Time series data

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1. What is Time series Data?

1. Time series data: data that is collected at different points in time.

Example:

- **Daily** closing stock prices,
- **Weekly** interest rates
- **Monthly** price indices and
- **Yearly** earnings.

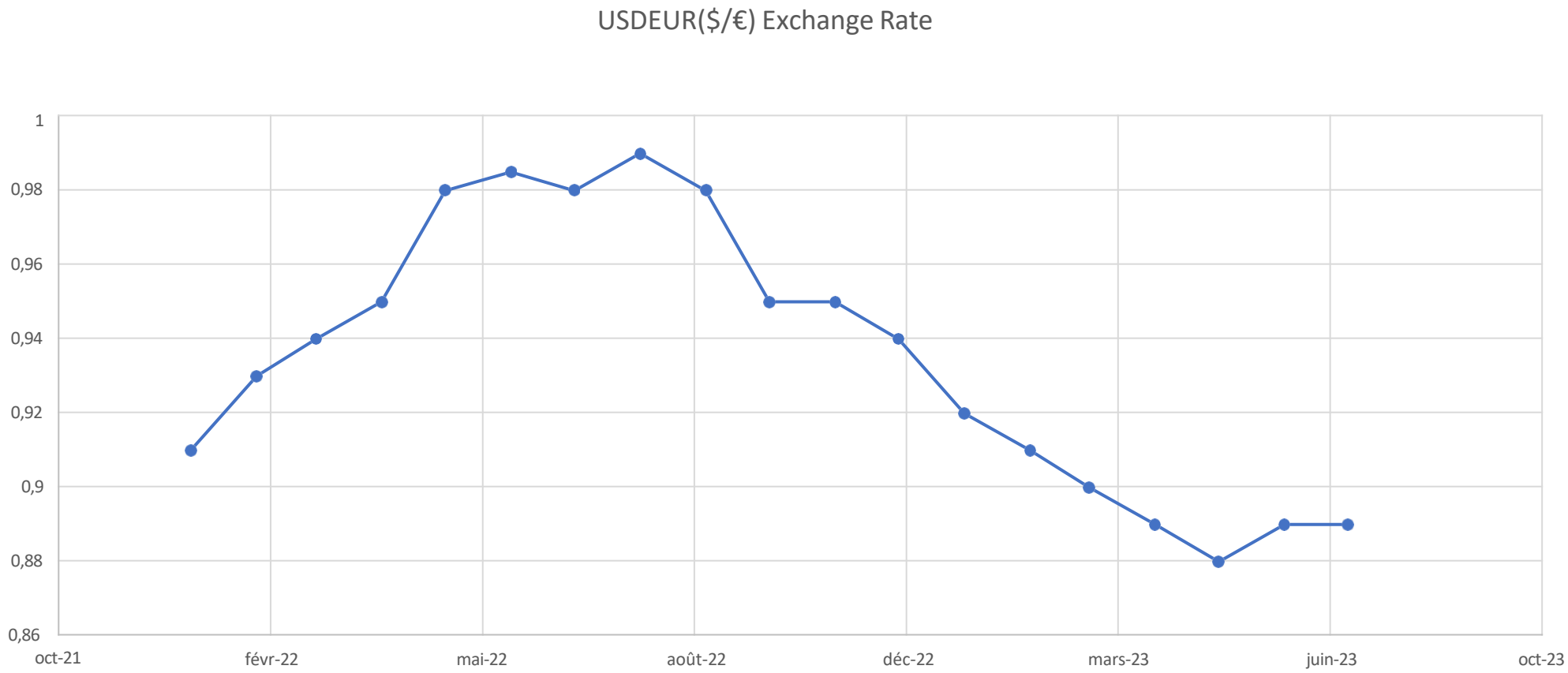
2. Examples of Time series Data

Obsno	Oil Price $	USDEUR($/€) Exchange Rate
janv-22	78,8	0,91
févr-22	75	0,93
mars-22	74	0,94
avr-22	69,5	0,95
mai-22	62	0,98
juin-22	61	0,985
juil-22	63	0,98
août-22	58	0,99
sept-22	61	0,98
oct-22	65	0,95
nov-22	66	0,95
déc-22	68	0,94
janv-23	71	0,92
févr-23	76	0,91
mars-23	77	0,9
avr-23	79	0,89
mai-23	81	0,88
juin-23	80,5	0,89
juil-23	80	0,89

