Applied Economic Forecasting

Basics of Time Series & Forecasting

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Section 1

Introduction to Economic Forecasting

Outline

1. What is Economic Forecasting?
2. Explaining Time Series
3. Forecasting Methods and Steps
4. Types of Forecasts
5. Data Sources
6. Forecasting Software

What is Economic Forecasting?

- Predicting future values based on
  - qualitative and/or qualitative judgement.

The appropriate forecasting methods depend largely on what data are available.

1. If there are no data available, or if the data available are not relevant to the forecasts, then **qualitative** forecasting methods must be used.

- require the use of well-developed judgmental forecast methods.

2. **Quantitative** forecasting can be applied when two conditions are satisfied:

i. numerical information about the past is available;
ii. it is reasonable to assume that some aspects of the past patterns will continue into the future.

What is Economic Forecasting?

Quantitative forecasts

Most quantitative prediction problems use either time series data or cross-sectional data (collected at a single point in time).

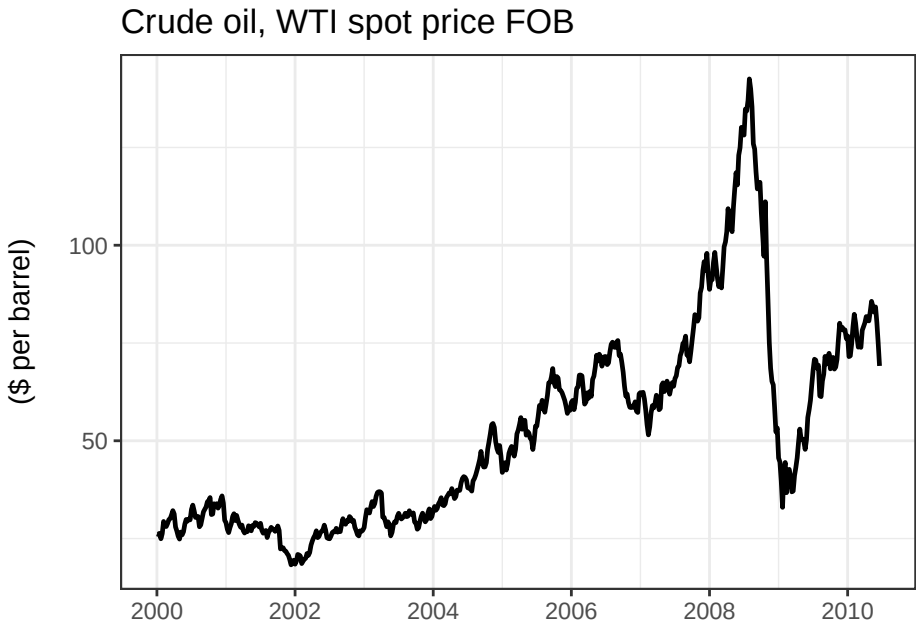
In this course, we are concerned with forecasting future data, and we will concentrate on the time series domain.

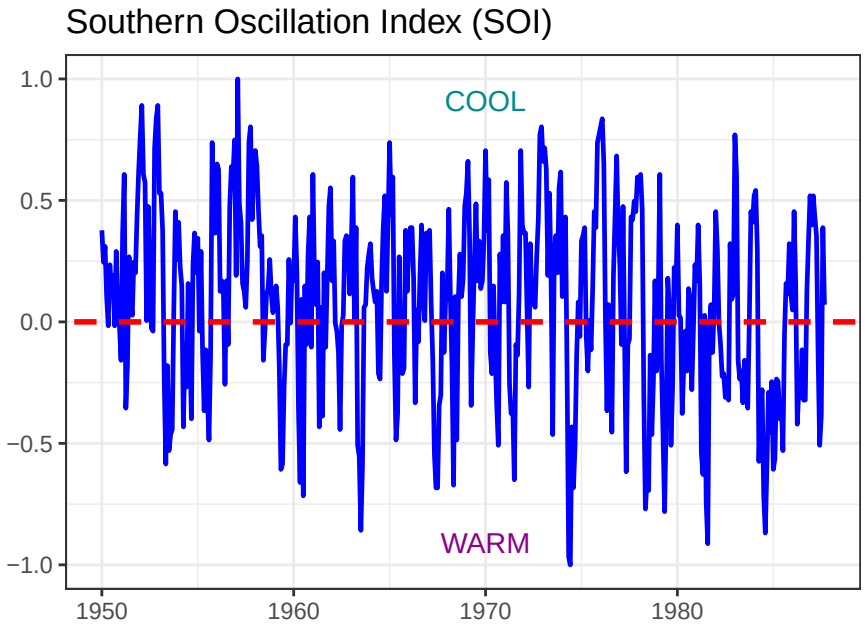
Often in forecasting, a key step is knowing when something can be forecast accurately, and when forecasts will be no better than tossing a coin. Good forecasts capture the genuine patterns and relationships which exist in the historical data, but do not replicate past events that will not occur again. ~Rob Hyndman

