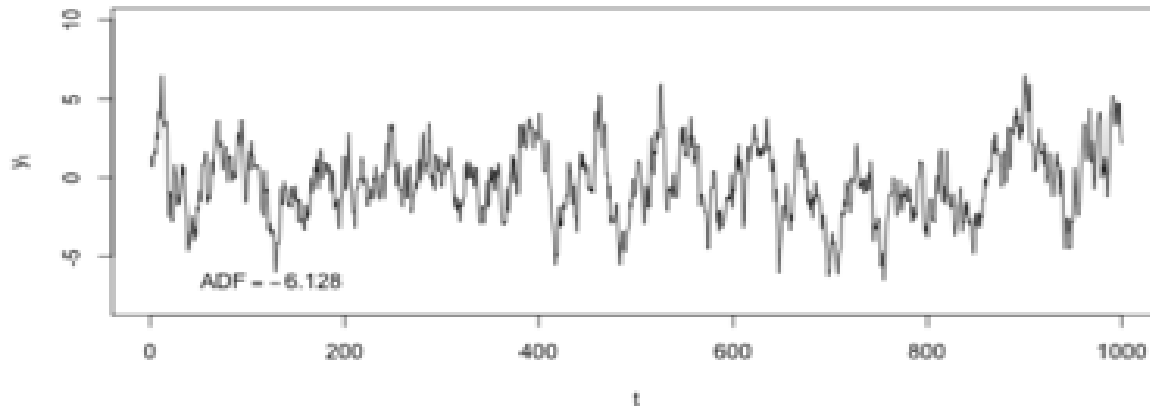
Example 4

Identify types of time series component(s) present in the plots below.

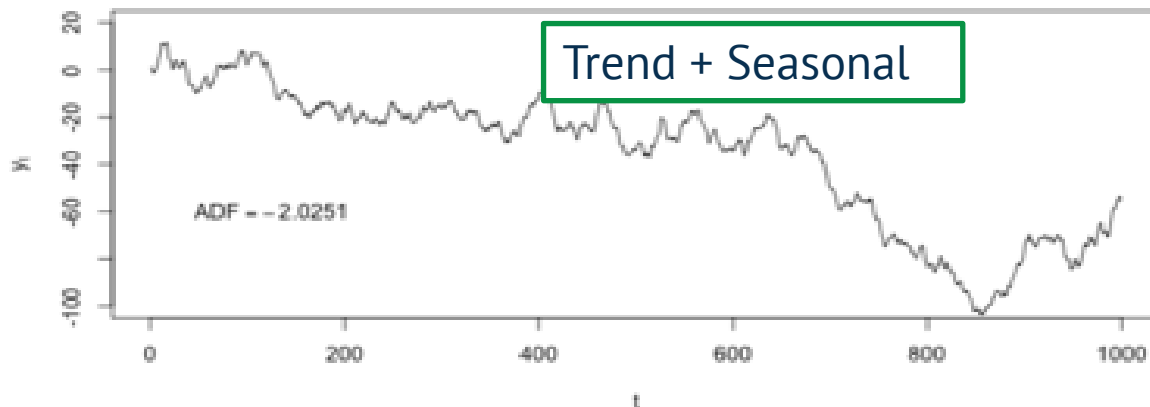


Time series are stationary if they do not have trend or seasonal effects

Stationary Time Series



Non-stationary Time Series



Properties of Stationary Series:

1. $E(Y_t) = \mu$
2. $\text{Var}(Y_t) = \sigma^2$
3. $\text{Cov}(Y_t, Y_{t-k}) = \gamma_k$
4. $\rho_k = \frac{\gamma_k}{\sigma^2}$

In other words, it has **constant mean and variance**, and covariance (and also correlation) between Y_t and Y_{t-1} is the same for all t .

Review Questions

Summary / Recap of Main Points

- understanding of time series characteristics, correlogram, autocorrelation, and stationary time series.
- the characteristics of time series.
- solve the model using computer software and interpret the results.

What To Expect Next Week

In Class

Preparation for Class

Smoothing Techniques