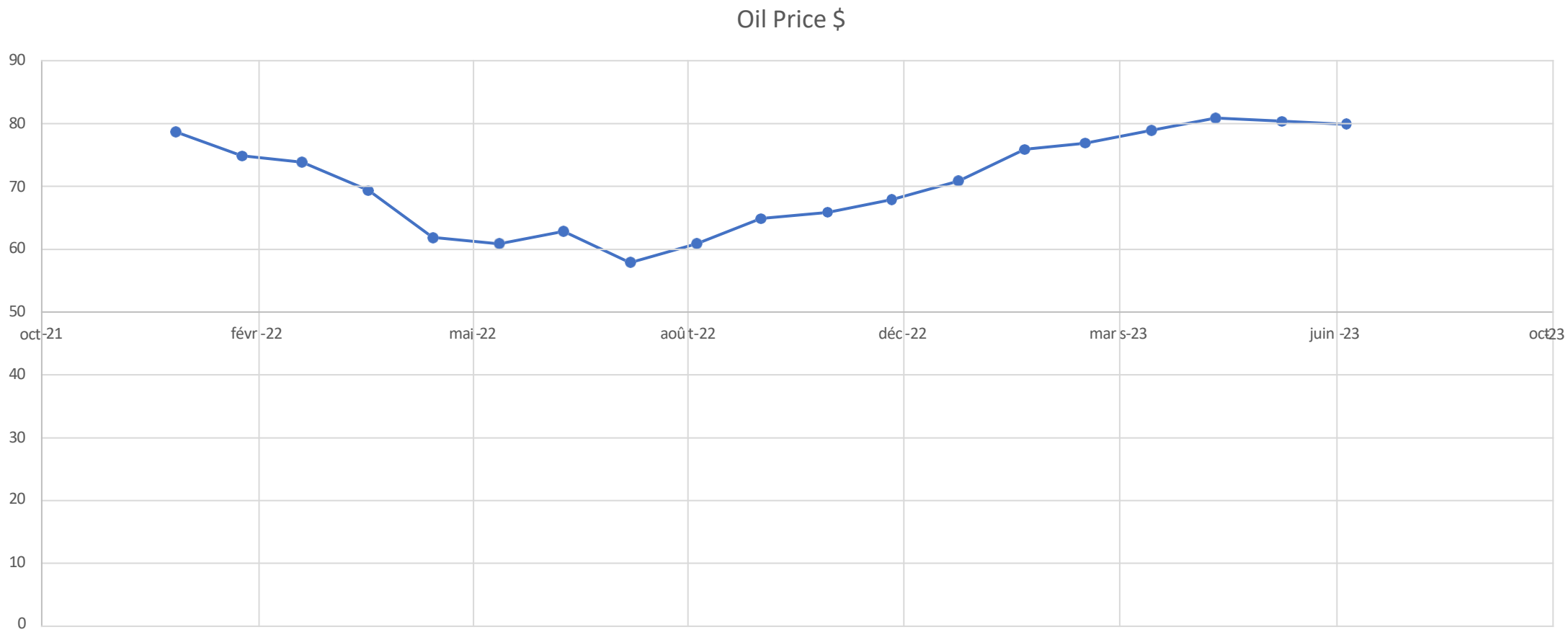
3. Time series Graph

- **A time series graph** plots observed values (of the variable such as Oil price, GDP, exchange rate, stock price index…..) on the y-axis against an increment of time on the x-axis. These graphs visually highlight the behavior and patterns of the data and can lay the foundation for building a reliable model.
- **For example,** the time series graph below plots the oil price and Dollar exchange rate per month; the data ranges from January 2022 to July 2023 the data is collected at a monthly frequency.

3. Time series Graph



3. Time Series Graph



3. Time Series Graph

4. Time series data Characteristics/Properties

- A time series is a collection of data y_t (t=1,2,…,T), with the interval between y_t and y_{t+1} being fixed and constant.

1. Properties #1: Serial Correlation

- Because time series data are ordered in time, past values may influence future values, this often results a on what we called **Serial correlation.**
- **Serial Correlation**: is a statistical term used to describe the relationship or the correlation between the **current value** of a variable and a **lagged value** of the same variable from earlier time periods.
- Serial correlation, also referred to as **autocorrelation,**

4. Time series data Characteristics/Properties

- **Correlation** measures the strength of the relationship between different variables, and **serial correlation or autocorrelation** determines the relationship between the same variable measured over different periods of time.
- Serial correlations, when they exist, can be either **positive** or **negative**.
- **Positive serial correlations** indicate that values are likely to change in future time periods in the same way, or direction, that they have in recent past time periods; **Negative serial correlations** indicate that values are likely to move in the opposite direction in future time periods compared to how the values have moved in recent past periods.

