Forecasting HICP for Norway

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# Harmonized Index of Consumer Prices (HICP)

- The Harmonized Index of Consumer Prices (HICP) is a list of the final costs paid by consumers for items in a basket of common goods
- It is a composite measure of inflation in the European Union
- Consumer goods here refer to sugar, jam, honey and other confectionery items
- Data sourced from FRED (economic research website)
- Data frequency is monthly starting from 2010 till 2021 (August)

Data Exploration (2010-2021)

HICP for Basket Goods (Sugar,Honey,Jam,Confectionery) in Norway(2010-2021)
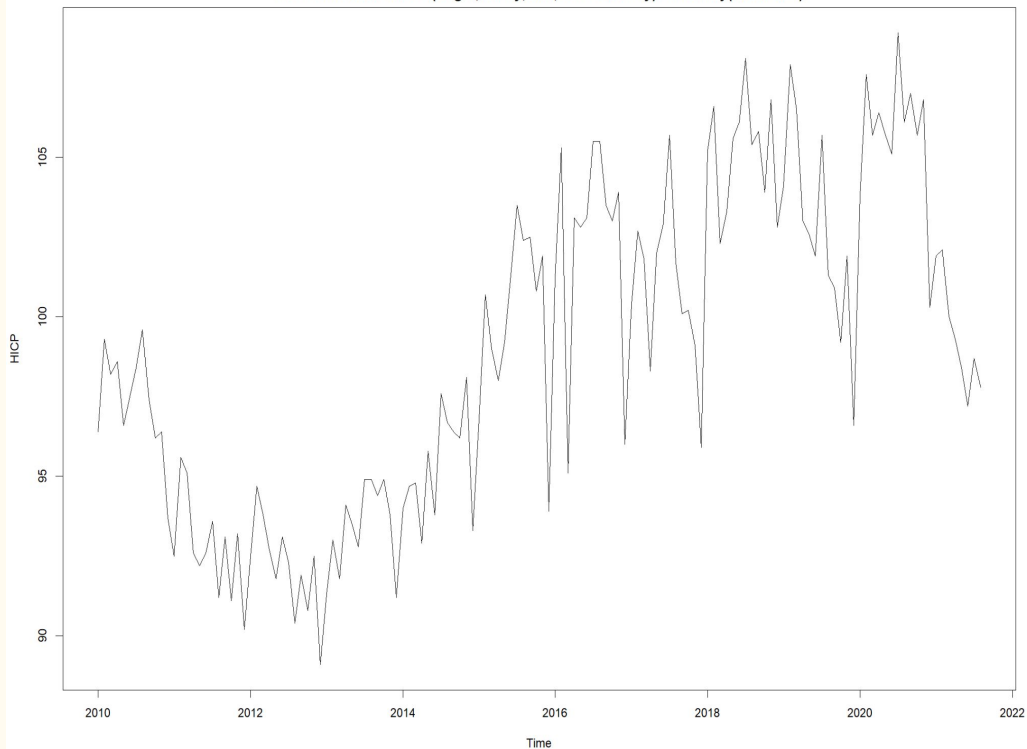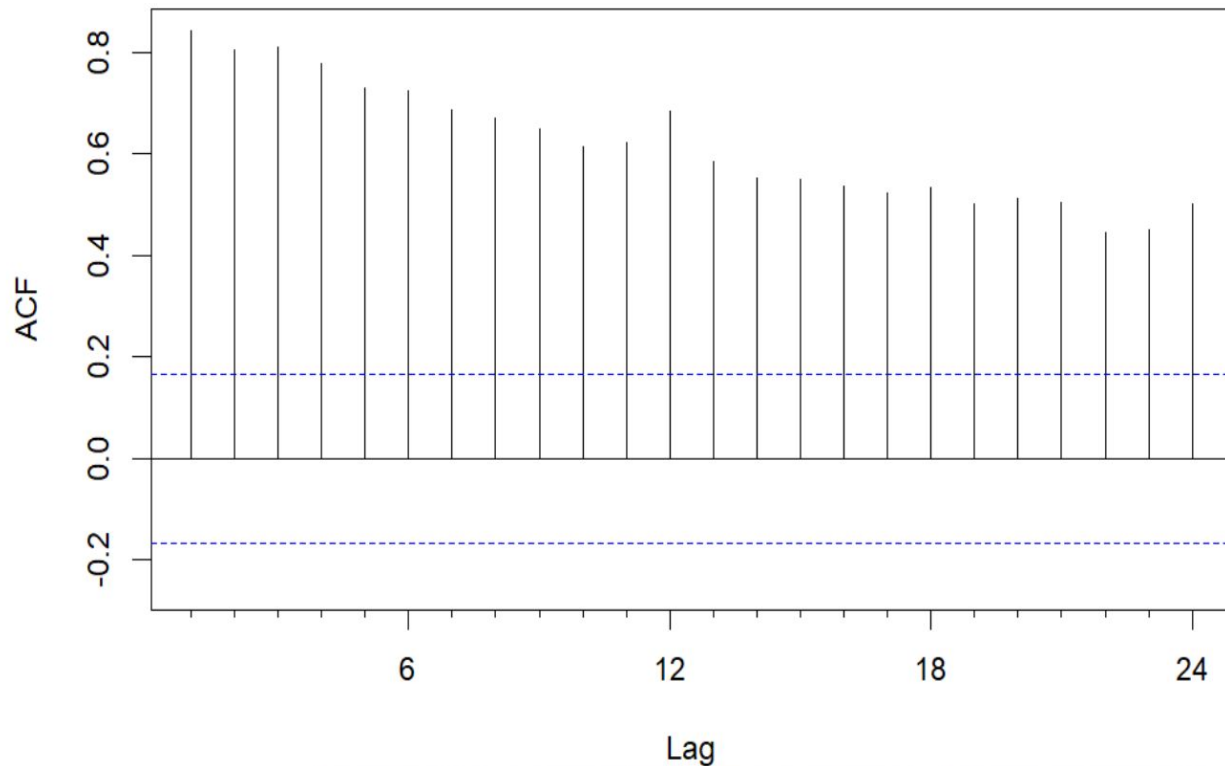

