Time Series Analysis
Homework Assignment 1

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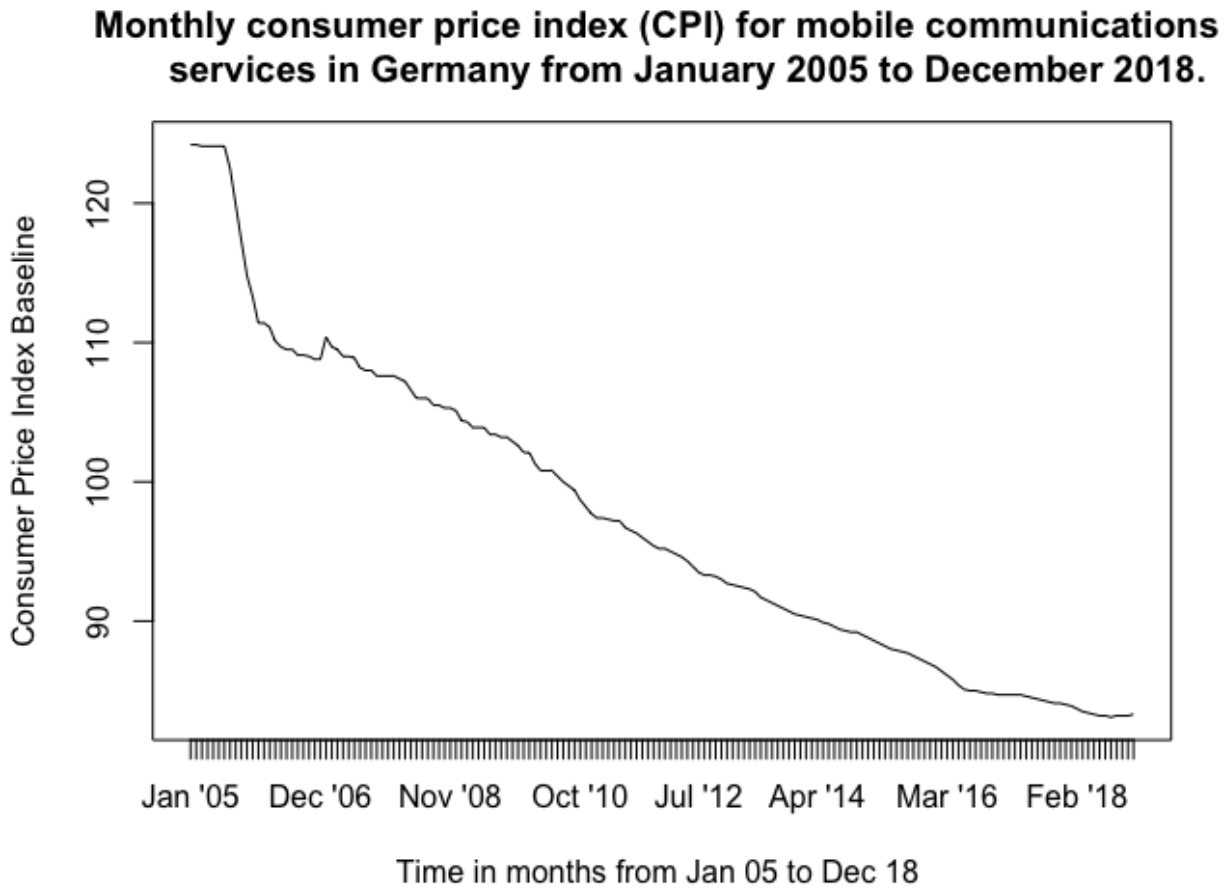
Time Series, Trends, Seasonal Effects, Regression

In this assignment we are dealing with the data set on the statistic of the monthly consumer price index (CPI) for mobile communications services in Germany from January 2005 to December 2018.
(https://www.statista.com/statistics/485983/mobile-communications-monthlycpi-germany/)

(a) To import the data into R and then plot it.

