

# SOK-3021 Økonomisk analyse av tidsserier

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## Course Description, curriculum, and Assessments

### Course Description:

- This course provides a basic introduction to time series analysis, with a focus on economic and financial data.
- Students will learn how to analyze, model, and forecast data that evolves over time.
- The course covers both univariate and multivariate time series models.
- Emphasis is placed on practical applications using R for statistical computing and data visualization.

### Course Curriculum:

- In this course, we will cover the four chapters from the Principles of Econometrics.5th Edition (POE5), Wiley - 2018.
- The four chapters include:
  - **Chapters 9:** Regression with Time-Series Data: Stationary Variables
  - **Chapter 12:** Regression with Time-Series Data: Nonstationary Variables
  - **Chapter 13:** Vector Error Correction and Vector Autoregressive Models
  - **Chapter 14:** Time-Varying Volatility and ARCH/GARCH Models

## **Assessments: Assignment and Exam**

### **Assignment:**

- This course includes one mandatory assignment (which must be presented orally).
- Completion of both the assignment & its presentation is required to be eligible for the final exam.
- Students are required to find their own time series data and apply the full time series modeling procedure.
- Submission deadline: At the end of the course

## **Assessments: Assignment and Exam**

### **School Exam:**

- Written school exam (Date: 27/04 at Kl 09:00)
- **Exam Type:** Closed part + Open part
- **Closed Exam (60-70%):**
  - True/False
  - Multiple Choice
  - Fill in the blank's questions
- **Open Part (30-40%):**
  - Designed to test your empirical ability

# Introduction to Time Series Analysis

## Type of Data

In economics, we often work with three types of data.

1. Cross-sectional data
2. Time series data
3. Pooled/Panel data

### Cross-sectional Data:

Cross-sectional data are data on one or more variables collected from multiple units at the same point in time.

Examples:

- Income, educational level, age, and gender of 1,000 households in Norway in 2025
- Health indicators (e.g., BMI, smoking status) of individuals surveyed once
- Test scores of students from different schools in the same academic year , etc.

### Time Series Data:

- A time series is a set of observations on the values that a variable takes at different times.
- It is collected at a regular time intervals, such as daily, weekly, monthly, quarterly, annually.

Examples:

- GDP of Norway, 1960-2025
- Monthly inflation rate & unemployment rate in Norway, 2000 - 2025, etc.

## Pooled/Panel Data

- Pooled data is a combination of both cross-sectional & time series data.
- It is data collected from multiple units observed over time.
- Panel/longitudinal data is a special type of pooled data in which the same cross-sectional unit (say , a family or firm) is surveyed over time.

### Examples:

- Household panels tracking consumption and demographics over time
- Country-level macroeconomic indicators (e.g., GDP, inflation) observed over several decades, etc.

## Time Series Data

- Time series data observe the same variable over multiple time periods.
- Such observations may be denoted by  $y_1, y_2, \dots, y_t, \dots, y_T$  since data are usually collected at discrete points in time

## Features of Time Series Data

- Time-series data have a natural ordering according to time
- Time-series observations on a given economic unit, observed over a number of time periods, are likely to be correlated
- That is, what happens today may depend on what happened yesterday
- In time series data, there is the mutual dependence between the observations, generally called SERIAL CORRELATION OR AUTOCORRELATION observation at time  $t$

## Time Series Analysis

- In time series analysis, we analyze the past behavior of a variable in order to predict its future behavior.
- Businesses are often very interested in forecasting time series variables since social and economic conditions are constantly changing over time.
- Time Series Analysis, using statistical methods, allows to enhance comprehension and predictions on any quantitative variable of interest (sales, demand of products, financial performance indicators, logistics, etc.)