Box-Plot of HICP
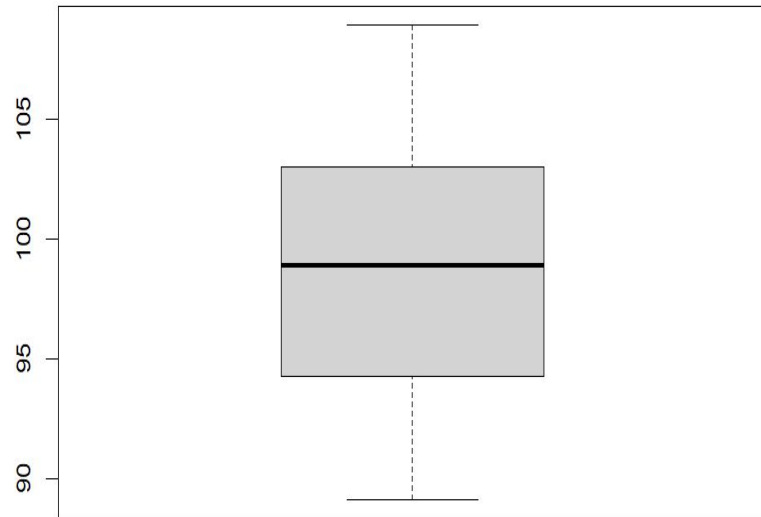
Accuracy Metric

- We are using Root Mean Square Error(RMSE) to determine the efficiency of the forecast.
- Reasons for using RMSE:
  -Root Mean Square Error (RMSE) is the standard deviation of the residuals (prediction errors).
  -RMSE is a measure of how spread out these residuals are. In other words, it tells you how concentrated the data is around the line of best fit.
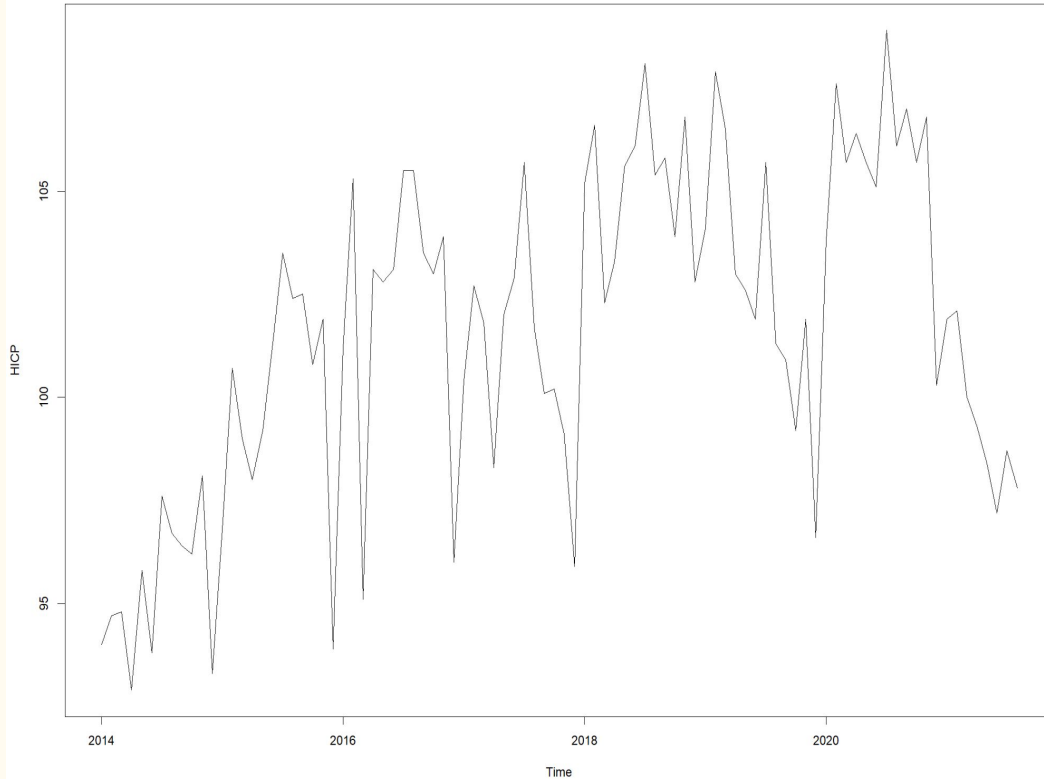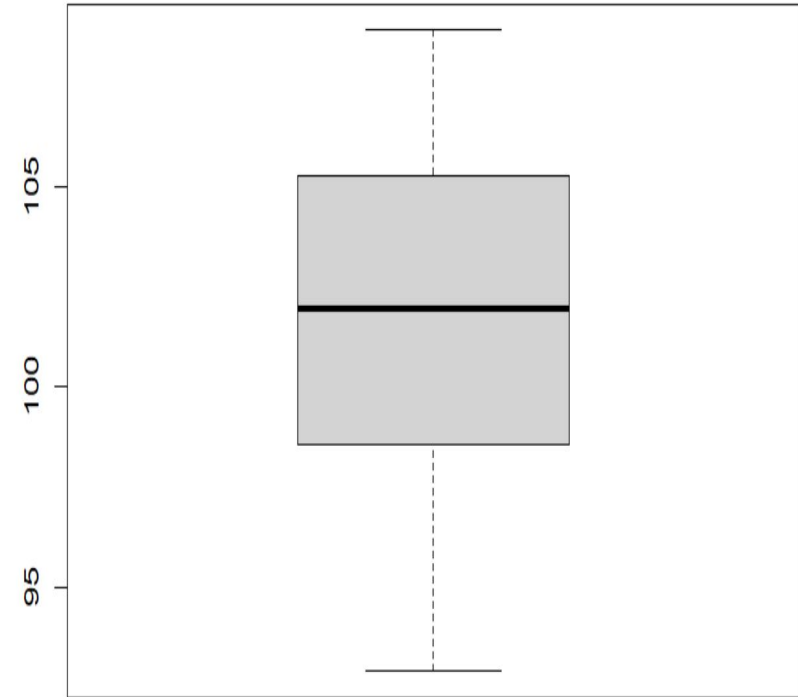
ACF of HICP (2010-2021)

- Not much seasonality to be seen
- Data looks highly correlated
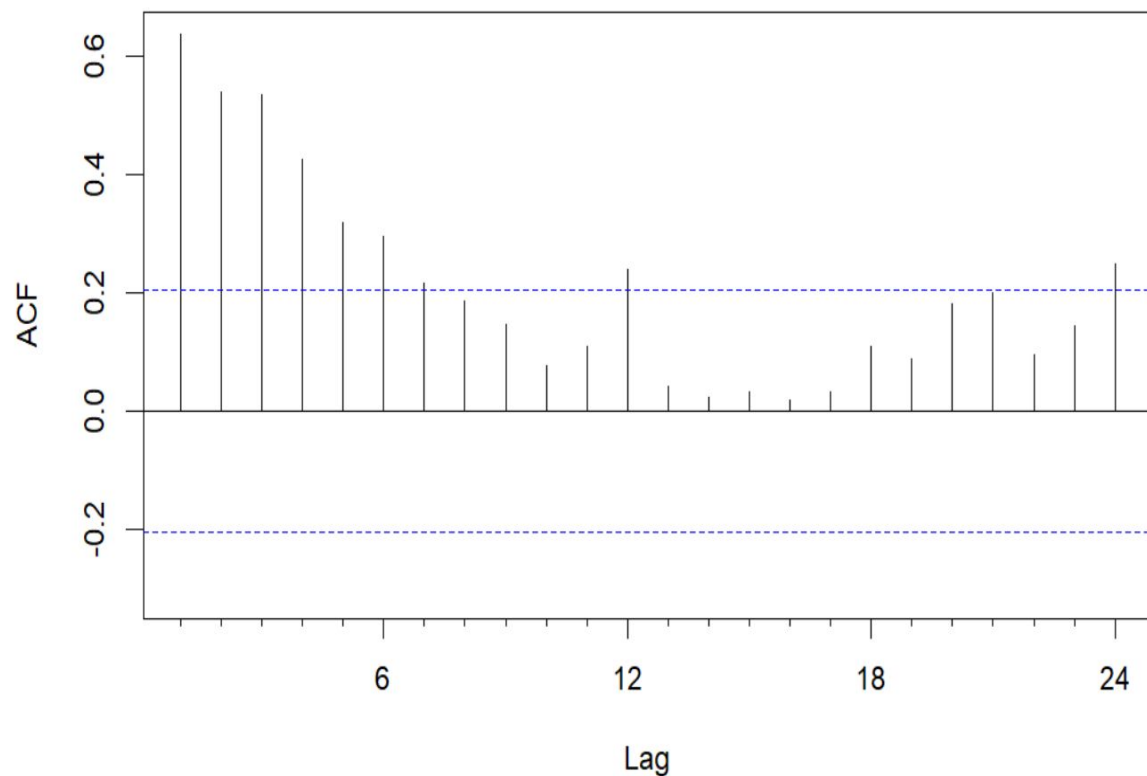
Updated Data (2014-2021)