First we need to set the local directory using setwd() and then import the required libraries. Then I imported the given data file using read_excel() and stored it in data.price

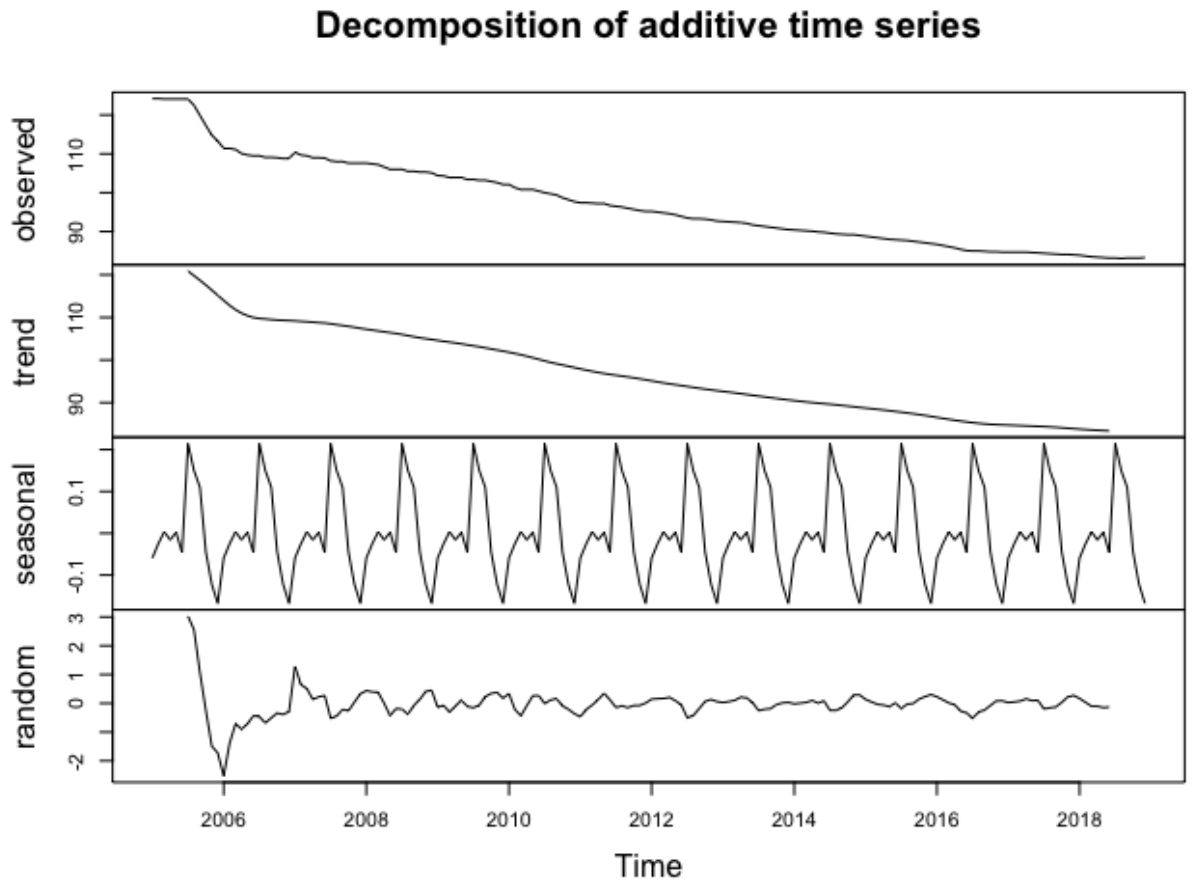
The CPI column is taken as a time series object with frequency as 1 as we need monthly CPI from Jan 2005 to Dec 2018. Then it is plotted using plot function and axis function to get the proper axis. X axis shows the ‘Time in months’ , y axis shows the CPI.



We observe that CPI decreases over time with irregularities which can be random.

(b) Decompose the time series into three parts: estimating trends, seasonal effects, and random series.

