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TIME SERIES FORECASTING

EXPONENTIAL SMOOTHING FORECAST

Model Validation

Predictive power of a model is estimated by comparing its forecasting performance on a Test Data

A part of sample data is used to train (develop) the model: Training Data

A part of sample is withheld from estimation process: Test Data

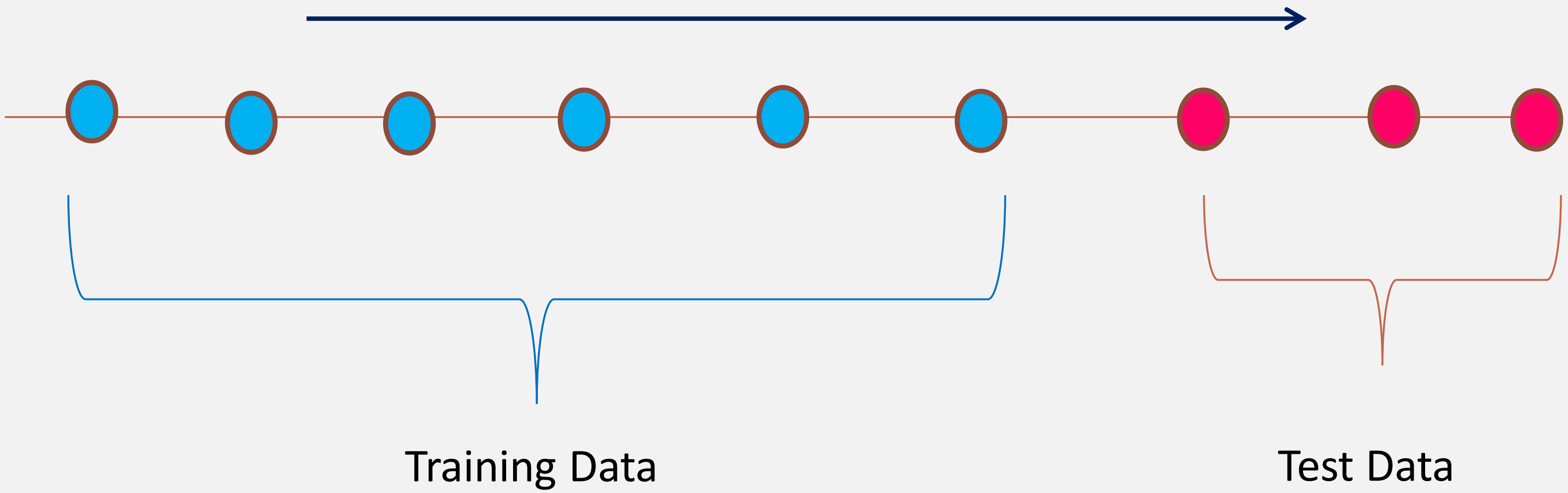
The model which gives smallest measure of error between forecast and actual series is the 'best'

Model Validation

- Training Data is used to identify a few working models
- The forecasts for training data are called fitted values
- Each of the models is tested against the observed values of the series for hold-out period
- The model is selected to be the best where observed and forecasted values are the closest

Model Validation

- For other predicting models hold-out sample is randomly chosen from the total sample
- Usually in 80:20 ratio
- For time series hold-out sample has to be the most recent period because of the ordered nature of the data

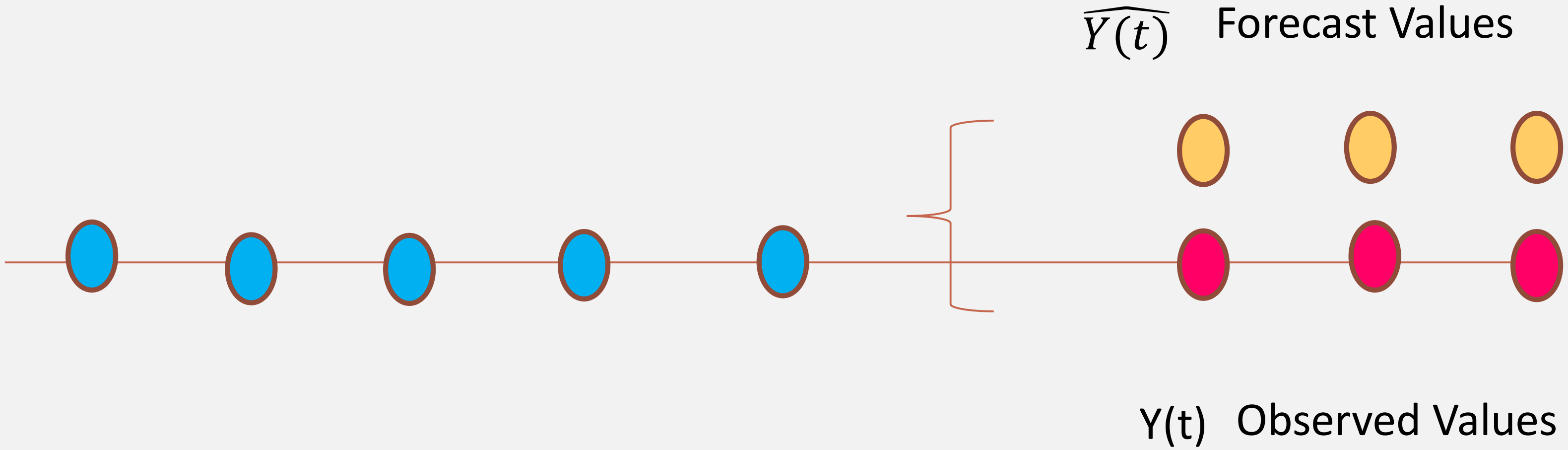


Model Validation

- If there is seasonality in the data, the at least one full season's data need to be held out for validation
- Once a model is selected, held-out period must be incorporated into the sample for final forecasts for future

