Global Mart Demand & Sales Forecasting
A Time Series Case Study
By

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Problem statement:

"Global Mart" is an online store super giant having worldwide operations. It takes orders and delivers across the globe and deals with all the major product categories - consumer, corporate & home office.
The sales/operations manager of "Global Mart" want to finalize the plan for next 6 months., hence want to forecast the demand and sales for the next 6 months.

Goal of the case study:

The store caters to 7 different market segments and in 3 major categories

- From the 7 segments in 3 different markets, identify two most consistently profitable groups.
- For the 2 most profitable segments, forecast the demand and sales for the upcoming six months based on historical data.

Problem breakdown:

- Data Understanding – Source of data, patterns in the data

- Data Preparation – Identify the two most profitable segment/market groups for model building

- Forecasting demand and sales data using Classical decomposition & Auto Arima methodologies

Problem Solving Methodology
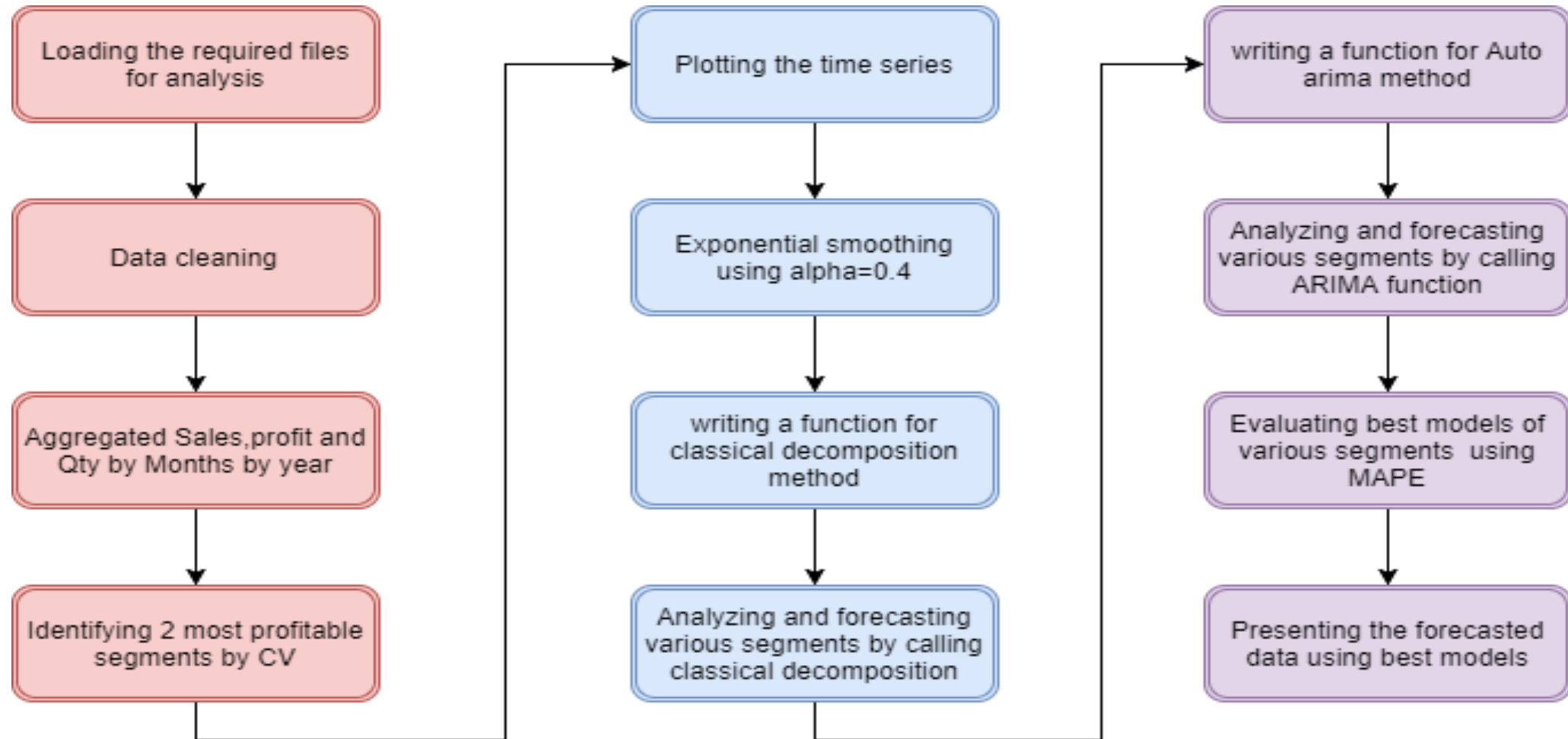
We are breaking down our analysis in following ways:

1. Eliminating the columns which are not required for our analysis after the data understanding and in the process simplify the analysis

We will retain only these :"Order.Date" ,"Segment","Market","Sales","Quantity","Profit"

Why these 6 attributes only : Order.Date for extracting the time series. Segment and Market for segmentation

Sales,Quantity,profit : for aggregation and applying the Coefficient of variation to come up with 2 profitable segments

 Use Sales and Quantity for the time series forecasting

2. Perform data quality checks

3. Lets aggregate the different performance units of the stores, i.e Sales,Quantity and Profit by Month and Year. Its easier to first create the aggregation and then subset into 21 buckets for Unique combination of Market and segment .This is also a way of coming with derived metrics

4. Now lets segment the whole dataset into subsets based on Unique number of Market and segments

5. Computing the coefficient of variation for each of 21 buckets and choosing the 2 most profitable segments based on least CV.

6.Coming up with customized functions for plotting time series, smoothing process, classical decomposition and ARIMA modelling techniques

7. Pass the individual dataframes based on the method and build 8 models, such as:
   a) Classical decomposition model for APAC Consumer Sales and APAC Consumer Quantity
   b) Classical decomposition model for EU Consumer Sales and EU Consumer Quantity
   c) Auto ARIMA model for APAC Consumer Sales and APAC Consumer Quantity
   d) Auto ARIMA model for EU Consumer Sales and EU Consumer Quantity

8. Analyze various parameters of the Models like the ARMA p,q order, ACF plots, test for white noise and plotting over all fit.
9. Evaluate MAPE for each model and store the forecast in dataframes
10. Conclude the forecast for the segments based on the best MAPE from the derived models.

Exploratory data analysis
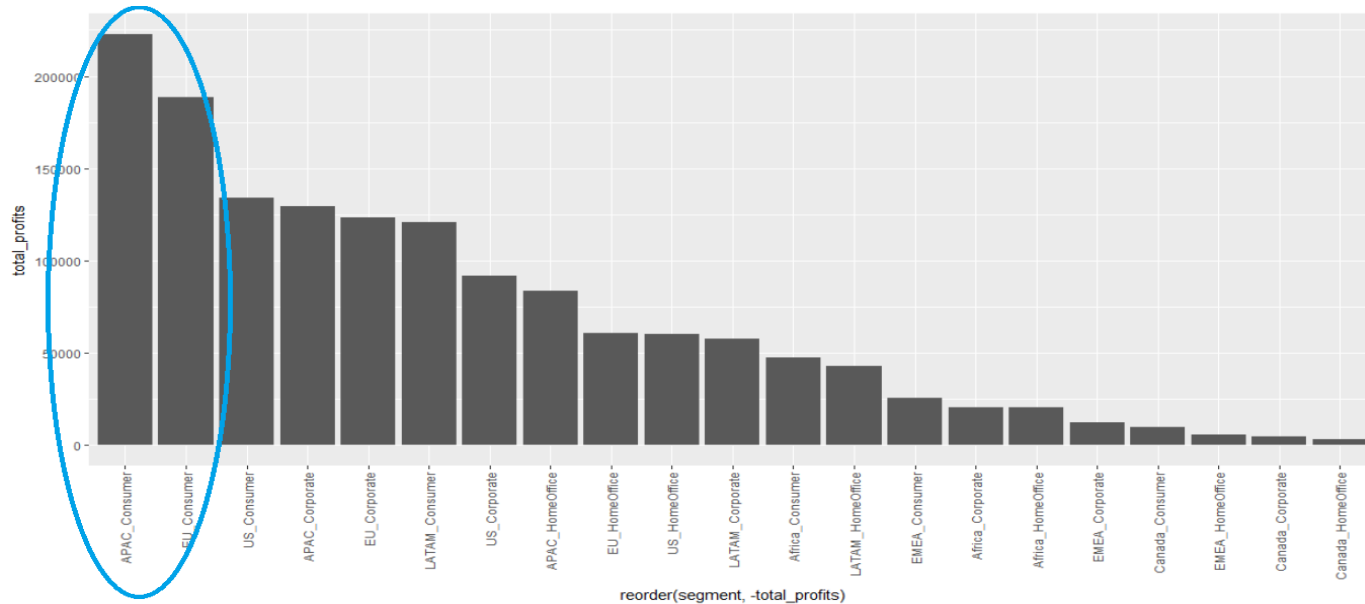
1. Unique Markets:
unique(superstore_aggregate$Market)
#[1] Africa APAC   Canada EMEA   EU   LATAM US

