# Time Series Analysis

## Homework Assignment 1

**Problem 1**

a) The plot below shows the average sales of souvenirs from January 1987 to December 1993.

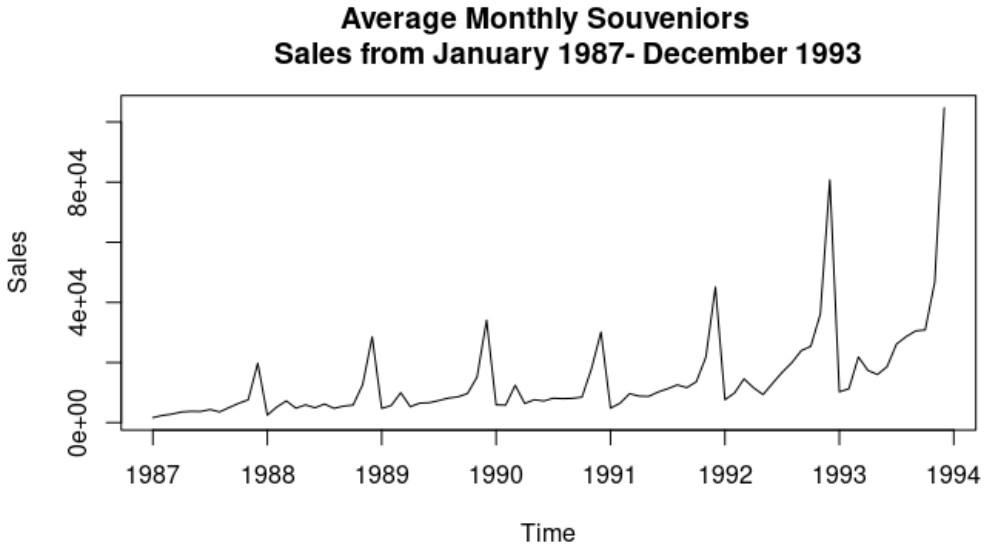


**Figure 1**

b) The decomposition to be used is multiplicative. This is because the fluctuation in seasonality increases as time increases. The result of the decomposition is in Figure 2

below. We can then observe the trend, seasonal and time series behaviours of the time series.

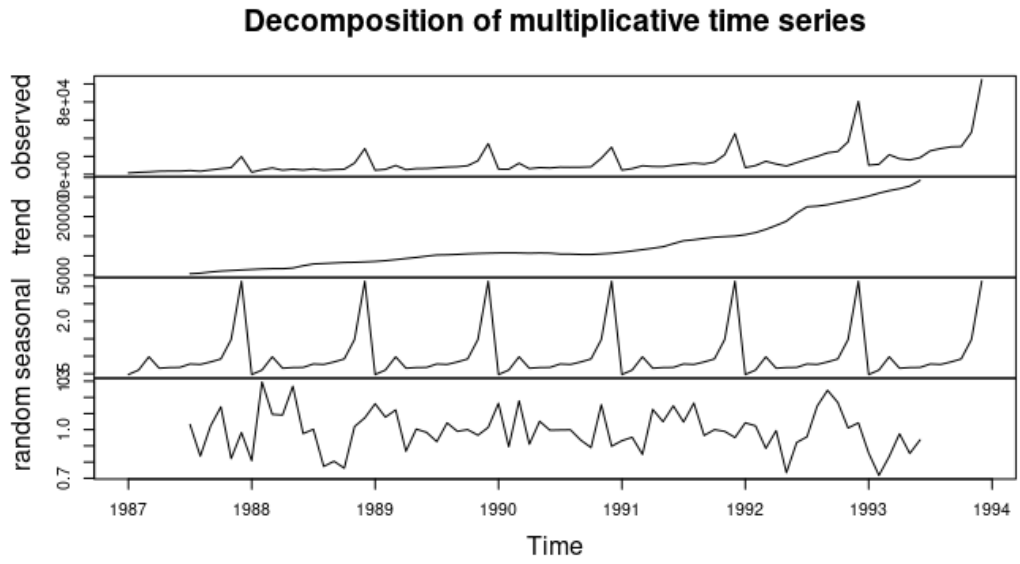


**Figure 2**

c) Taking the logarithm of data before fitting a linear regression model helps reduce to make data more interpretable especially if the data grows exponentially. Most specifically, it converts a multiplicative model into an additive model. As shown in Figure 3 below, the level of fluctuation throughout the time series is almost the same unlike the results in Figure 1, before taking the logarithm of the data.

