Time Series Forecasting Assignment

1. There is an increasing trend in item 1 sales and a decreasing trend in item 2 sales. Seasonality can be observed in both the series.

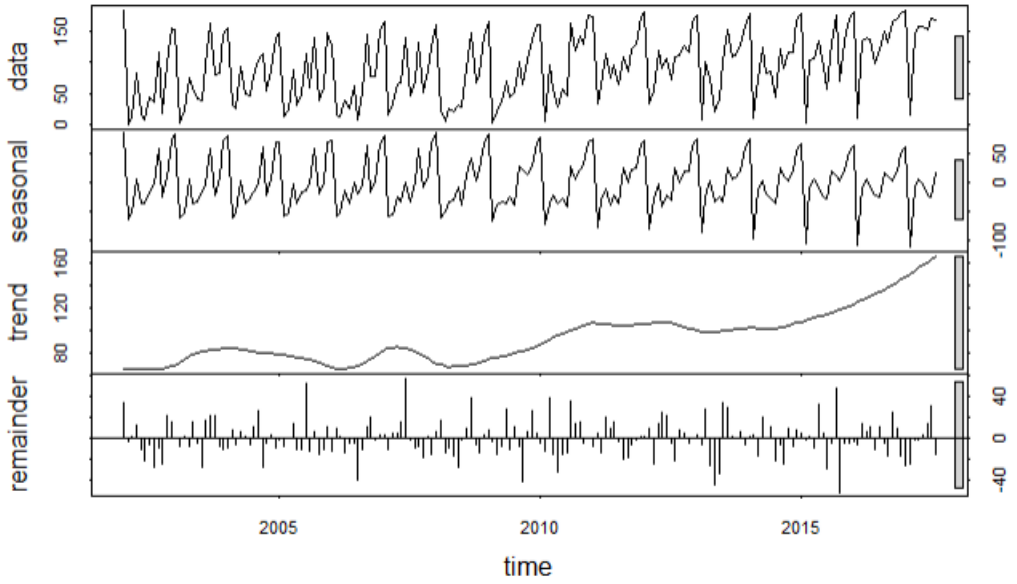

Figure 1: Item 1 Sales Decomposition