## Area of Applications of Time Series Data

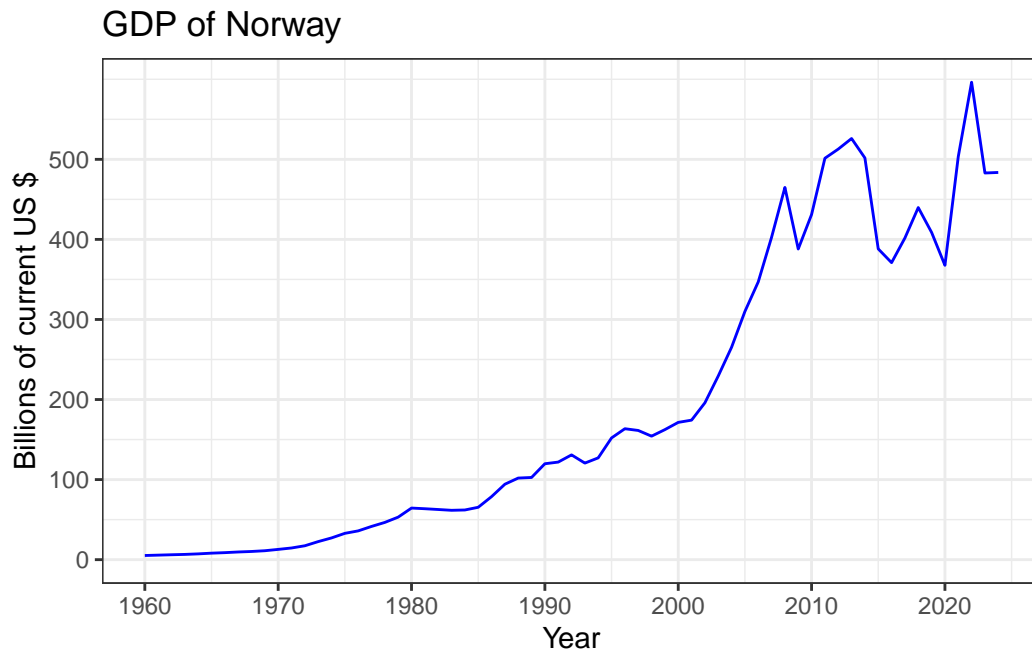
The fields of application of Time series Analysis are numerous: Demand Planning is one of the most common application, however, from industry to industry there are other possible uses. For instance:

- (a). Economics: GDP, monthly unemployment rates, inflation rates, stock market prices, sales, prices, etc.
- (b). Epidemiology: the number of influenza cases observed over sometime period, the number of COVID-19 cases and deaths, etc.
- (c). Social sciences: population series, such as birthrates, school enrollments, etc.
- (d). Transport: Number of traffic accidents per day, month, or year, number of passengers traveling through airports each month or year, etc
- (e). Global warming, CO2 concentration in the atmosphere in 2050, etc.

## Forecasting

- Once someone said:  
“Forecasting is the art of saying what will happen in the future and then explaining why it didn’t”
- The reality is that forecasting is a really tough task, and you can do really bad,
- History is full of examples of «bad forecasts», just like IBM Chairman’s famous quote in 1943: “there is a world market for maybe five computers in the future.”
- But we can definitely reduce uncertainty and improve the accuracy of our forecasts

## Graphical Analysis: Time Plot



- What do you notice about the movement of GDP over time?
- Can you see periods of faster or slower growth?

Response [[https://raw.githubusercontent.com/uit-SOK-3021-v26/uit-SOK-3021-v26.github.io/main/inflation\\_Norway.xlsx](https://raw.githubusercontent.com/uit-SOK-3021-v26/uit-SOK-3021-v26.github.io/main/inflation_Norway.xlsx)]