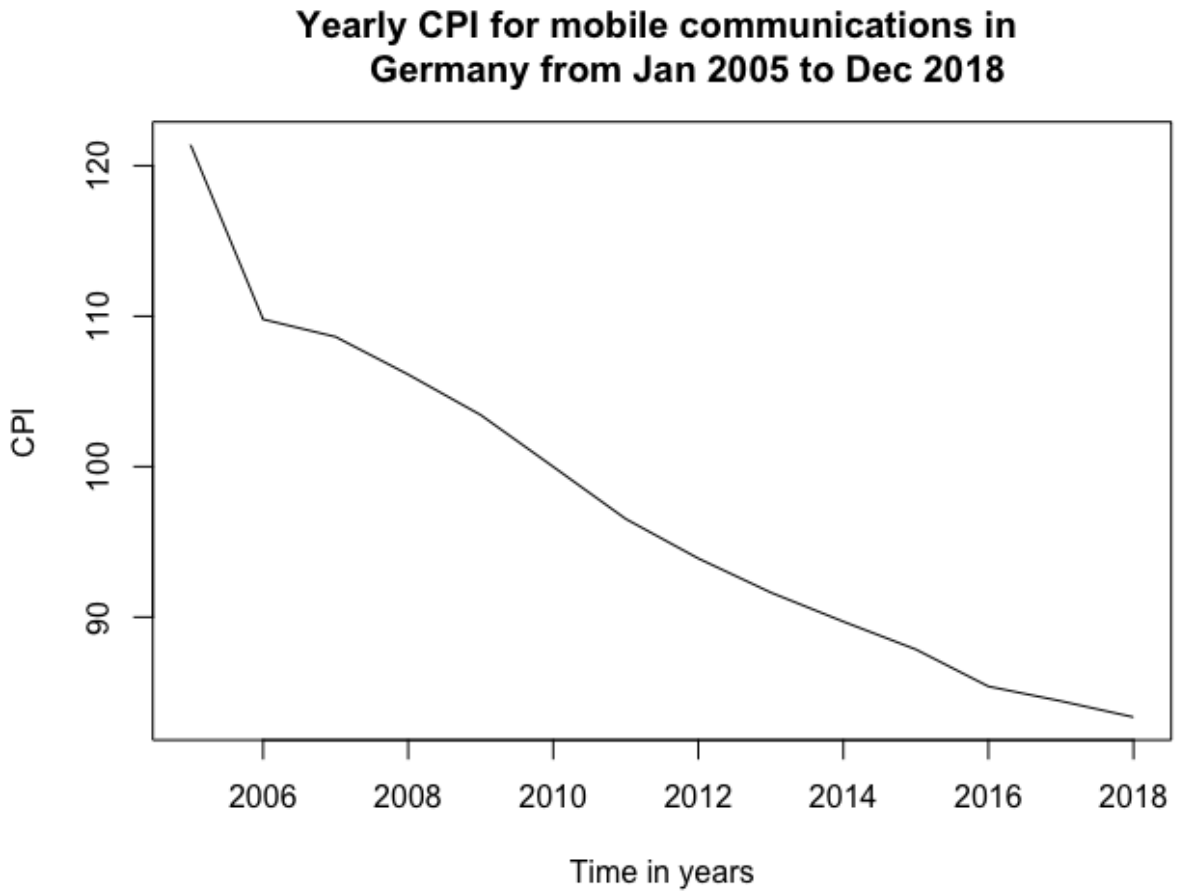
To decompose the time series into estimating trends, seasonal effects and randomness, we need to find how the CPI changes over years. Hence a time series object is created taking CPI with frequency = 12. Then we use plot.decompose() to get the below plot.



We observe that slight seasonal changes occur. Randomness is also present throughout. But the overall trend is that of decreasing.