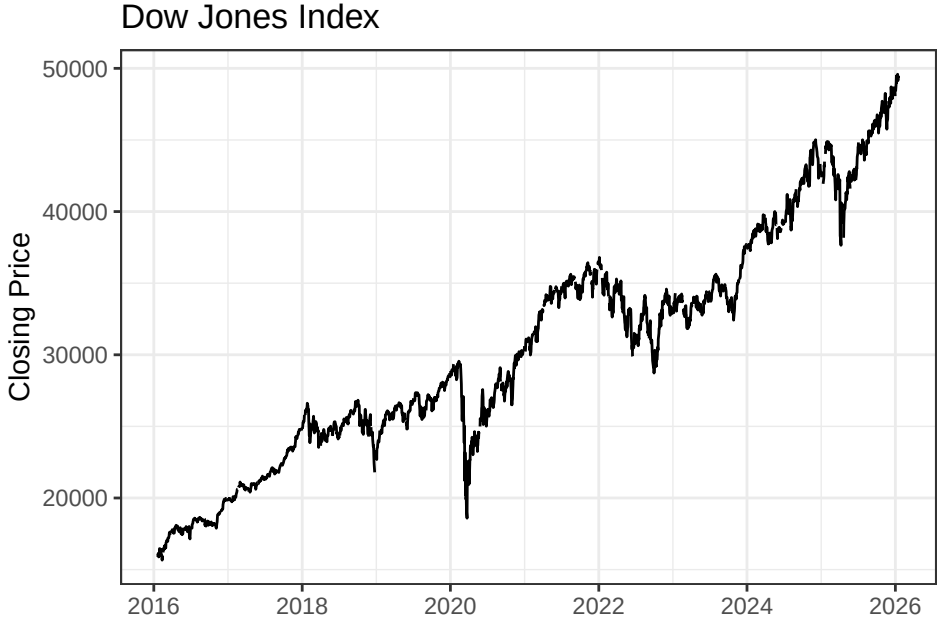
What is Time Series?

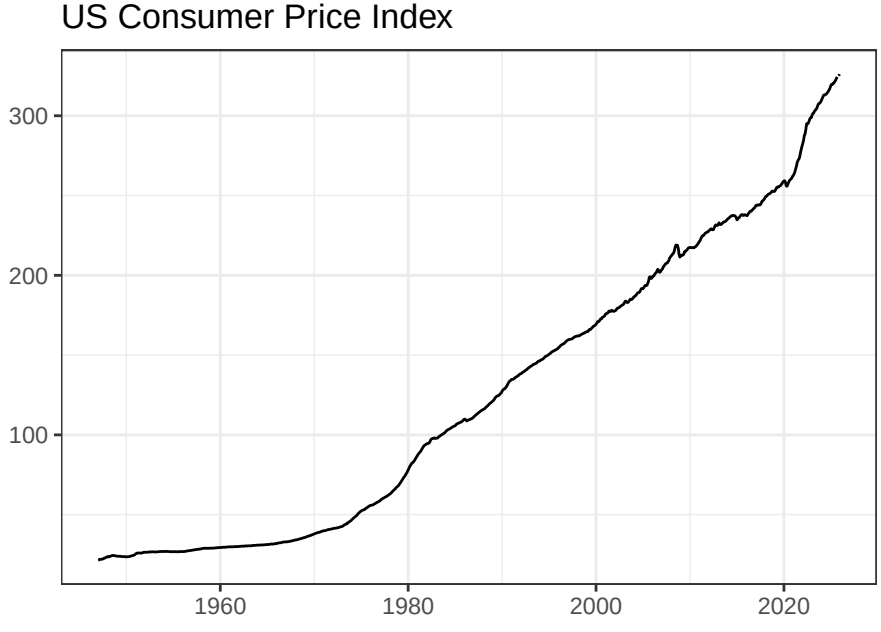
A time series is a sequence of measurements over time, usually obtained at regular, equally spaced intervals

- Every minute
- Hourly
- Daily
- Weekly
- Monthly
- Quarterly
- Yearly


Crude oil, WTI spot price FOB
($ per barrel)
100
50
2000
2002
2004
2006
2008
2010


Southern Oscillation Index (SOI)
1.0
0.5
0.0
−0.5
−1.0
COOL
WARM
1950
1960
1970
1980


Dow Jones Index
Closing Price
50000
40000
30000
20000
2016
2018
2020
2022
2024
2026


US Consumer Price Index
300
200
100
1960
1980
2000
2020

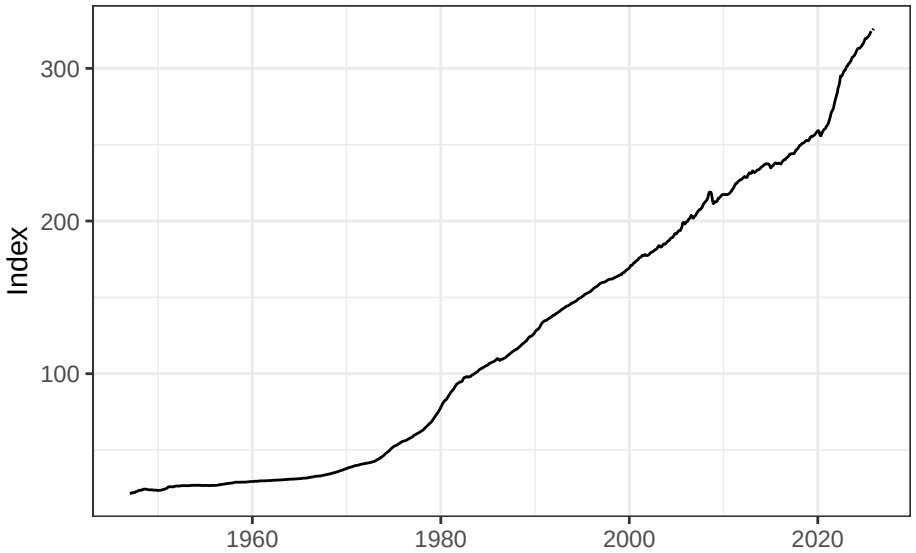
Components of a Time Series

- **Trends** (longrun increase or decrease in the data.)
  - Linear
  - Nonlinear
- **Seasonality** (occurs when a time series is affected by seasonal factors such as the time of the year or the day of the week.)
  - Seasonality is **always of a fixed and known frequency**. For example:
  - monthly data will have a seasonal pattern that repeats every 12 months.
  - quarterly data will have a seasonal pattern that repeats every 4 quarters.
- **Cycles**
  - Rises and falls that are not of a fixed/predictable frequency
  - These fluctuations are usually due to "business cycle" conditions (not seasonal effects).
  - Agricultural prices often exhibit cyclical patterns due to supply and demand conditions (e.g., inventory cycles, etc.).