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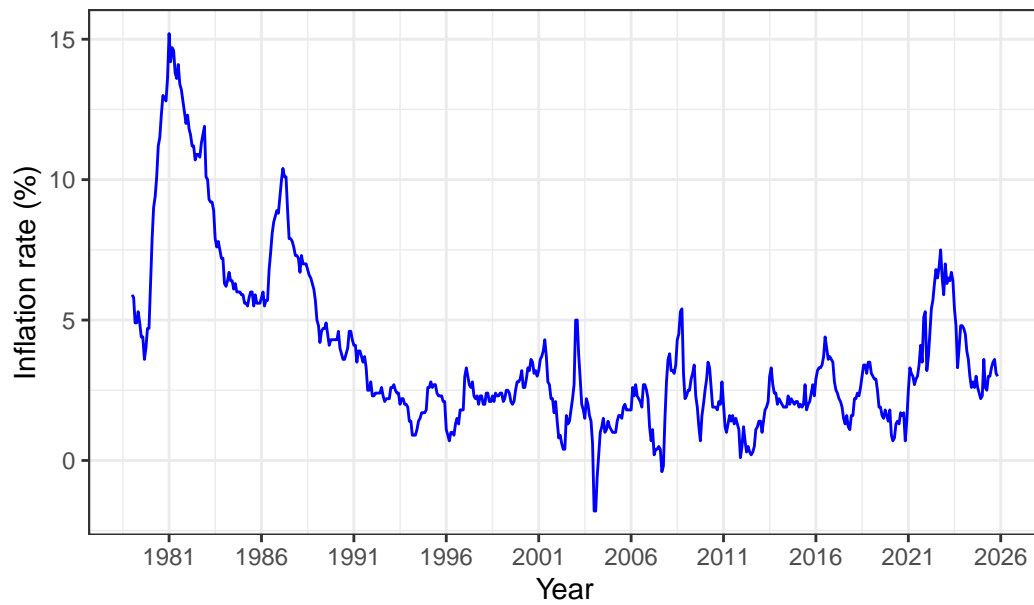
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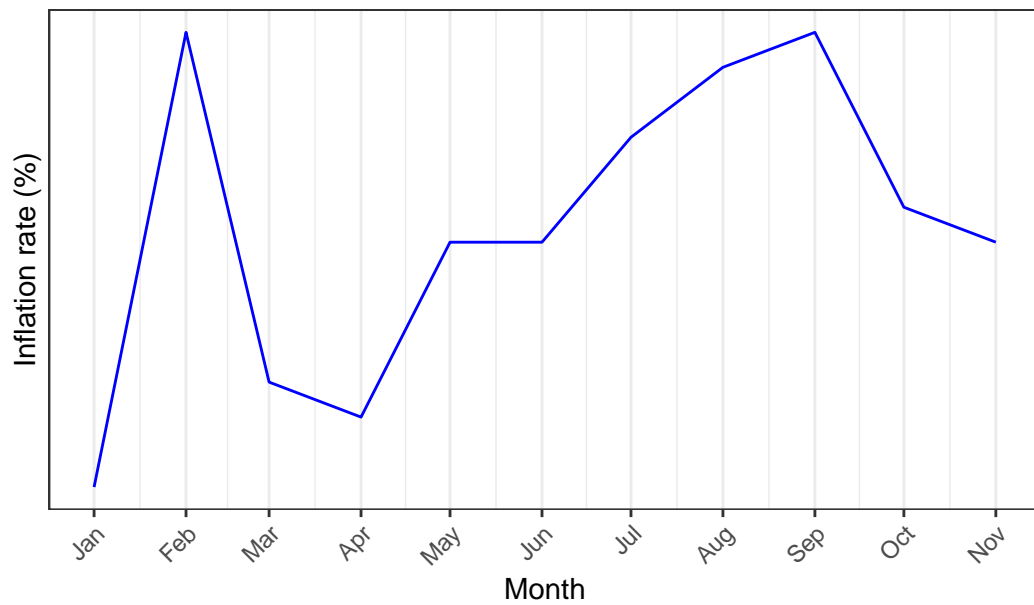
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Monthly Inflation in Norway

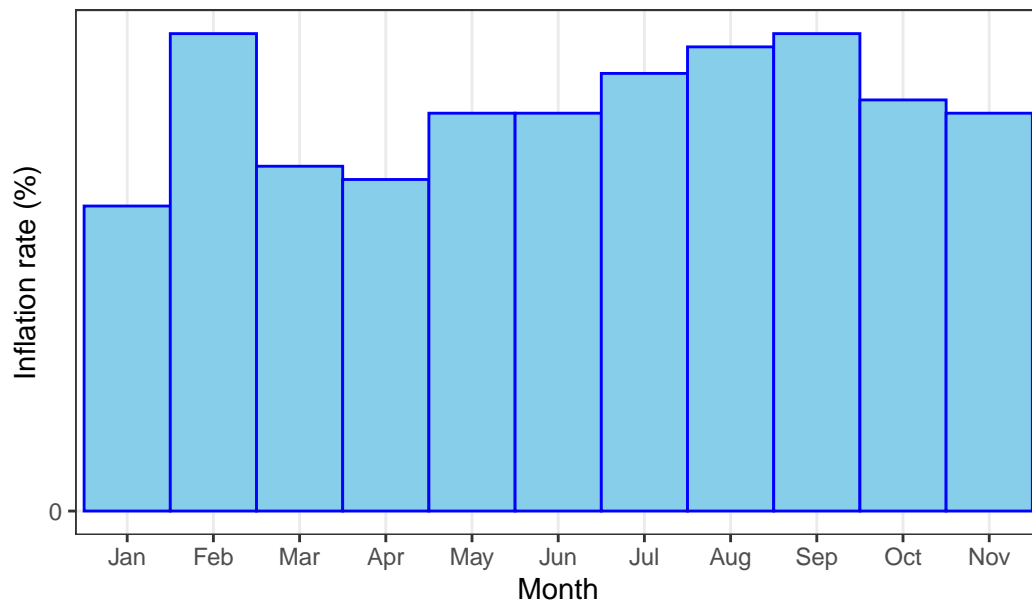


- Does inflation change smoothly or abruptly?