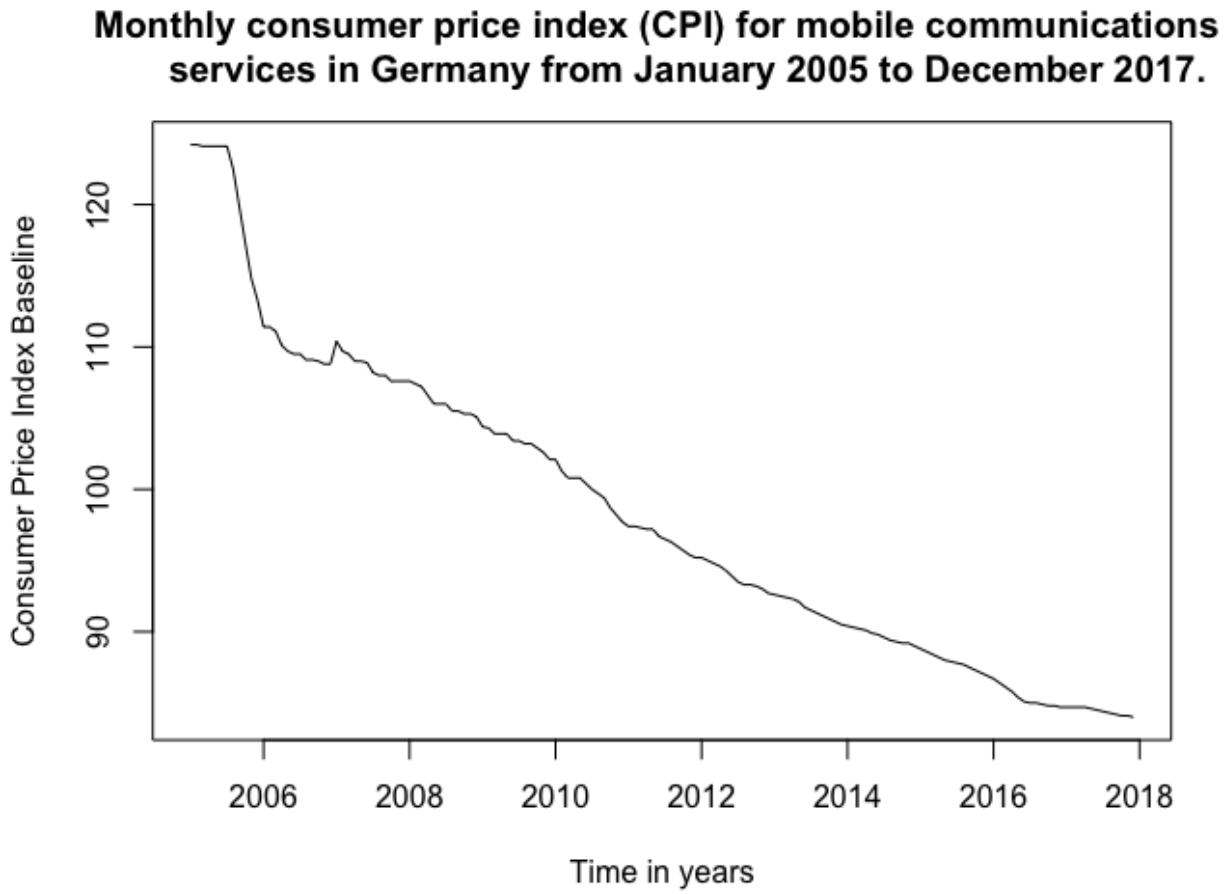
(c) Use the aggregate function to remove any seasonal effects within each year and produce an annual series of mean CPI for the period 2005- 2018.

aggregate() on the yearly data divided by 12, removes all the seasonality and provides us with a smooth graph.



(d) Use the window function to plot the data from January 2005 to December 2017.

Here we change the end to (2017,12) and then take this subset using window(). This new object is then plotted.



We observe that the graph stops just before 2018 i.e, it is there only till Dec, 2017.

(e) Use the command lm to estimate the parameters $\hat{\alpha}$ and $\hat{\beta}$ in the simple linear regression model.

We use time() of the time series object to get the X axis values, Y values - time series obj. Then using lm() we find the estimate parameters as :

```
Call:
lm(formula = price.win ~ TIME.price)

Coefficients:
(Intercept)   TIME.price
   5694.604       -2.782
```

(f) Use commands summary and abline to add lines to existing plots in step (e).

Summary() function outputs the results of the linear regression.