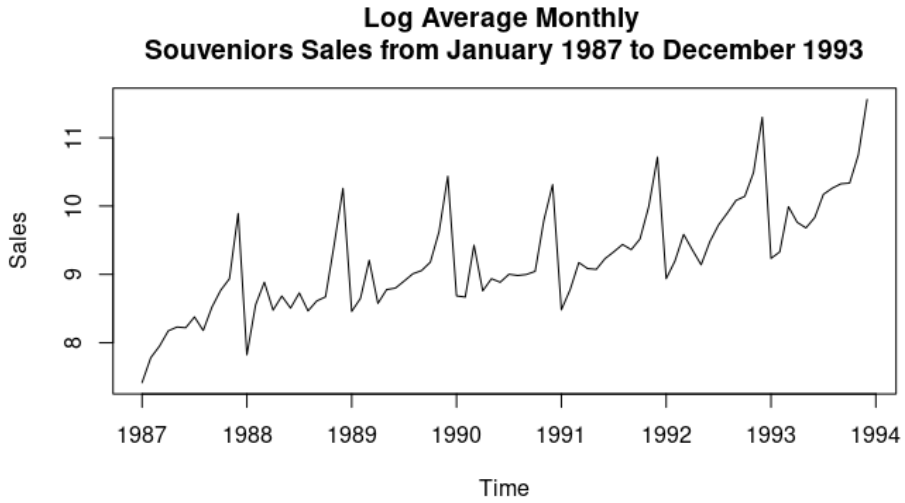


**Figure 3**

d) The estimated values are as follows;

- alpha = -580.76432

- beta = 0.29641

Figure 4 below shows the fitted linear regression model.

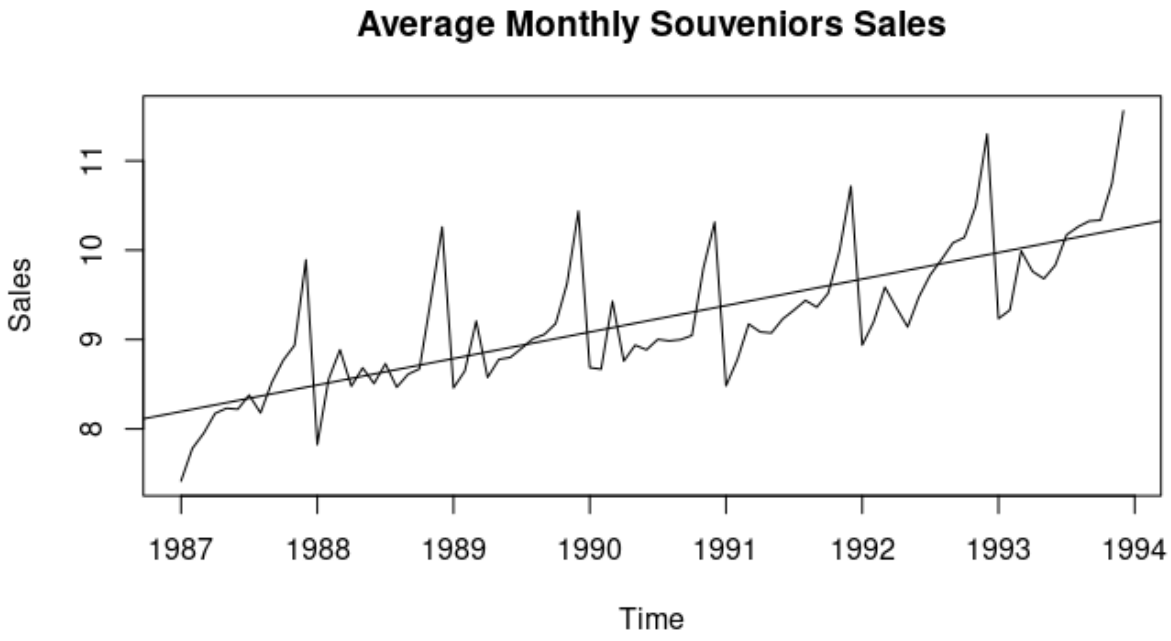


**Figure 4**

e) The estimated alpha and beta values above can be used to predict as follows;

➔ Prediction sales for April 1994

exp(-580.76432 + 0.29641 * (1994 * (3/12)))

= 8.887516e-189

➔ Prediction sales for January 1995

exp(-580.76432 + 0.29641 * (1995 * (0/12)))

= 5.987707e-253

f) In this section, we can remove seasonal effects and results in an annual time series as shown in Figure 5. We can see the time series without the seasonal effects.