Monthly Inflation in Norway (2025)



Monthly Inflation in Norway (2025)

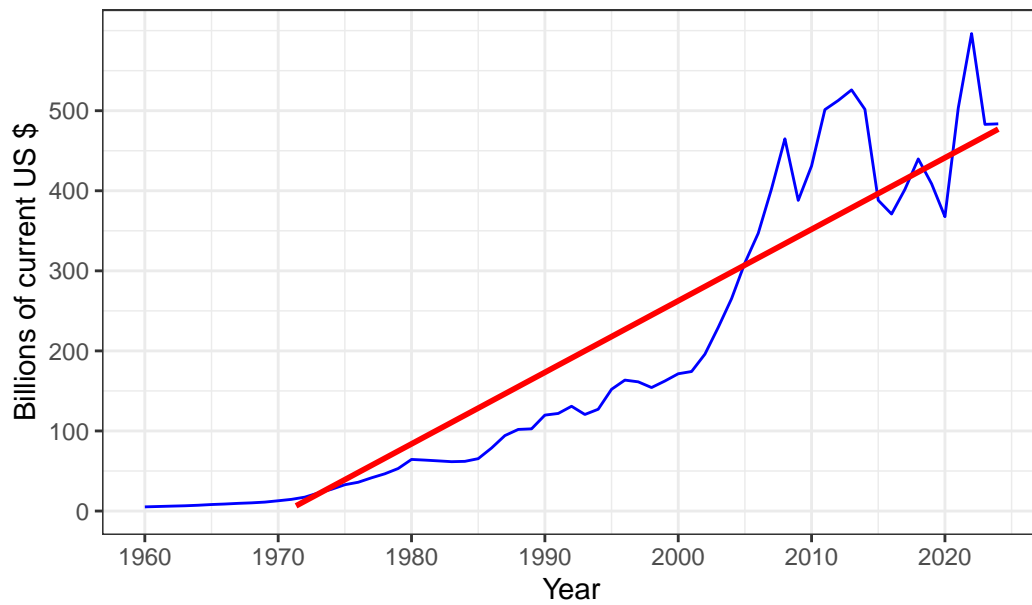


## Components of a Time Series: Trend, cycles and seasonality

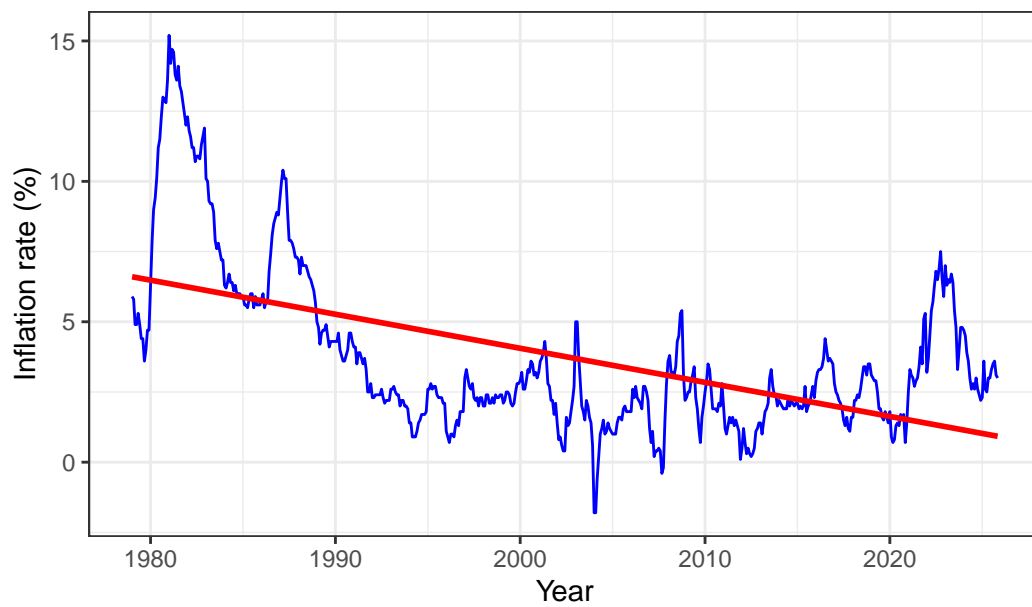
### Trend

- The general direction in which the series is running during a long period
- A TREND exists when there is a long-term increase or decrease in the data.
- It does not have to be necessarily linear (could be exponential or others functional form).