4. Time series data Characteristics/Properties

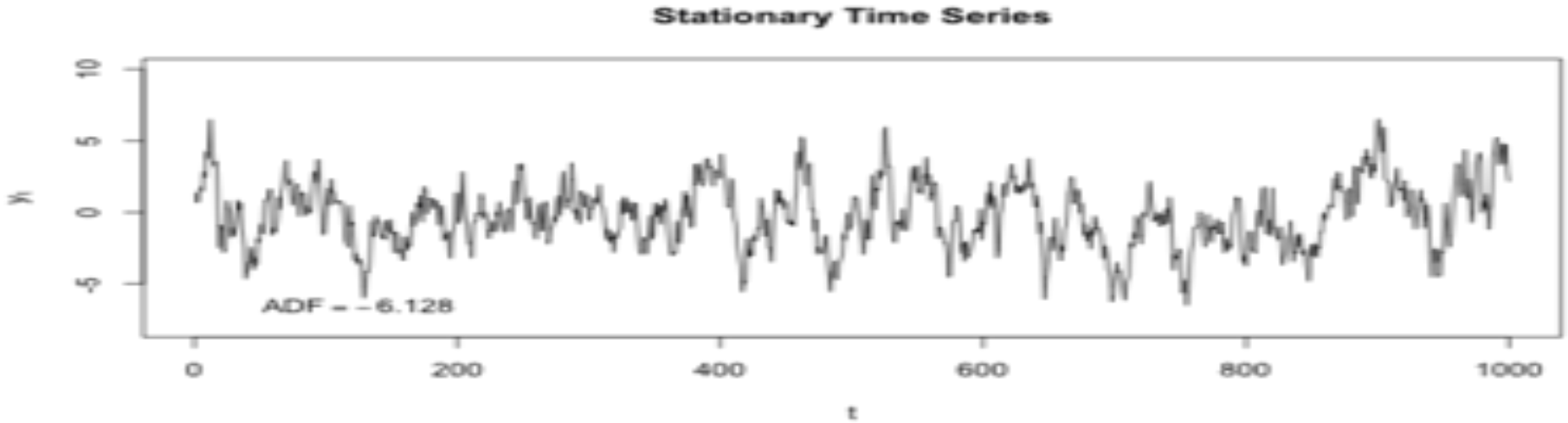
- **A serial correlation value of zero** indicates that **no correlation exists**.
- **Values nearer to +1** indicate a positive serial correlation, while

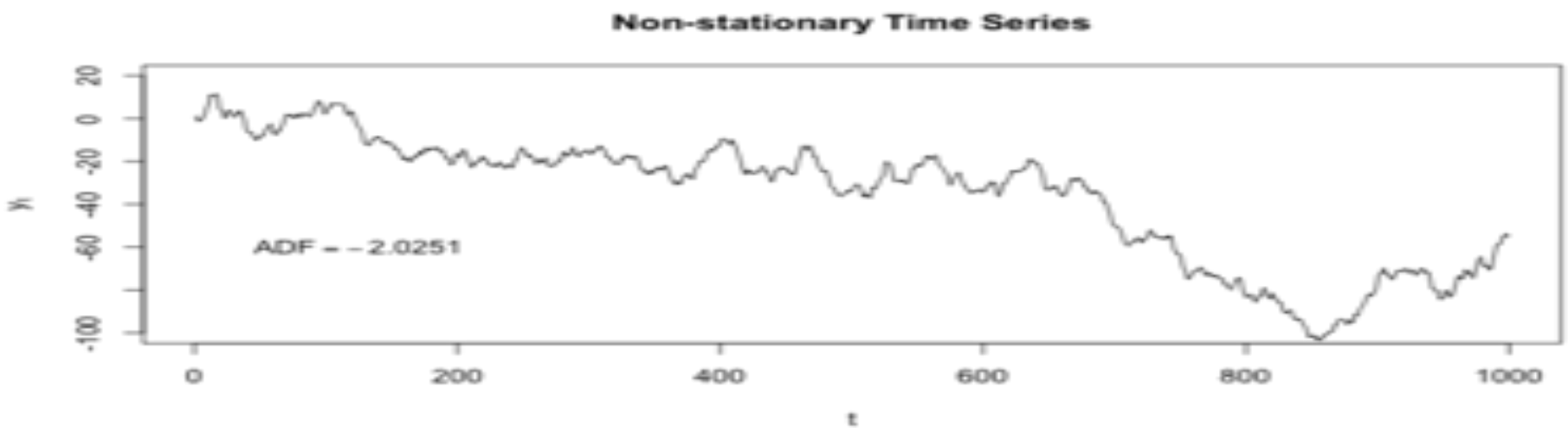
values between zero and -1 indicate a negative serial correlation.

4. Time series data Characteristics/Properties

2. Properties #2: Stationarity

- Stationarity mean a **flat looking series**, **without trend, constant mean and variance over time** and no periodic fluctuations **(seasonality).**
- Stationary data refers to the time series data that **mean and variance do not vary across time**. The data is considered **non-stationary** if there is a **strong trend or seasonality observed** from the data.


Stationary Time Series
yt
10
5
0
-5
ADF = -6.128
0
200
400
600
800
1000
t


Non-stationary Time Series
yt
20
0
-20
-40
-60
-100
ADF = -2.0251
0
200
400
600
800
1000
t

4. Time series data Characteristics/Properties

3. **Properties #3: Exogenous & Endogenous properties:** in time series analysis, exogenous and endogenous variables are two types of variables.

- **Exogenous Variables:** also known as external variables are factors that influence the time series being studied, but that are not explained by other variables within a model. It can help explain the variation in the dependent variable and improve the accuracy and predictive power of the model.