HICP for Norway (2014-2021)

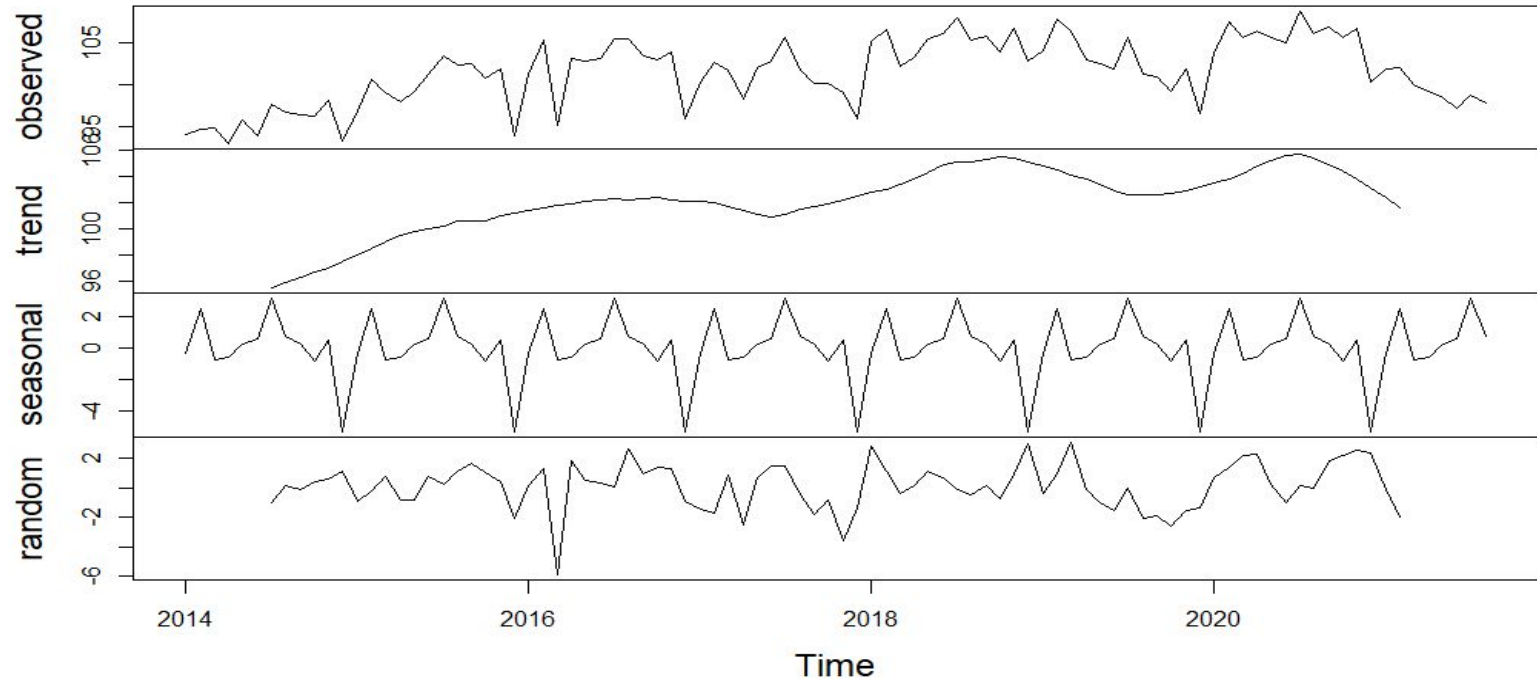BoxPlot of HICP (2014 onwards)

ACF of HICP (2014-2021)

- Can see some seasonality here
- Significant lags can be seen
- Time Series data shows index dipping in Dec every year
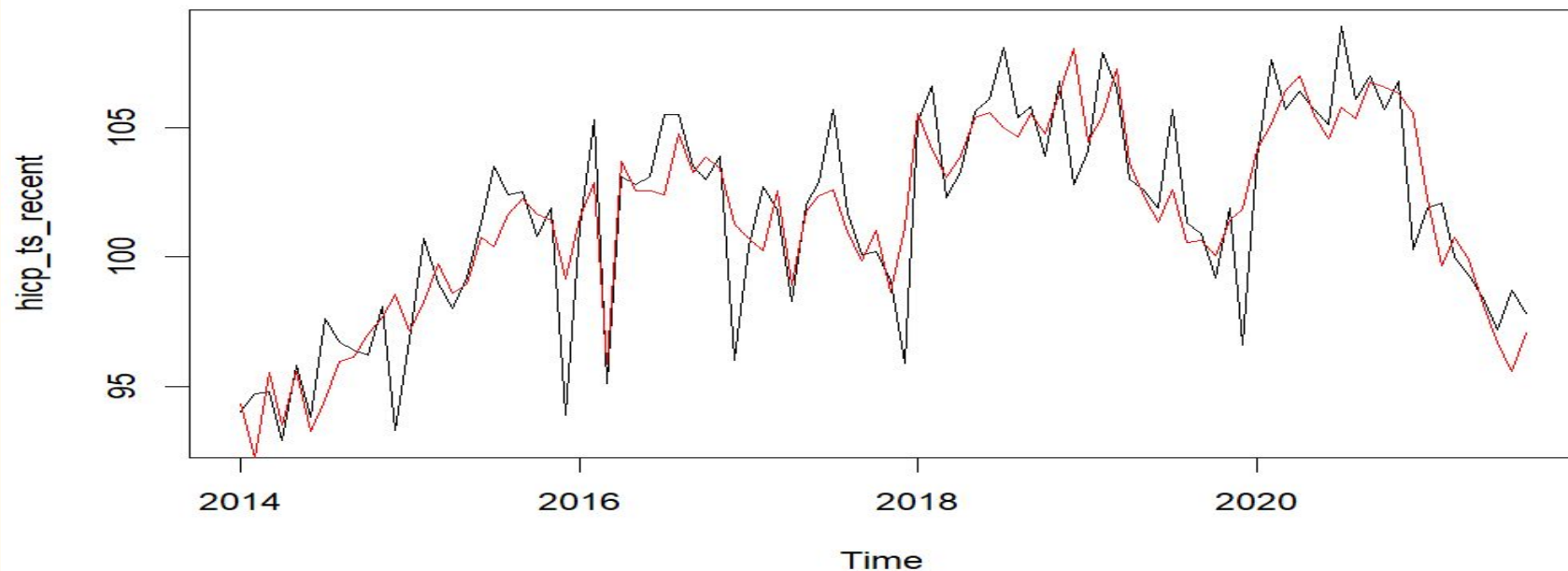
Decomposition of Time Series