GDP of Norway with linear trend



Monthly Inflation in Norway with a linear Trend

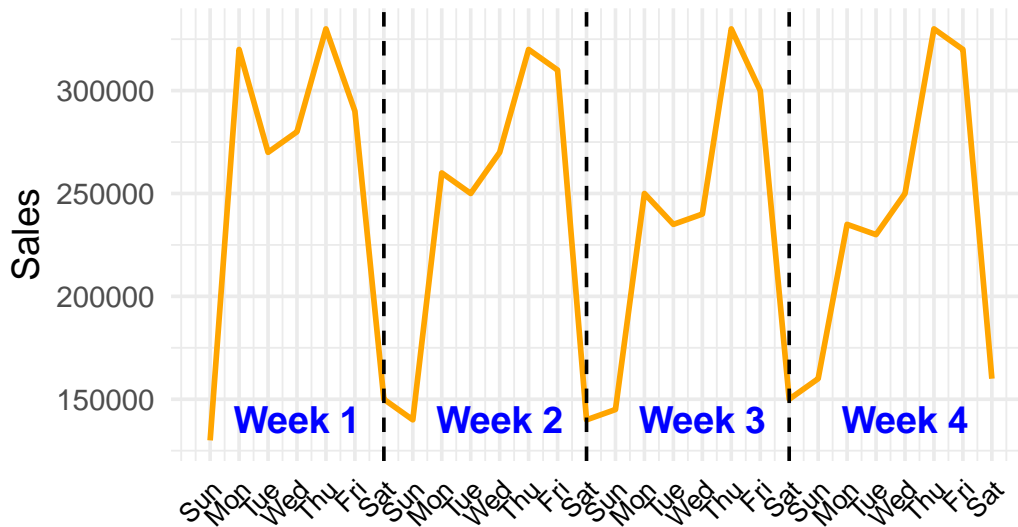


## SEASONAL EFFECTS

- Short-term fluctuations that occur regularly – often associated with months or quarters

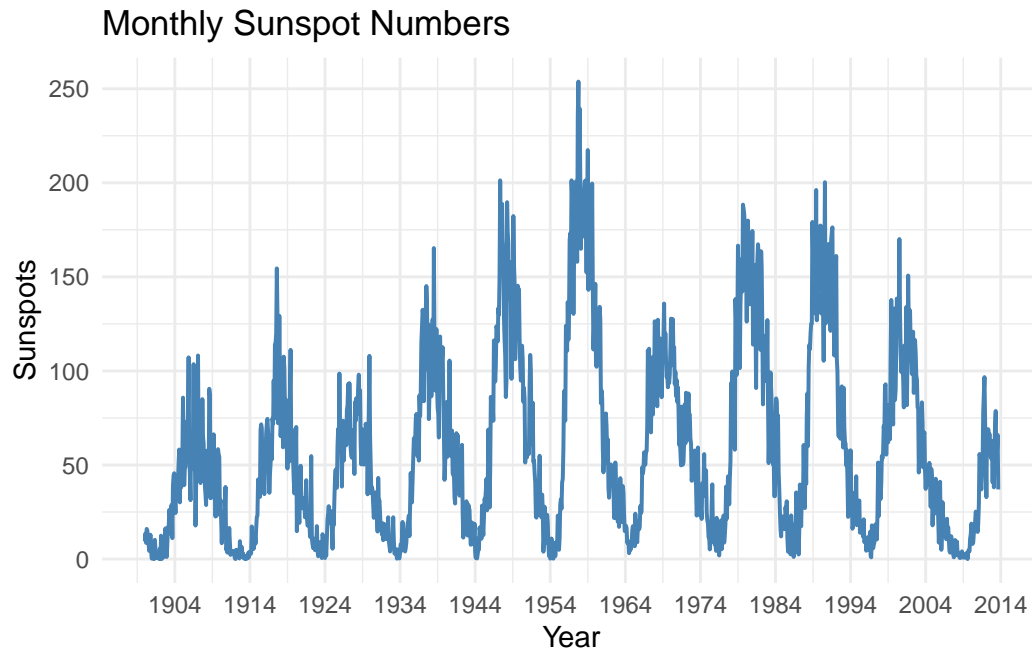
- A SEASONAL PATTERN exists when a series is influenced by seasonal factors (e.g., the quarter of the year, the month, day of the week).
- Seasonality is always of a fixed and known period.