Measures of Forecast Accuracy

- Performance of forecast method is tested by comparing the forecast values with the test sample observations



Compare the observed and forecast values through various methods

Measures of Forecast Accuracy

- Residual sum of squares

$$\text{RSS} = \sum\left(Y(t) - \widehat{Y(t)}\right)^2$$

- Mean sum of squares

$$\text{MSS} = \frac{1}{T}\sum\left(Y(t) - \widehat{Y(t)}\right)^2$$

- Mean absolute deviation

$$\text{MAD} = \frac{1}{T}\sum\left(|Y(t) - \widehat{Y(t)}|\right)$$

- Mean absolute percent error

$$\text{MAPE} = \frac{1}{T}\sum\left[\left(|Y(t) - \widehat{Y(t)}|\right)/\, Y(t)\right] \times 100$$

Forecast by Average

- Using mean of all past observations – easiest, intuitive, naïve
- Naturally does not work well!!
- Can this scheme be modified to get useful forecasts?

Exponential Smoothing

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- Weighted averages of past observations
- Weights decaying as observations get older
- Practically speaking, only the recent observations matter
- One or more parameters control how fast the weights decay
- These parameters have values between 0 and 1

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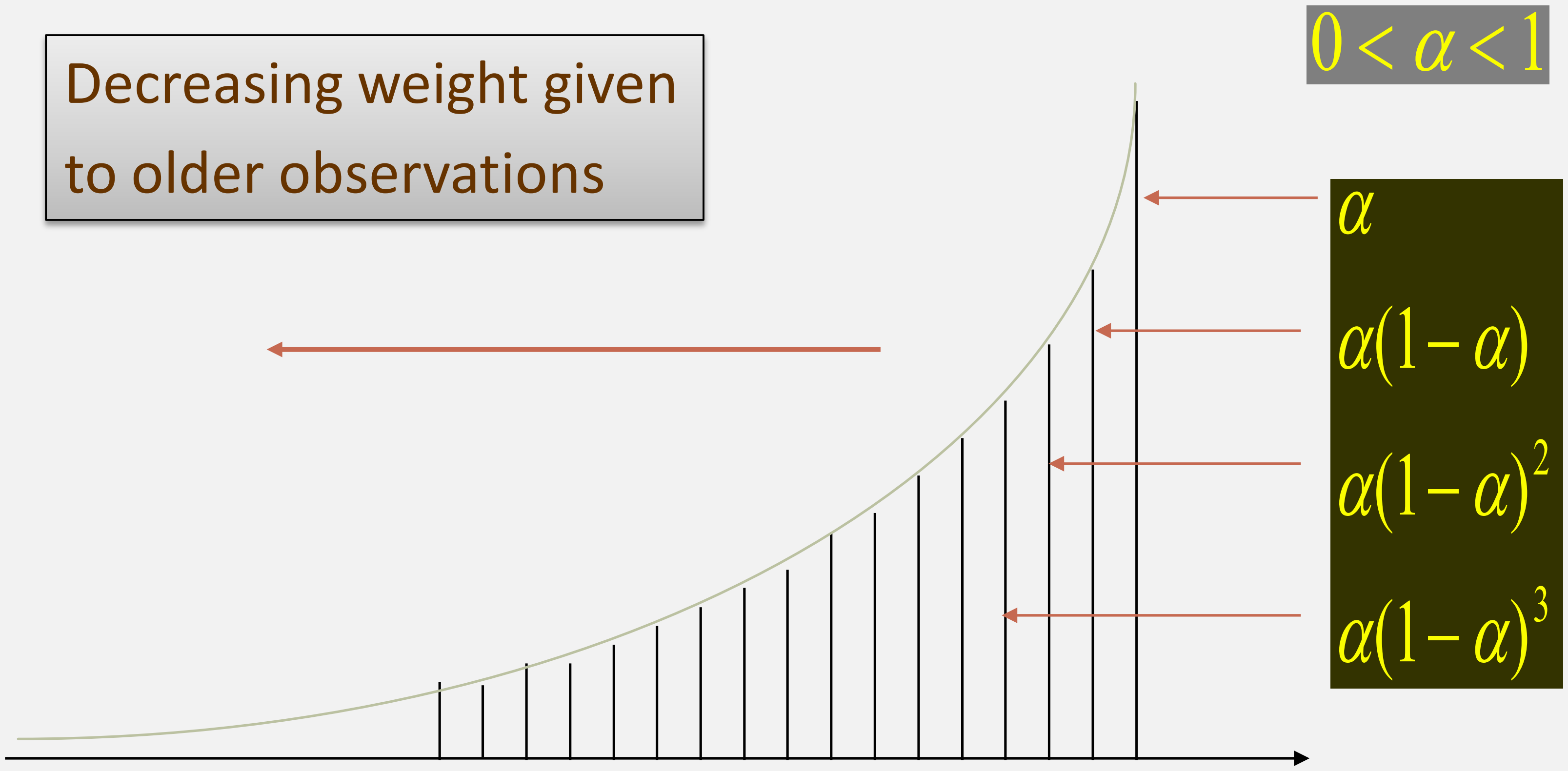
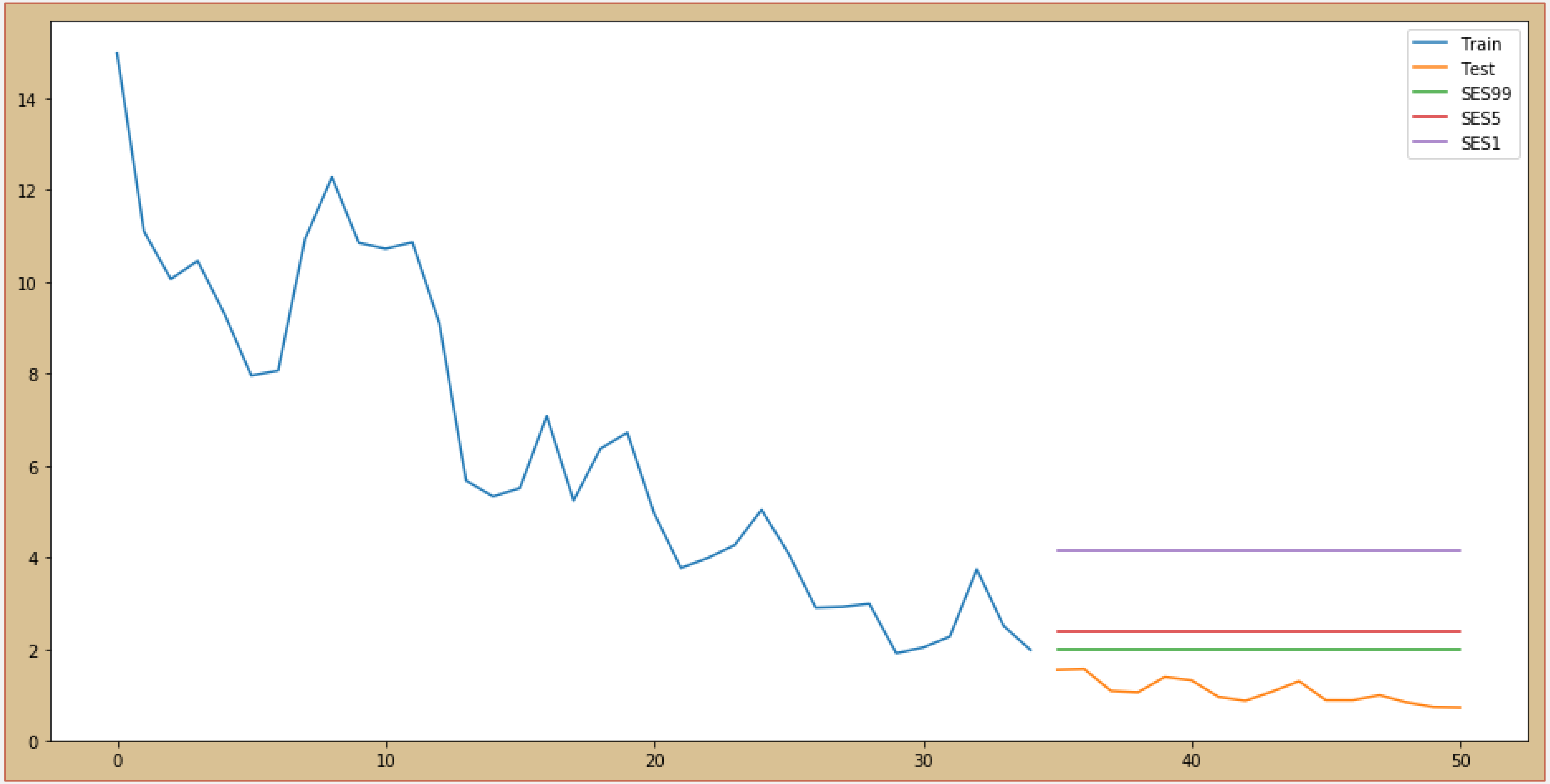