Decomposition of additive time series

Seasonally Adjusted HICP

Seasonally Adjusted HICP Data

```
-0.03    0.24  -0.08  -0.06   0.02   0.05   0.31   0.07   0.03  -0.08   0.05  -0.52
```

Naive Forecasting

- We start with the simplest of forecast first which is Naive Forecasting.

- Naive Forecasting principle considers the latest data points to be most relevant


Forecasts from Naive method
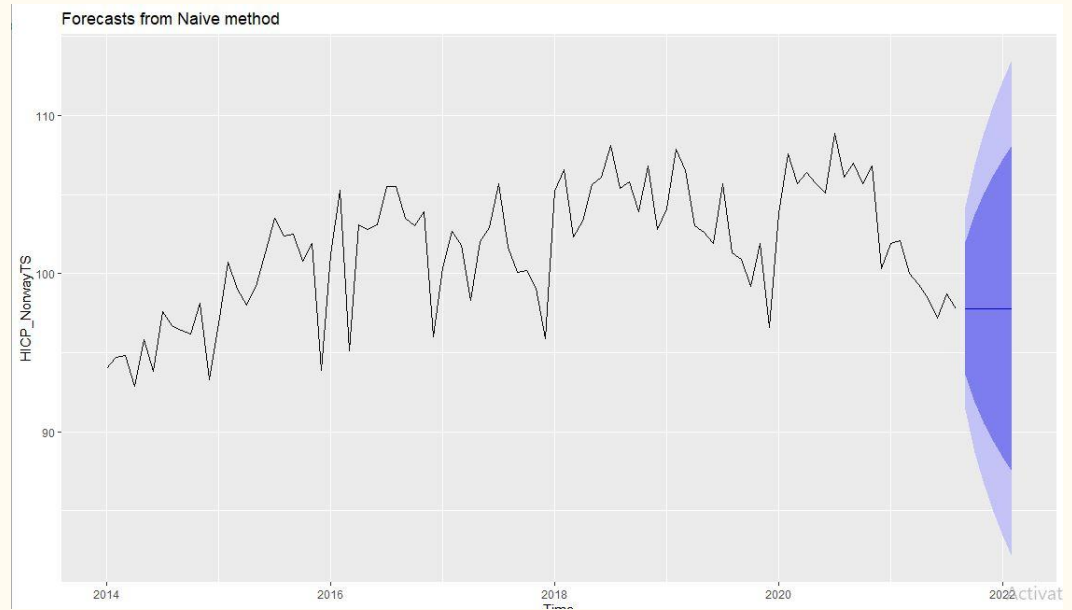
Naive Forecast

|	Point Forecast	Lo 80	Hi 80	Lo 95	Hi 95
Sep 2021	97.8	93.59444	102.0056	91.36815	104.2319
Oct 2021	97.8	91.85244	103.7476	88.70399	106.8960
Nov 2021	97.8	90.51575	105.0842	86.65971	108.9403
Dec 2021	97.8	89.38888	106.2111	84.93630	110.6637
Jan 2022	97.8	88.39608	107.2039	83.41794	112.1821
Feb 2022	97.8	87.49852	108.1015	82.04525	113.5548
Mar 2022	97.8	86.67313	108.9269	80.78292	114.8171
Apr 2022	97.8	85.90488	109.6951	79.60798	115.9920
May 2022	97.8	85.18332	110.4167	78.50445	117.0956
Jun 2022	97.8	84.50085	111.0992	77.46070	118.1393
Jul 2022	97.8	83.85173	111.7483	76.46796	119.1320
Aug 2022	97.8	83.23151	112.3685	75.51941	120.0806