### Seasonal effect example (Weekly seasonality) Newspapers Daily Sales



### CYCLE

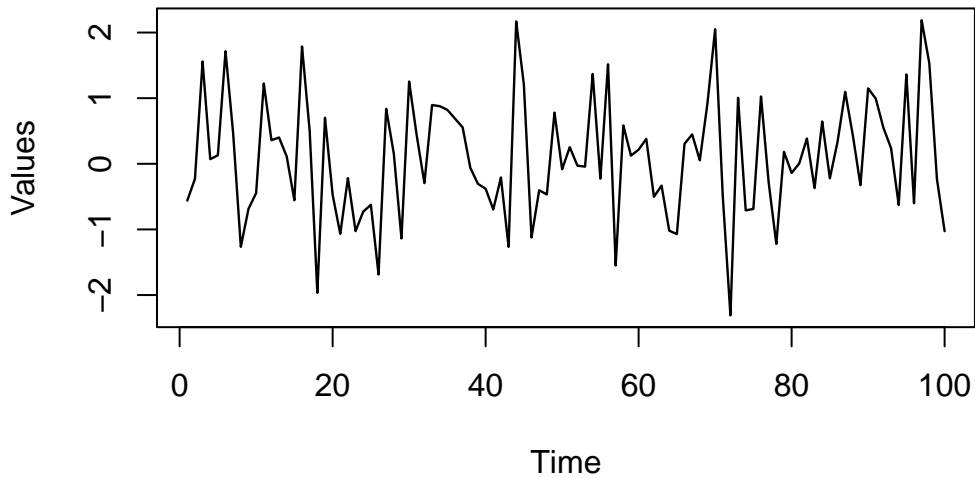
- Long-term fluctuations that occur regularly in the series A CYCLE is an oscillatory component (i.e. Upward or Downward swings) which is repeated after a certain number of years, so:
- May vary in length and usually lasts several years (from 2 up to 20/30)
- Difficult to detect, because it is often confused with the trend component



## RESIDUAL

- Whatever remains after the other components have been taken into account
- The residual/error component is everything that is not considered in previous components
- Typically, it is assumed to be the sum of a set of random factors (e.g. a white noise series) not relevant for describing the dynamics of the series

## Example of White Noise Series



The four components above can be combined in the additive time series model as follow:

$$Y_t = T_t + S_t + C_t + R_t$$

where  $Y_t$  is the actual value,  $T_t$  is the trend/long-term movement,  $S_t$  is the seasonal component,  $C_t$  is cyclical movement, and  $R_t$  is the residual/random movement.

### Task:

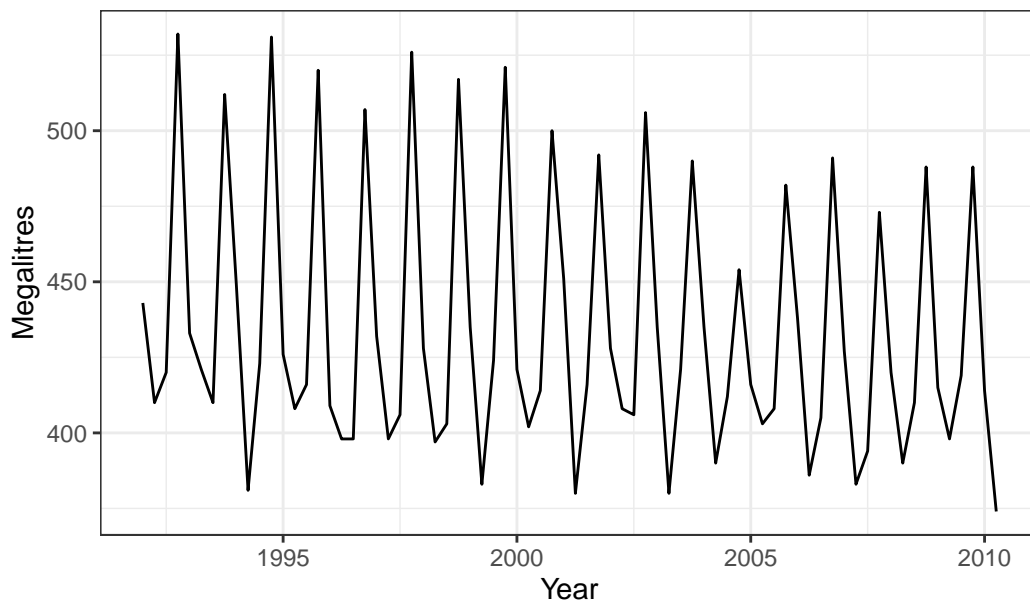
- From the R package **fpp2** in R, load the quarterly beer production data in Australia.
- plot the time series plot of the data
- find the trend, seasonality, and noise of the the quarterly beer production

```
# The time series plot below shows the quarterly beer production in Australia
library(fpp2)
# ausbeer
beer2 <- window(ausbeer, start=1992)
beer2
```