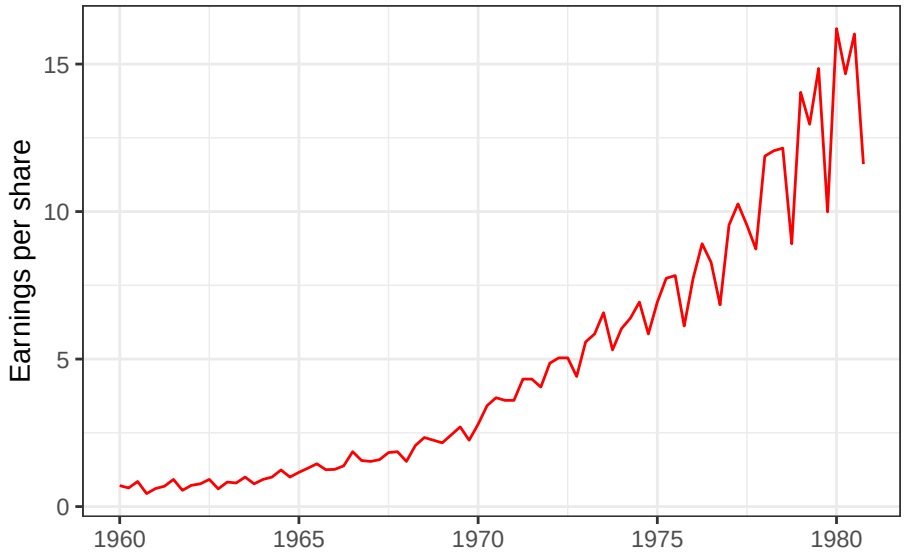
(Linear) trend models

Examples: Data with Linear Trends

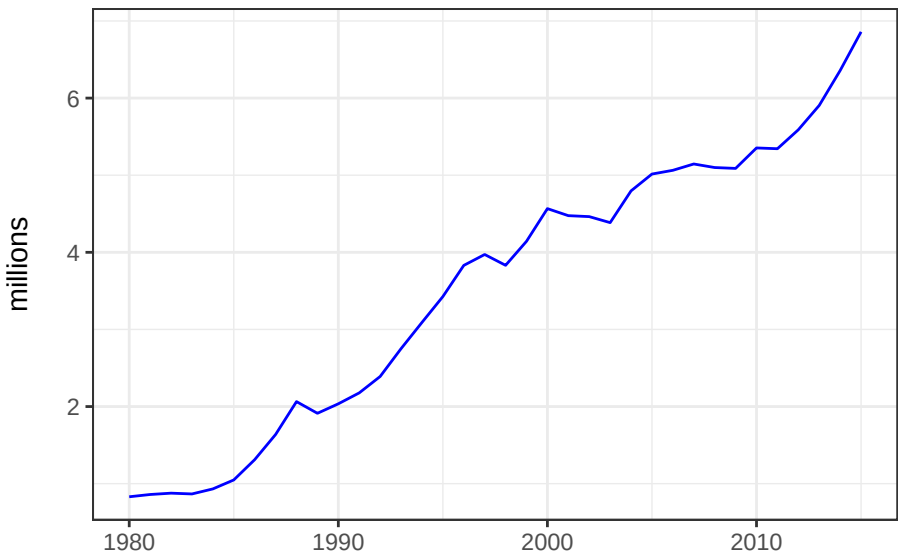
US Consumer Price Index



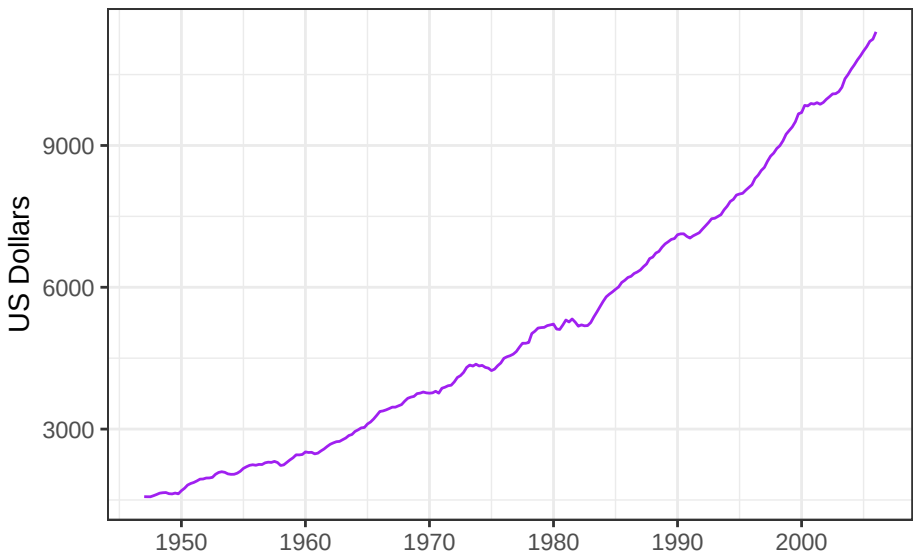