4. Time series data Characteristics/Properties

- **Endogenous Variables:** known as dependent variables, are the main focus of the time series analysis. Endogenous variables: Variables that are explained by other variables within a model.
- **Example:** Suppose an economist is interested in understanding the factors that affect consumer spending. He collects data and builds the following regression model:
- Consumer Spending = B_0 + B_1(Income) + B_2(Investment Returns) + B_3(Government Tax Rates)
- Here is how to identify each variable in the model:

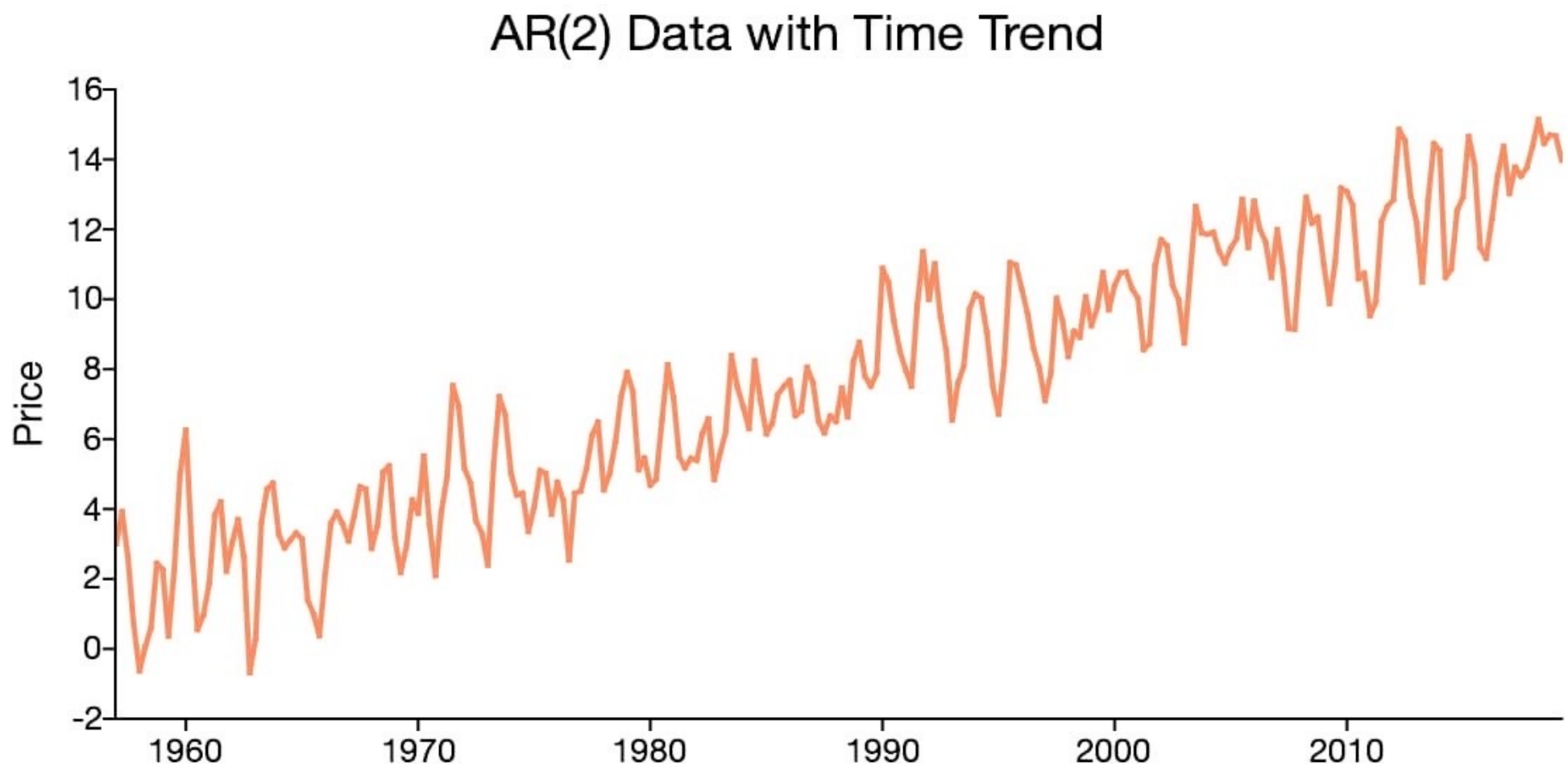
4. Time series data Characteristics/Properties

- **Consumer Spending:** This variable is **endogenous** because it can be explained by income, investment returns, and government spending.
- **Income:** This variable is **endogenous** because it is affected by government tax rates.
- **Investment Returns:** This variable is **endogenous** because it is influenced by government tax rates.
- **Government tax rates:** This variable is **exogenous** because it is not influenced by the other variables in the model. In other words, the amount that an individual earns in income or earns in investment returns cannot effect the tax rates set by the government in any way.

4. Time series data Characteristics/Properties

4. **Propertie #4: Trend:** a trend is a pattern found in time series datasets; it is used to describe if the data is showing an upward or downward movement for part or all of the time series.

- The Trend is the long term evolution of the series that can be observed on several decades
- A time series plot that looks like it centers around an increasing or decreasing line, like that in the plot below, suggests the presence of a time trend.