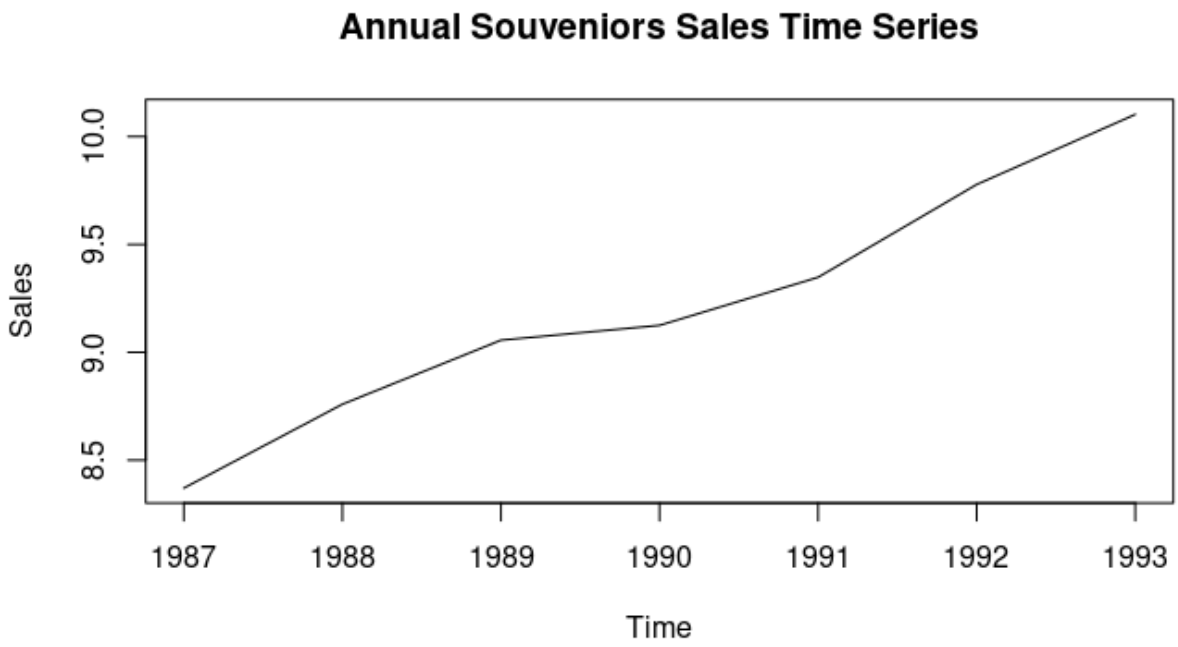


**Figure 5**

**Problem 2**

a) Figure 6 shows the time series for monthly births in Germany from 2003 to 2021.