2. Unique Segments:
unique(superstore_aggregate$Segment)
#[1] Consumer   Corporate   HomeOffice
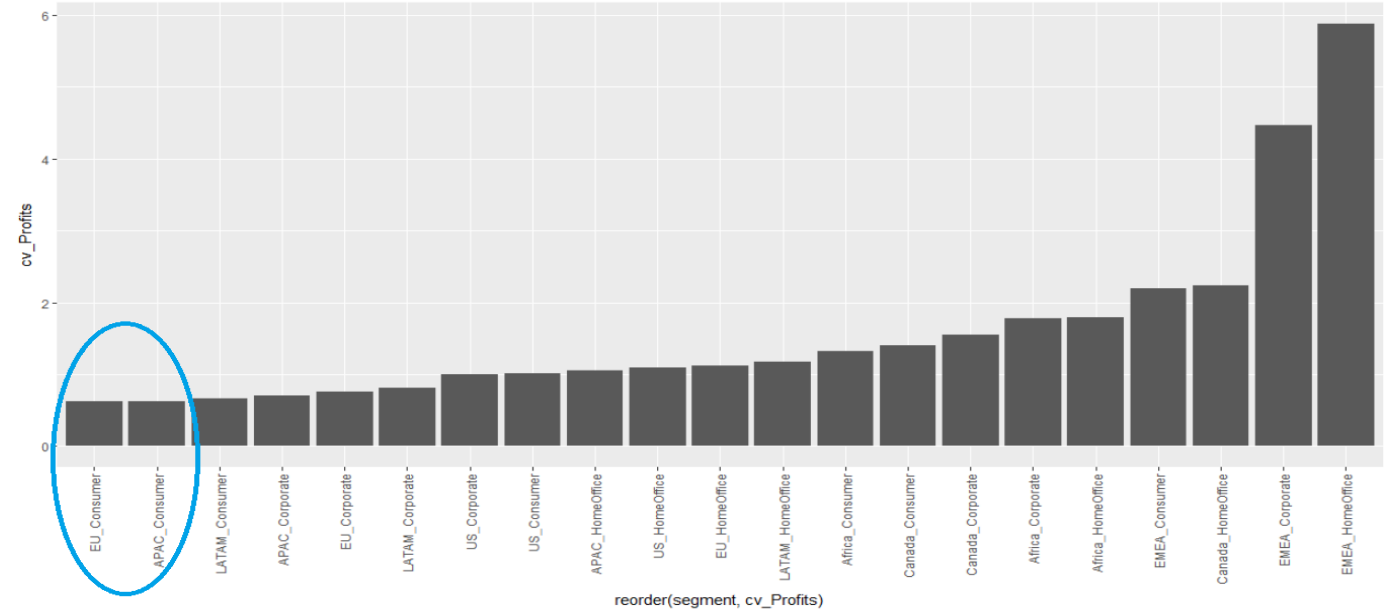
3. Two most profitable segments are EU consumer
And APAC Consumer based on least CV and max
Profits, implying they are consistently profitable
Segments

Exploratory data analysis Cont

Visualising various trends for sales,Quantity and profits for APAC_Consumer
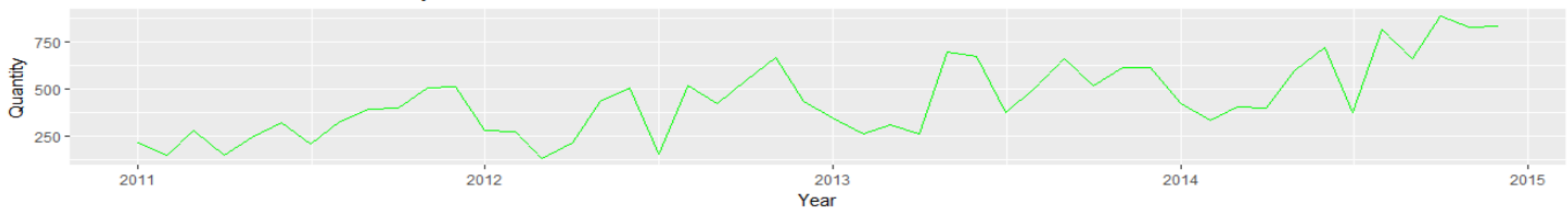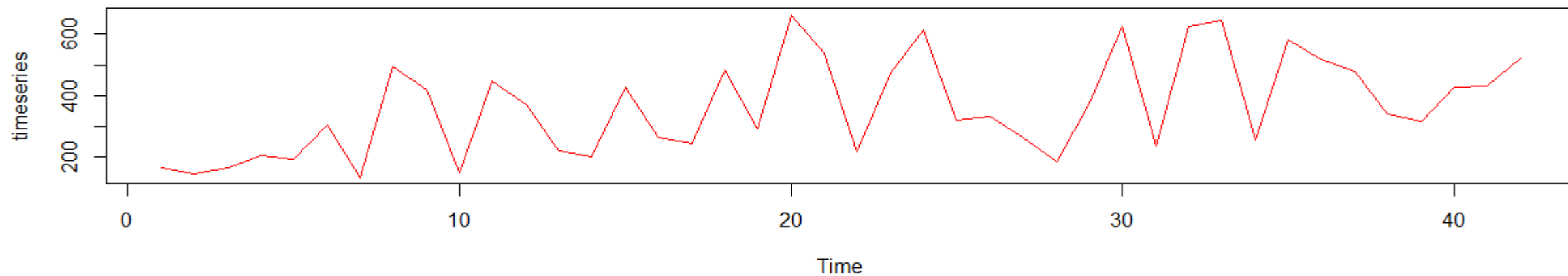
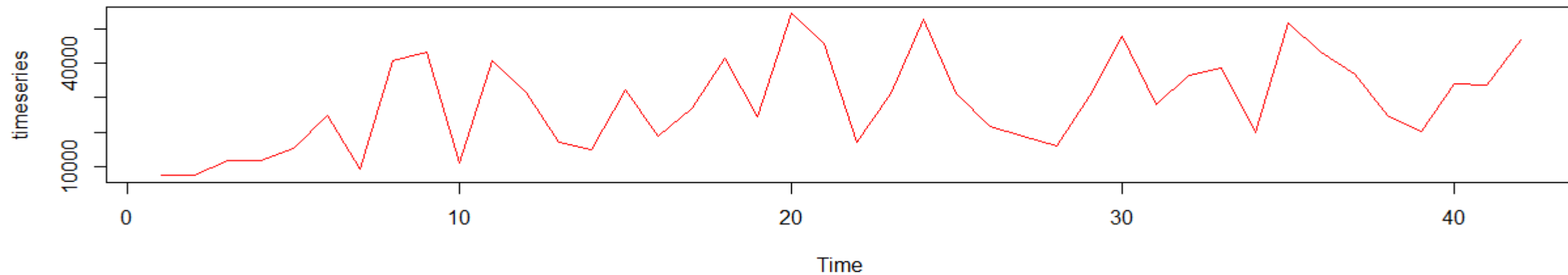Visualising various trends for sales,Quantity and profits for EU _Consumer
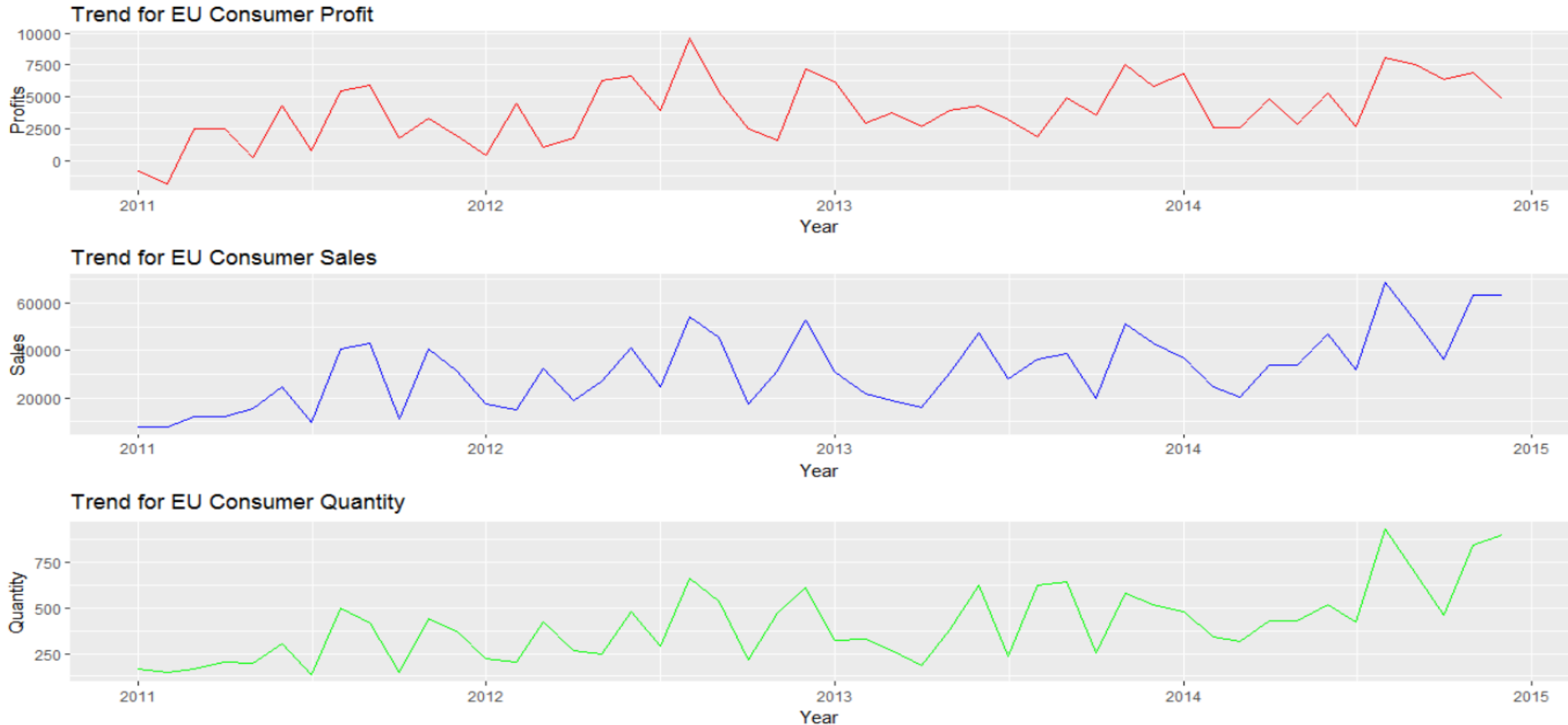
Monthly Demand in EU Consumer Segment(training set)