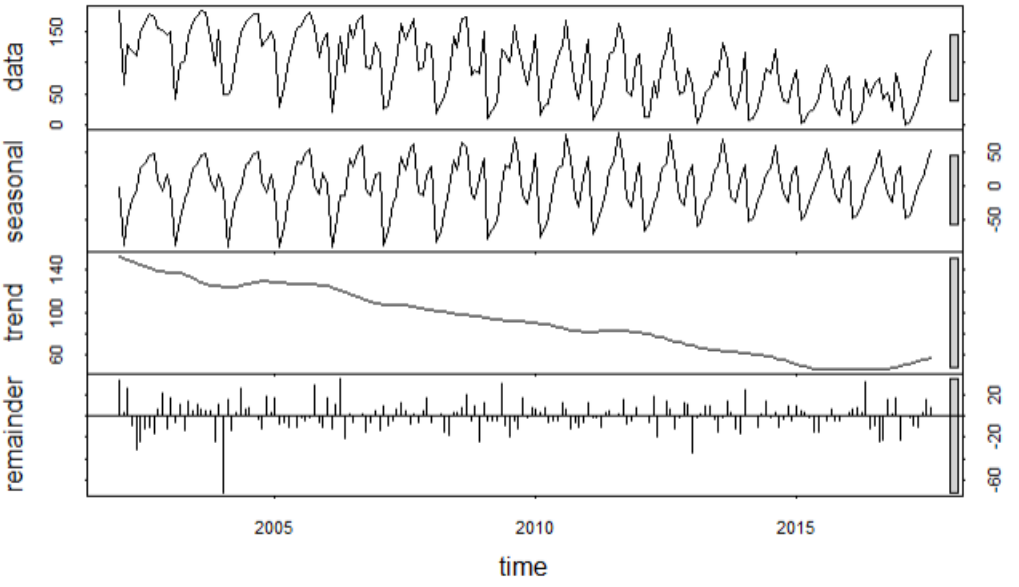

Figure 2: Item 2 Sales Decomposition

2. Monthly plots:

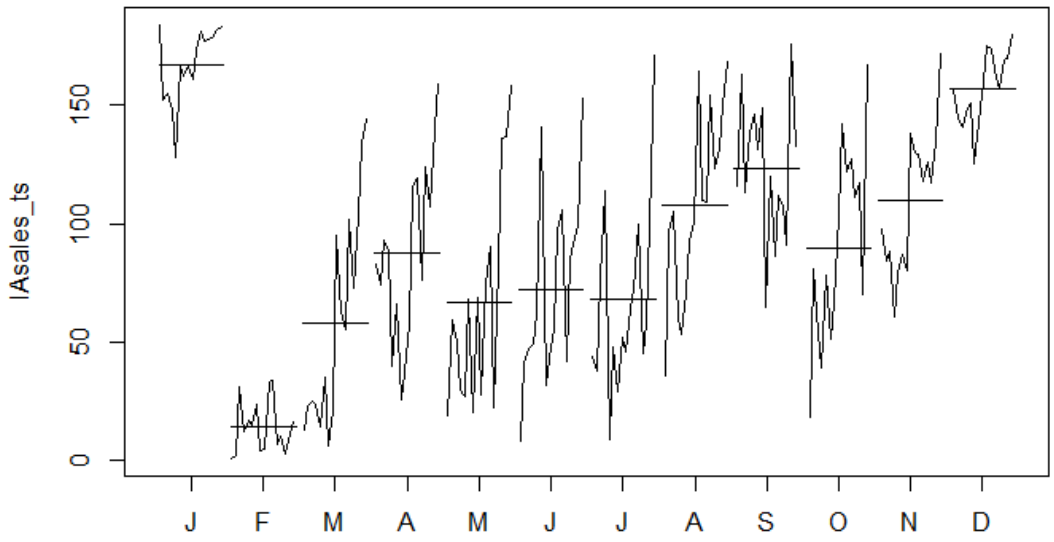

Figure 3: Monthly Plot for Item 1

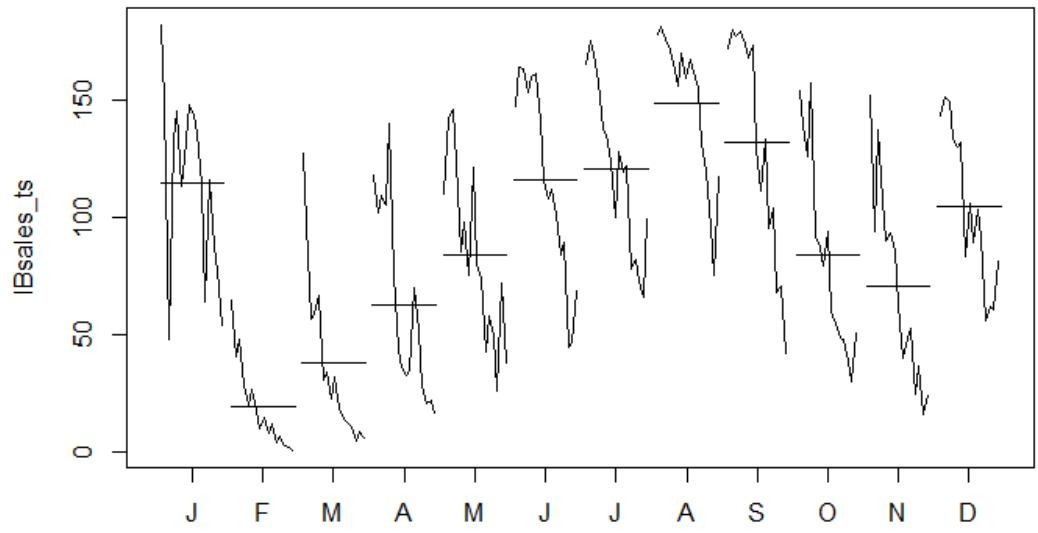

Figure 4: Monthly Plot for Item 2

Deseasonalized sales:

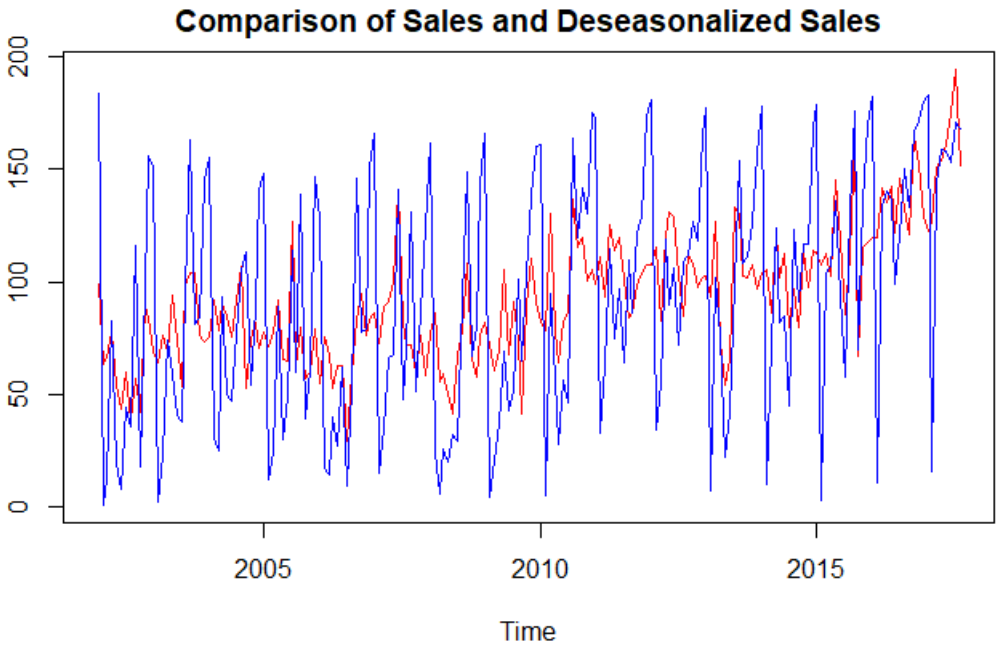

Figure 5: Comparison of Sales and Deseasonlised Sales for Item 1

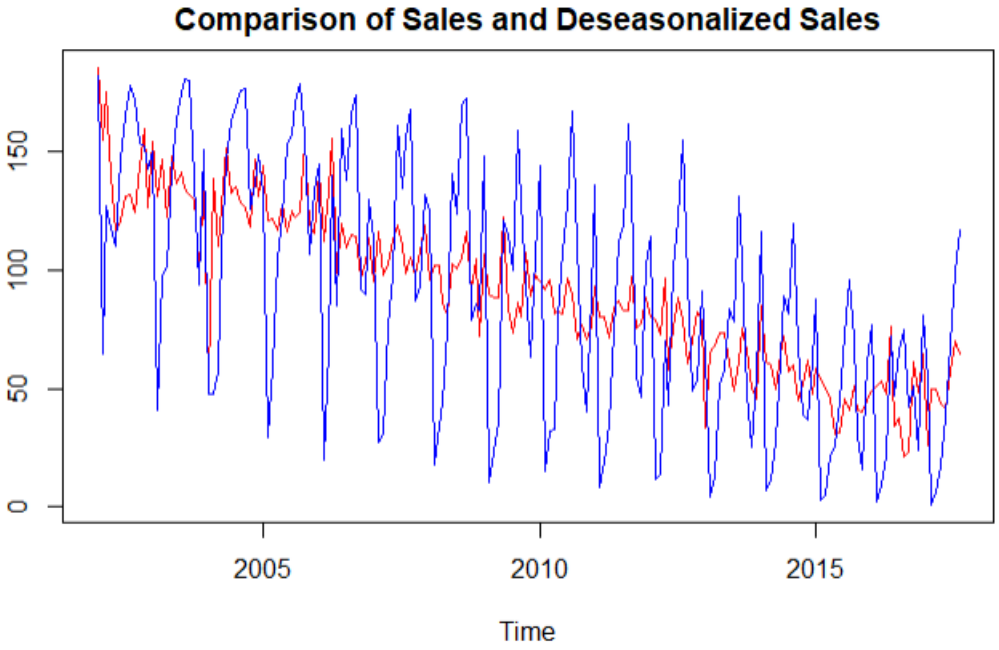

Figure 6: Comparison of Sales and Deseasonalised Sales for Item

3. Additive seasonality is observed in Item 1 sales,
   Multiplicative seasonality can be observed in Item 2 sales.

   Item 1 is more of a winter product, there are higher sales recorded during winter season months than of summer season months with highest sales being recorded in January, December.
   The sales of item 2 increases from February to August and then maintains a decreasing pace which shows the product is clearly a summer product with the peak sales value recorded in August and least value recorded in February.