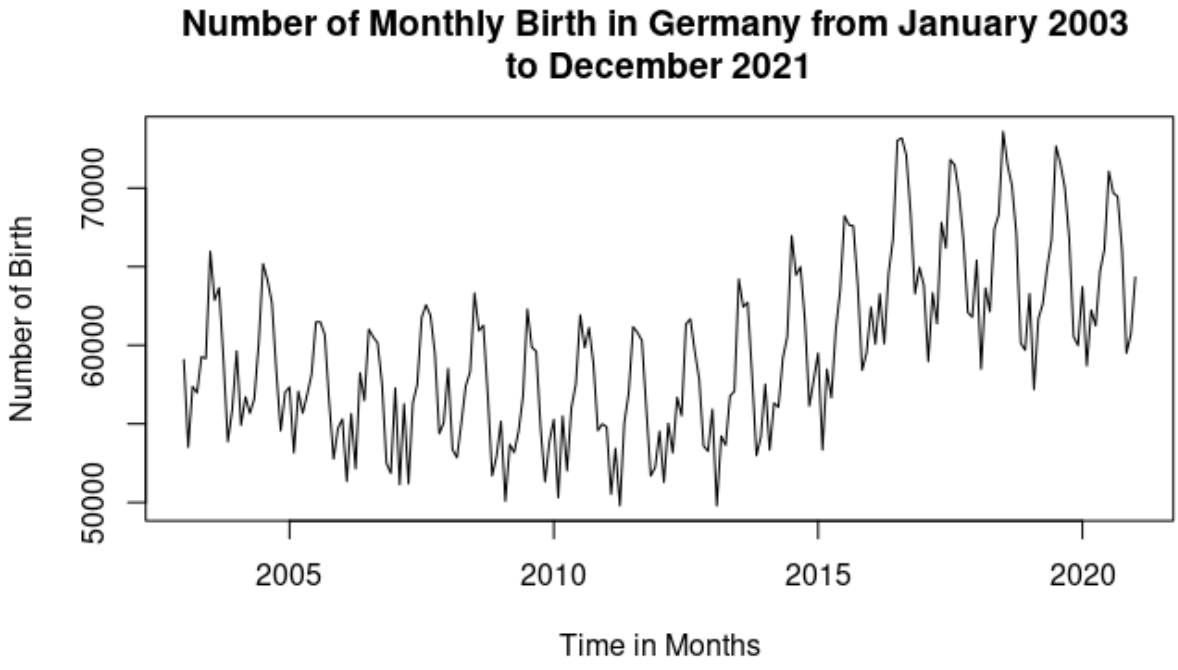


**Figure 6**

b) Applying Holt-Winters filtering results to Figure 7. We can further decompose this result to obtain level, slope, and seasonal components as shown in Figure 8.