Johnson & Johnson Earnings



Total International Visitors to Australia



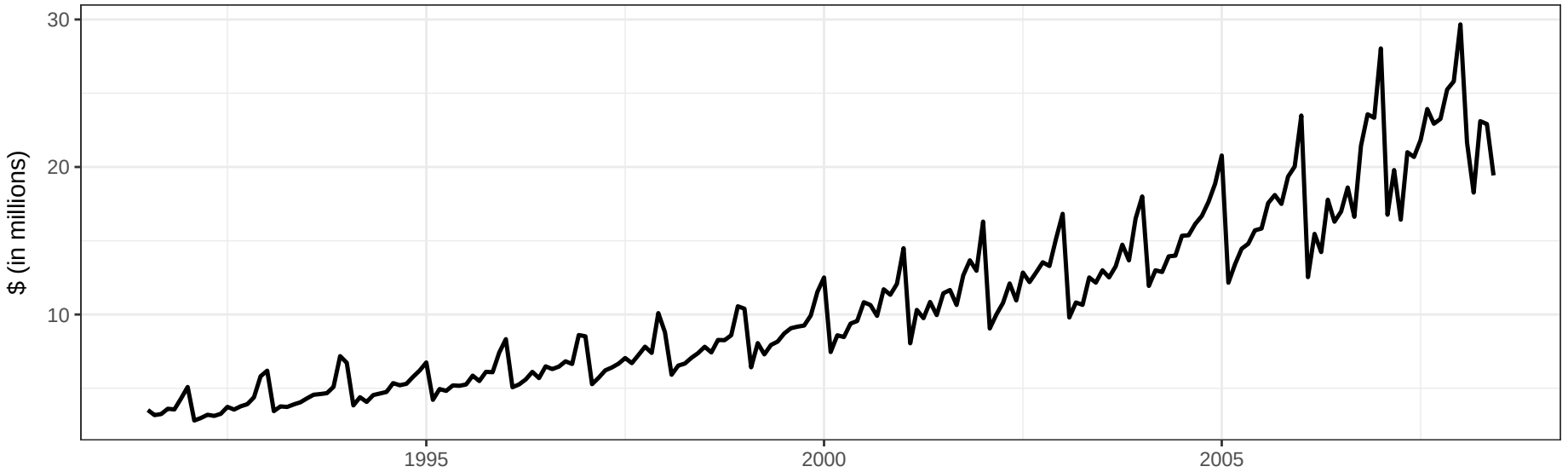
Quarterly US GDP



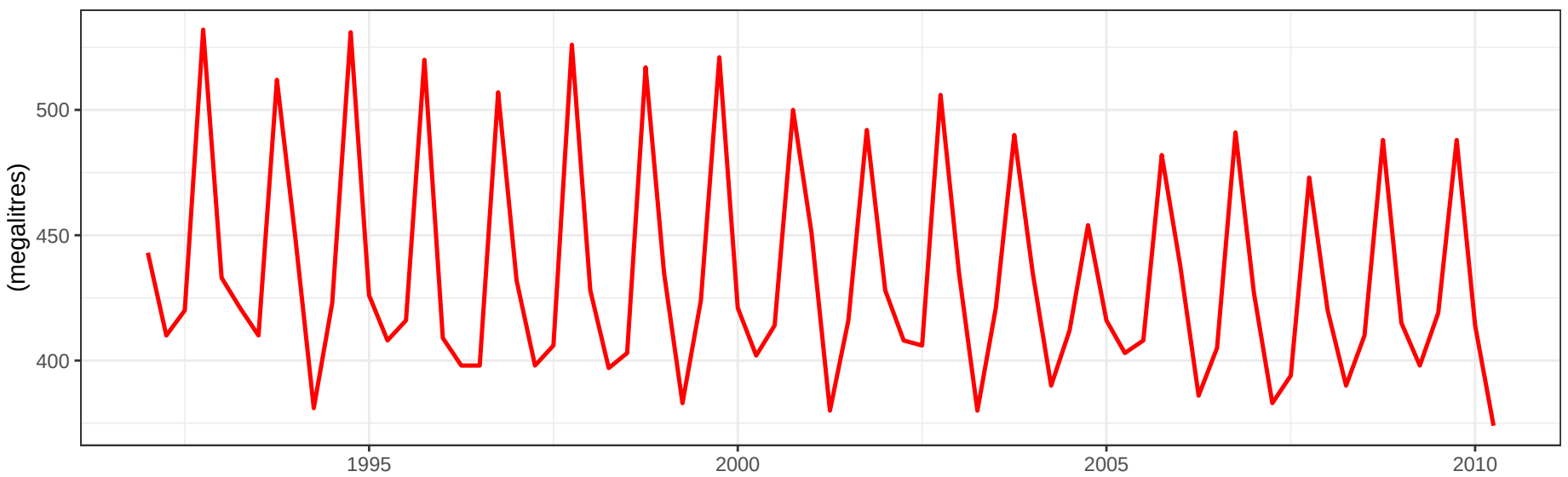
Trends and Seasonality?