AR(2) Data with Time Trend
Price
16
14
12
10
8
6
4
2
0
-2
1960
1970
1980
1990
2000
2010

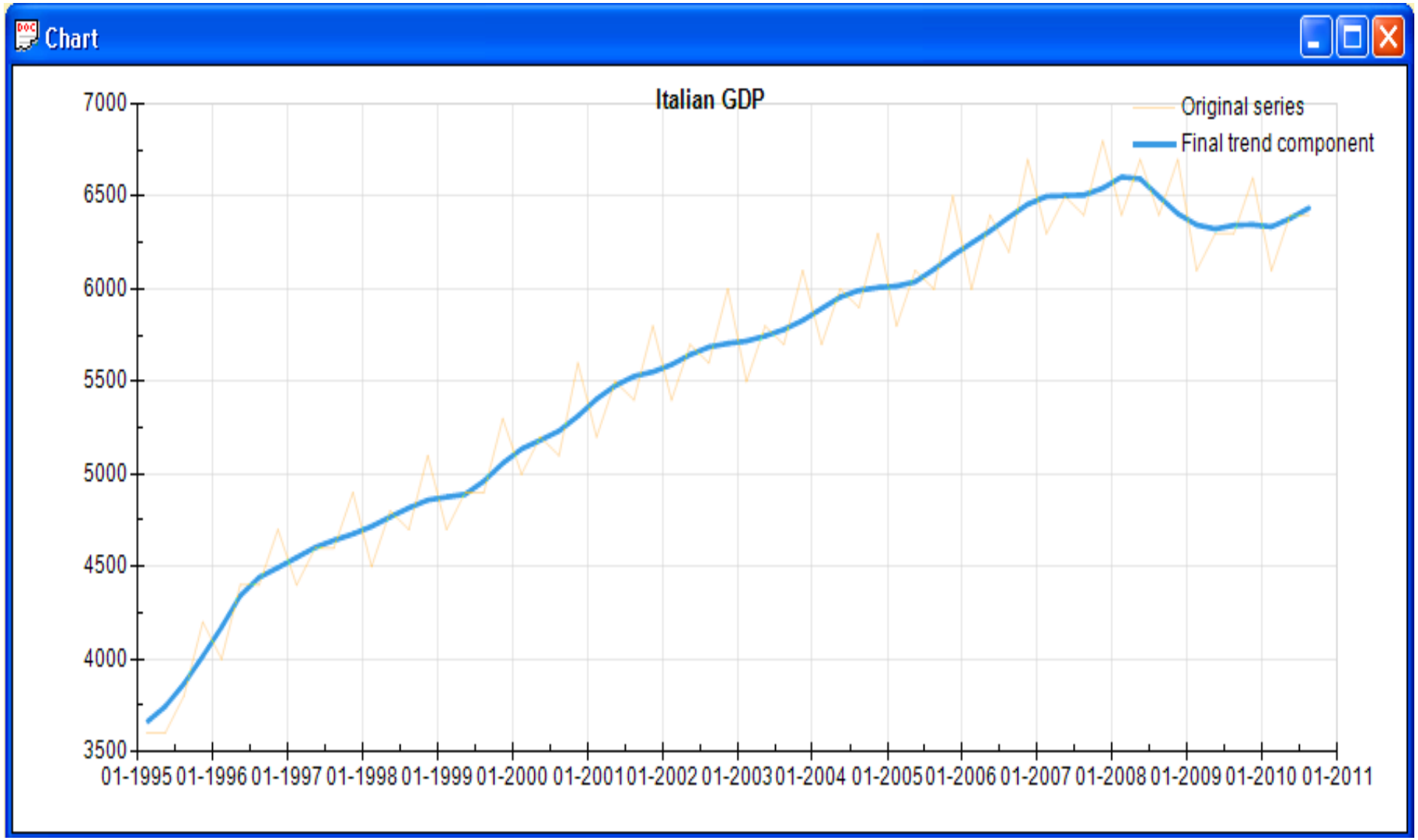


Chart
Italian GDP
Original series
Final trend component
7000
6500
6000
5500
5000
4500
4000
3500
01-1995 01-1996 01-1997 01-1998 01-1999 01-2000 01-2001 01-2002 01-2003 01-2004 01-2005 01-2006 01-2007 01-2008 01-2009 01-2010 01-2011

4. Time series data Characteristics/Propertie

5. **Property #5: Seasonality:** Seasonality occurs when time series data exhibits regular and predictable patterns at time intervals that are smaller than a year.