	Qtr1	Qtr2	Qtr3	Qtr4
1992	443	410	420	532
1993	433	421	410	512
1994	449	381	423	531
1995	426	408	416	520
1996	409	398	398	507

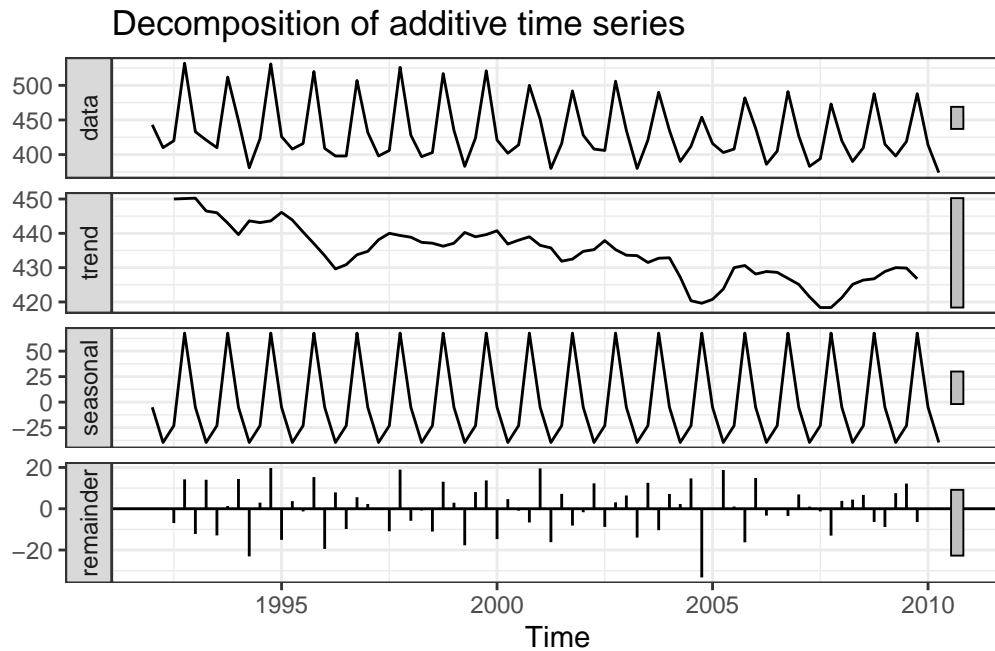
1997	432	398	406	526
1998	428	397	403	517
1999	435	383	424	521
2000	421	402	414	500
2001	451	380	416	492
2002	428	408	406	506
2003	435	380	421	490
2004	435	390	412	454
2005	416	403	408	482
2006	438	386	405	491
2007	427	383	394	473
2008	420	390	410	488
2009	415	398	419	488
2010	414	374		

```
ggplot2::autoplot(beer2) + xlab("Year") + ylab("Megalitres")+theme_bw()
```



The time series decomposition of the quarterly beer production in Australia:

```
ggplot2::autoplot(decompose(beer2))+theme_bw()
```