Examples of Data with Seasonality

Monthly Antidiabetic Drug Subsidy



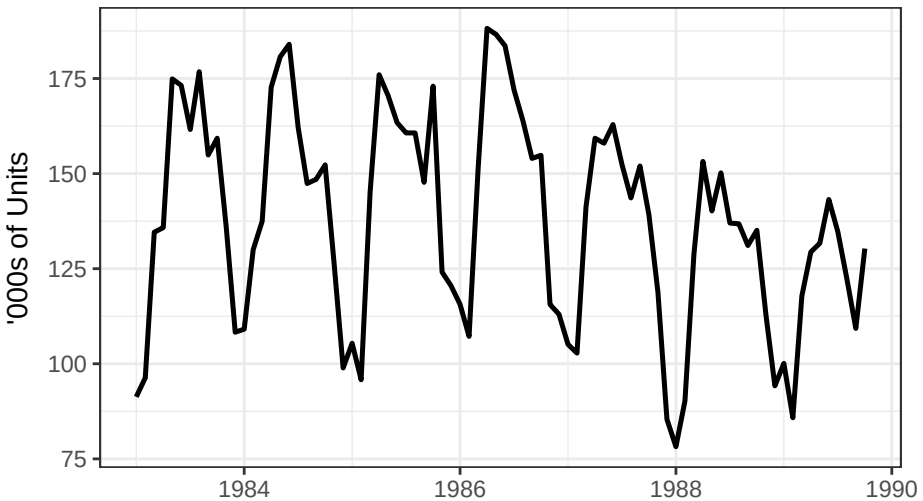
Quarterly Australian Beer Sales



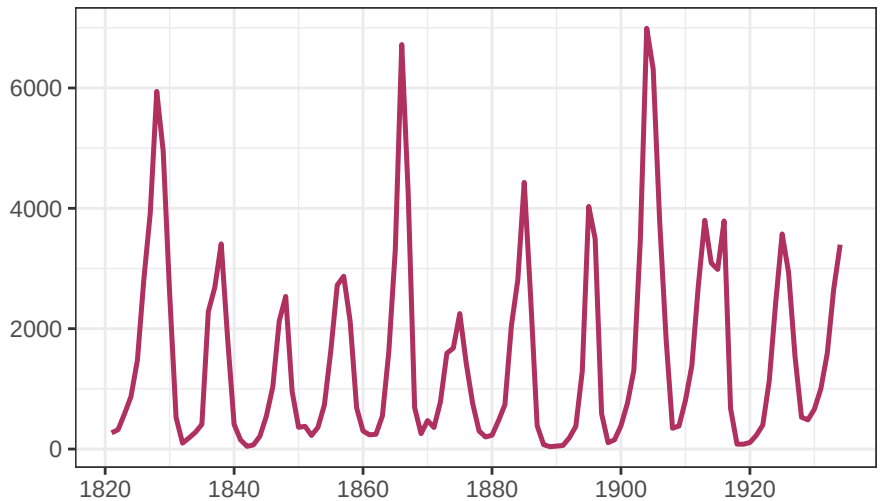
Models with cycles

Examples of Data with Cycles

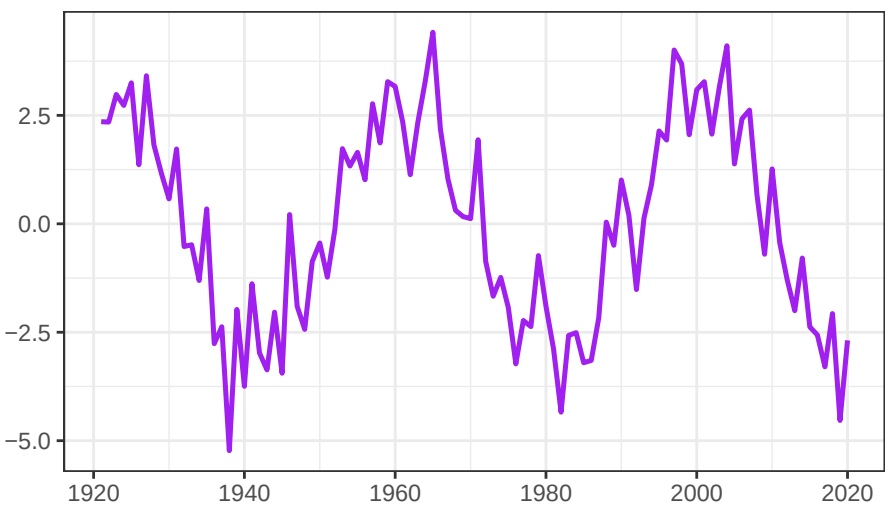
Monthly housing starts in the US



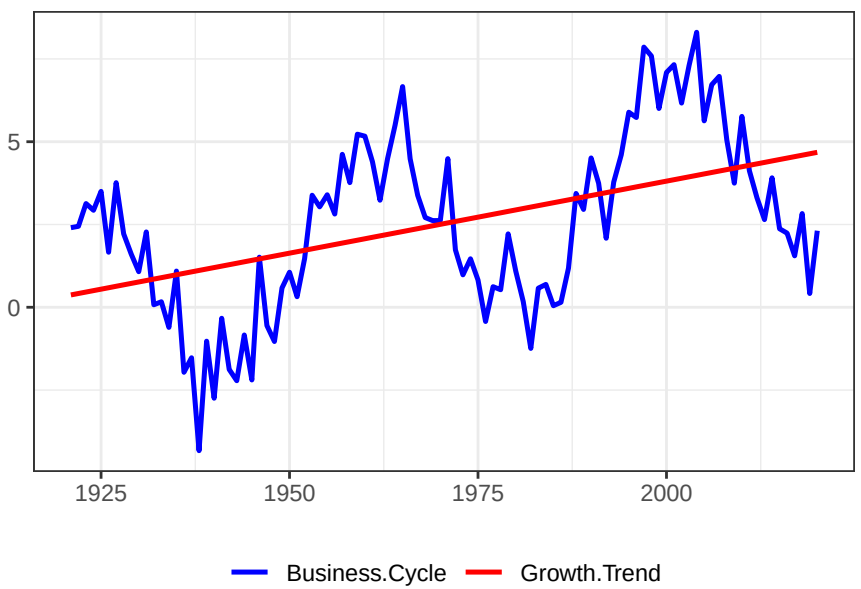
Annual Canadian Lynx Trapping



Simulated Data



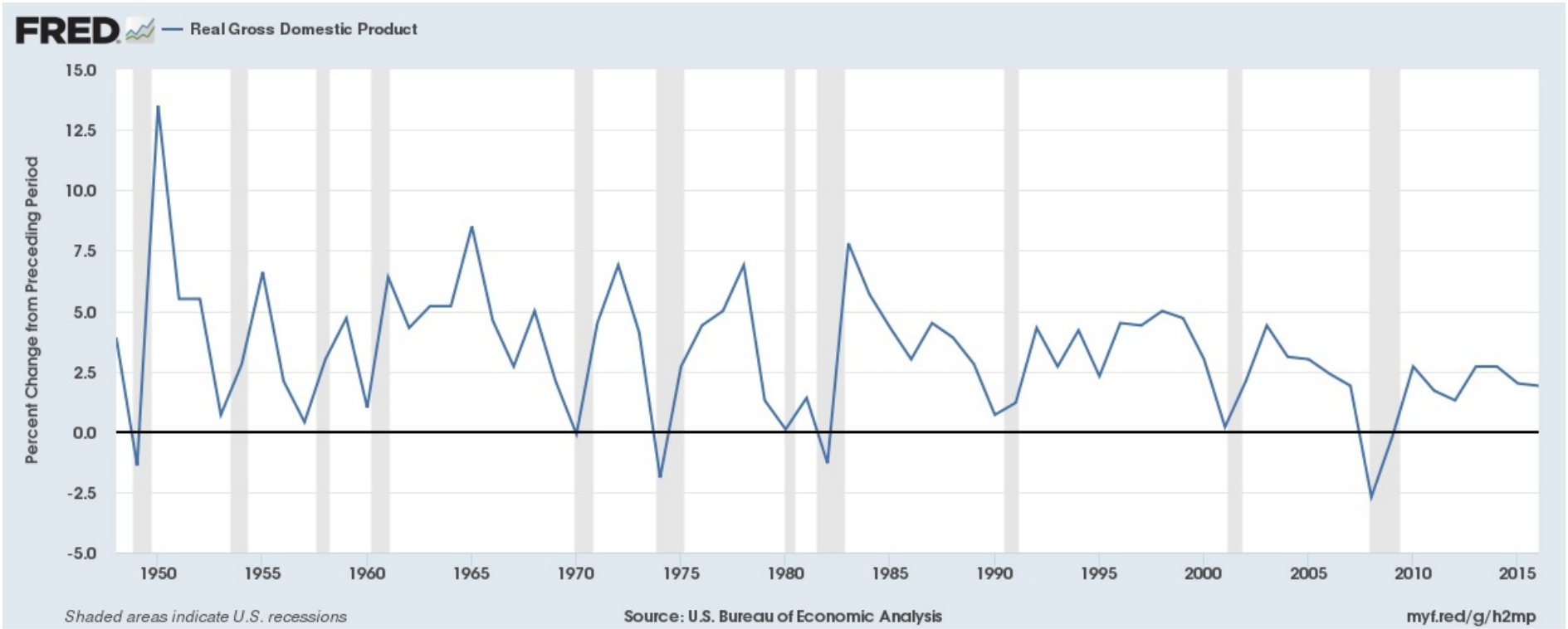
Simulated Business Cycle Data??



Seasonal or cyclic?

Differences between seasonal and cyclic patterns:

- seasonal pattern have a constant length vs. cyclic pattern which have varying lengths
- average length of cycles are much longer than length of seasonal pattern
- the magnitude of cycles are more variable than magnitude of seasonal pattern
- Timing of peaks (highs) and troughs (lows) are predictable with seasonal data, but unpredictable in the long term with cyclic data.


FRED
Real Gross Domestic Product
Percent Change from Preceding Period
15.0
12.5
10.0
7.5
5.0
2.5
0.0
-2.5
-5.0
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
Shaded areas indicate U.S. recessions
Source: U.S. Bureau of Economic Analysis
myf.red/g/h2mp

Forecasting Methods & Steps

1. Problem formulation
2. Data collection
3. Data manipulation and cleaning
4. Model building
5. Model evaluation
6. Model implementation (the actual forecast)
7. Forecast evaluation

Forecasting Methods & Steps

1. **Problem formulation**
   - Why is a forecast needed?
   - Who will use the forecast?
   - What are specific requirements on forecasting?