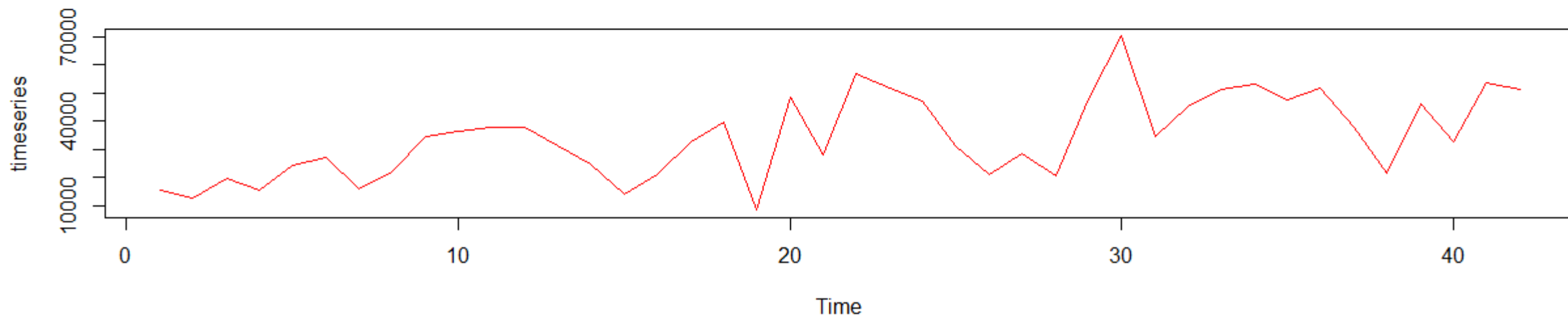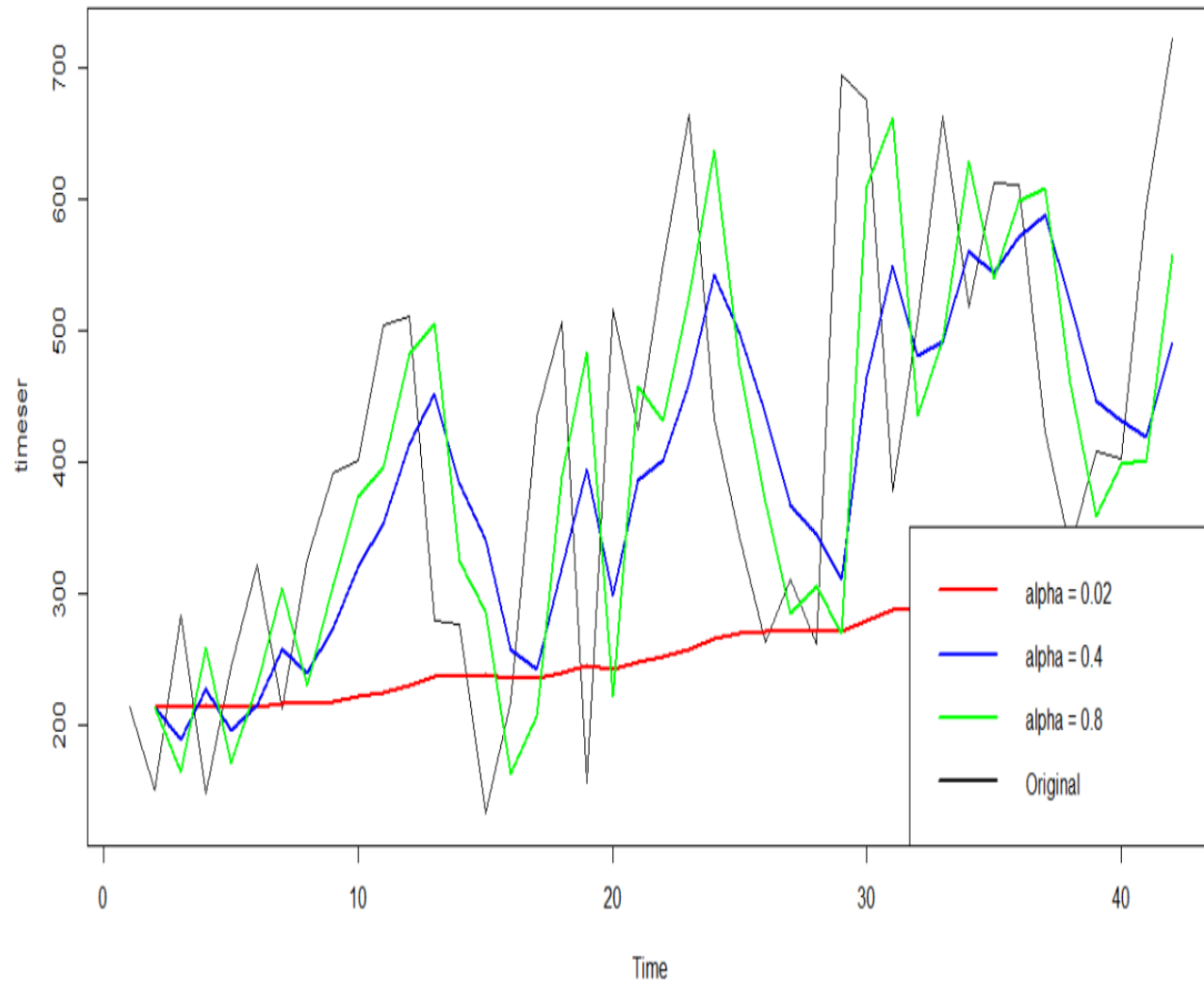Monthly Sales in EU Consumer Segment(Training set)