Simple Exponential (SES)

If the time series neither has a pronounced trend nor seasonality: Almost non-available!

Petrol Consumption



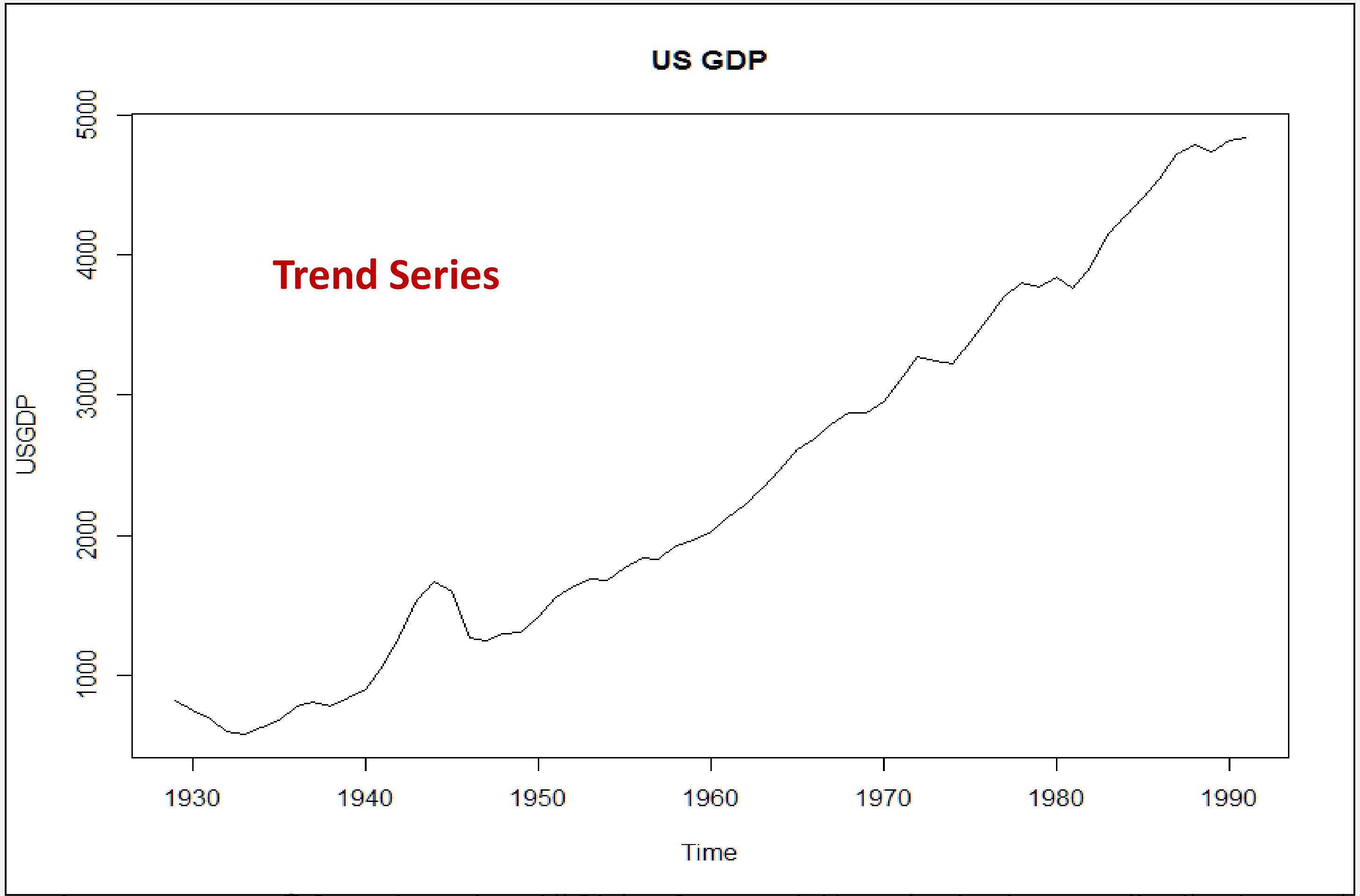
Exponential Smoothing

- Performance of the smoothing parameter α controls performance of the method
- If α is closer to 1, forecasts follow the actual observations more closely
- If α is closer to 0, forecasts are farther from the actual observations and the line is smooth