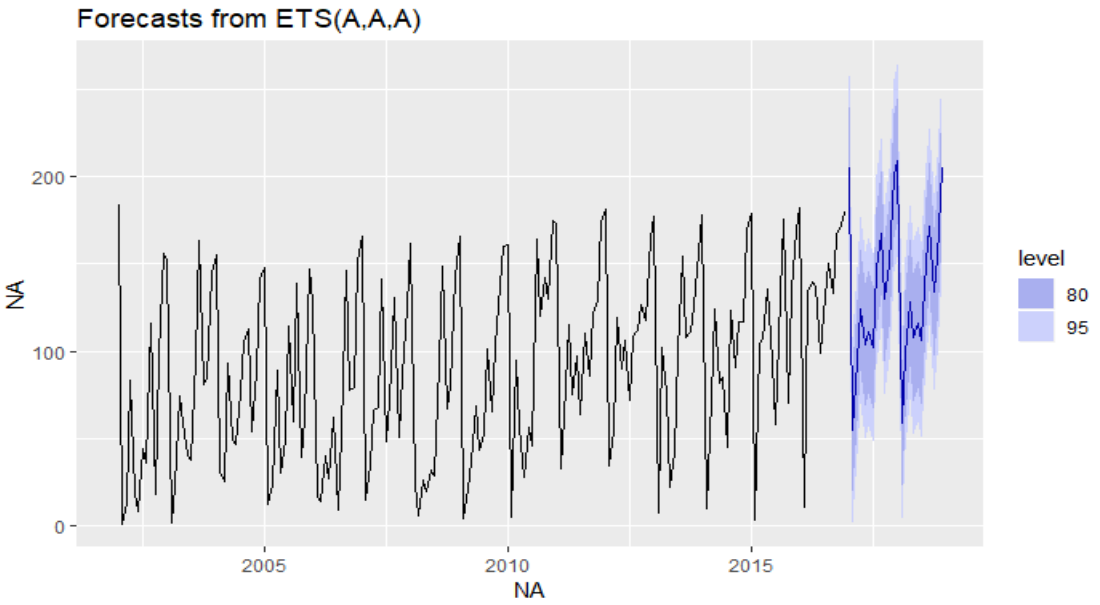

Figure 7: Forecast of Test Set for Item 1

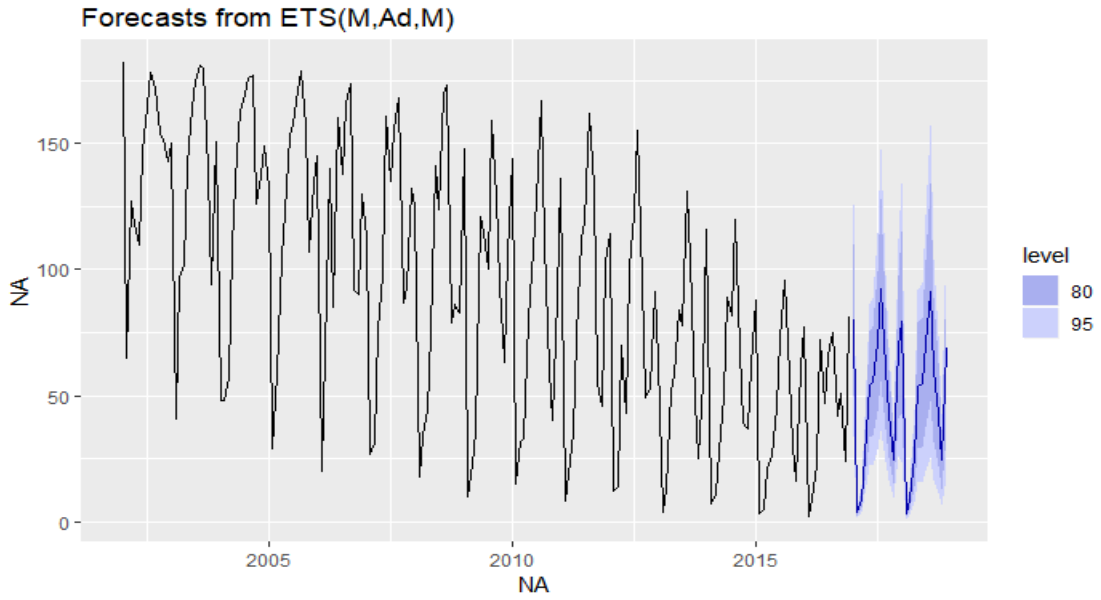

Figure 8: Forecast of Test Set for Item 2

Forecast Accuracy:

```
                    ME      RMSE       MAE        MPE      MAPE      MASE         ACF1
Training set  0.1001014 25.77796 20.24581 -24.01145 56.04113 0.8219663 -0.02486932
Test set     26.2676784 44.15409 41.51524 -10.37814 53.19542 1.6854908  0.29356677
             Theil's U
Training set        NA
Test set     0.3964163
```