   - What level of detail or aggregation is required?
   - What is the proper time horizon?
   - What forecasting methods should be chosen?

2. **Data collection**

- Where to obtain data required by the forecasting problem?
- What are data frequencies, sample periods, sources?
- How much does data collection cost?
- What level of data is required?
- What is the data quality?

Forecasting Methods & Steps

3. **Data manipulation and cleaning**

- Missing values
- Outliers
- Different data sources
- Different units
- ...

Forecasting Methods & Steps

4. **Model building**

- This will depend on the characteristic of the data and the purpose for the forecast.
- See How to choose the right forecasting Technique

5. **Model evaluation**

- Is the chosen model best suited for data?
- Are the underlying assumptions of the model satisfied?
  - For example, assumptions for ordinary least square (OLS) regression:
    - A.1: zero error term mean
    - A.2: error terms are homoscedasticity
    - A.3: error terms have no autocorrelation
    - A.4: no multicollinearity
    - A.5: explanatory variables and error terms are uncorrelated.
    - ...

Forecasting Methods & Steps

6. **Model implementation for forecasting**

- rolling window forecast
- recursive/expanding window forecast
- estimation period and forecasting period
- parameter updating frequencies
- ...

7. **Forecast Evaluation**

- Choice of loss functions:
  - Mean Absolute Deviations (MAD)

$$MAD = \frac{1}{T}\sum_{t=1}^{T}\left|\underbrace{y_t - \widehat{y}_t}_{e_t}\right|$$