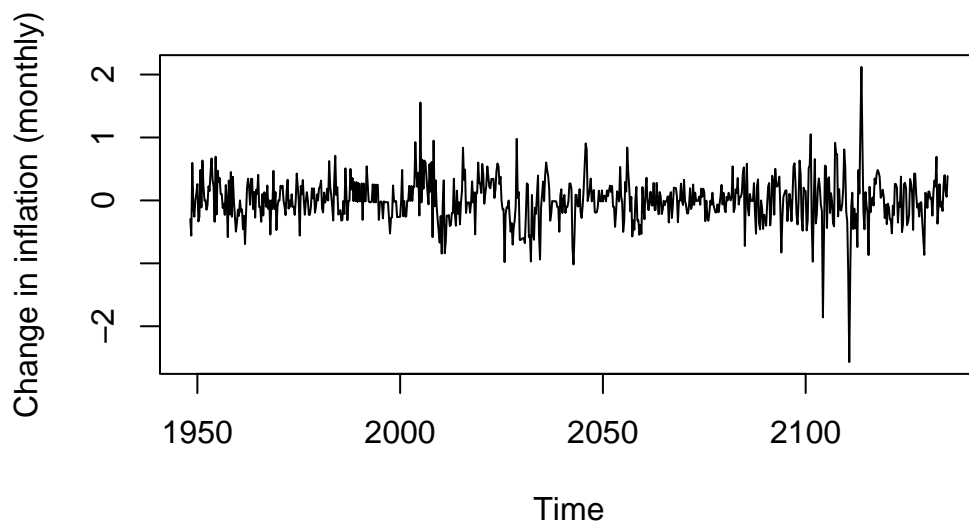
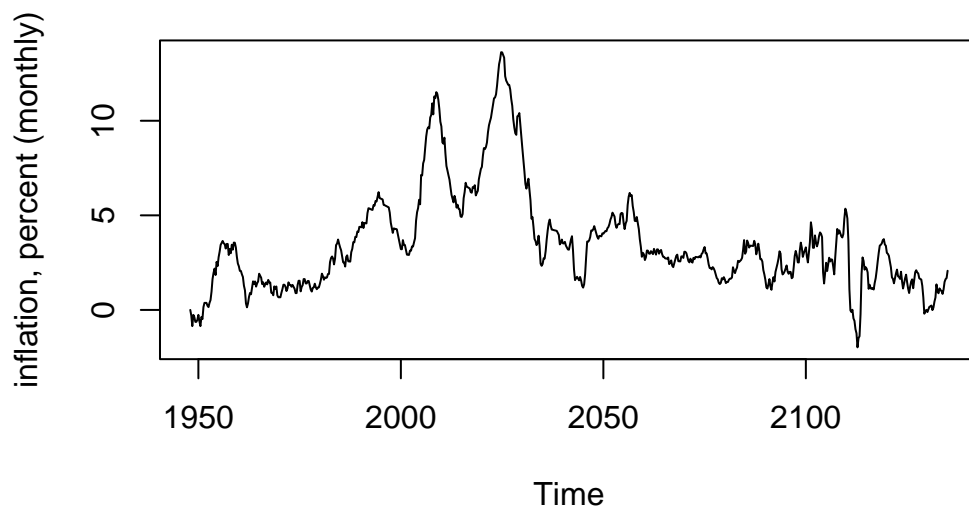
## Some Time series Terms

**Stationary Data** - a time series variable exhibiting no significant upward or downward trend over time.

- A Stationary time series data has constant means, variance and autocovariance overtime.

**Nonstationary Data** - a time series variable exhibiting a significant upward or downward trend over time.

- Non-stationary time series data has means and variances that change over time



**Notes:**

- The first figure above is non-stationary while the second one is stationary
- A Stationary time series data has constant means, variance and autocovariance overtime.

- Non-stationary time series data has means and variances that change over time

## Approaching Time Series Analysis

- There are many, many different time series techniques/models.
- It is usually impossible to know which technique will be best for a particular data set.
- It is customary to try out several different techniques and select the one that seems to work best.
- To be an effective time series modeler, you need to keep several time series techniques in your “tool box.”

### Task & Dataset:

- Download annual CO<sub>2</sub> emissions data from OurWorld in Data: (<https://ourworldindata.org/co2-emissions>).
- Construct time-series plots of annual CO<sub>2</sub> emissions for the world and for Norway from 1960 to 2024.
- Describe the main pattern of the plot.

```
#CO2 emission data by country

# Load necessary library
library(readr)

# Direct URL to the CO2 emissions dataset (production-based)
url <- "https://github.com/owid/co2-data/raw/master/owid-co2-data.csv"

# Read the CSV directly into R
co2_data <- read_csv(url)

# Preview the dataset
#head(co2_data)

#View(co2_data)

#co2_data %>% filter(year>=1960) %>% filter(country=="Norway")
```