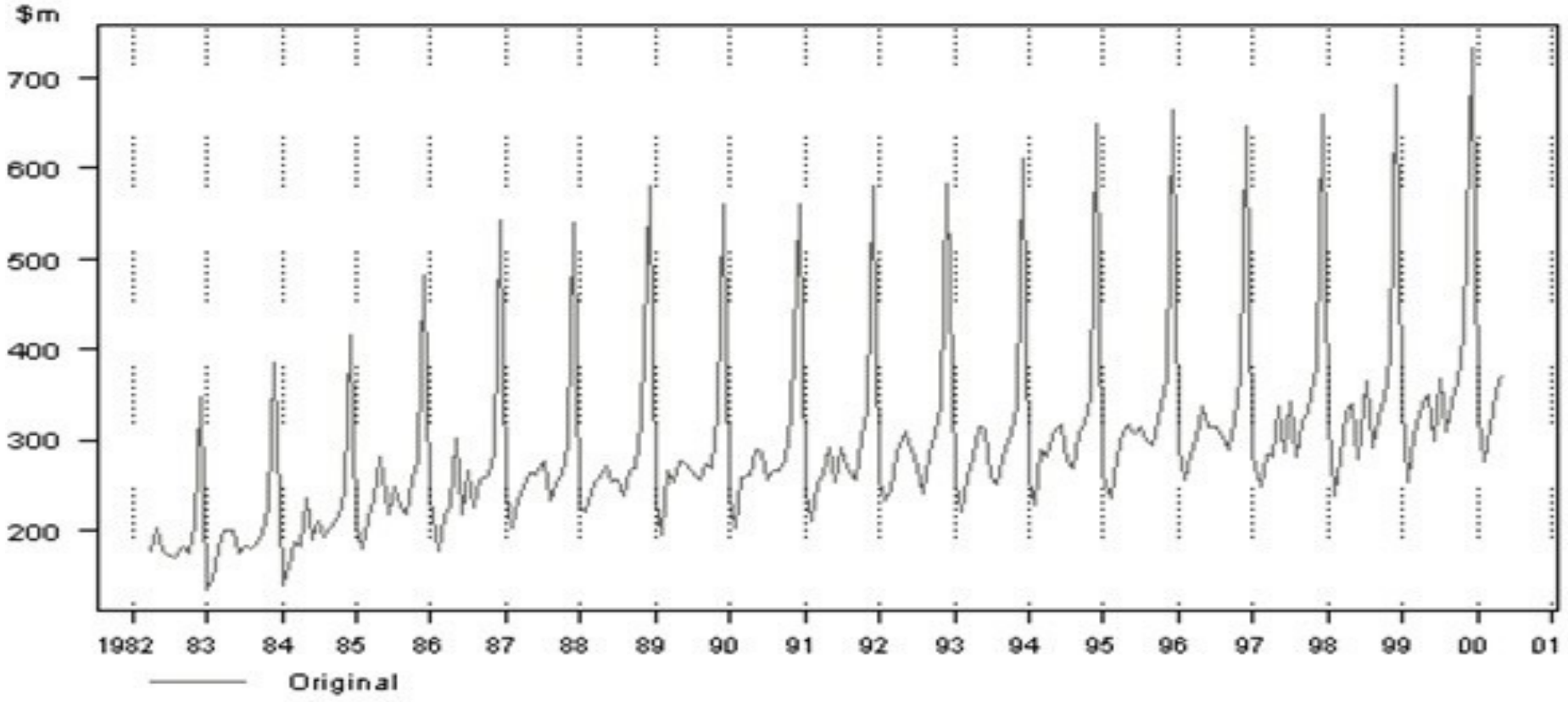
- An example of a time series with seasonality is retail sales, which often increase between September to December and will decrease between January and February.

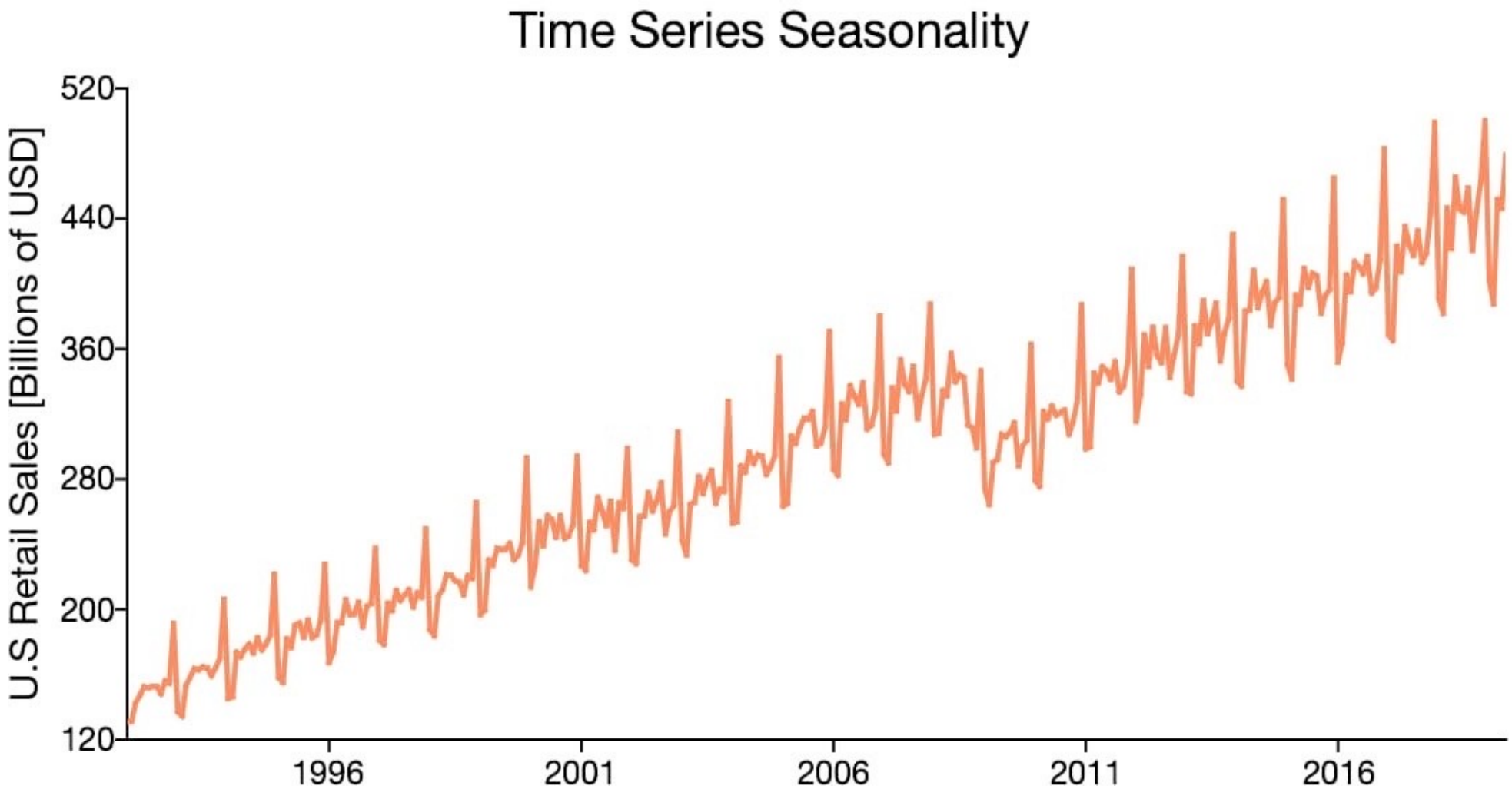
4. Time series data Characteristics/Propertie