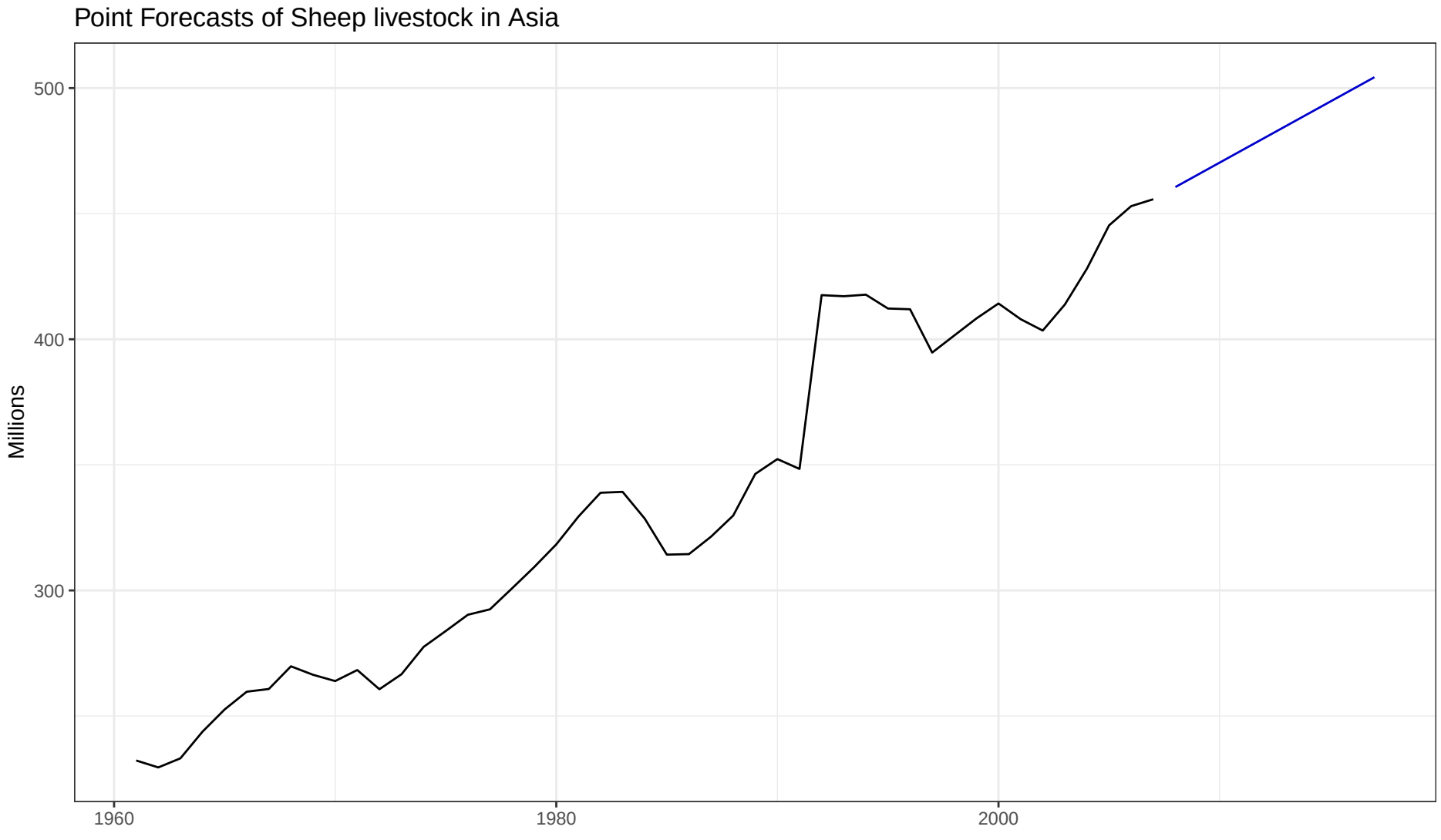
  - Mean Squared Error (MSE)

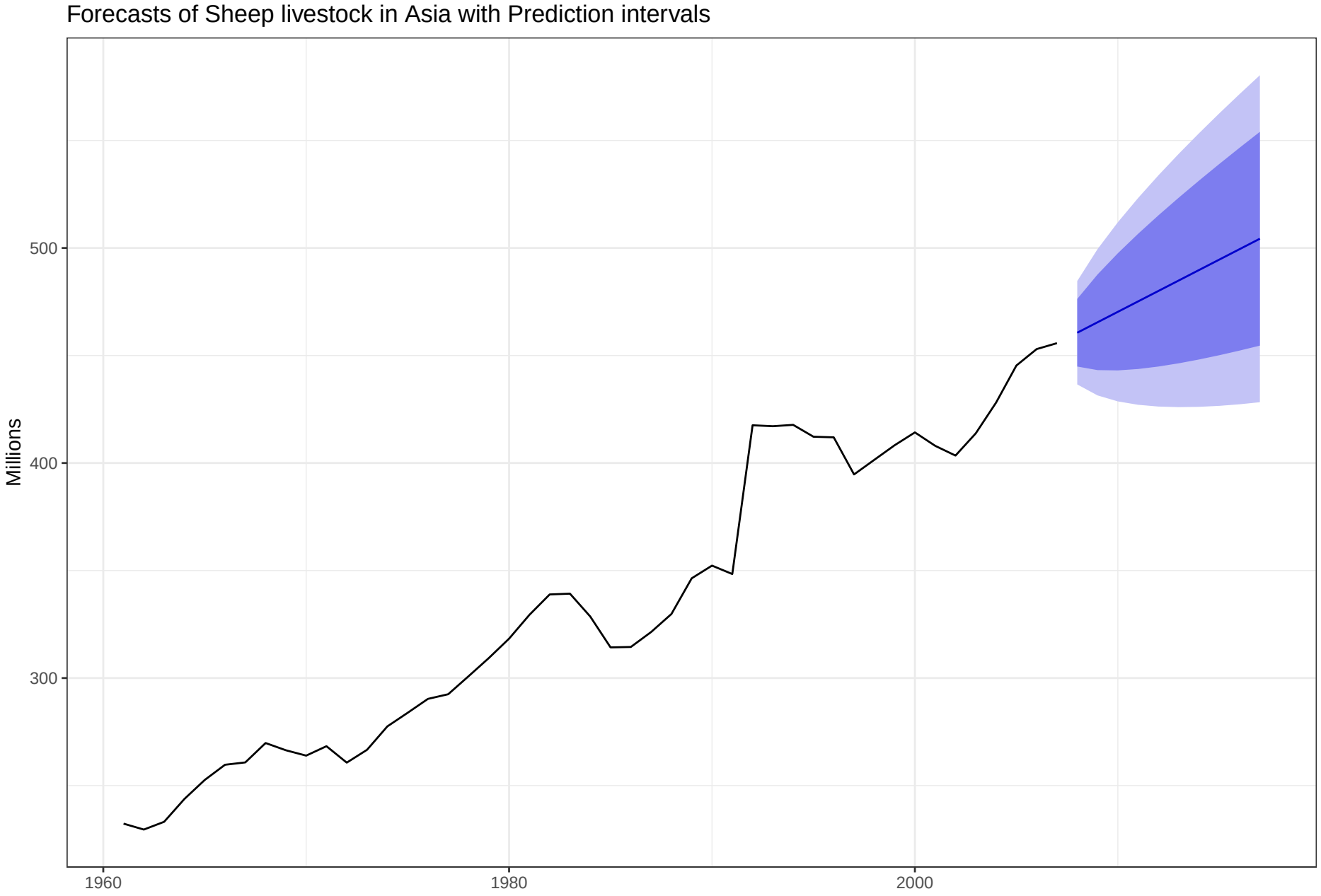
$$MSE = \frac{1}{T}\sum_{t=1}^{T}\left(y_t - \widehat{y}_t\right)^2$$