Residual Analysis of Naive
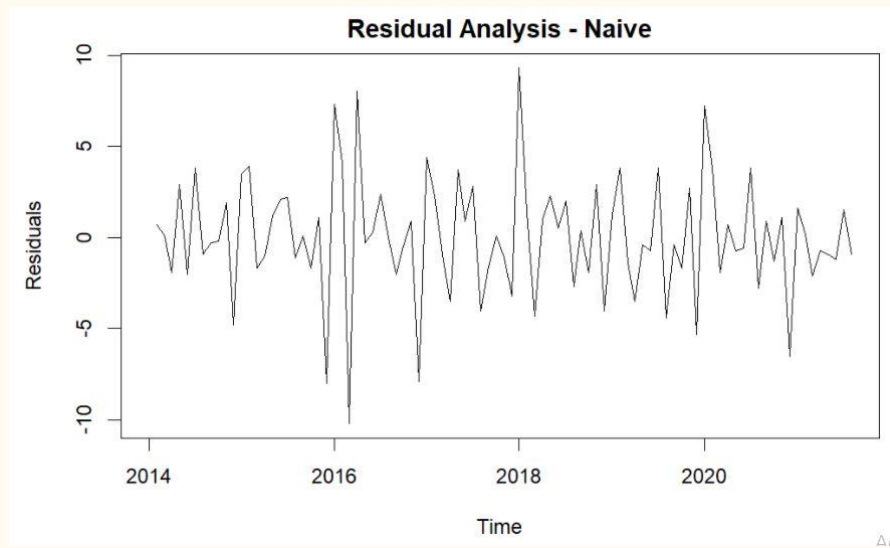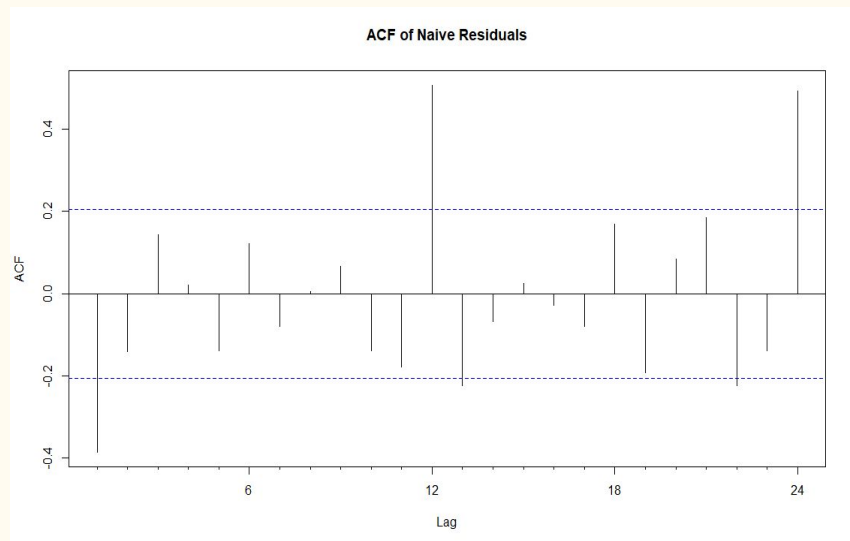
Histogram of Naive Residuals
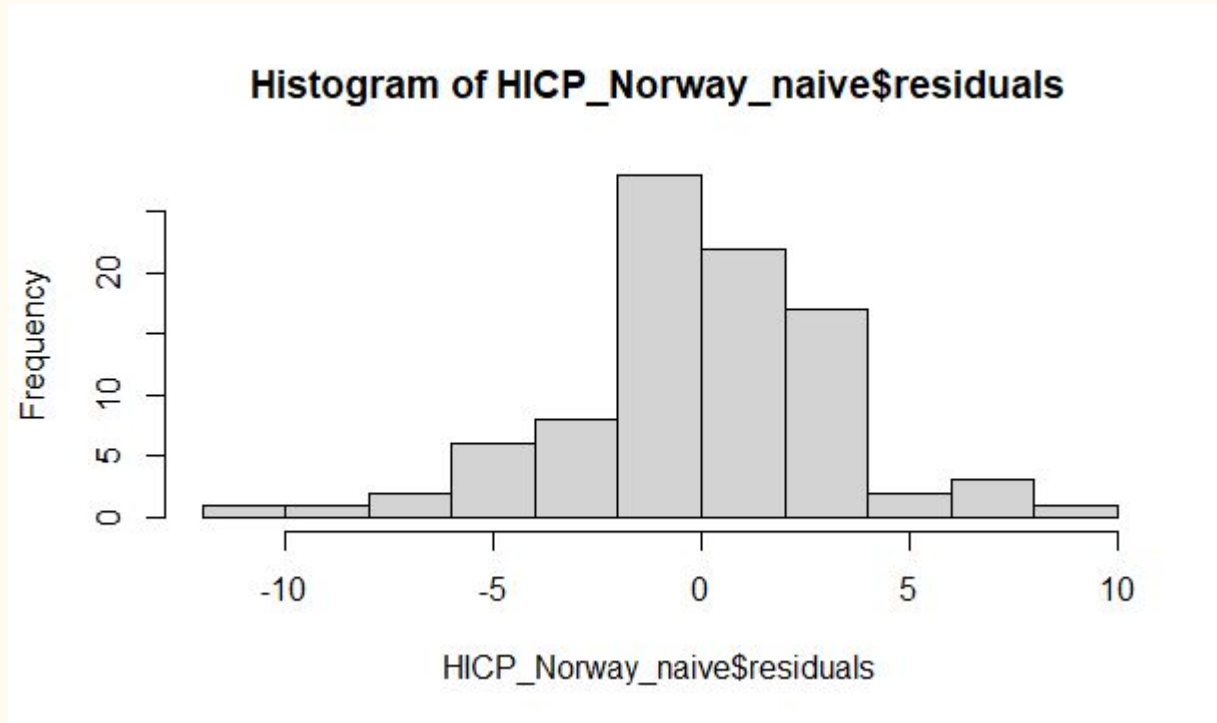
Residual Vs Actual and Residual Vs Fitted
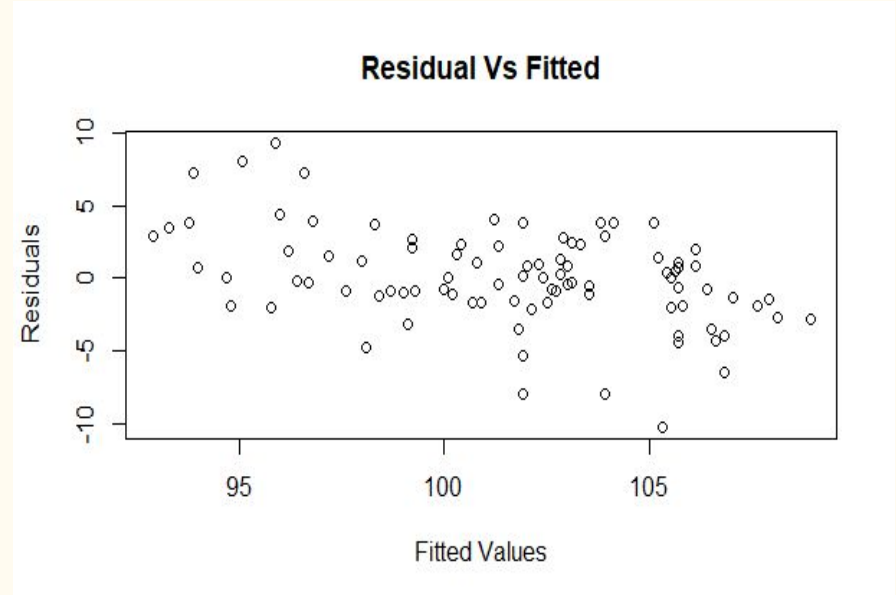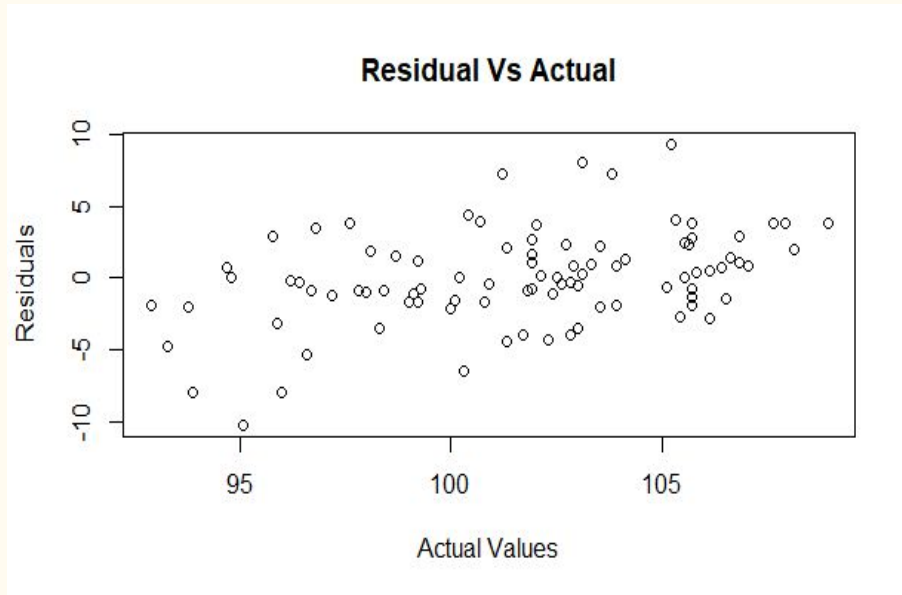
Accuracy of Naive Model

	ME	RMSE	MAE	MPE	MAPE	MASE
Training set	0.04175824	3.281617	2.43956	-0.009851831	2.415338	0.6313971

- Considering the RMSE value for the comparison of models.
- RMSE is 3.2816

ETS Forecasting

Exponential smoothing breaks down the data into its components such as seasonality, trend and noise.