Time series plots for various segments

Monthly Demand in APAC Consumer Segment(training set)
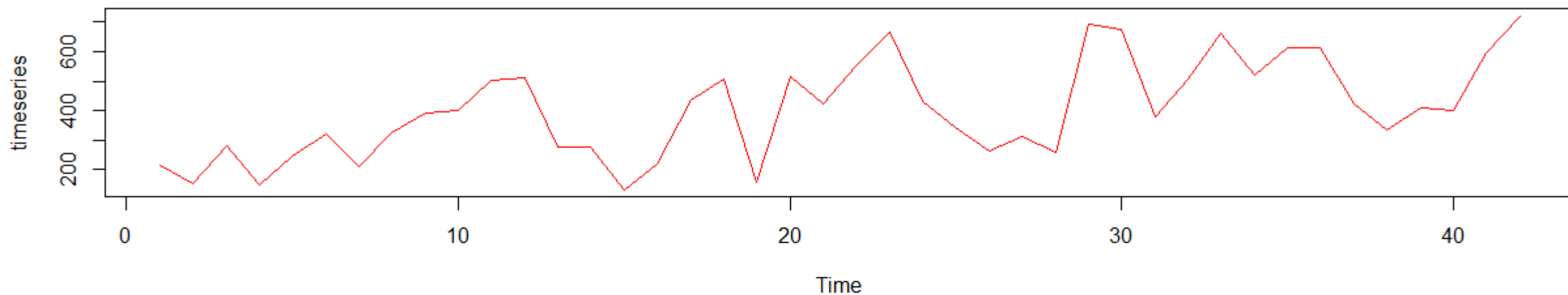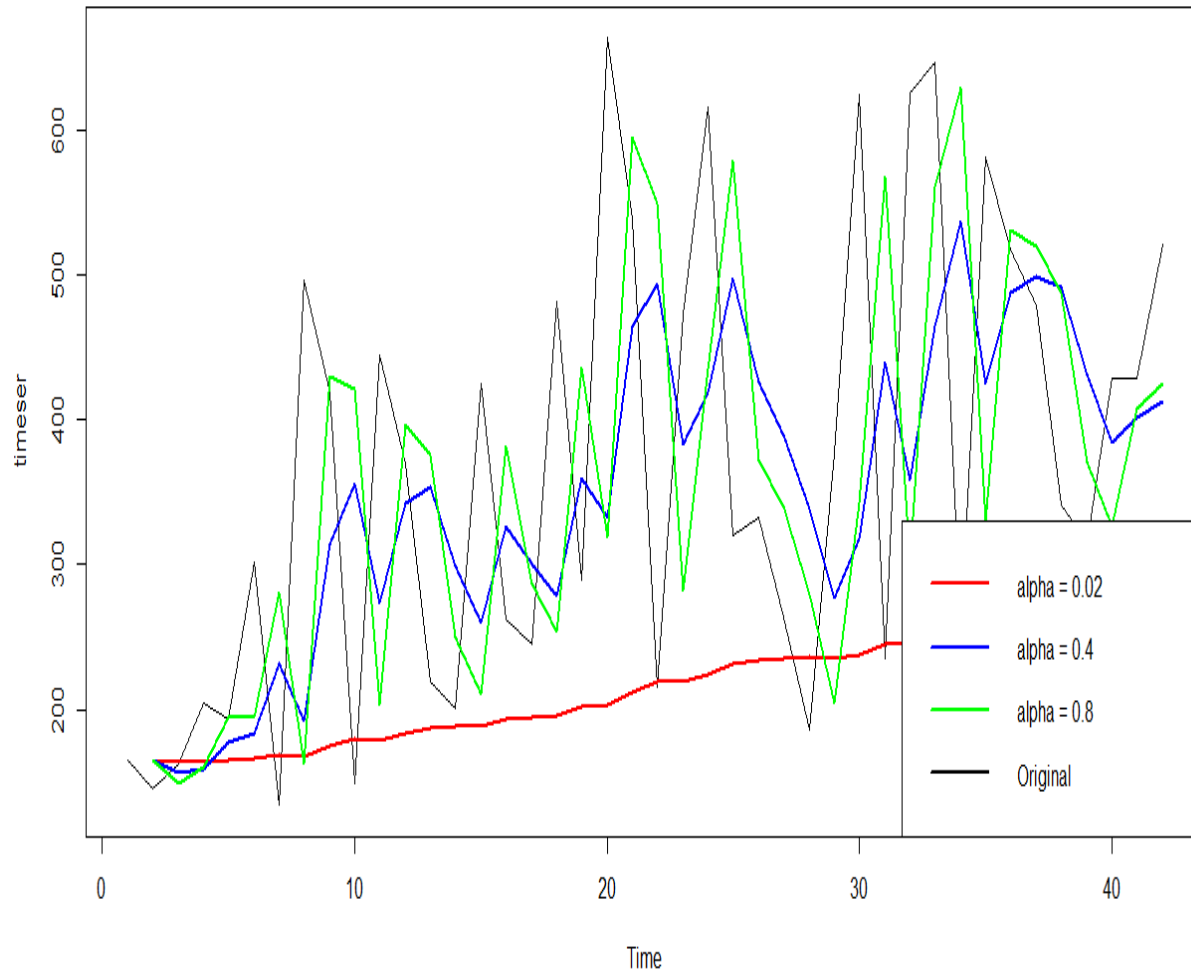
Monthly Sales in APAC Consumer Segment(Training set)
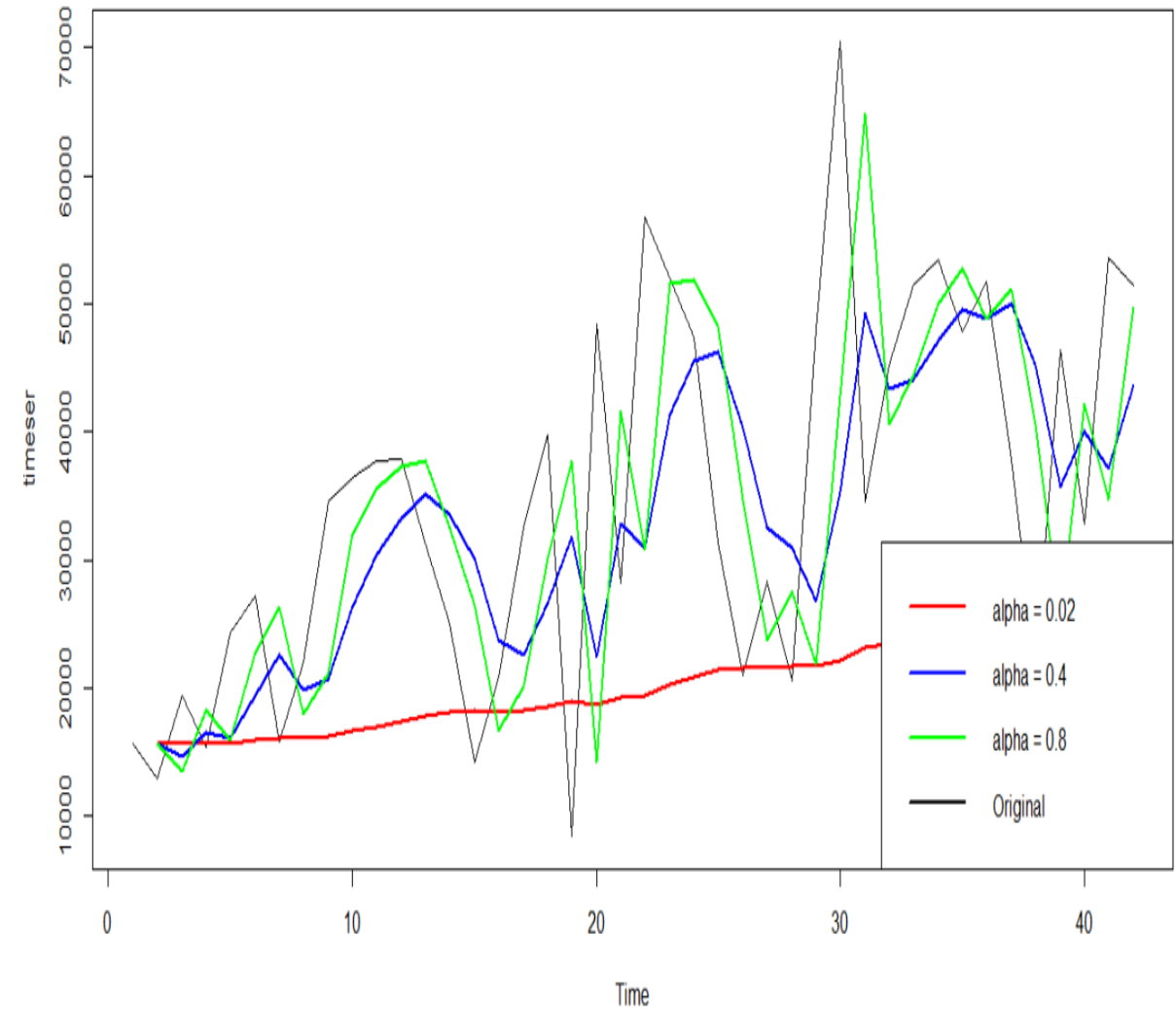
Smoothened series plots for various segments
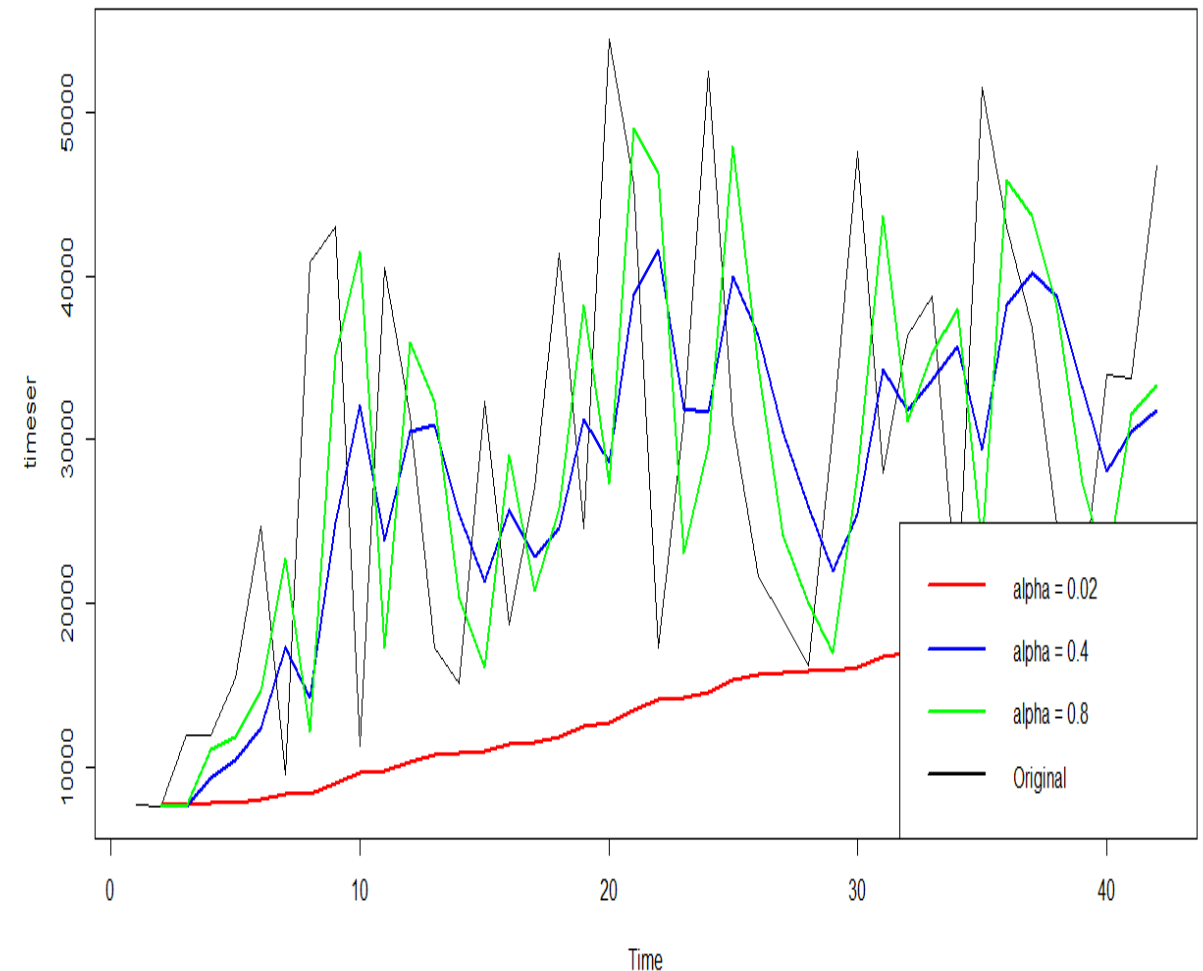
Smoothened series plots for various segments

Classical decomposition method: APAC Consumer Sales

The redline is the lmfit using sine function

Plot of locally predictable series

Getting Visual fit of data: Black lines represents original series, red lines represents predicted series

Findings:

1. ARIMA fit gives ARIMA(0,0,0) with zero mean with AIC=903.79 AICc=903.89 BIC=905.53

2. KPSS Level = 0.069008, Truncation lag parameter = 1, p-value = 0.1 confirming residual series is white noise

3. ACF plot indicates ACF of 1 at lag 0 indicating strong stationarity
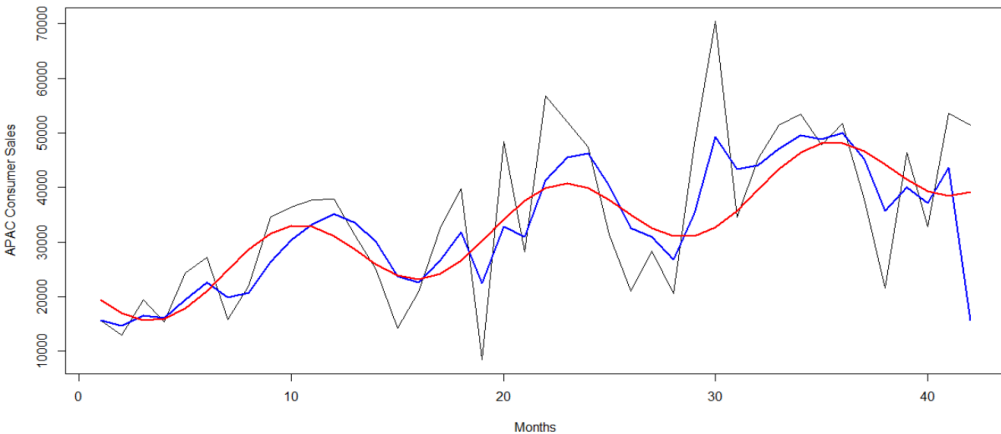
4. The accuracy using MAPE= 20.88024