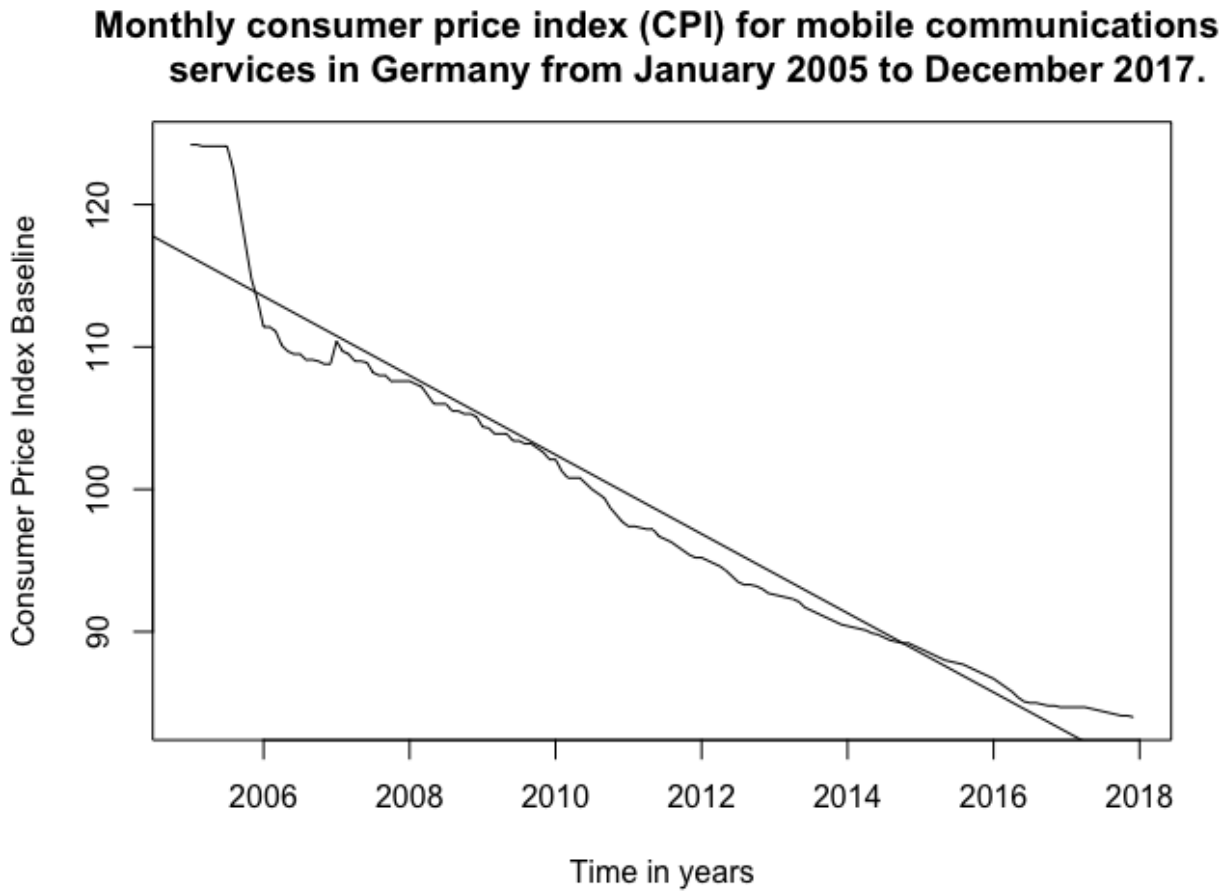
```
Call:
lm(formula = price.win ~ TIME.price)

Residuals:
    Min      1Q  Median      3Q     Max
-2.9260 -1.4874 -0.6613  0.6117  9.1555

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 5694.60420  105.10543   54.18   <2e-16 ***
TIME.price    -2.78218    0.05225  -53.24   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 2.449 on 154 degrees of freedom
Multiple R-squared:  0.9485,    Adjusted R-squared:  0.9481
F-statistic:  2835 on 1 and 154 DF,  p-value: < 2.2e-16
```

abline() function - adds lines to graph. Hence we can pass the result of lm to obtain the regression line.



We can see the the line is also decreasing.

(g) Make predictions "by hand" for June 2018, June 2019 and June 2020.

We can make the predictions using the parameters found above :

Prediction for CPI value for June 2018 =
5694 + -2.78218 *(2018 + 5/12) = 5694 - 5615.599 = 78.401

Prediction for CPI value for June 2019 =
5694 +-2.78218 * (2019+ 5/12) = 5694 - 5618.38 = 75.62

Prediction for CPI value for June 2020 =
5694 +-2.78218 * (2020+ 5/12) = 5694 - 5621.16 = 72.84

We observe that the predicted values also show a decreasing trend.