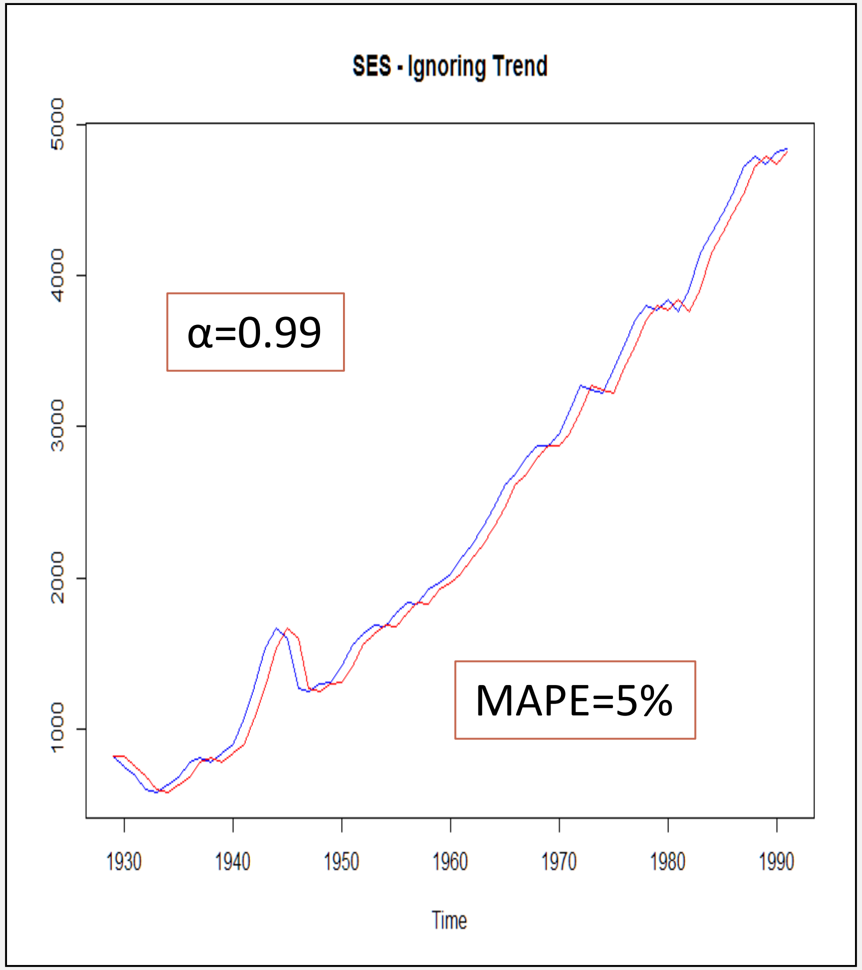
Double Exponential

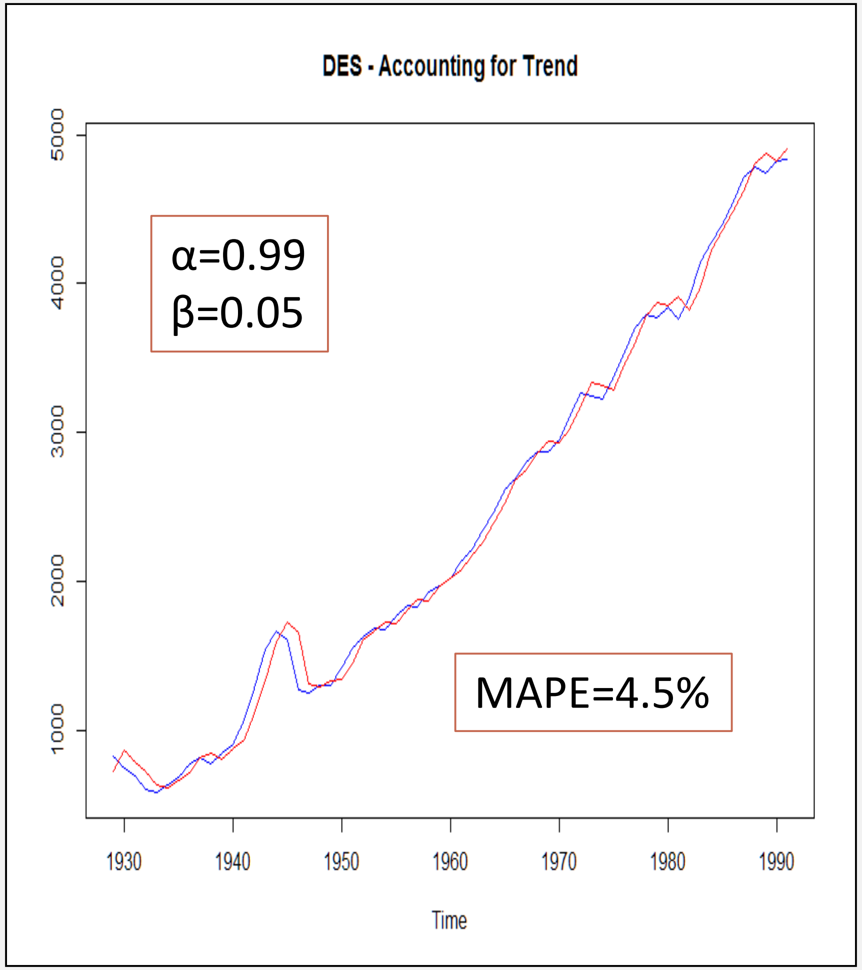
- Applicable when data has Trend but no seasonality
- An extension of SES
- Two separate components are considered: Level and Trend
- Level is the local mean
- One smoothing parameter α corresponds to the level series
- A second smoothing parameter β corresponds to the trend series
- Also known as Holt model