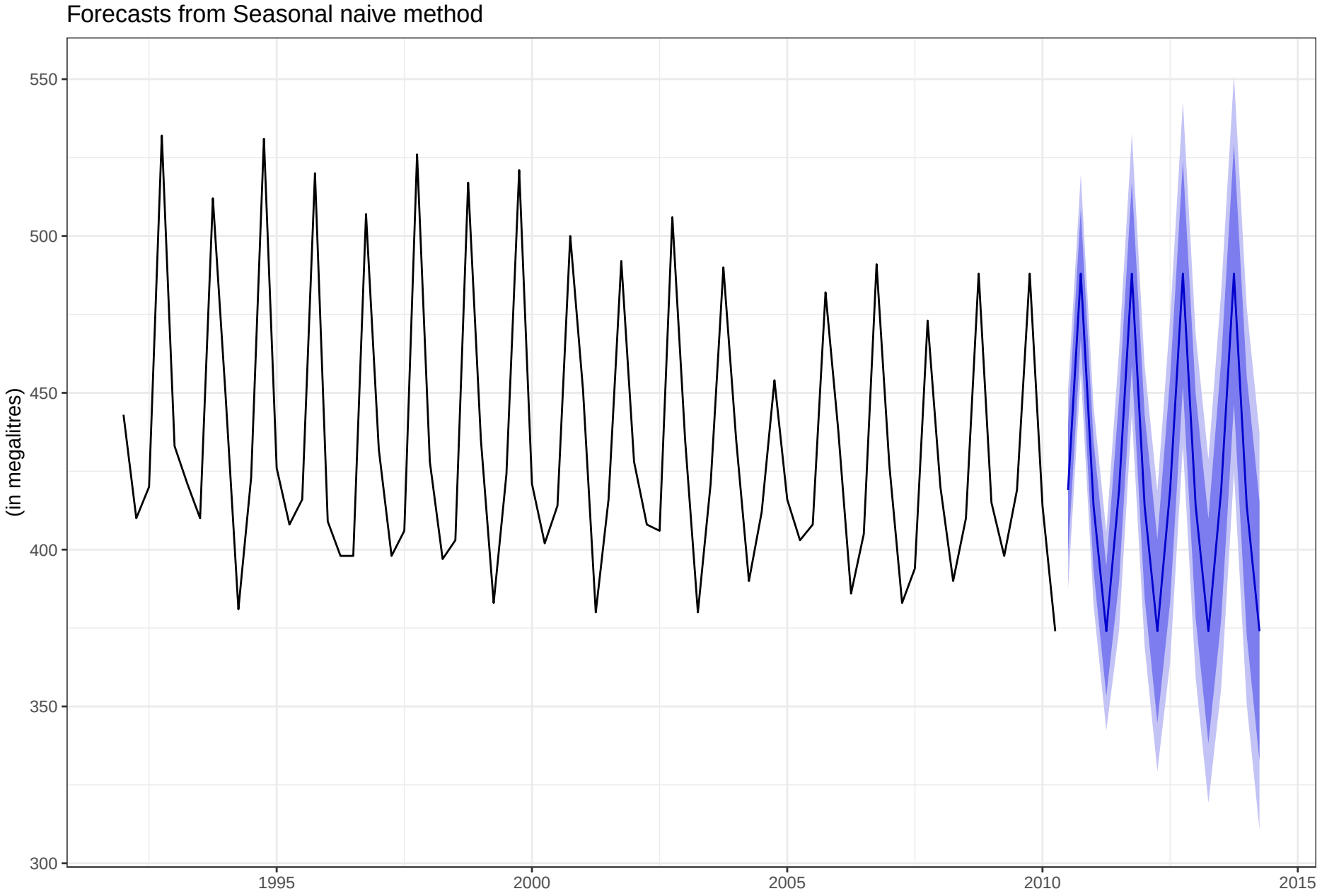
  - Root Mean Squared Error (RMSE)

$$RMSE = \sqrt{MSE} = \sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(y_t - \widehat{y}_t\right)^2}$$

❽ Types and Objectives of Forecasting




Forecasts of Sheep livestock in Asia with Prediction intervals
Millions
500
400
300
1960
1980
2000


Forecasts from Seasonal naive method
(in megalitres)
550
500
450
400
350
300
1995
2000
2005
2010
2015

Data Sources

- Federal Reserve Economic Data (https://fred.stlouisfed.org/)
- The World Bank (http://data.worldbank.org/)
- EuroStat (http://ec.europa.eu/Eurostat)
- U.S. Bureau of Economic Analysis (http://www.bea.gov)
- U.S. Bureau of Labor Statistics (http://www.bls.gov)
- U.S. Census Bureau (http://www.census.gov)
- OECD iLibrary (http://www.oecd-ilibrary.org/statistics)
- IMF Data (https://www.imf.org/en/Data)
- Financial Time Series (http://www.finance.yahoo.com)
- Energy Information Administration (http://www.eia.gov)
- ...

Forecasting Software

- General statistical packages
  - Minitab
  - Excel
  - SPSS
  - EVIEWS
- General statistical programming software:
  - **R**
  - Matlab
  - Mathematica
  - SAS
  - Stata
  - C
  - Fortran
  - Python