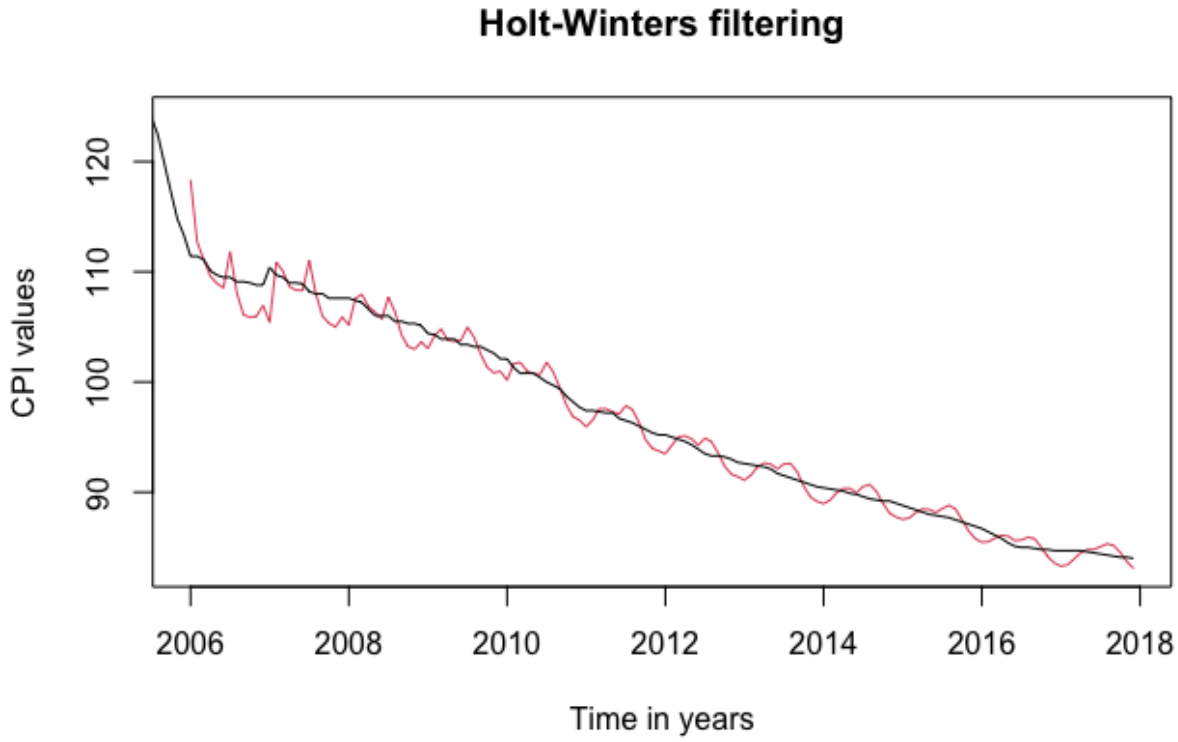
(h) Use the Holt-Winters method to get the smoothing parameters α, β and γ for the monthly CPI time series from January 2005 to December 2017.

We can get the smoothing parameters by using the HoltWinters() on the time series object. We can access them from the result and print them :

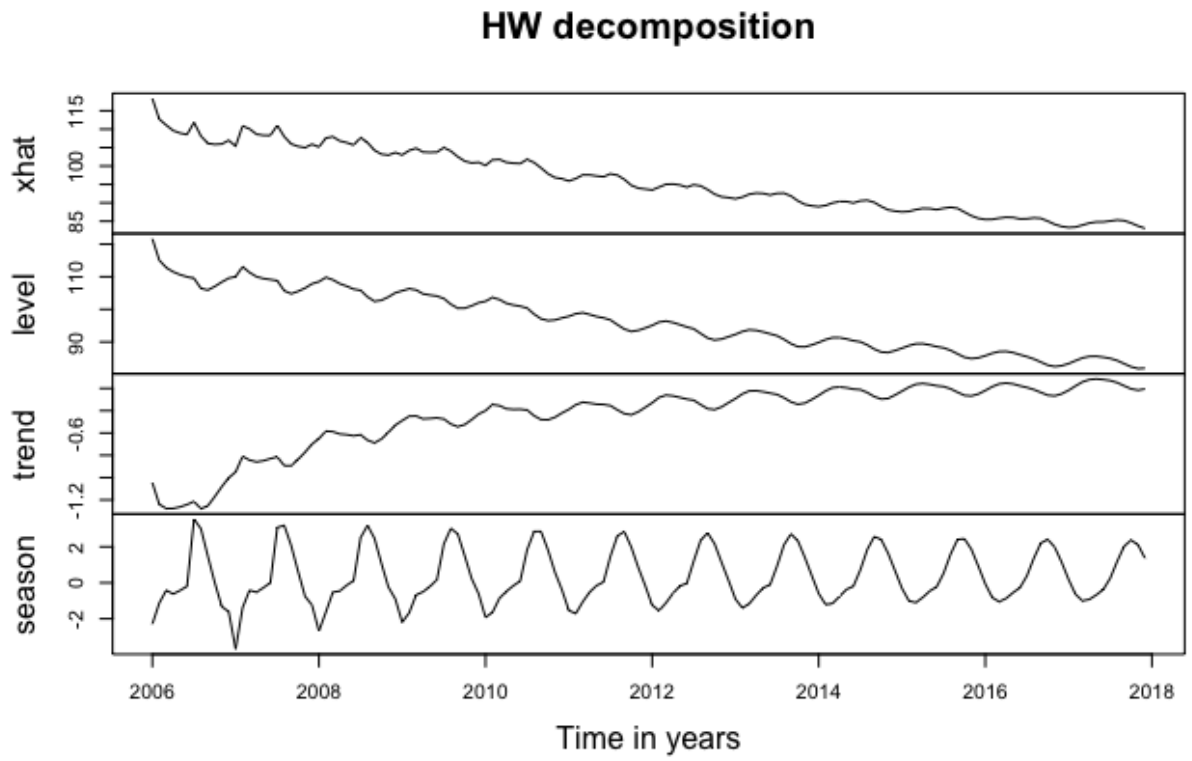
```
> series.hw$alpha
    alpha
0.8001131
> series.hw$beta
      beta
0.03511733
> series.hw$gamma
gamma
    1
>
```