Decomposition by ETS(A,Ad,A) method
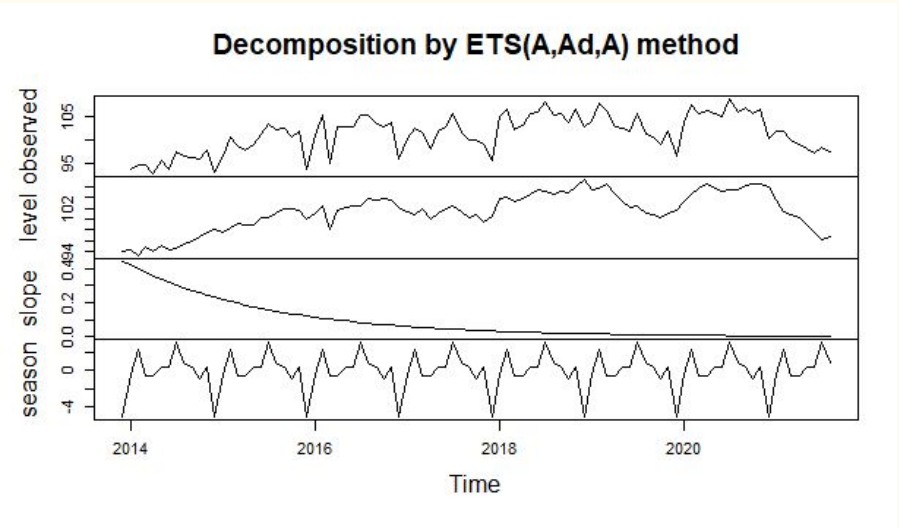
Smoothing Factor of ETS

```
ETS(A,Ad,A)

Call:
 ets(y = HICP_NorwayTS)

  Smoothing parameters:
    alpha = 0.6337
    beta  = 1e-04
    gamma = 1e-04
    phi   = 0.9474

  Initial states:
    l = 93.9623
    b = 0.4439
    s = -5.244 0.4416 -0.866 0.3362 0.8946 3.1326
          0.4067 0.3043 -0.6567 -0.6168 2.2718 -0.4045

  sigma:  1.9873

     AIC      AICc      BIC
559.5744 568.9443 604.9666
```
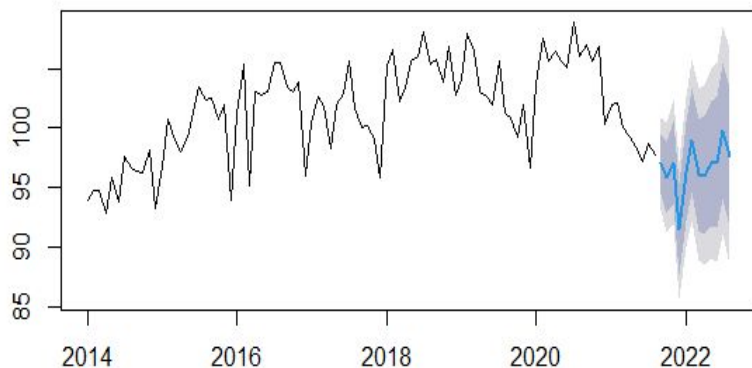
ETS Forecasting

Forecasts from ETS(A,Ad,A)

Forecasts:

|	Point Forecast	Lo 80	Hi 80	Lo 95	Hi 95
Sep 2021	97.02262	94.47581	99.56943	93.12761	100.91762
Oct 2021	95.82236	92.80711	98.83761	91.21093	100.43379
Nov 2021	97.13167	93.71143	100.55190	91.90087	102.36246
Dec 2021	91.44776	87.66557	95.22995	85.66340	97.23212
Jan 2022	96.28891	92.17642	100.40141	89.99940	102.57843
Feb 2022	98.96645	94.54820	103.38469	92.20933	105.72357
Mar 2022	96.07947	91.37524	100.78369	88.88497	103.27396
Apr 2022	96.04084	91.06699	101.01469	88.43400	103.64769
May 2022	97.00315	91.77351	102.23279	89.00510	105.00120
Jun 2022	97.10667	91.63313	102.58021	88.73561	105.47773
Jul 2022	99.83386	94.12679	105.54093	91.10565	108.56206
Aug 2022	97.59701	91.66557	103.52846	88.52565	106.66838