Classical decomposition method:APAC Consumer Qty

The redline is the lmfit   using sine function

Plot of locally predictable series

Getting Visual fit of data: Black lines represents original series, red lines represents predicted series

Findings:

1. ARIMA fit gives ARIMA(0,0,0) with zero mean with AIC=527.72 AICc=527.82   BIC=529.46

2. KPSS Level = 0.082695, Truncation lag parameter = 1, p-value = 0.1 confirming residual series is white noise

3. ACF plot indicates ACF of 1 at lag 0 indicating strong stationarity

4. The accuracy using MAPE= 26.13344

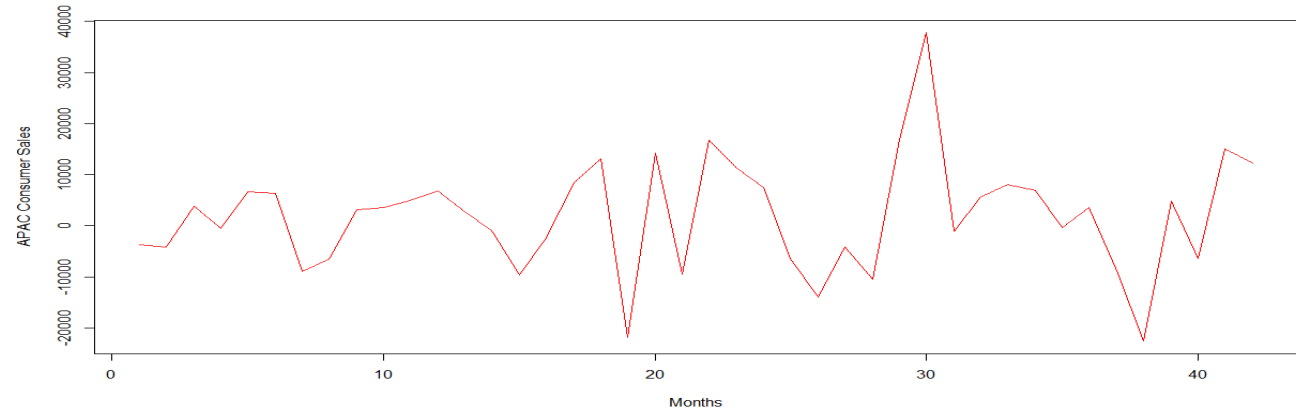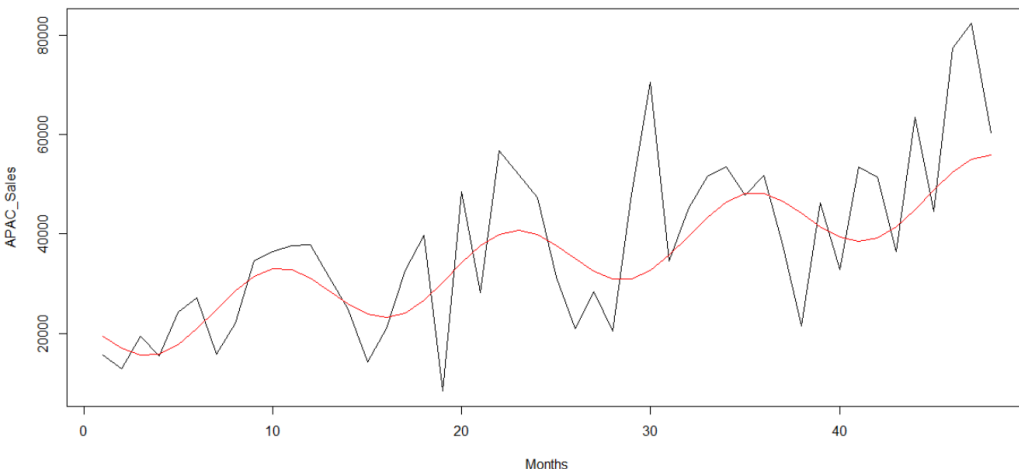# Classical decomposition method: EU Consumer Sales

The redline is the lmfit   using sine function

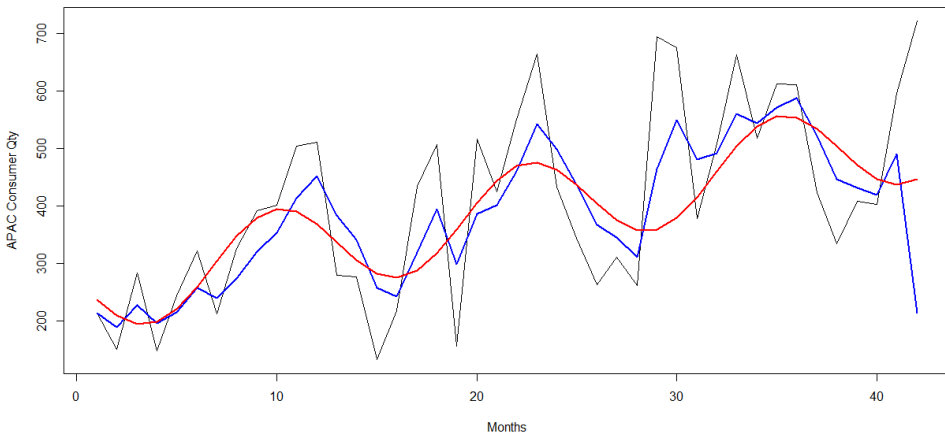

Plot of locally predictable series

Getting Visual fit of data: Black lines represents original series, red lines represents predicted series
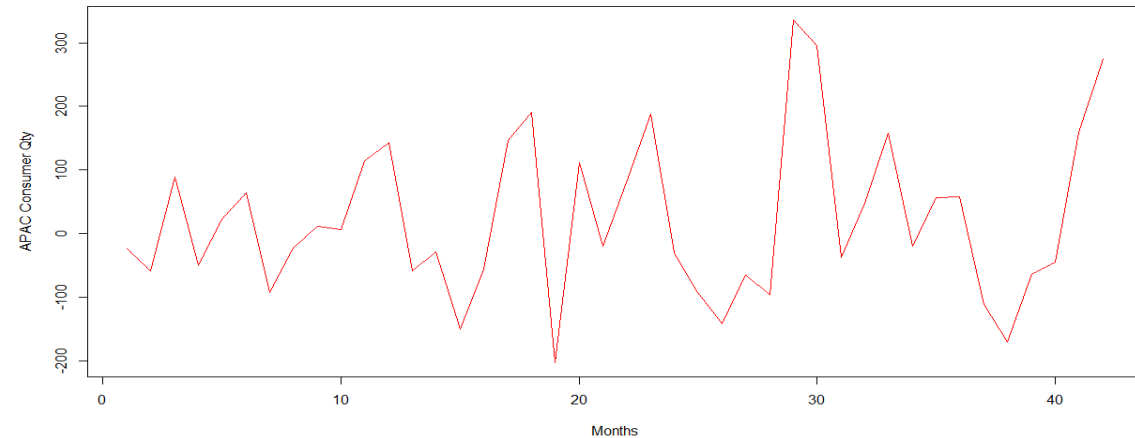

Findings:

1. ARIMA fit gives ARIMA(0,0,0) with zero mean with AIC=902.92 AICc=903.02   BIC=904.66

2. KPSS Level = 0.079523, Truncation lag parameter = 1, p-value = 0.1 confirming residual series is white noise

3. ACF plot indicates ACF of 1 at lag 0 indicating strong stationarity

4. The accuracy using MAPE= 24.61031
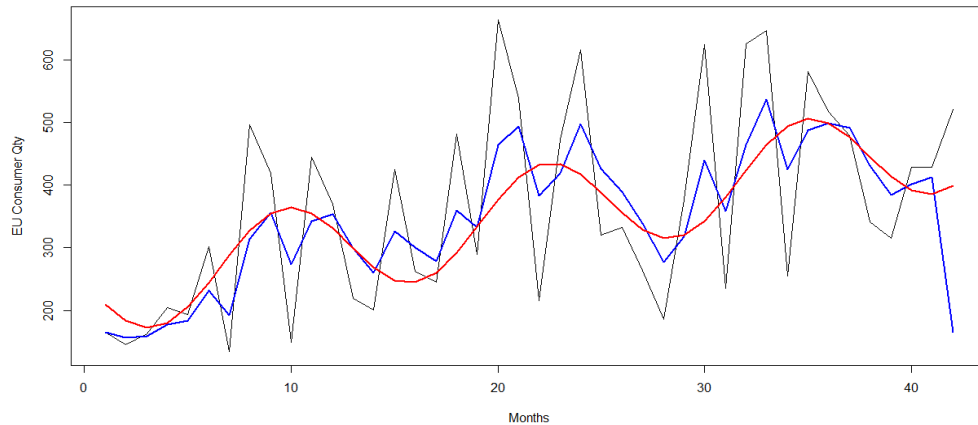
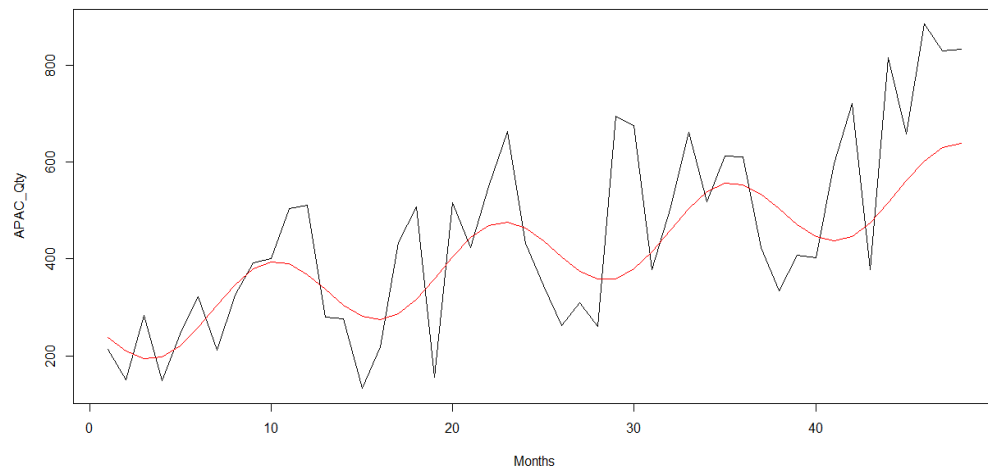# Classical decomposition method: EU Consumer Qty