Caselet V: US GDP

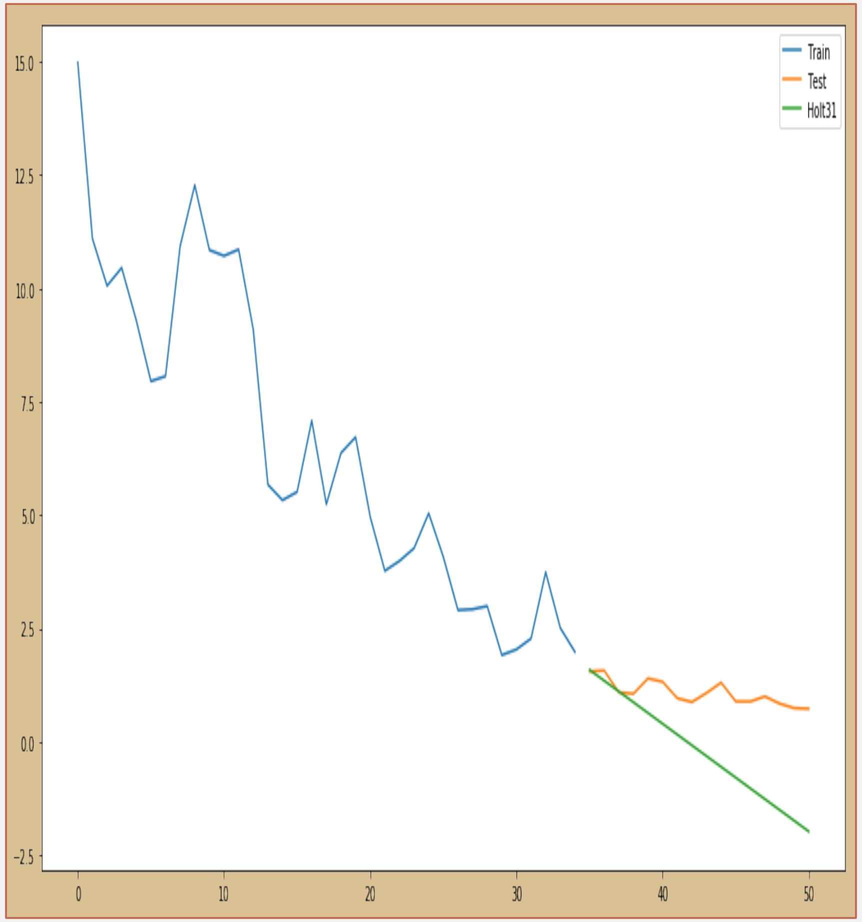


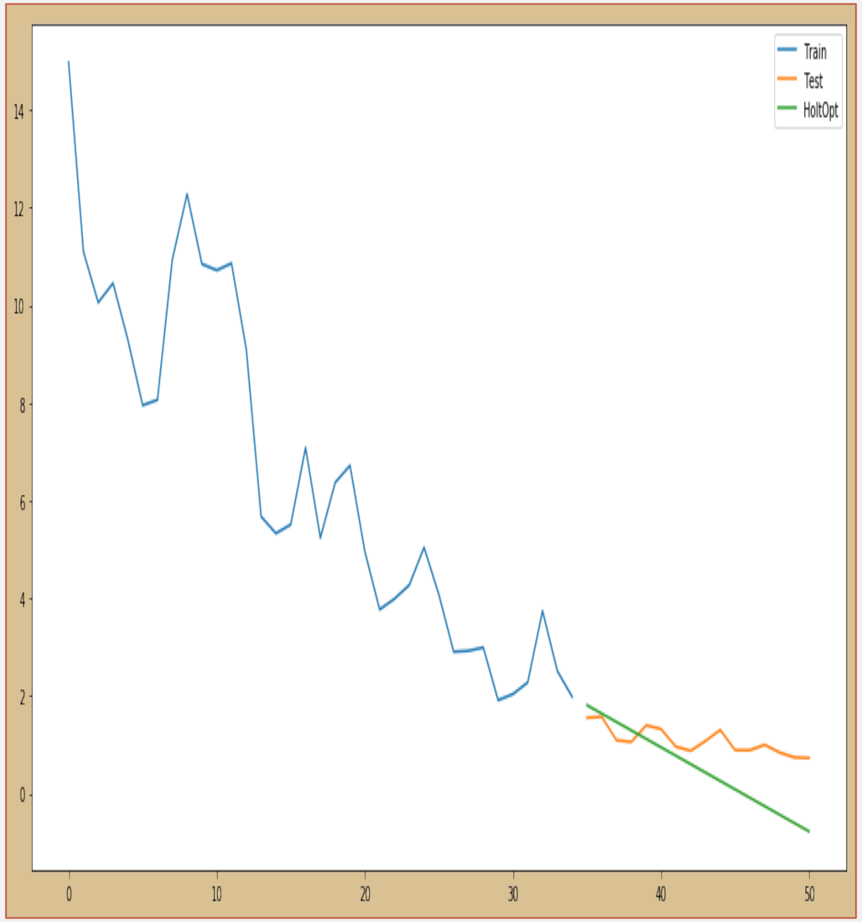
Caselet V: US GDP



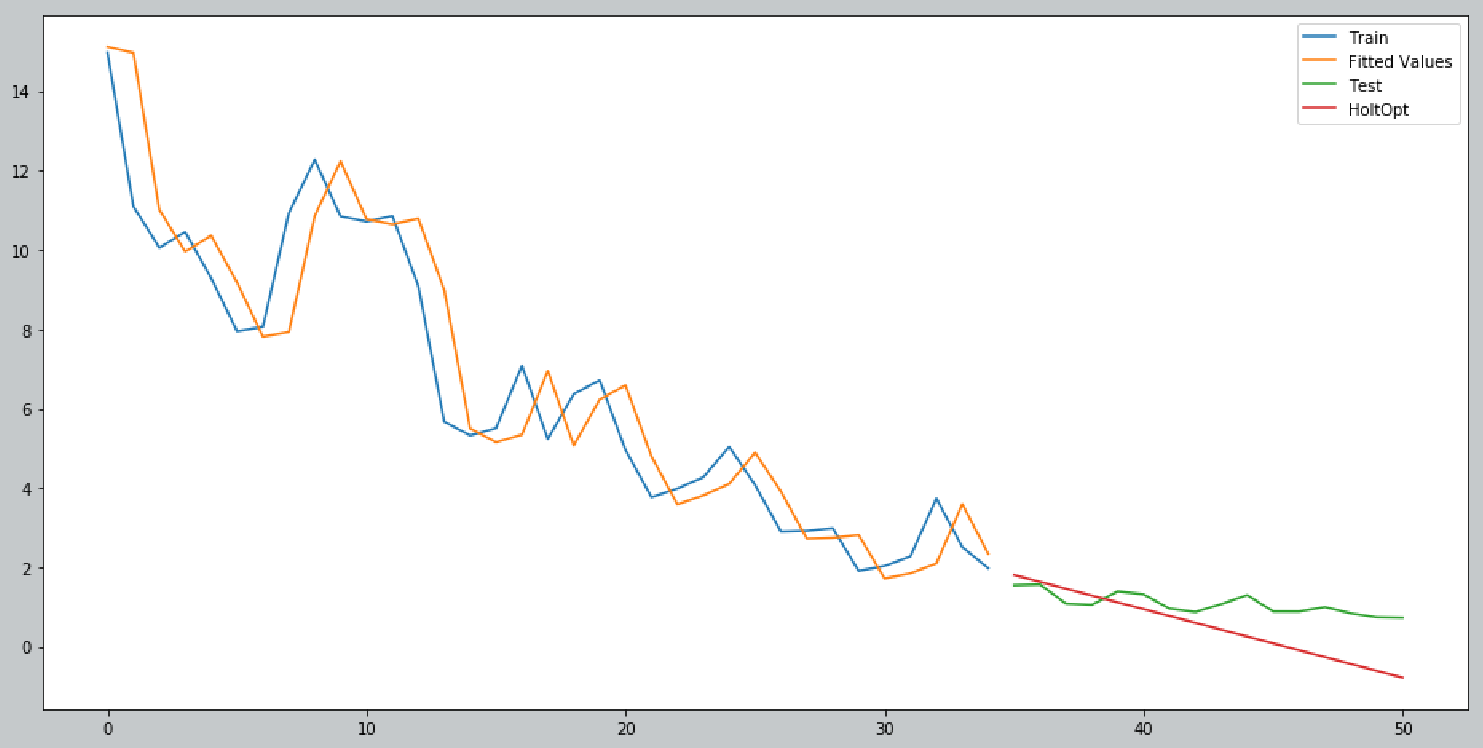


Petrol Consumption





Petrol Consumption



Exponential Smoothing with Seasonality: Holt-Winters' Model

- Because Seasonality can be additive or multiplicative, HW model can be additive or multiplicative

- Simultaneously smooths the level, trend and seasonality

- Three separate smoothing parameters

  - **α: Smooths level;** **$0 < \alpha < 1$**
  - **β: Smooths trend;** **$0 < \beta < 1$**
  - **γ : Smooths seasonality;** **$0 < \gamma < 1$**

Champagne Sales

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Model Estimates

Smoothing parameters:

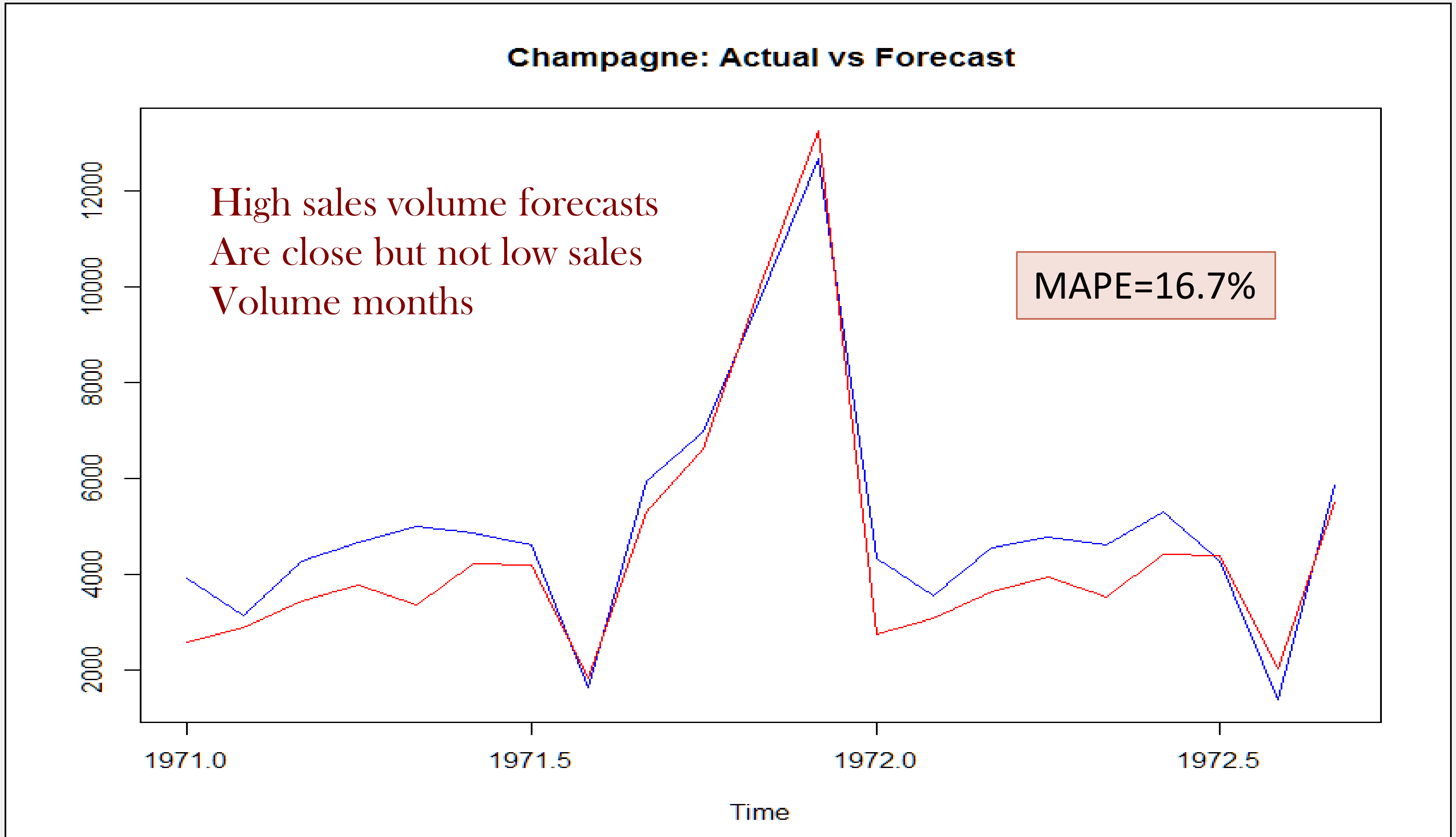
alpha = 0.0842

beta = 1e-04

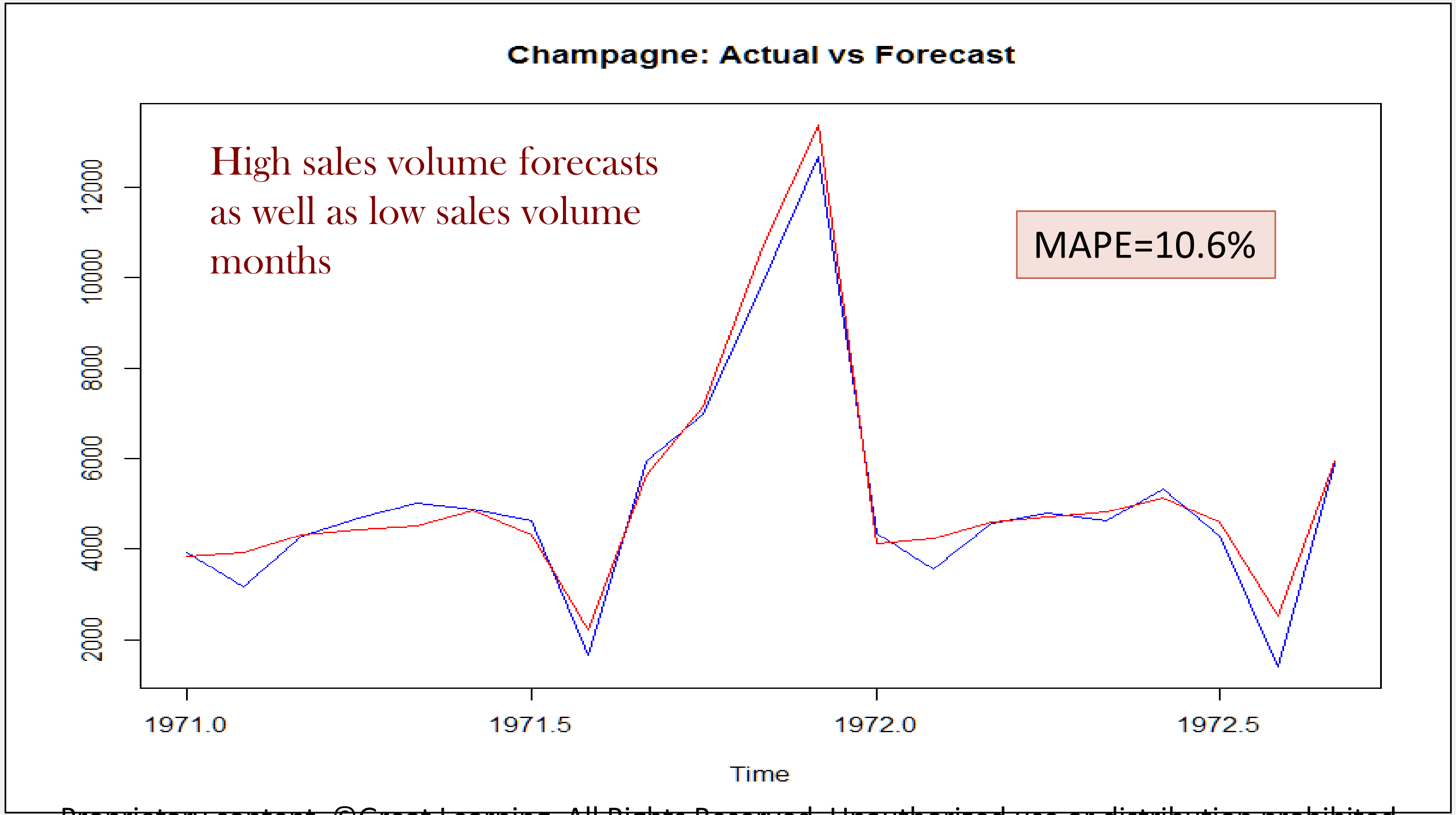
gamma = 0.7608

- Smoothing parameter for trend (β) almost 0 corroborates well with insignificant YOY movement
- Smoothing parameter for seasonality(γ) fairly high that almost all fluctuations are due to seasonality

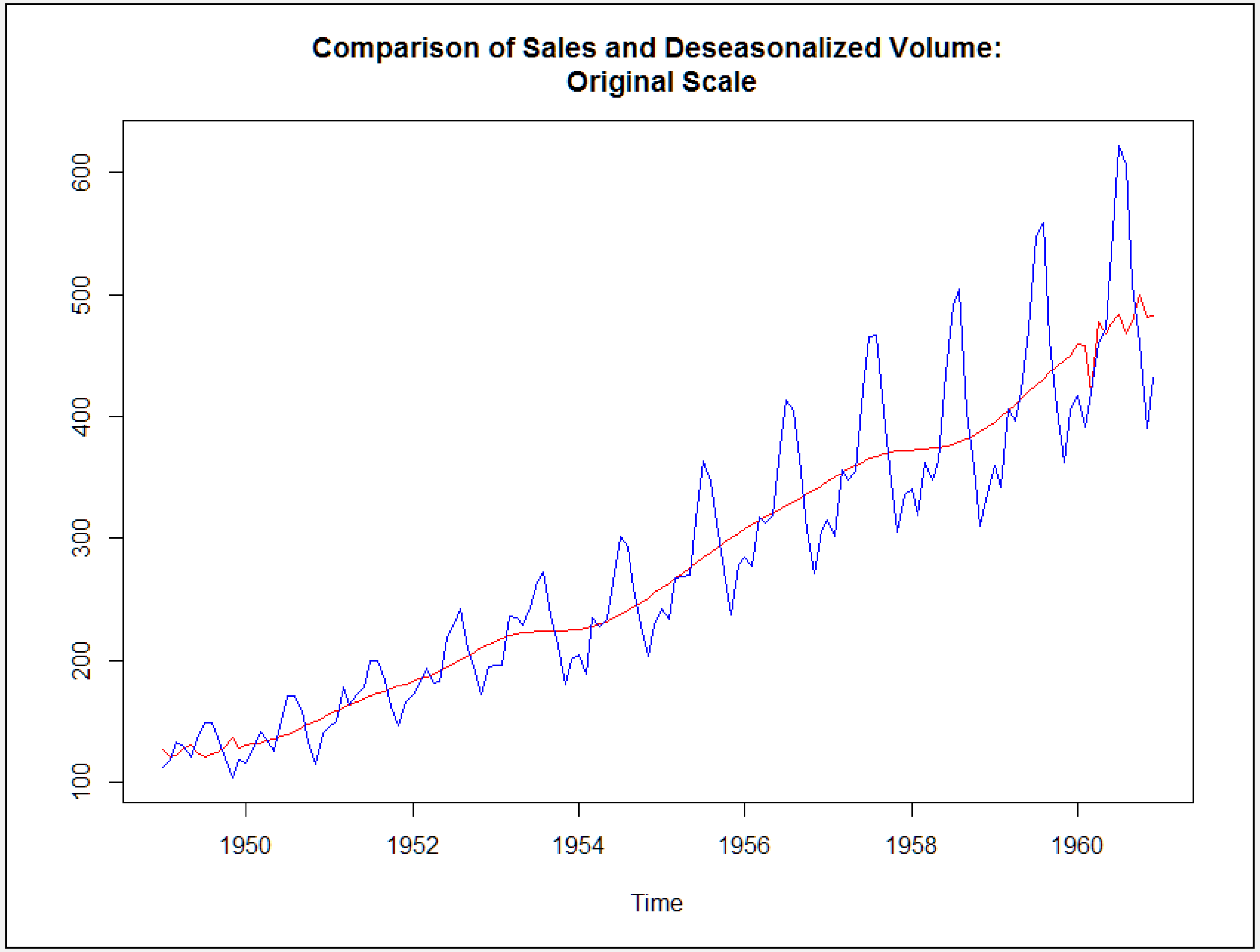
Champagne Sales



Champagne Sales



Passenger Volume



Significant trend and seasonality both

Passenger Volume

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Model Estimates

Smoothing parameters:

alpha = 0.3515

beta = 0.0147

gamma = 0.6481

- Smoothing parameter for trend (β) small compared to other parameters
- Indicates almost a straight line trend
- Smoothing parameter for seasonality(γ) fairly high

Passenger Volume