Figure 9: Item 1 Time Series Forecast Accuracy

```
                    ME      RMSE       MAE        MPE      MAPE      MASE       ACF1
Training set -0.999768 24.12504 17.02732 -11.58267 25.57457 1.0083153 0.2022400
Test set      1.094757 18.07824 15.39459 -47.33290 64.49260 0.9116287 0.4142697
             Theil's U
Training set        NA
Test set     0.6428301
```

Figure 10: Item 2 Time Series Forecast Accuracy

```
Series: IAsales.dif.train
ARIMA(0,0,1)(1,1,1)[12]

Coefficients:
          ma1     sar1     sma1
      -0.8854  -0.0249  -0.6688
s.e.   0.0458   0.1226   0.1046

sigma^2 estimated as 766.5:  log likelihood=-794.74
AIC=1597.49   AICc=1597.74   BIC=1609.96
                    ME     RMSE       MAE      MPE      MAPE      MASE         ACF1
Training set   1.061426  26.5007  19.26445     -Inf       Inf 0.6134942  0.03169806
Test set     146.167746 151.3319 146.16775 218.1729 218.1729 4.6548462 -0.20342102
             Theil's U
Training set        NA
Test set     0.5419984
```

Figure 11: Item 1 ARIMA Forecast Accuracy

```
Series: IBsales.dif.train
ARIMA(1,0,0)(1,1,0)[12] with drift

Coefficients:
          ar1     sar1   drift
      -0.5791  -0.3993  0.0247
s.e.   0.0636   0.0719  0.0735

sigma^2 estimated as 615.8:  log likelihood=-773
AIC=1554.01   AICc=1554.26   BIC=1566.48
                     ME     RMSE       MAE      MPE      MAPE      MASE        ACF1
Training set -0.06603631 23.75220 17.69930      Inf       Inf 0.7378389 -0.1746747
Test set     47.84785390 60.49213 47.84785 968.7517 968.7517 1.9946559  0.3702697
             Theil's U
Training set        NA
Test set     0.9293303
```

Figure 12: Item 2 ARIMA Forecast Accuracy

```
Smoothing parameters:
  alpha = 0.0416
  beta  = 1e-04
  gamma = 1e-04
  phi   = 0.9564
```

Figure 13: Smoothing Parameters for Item 1

```
Smoothing parameters:
  alpha = 0.1202
  beta  = 1e-04
  gamma = 0.3937
  phi   = 0.98
```

Figure 14: Smoothing Parameters for Item 2

4. Both the series are stationary series.
   H0: Time Series is non-stationary,
   Ha: Time Series is stationary.

```
p-value smaller than printed p-value
        Augmented Dickey-Fuller Test

data:  IAsales.train
Dickey-Fuller = -8.9056, Lag order = 5, p-value = 0.01
alternative hypothesis: stationary

p-value smaller than printed p-value
        Augmented Dickey-Fuller Test

data:  IBsales.train
Dickey-Fuller = -10.779, Lag order = 5, p-value = 0.01
alternative hypothesis: stationary
```