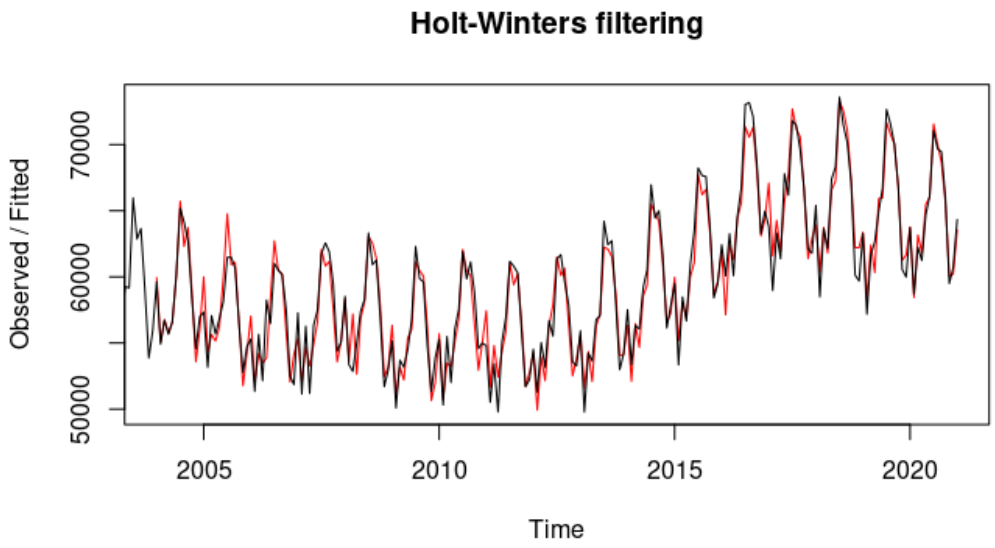


**Figure 7**

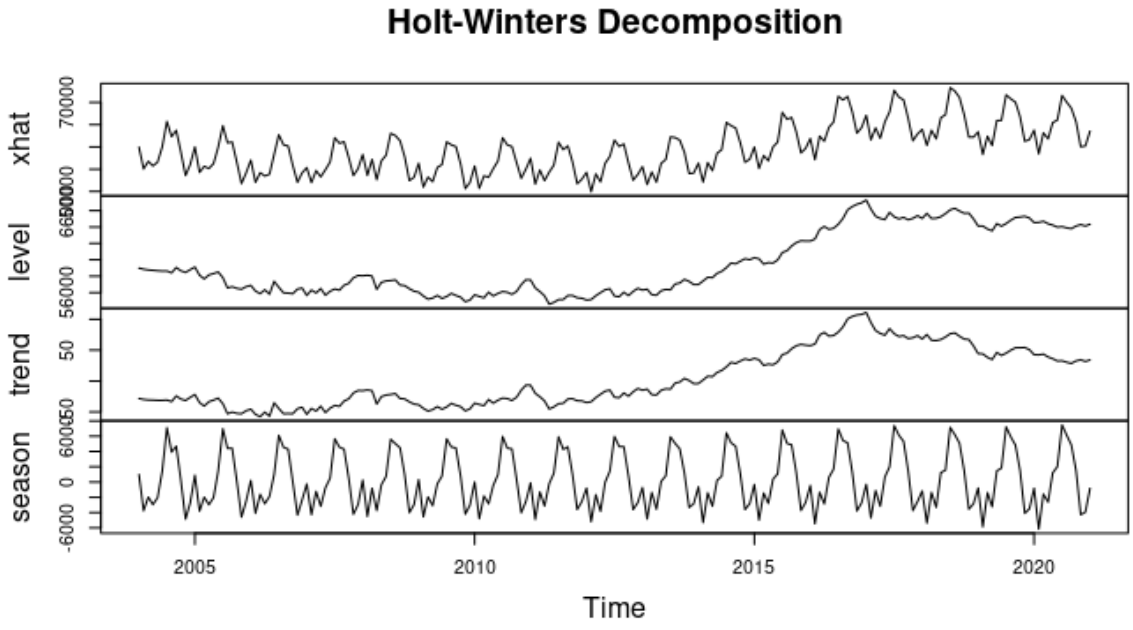


**Figure 8**

c) We then used the Holt-Winters method to make predictions for the number of births in Germany for each month in 2022 and plotted it as shown in Figure 9.

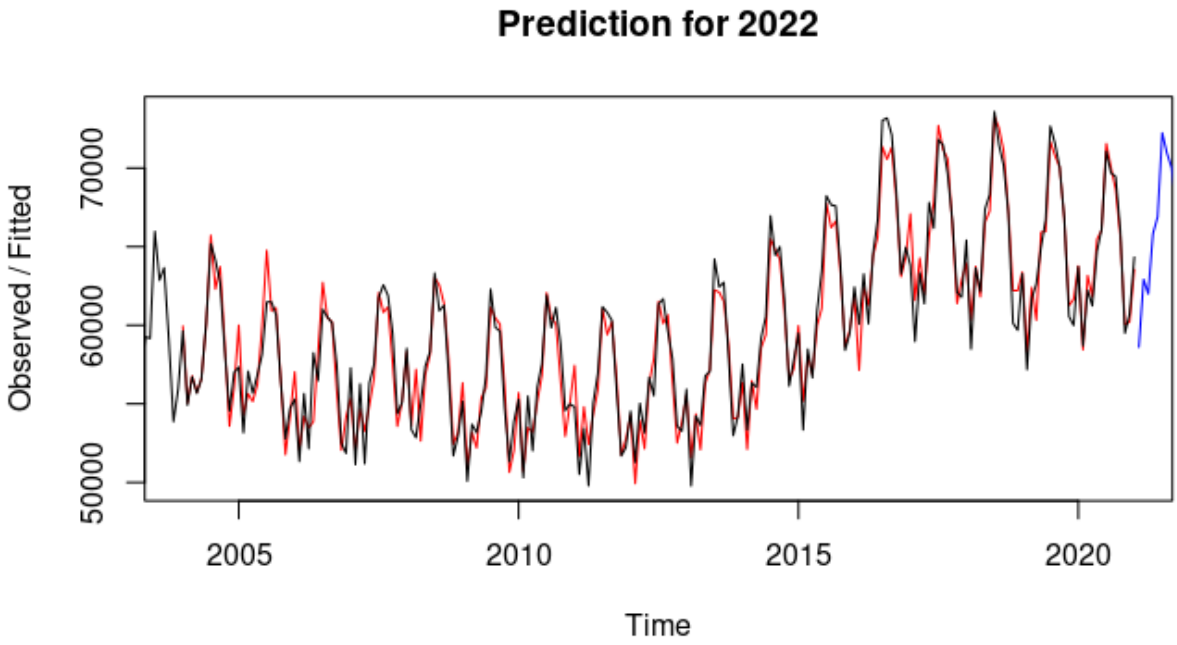


**Figure 9**