Histogram of Residuals for ETS

Histogram of Residuals for ETS
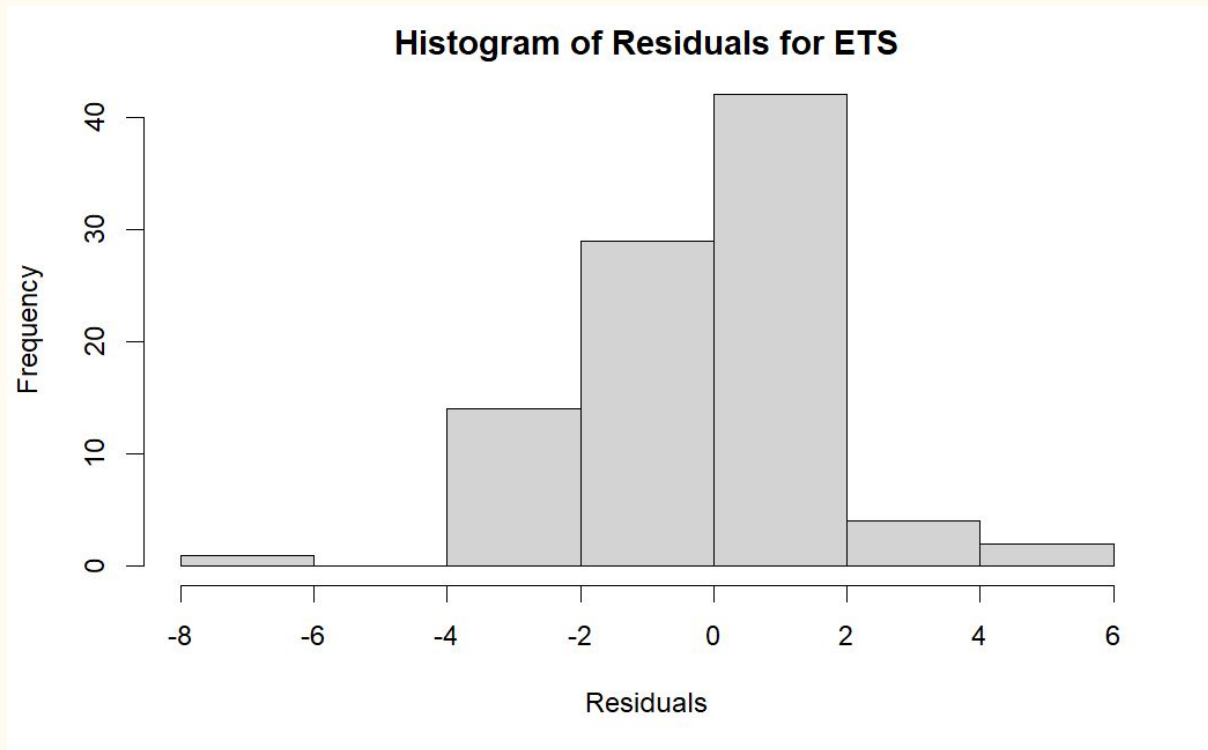
Residual Analysis of ETS
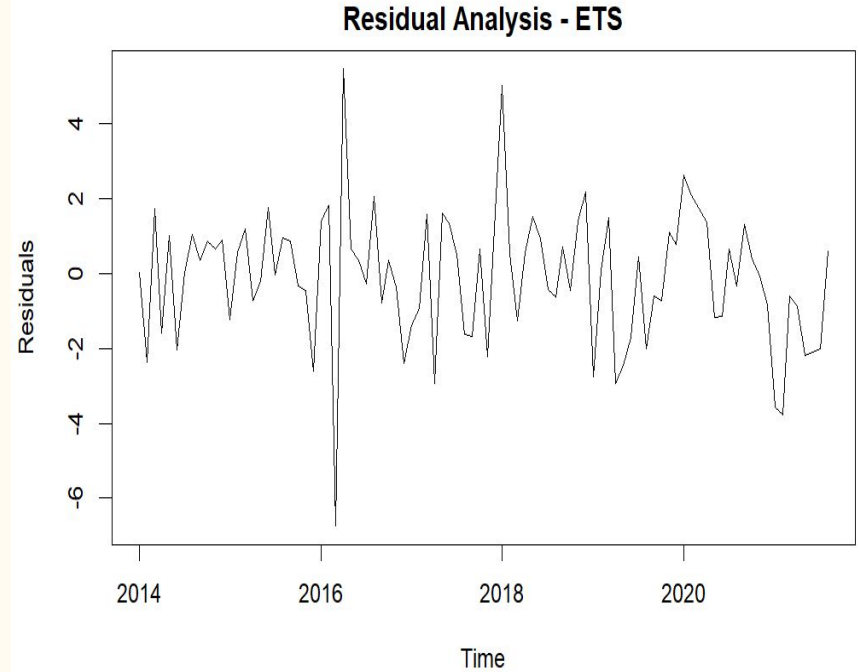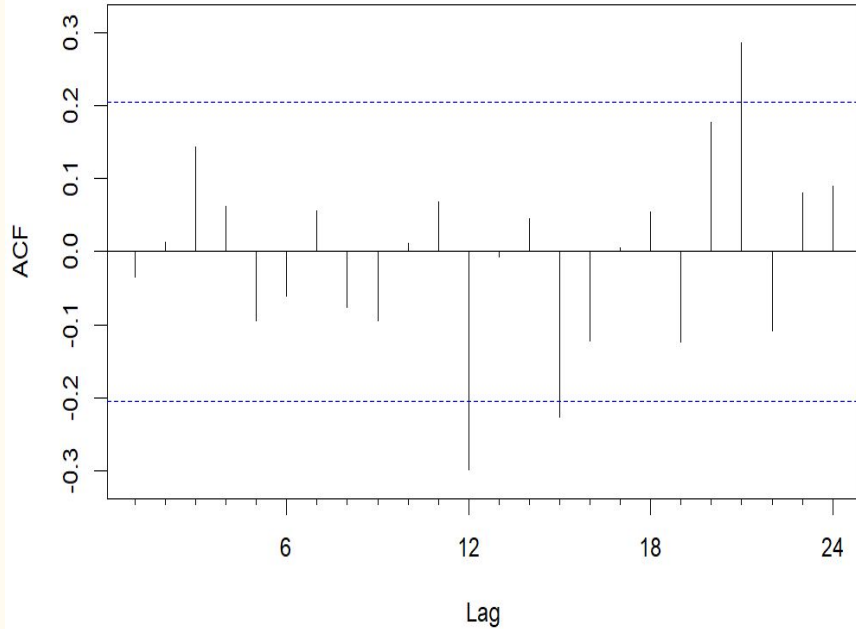
Residual Vs Actual and Residual Vs Fitted
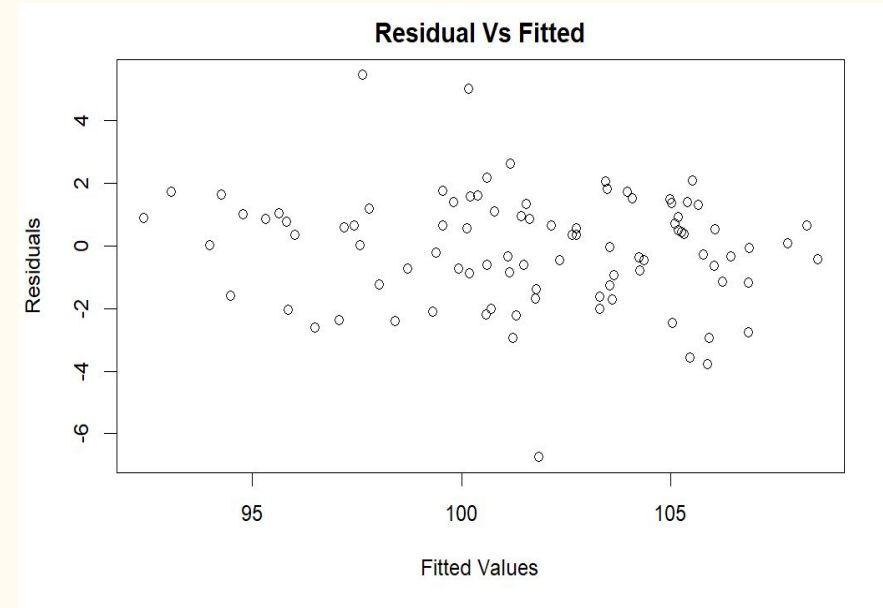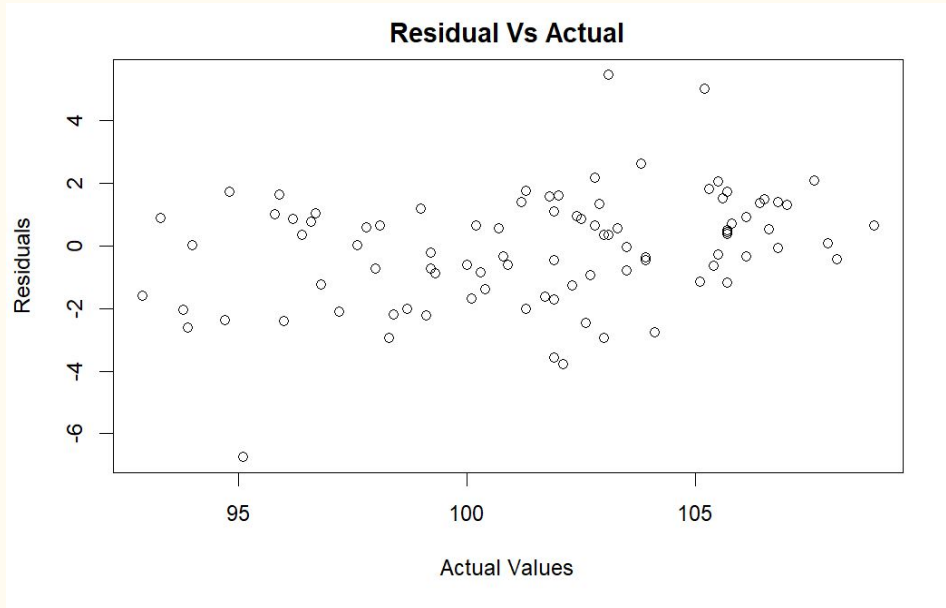
Accuracy Measure - ETS Model

|	ME	RMSE	MAE	MPE	MAPE	MASE
Training set	-0.08966673	1.794307	1.375361	-0.1109913	1.363334	0.3559654