(i) Use the HoltWinters function to plot the time series at , bt and st introduced in step (h).

We can also plot this resulted series - (output of HoltWinters Fitting): Red line shows the fitted values



We can also plot the HW decomposition after fitting which shows the trend, slope, seasonal impact and the fitted CPI values:

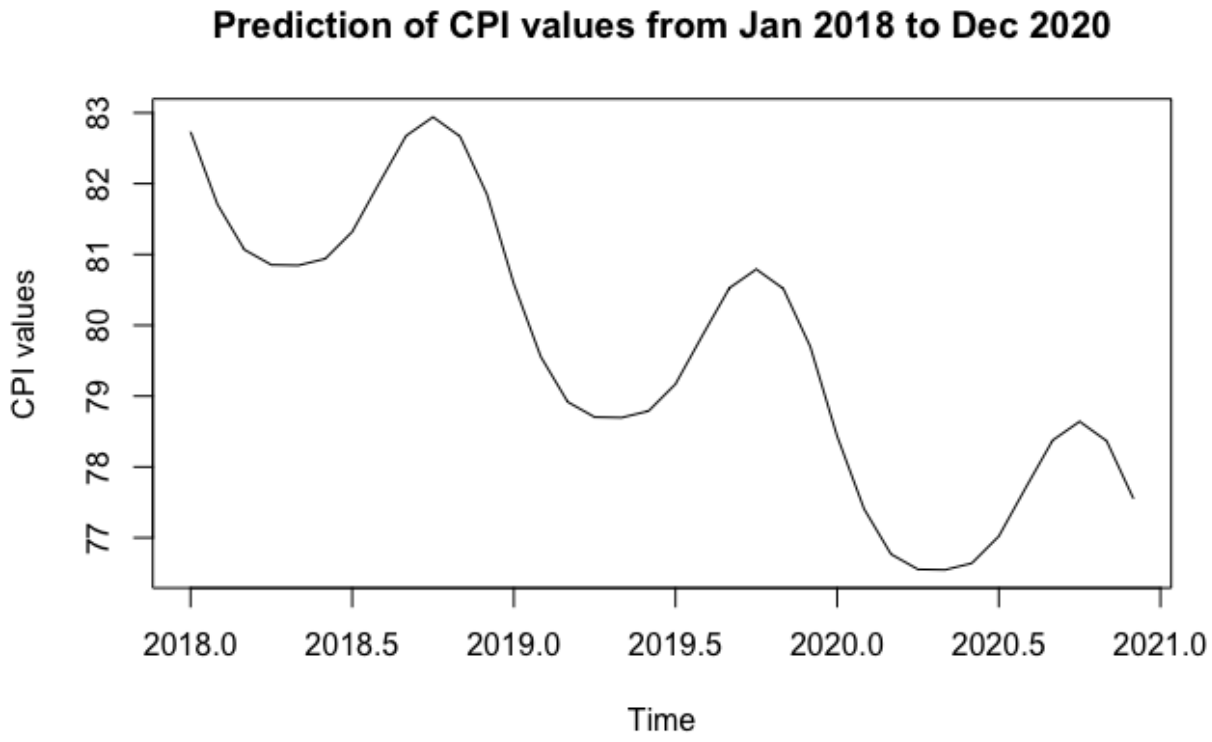


(j) Make predictions "by the Holt-Winters method" for each month in 2018, 2019 and 2020.