Figure 15: Stationarity Test for Item 1 & Item 2

5. Clearly, Time Series is a better process than Auto Regression for the given sales series.

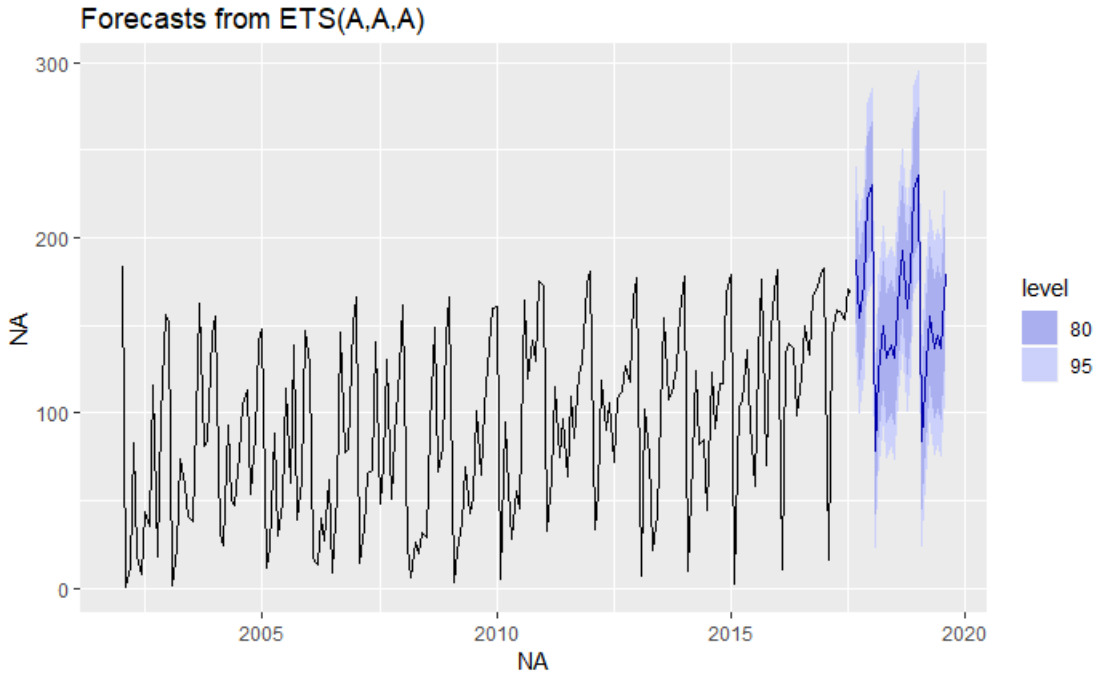

Figure 16: Future Forecast of Item 1

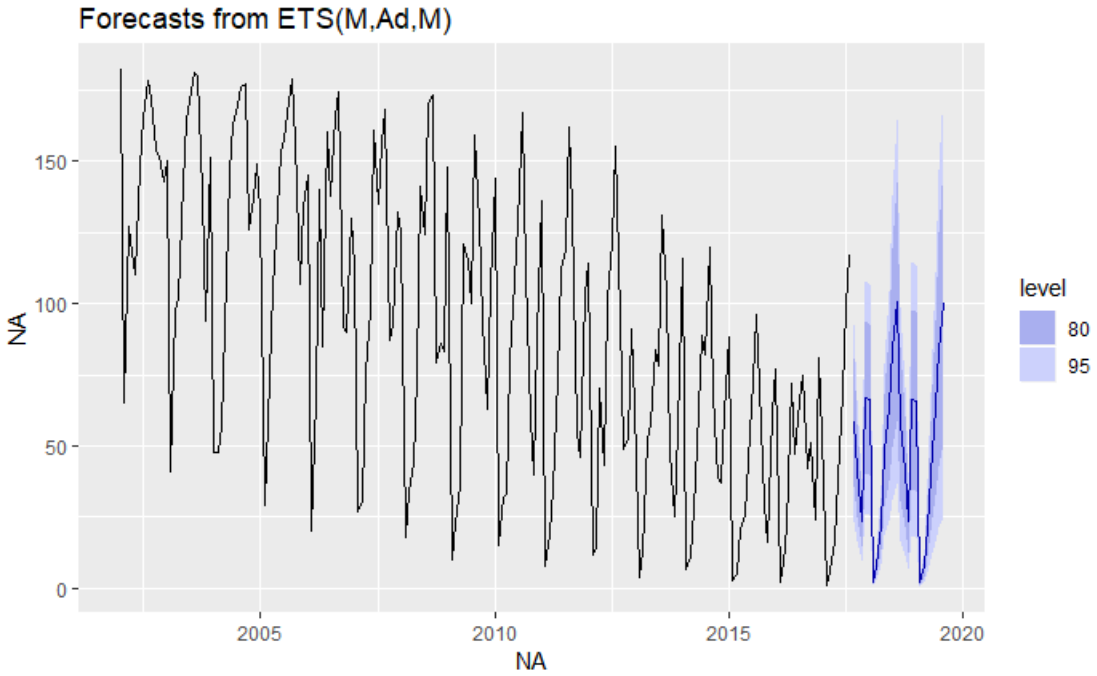

Figure 17: Future Forecast of Item 2