The redline is the lmfit   using sine function
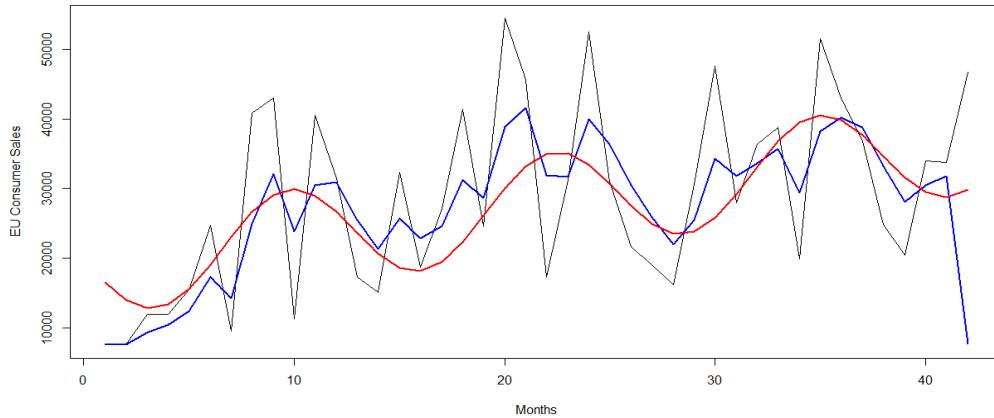

Plot of locally predictable series

Getting Visual fit of data: Black lines represents
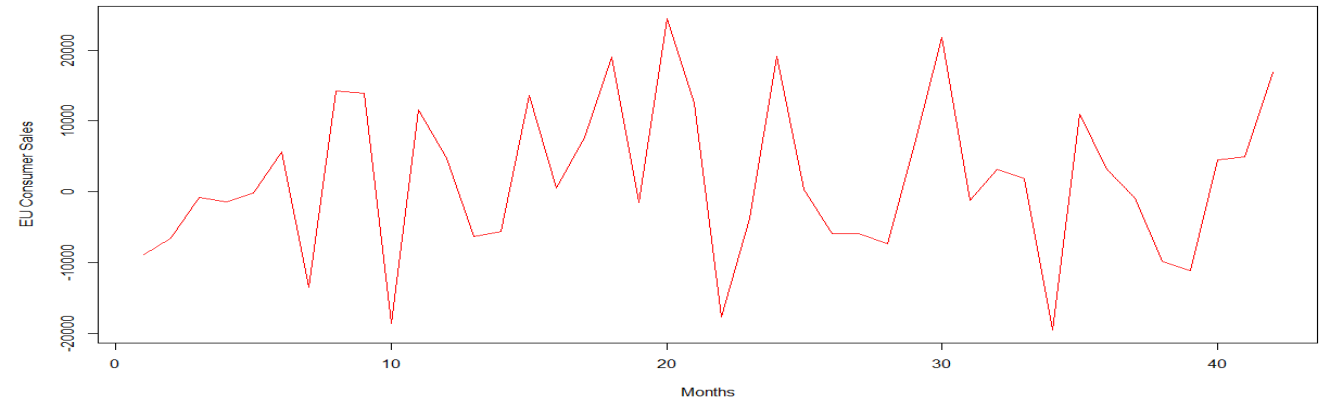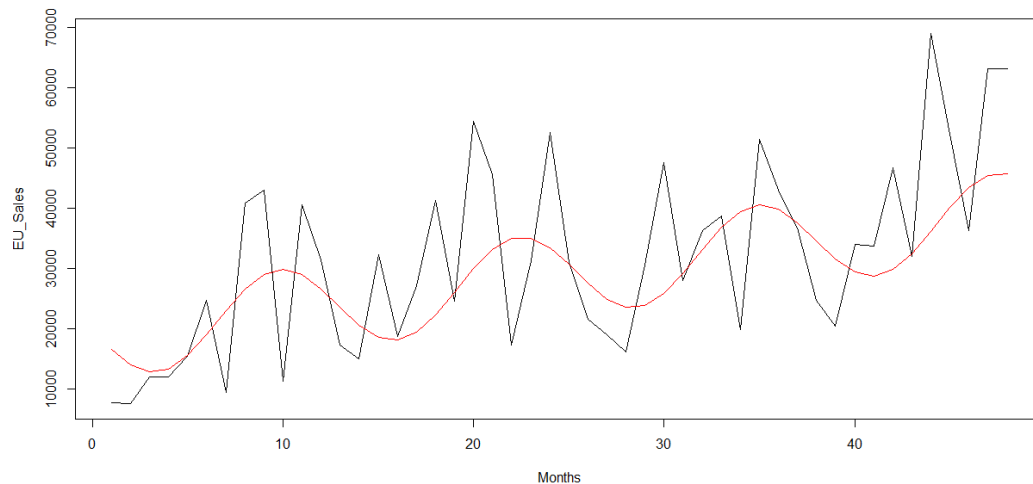original series, red lines represents predicted series
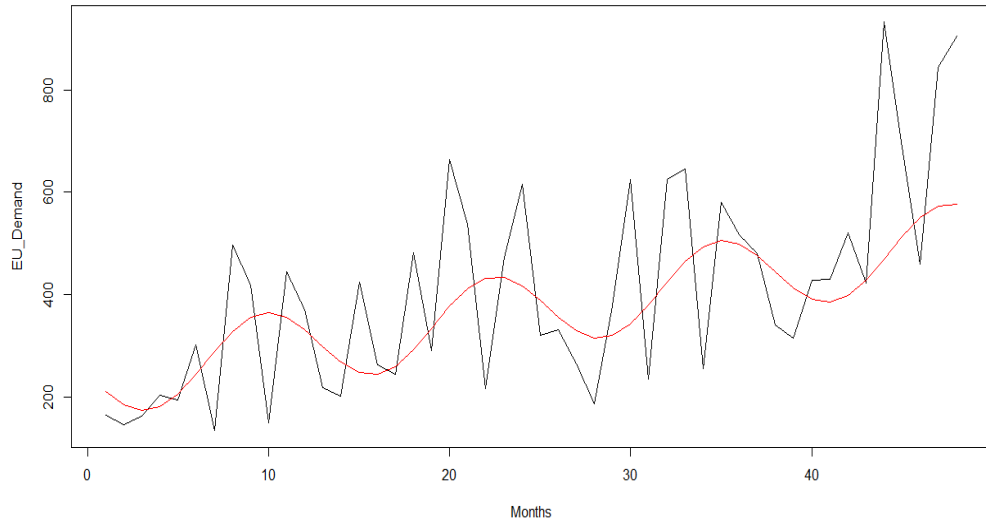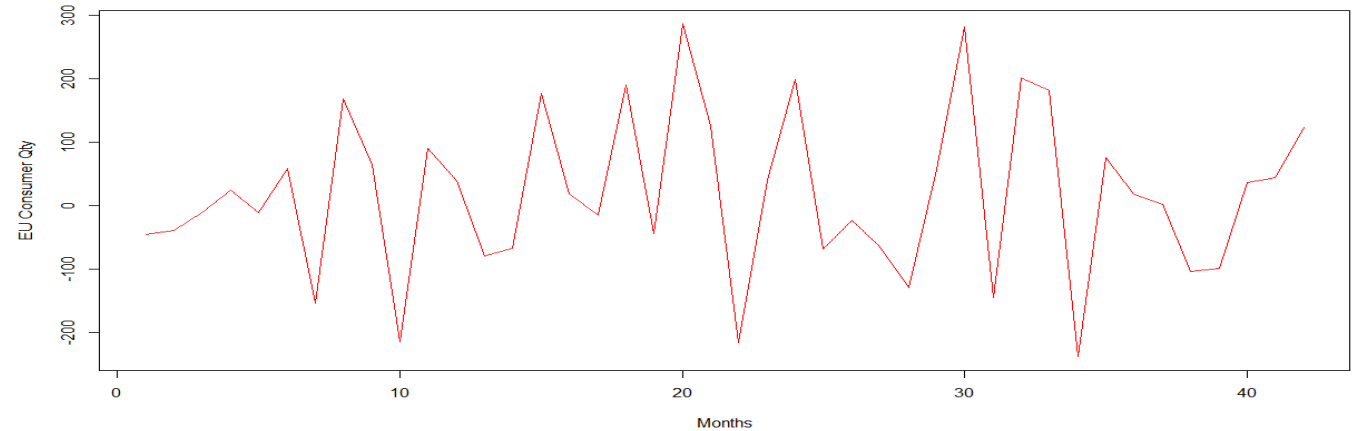
Findings:

1. ARIMA fit gives ARIMA(1,0,2) with zero mean with AIC=526.65
   AICc=527.73   BIC=533.6

2. KPSS Level 0.063004, Truncation lag parameter = 1, p-value = 0.1
   confirming residual series is white noise

3. ACF plot indicates ACF of 1 at lag 0 indicating strong stationarity

4.   The accuracy using MAPE= 27.43684

Auto ARIMA method: APAC Consumer Sales

The redline is the auto ARIMA fitted line
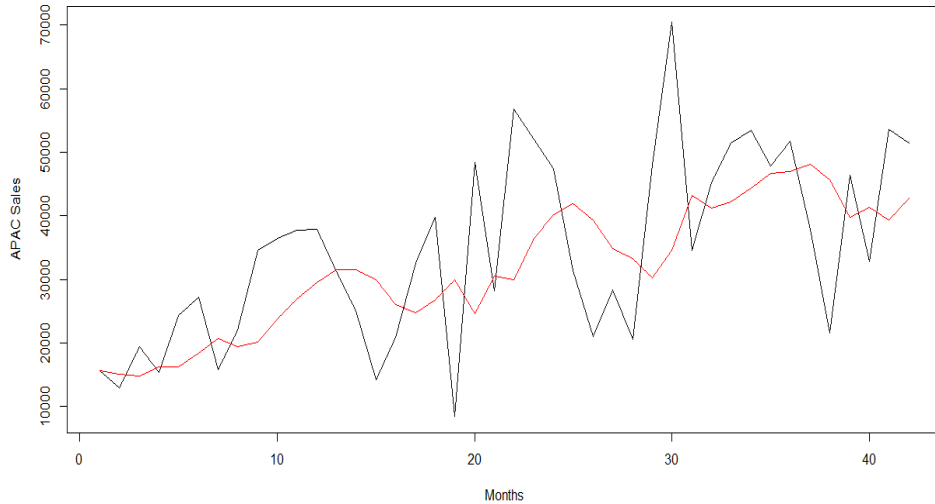
Plotting the predictions along with original values
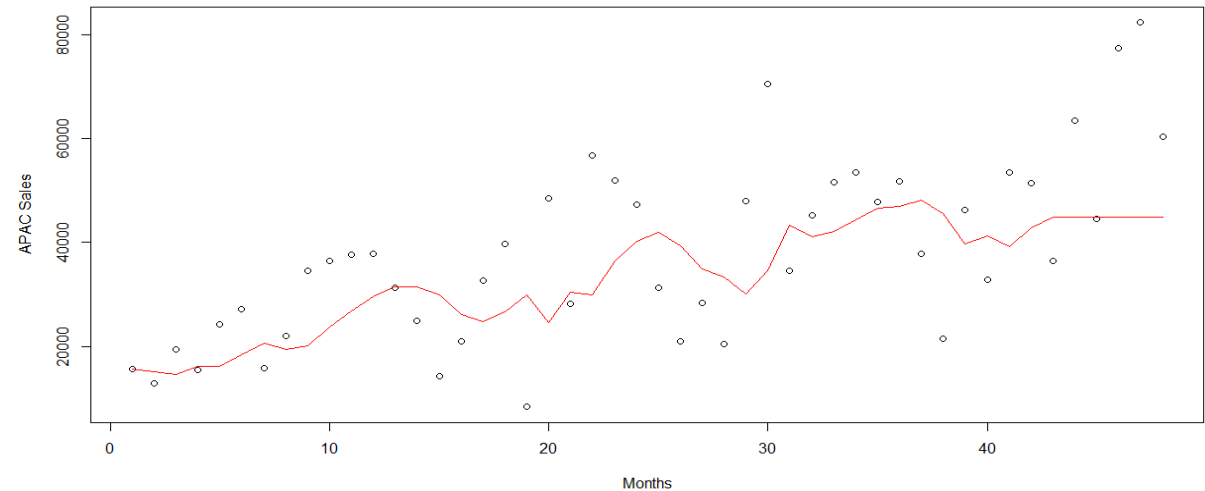
Findings:

1. ARIMA fit gives ARIMA(0,1,1) with AIC=898.23   AICc=898.55   BIC=901.66

2. KPSS Level = 0.042734, Truncation lag parameter = 1, p-value = 0.1

3. The accuracy using MAPE=   27.68952

The redline is the auto ARIMA fitted line

Plotting the predictions along with original values

Findings:

1. ARIMA fit gives ARIMA(0,1,0) with AIC=534.14 AICc=534.24 BIC=535.85

2. KPSS Level = 0.031535, Truncation lag parameter = 1, p-value = 0.1

3. The accuracy using MAPE= 26.24458

The redline is the auto ARIMA fitted line
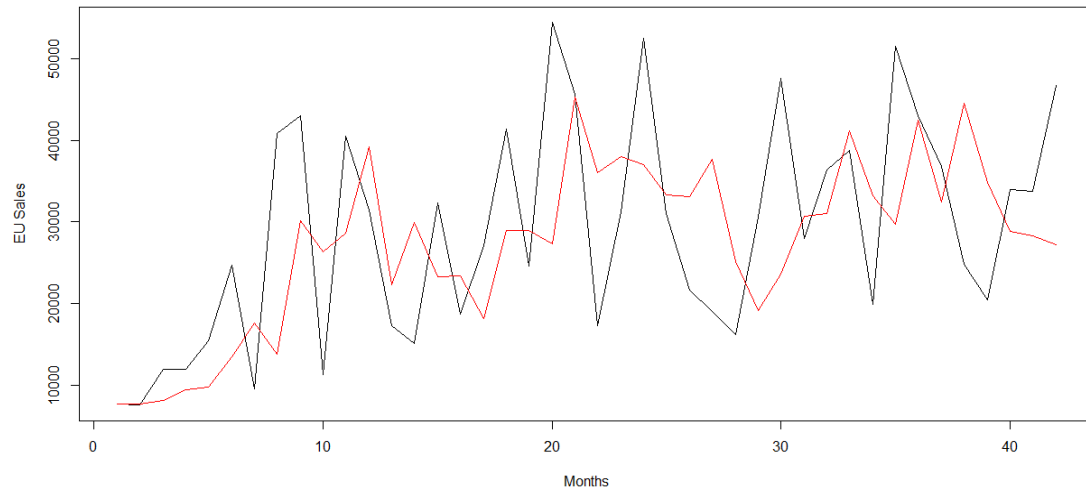
Plotting the predictions along with original values
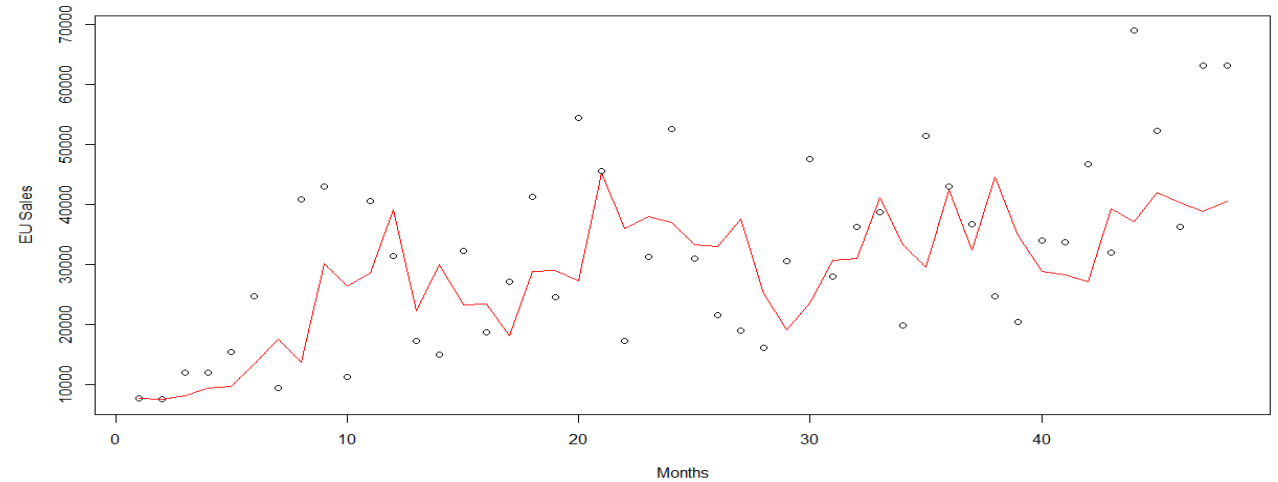
Findings:

1. ARIMA fit gives ARIMA(2,1,0) with AIC=897.67   AICc=898.32   BIC=902.81

2. KPSS Level = 0.05314, Truncation lag parameter = 1, p-value = 0.1

3. The accuracy using MAPE=   28.9226

The redline is the auto ARIMA fitted line
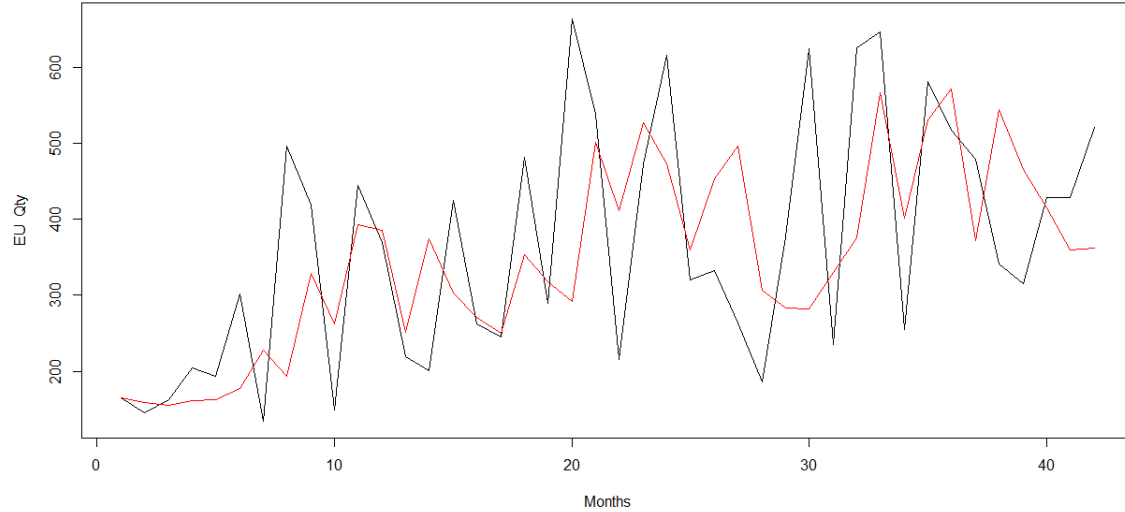
Plotting the predictions along with original values
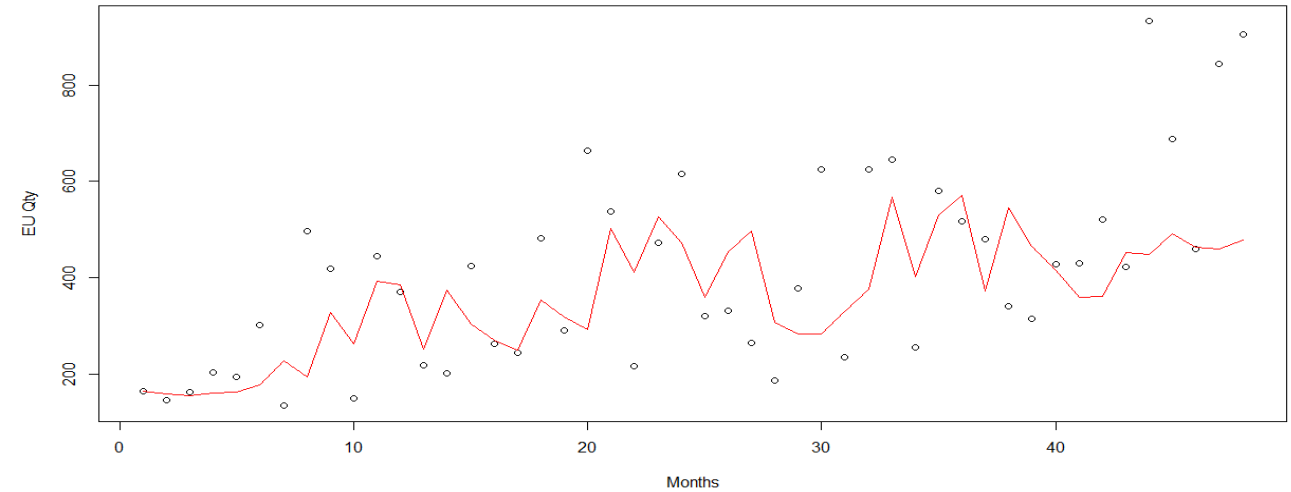
Findings:
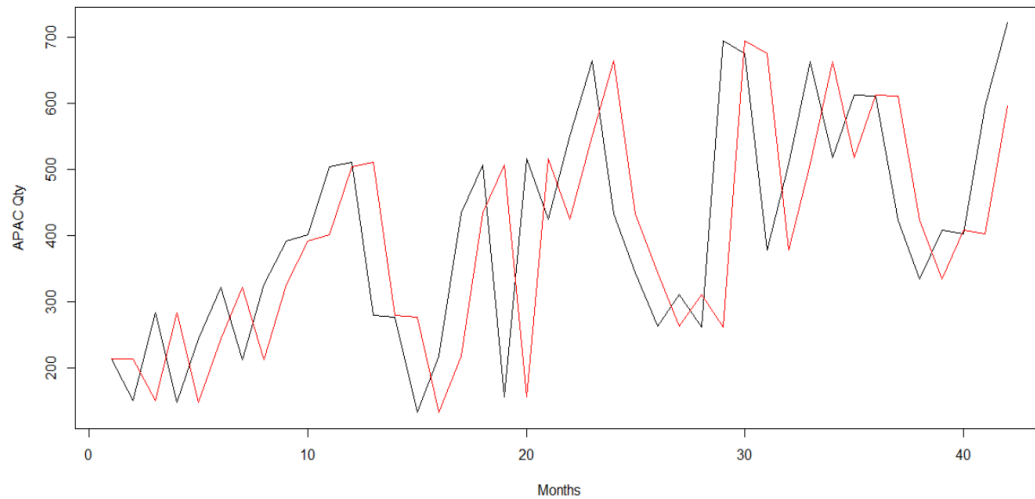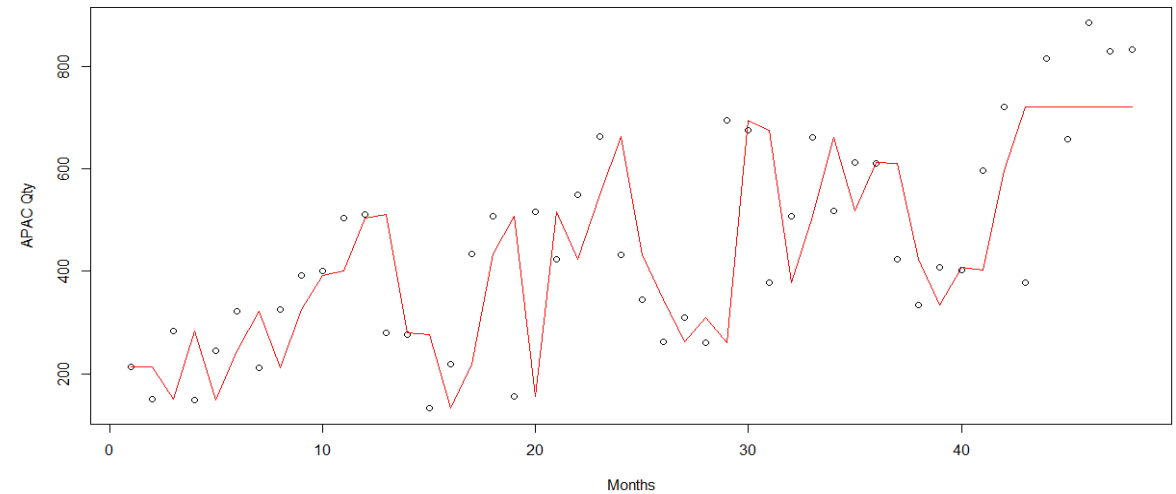
1. ARIMA fit gives ARIMA(2,1,0) with AIC=529.8 AICc=530.44 BIC=534.94

2. KPSS Level = 0.047939, Truncation lag parameter = 1, p-value = 0.1

3. The accuracy using MAPE= 30.13319

Comparison of Models using MAPE

Parameter	MAPE (Classic Decomposition)	MAPE (Auto Arima)
APAC Sales	20.88024	27.68952
APAC Quantity	26.13344	26.24458
EU Sales	24.61031	28.9226
EU Quantity	27.43684	30.13319

Since the Classical decomposition models have given a better MAPE compared to the Auto ARIMA models, we shall Base our forecast based on the classical decomposition methodology.

Forecast for APAC Consumer Sales($)

	Months	Actual_Value	Forecasted_Value	percent_Deviation
1	Jul 2014	36524.30	41497.64	13.62%
2	Aug 2014	63521.77	44971.10	-29.20%
3	Sep 2014	44477.27	48909.05	9.96%
4	Oct 2014	77379.83	52495.90	-32.16%
5	Nov 2014	82286.36	55002.04	-33.16%
6	Dec 2014	60292.13	55962.42	-7.18%

	Months	Forecasted_Value
1	Jan 2015	55290.49
2	Feb 2015	53299.31
3	Mar 2015	50624.96
4	Apr 2015	48070.78
5	May 2015	46410.67
6	Jun 2015	46199.67

Forecast for APAC Consumer Quantity

	Months	Actual_Value	Forecasted_Value	percent_Deviation
1	Jul 2014	377	474.4282	25.84%
2	Aug 2014	816	515.4737	-36.83%
3	Sep 2014	658	561.1942	-14.71%
4	Oct 2014	885	601.9784	-31.98%
5	Nov 2014	829	629.4238	-24.07%
6	Dec 2014	833	638.3934	-23.36%

	Months	Forecasted_Value
1	Jan 2015	628.27
2	Feb 2015	603.13
3	Mar 2015	570.69
4	Apr 2015	540.49
5	May 2015	521.5
6	Jun 2015	519.96

Forecast for EU Consumer Sales($)

	Months	Actual_Value	Forecasted_Value	percent_Deviation
1	Jul 2014	31967.69	32473.99	1.58%
2	Aug 2014	68951.72	36180.25	-47.53%
3	Sep 2014	52328.68	40132.04	-23.31%
4	Oct 2014	36348.31	43465.34	19.58%
5	Nov 2014	63218.71	45467.55	-28.08%
6	Dec 2014	63178.60	45751.97	-27.58%

	Months	Forecasted_Value
1	Jan 2015	44352.49
2	Feb 2015	41715.26
3	Mar 2015	38589.47
4	Apr 2015	35843.95
5	May 2015	34254.41
6	Jun 2015	34313.53

Forecast for EU Consumer Quantity

	Months	Actual_Value	Forecasted_Value	percent_Deviation
1	Jul 2014	423	428.6024	1.32%
2	Aug 2014	932	469.7045	-49.60%
3	Sep 2014	688	513.2496	-25.40%
4	Oct 2014	459	549.9571	19.82%
5	Nov 2014	843	572.2203	-32.12%
6	Dec 2014	905	575.9691	-36.36%

	Months	Forecasted_Value
1	Jan 2015	561.67
2	Feb 2015	534.19
3	Mar 2015	501.66
4	Apr 2015	473.41
5	May 2015	457.74
6	Jun 2015	459.87

Recommendations to Global Mart sales manager

1. By looking at the forecasted values in the previous slides, the demand and sales is in a downtrend for the period of Jan 2015-June 2015

2. Avoid making excessive adjustments to the forecast, even if you discover it's too optimistic or pessimistic.

3. Your sales people probably have the best knowledge of your customers' buying intentions, therefore:
   ➢ ask for their opinions
   ➢ give them time to ask their customers about this
   ➢ get the sales team's agreement to any targets that will be set

4. Having built your sales forecast, you need someone to challenge it. Get an experienced person - your accountant or a senior sales person - to review the whole document.

5. If you are planning for new markets and new products, explain how you're going to improve sales and profit margins for your existing products and markets. It is often helpful to identify how you will remove barriers to sales:
   ➢ Can you increase the activity levels of the sales team –aggressive online marketing /promotions
   ➢ Can you increase the conversion rate of online marketing /sales - through better sales training, better sales support materials or improved sales incentives?