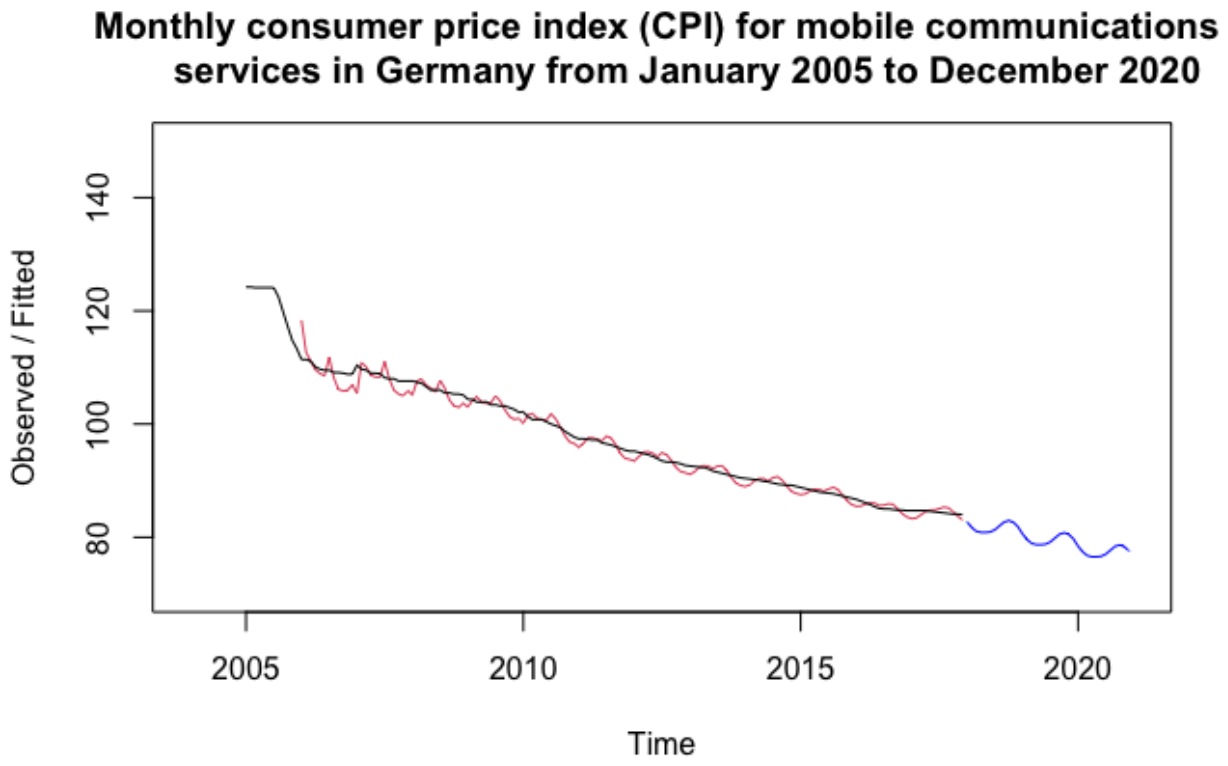
We can make predictions for each month in 2018, 2019 and 2020 using the predict(). We can specify the till when to predict using n.ahead

```
> series.hw.predict
          Jan      Feb      Mar      Apr      May      Jun      Jul      Aug      Sep      Oct
2018 82.73340 81.70623 81.06730 80.85304 80.84591 80.93922 81.32052 82.00581 82.67596 82.94044
2019 80.58376 79.55659 78.91766 78.70339 78.69626 78.78958 79.17088 79.85617 80.52631 80.79079
2020 78.43411 77.40695 76.76801 76.55375 76.54662 76.63994 77.02124 77.70653 78.37667 78.64115
          Nov      Dec
2018 82.66783 81.85036
2019 80.51819 79.70071
2020 78.36854 77.55107
```

We can observe that the predicted values also show a decreasing trend. The values found by hand and found by HW method are slightly different even though they show similar trend.



We can also plot the predicted values along with the original values. In this graph, the black line represents the original values, the red line represents the predicted values and the blue line represents the newly predicted values(forecast) for 2018-2020.


Monthly consumer price index (CPI) for mobile communications services in Germany from January 2005 to December 2020
Observed / Fitted
80
100
120
140
2005
2010
2015
2020
Time