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




Time Series Seasonality
U.S Retail Sales [Billions of USD]
520
440
360
280
200
120
1996
2001
2006
2011
2016

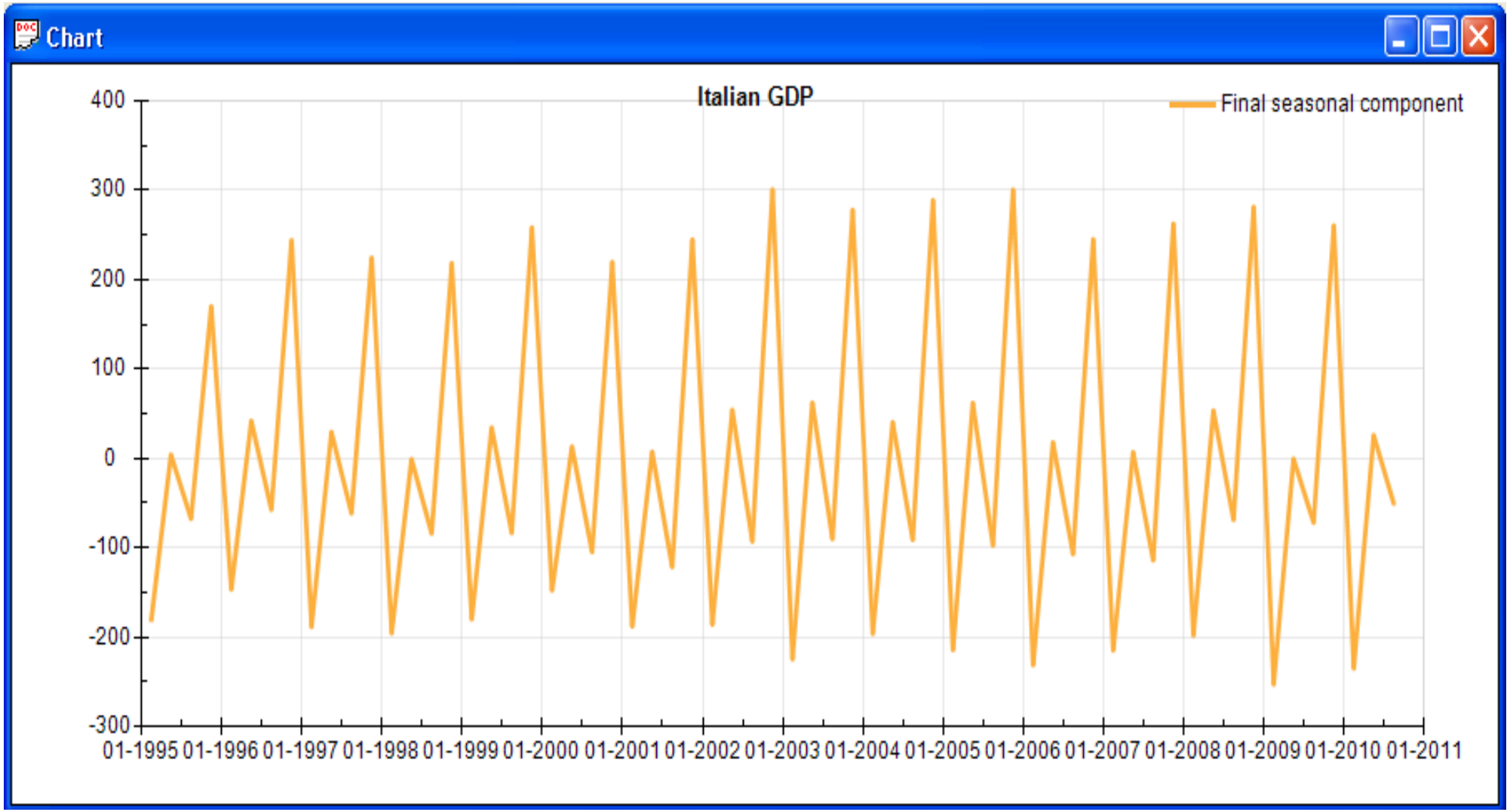


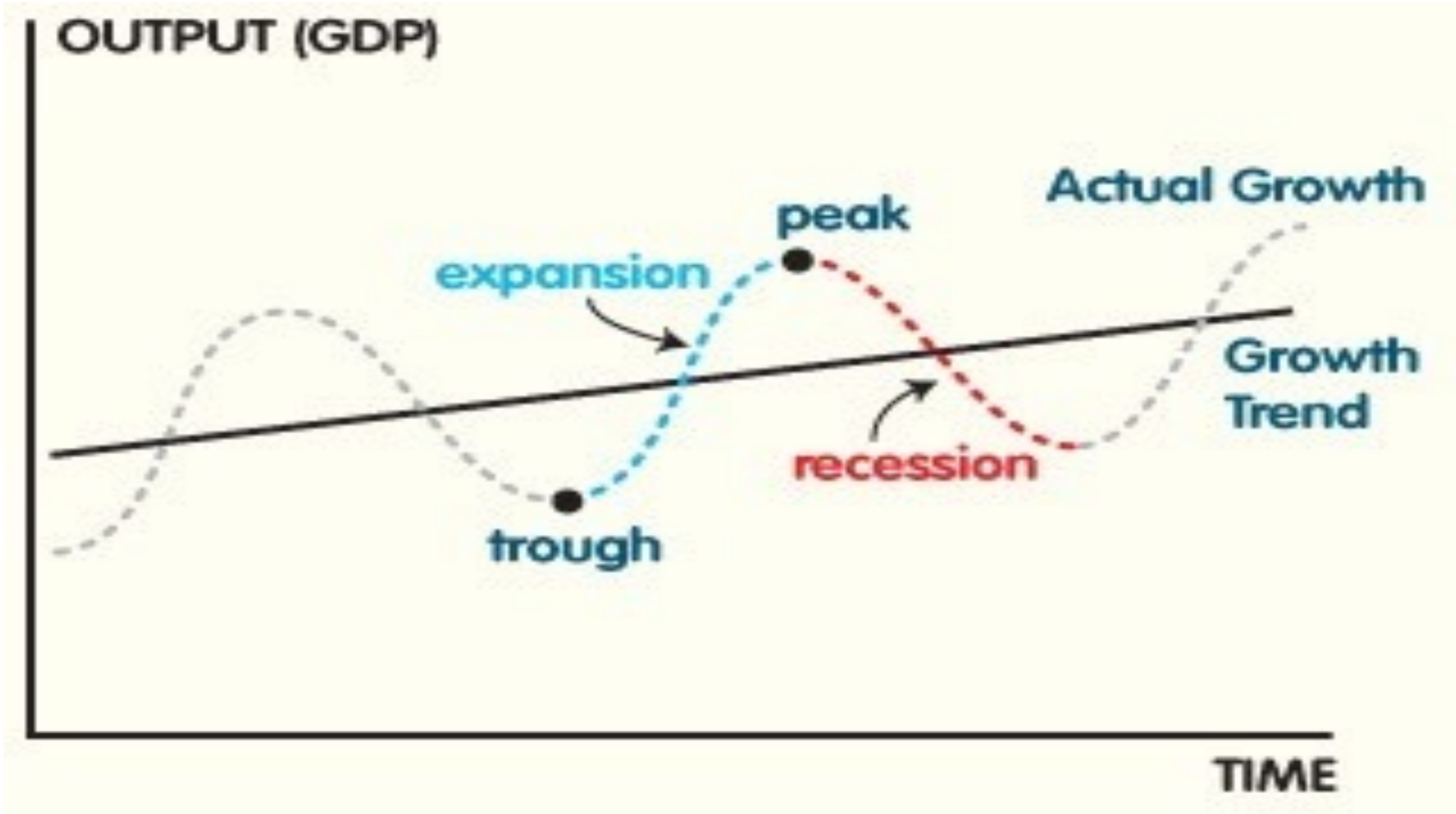
Chart
Italian GDP
Final seasonal component
400
300
200
100
0
-100
-200
-300
01-1995 01-1996 01-1997 01-1998 01-1999 01-2000 01-2001 01-2002 01-2003 01-2004 01-2005 01-2006 01-2007 01-2008 01-2009 01-2010 01-2011

4. Time series data Characteristics/Properties

6. **Properties #6: Cyclical variation:** Cyclical variations also have recurring patterns but with a longer and more **erratic time scale** compared to Seasonal variations.

Example include:

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


OUTPUT (GDP)
Actual Growth
peak
expansion
Growth
Trend
recession
trough
TIME

4. Time series data Characteristics/Properties

6. **Properties #6: 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.

4. Time series data Characteristics/Properties

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)