The RMSE and MAE values are comparatively better than NAIVE Model but it can improved using other models.

HOLT-WINTERS

- The fit seems much better than previous models.
- Takes into account level, trend and seasonality component
- Smoothing parameters:
  alpha: 0.6082252
  beta : 0.04712925
  gamma: 0.2289245

Holt-Winters Fitting
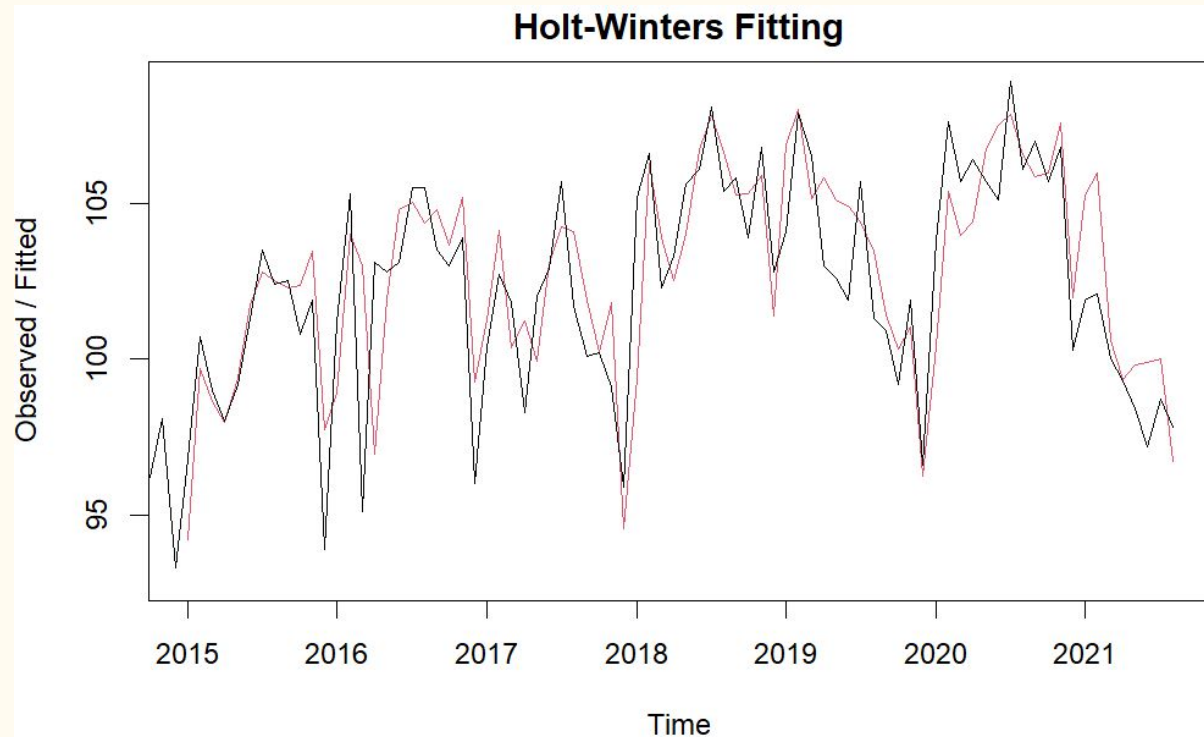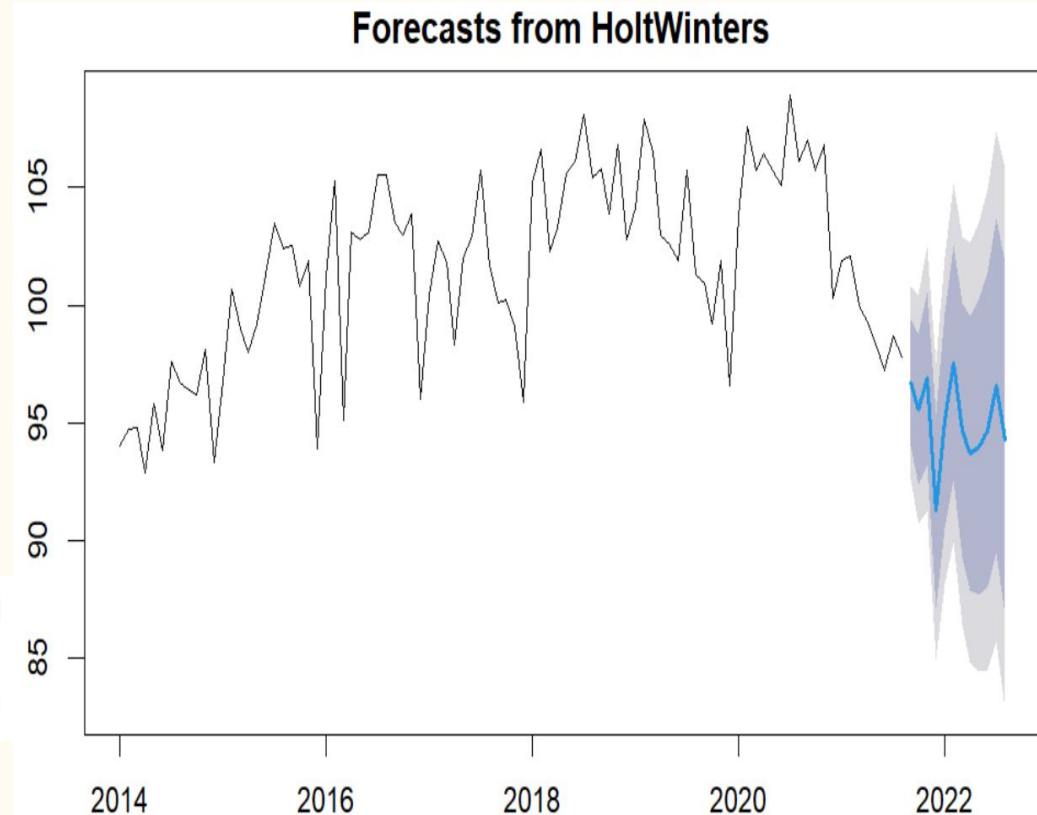
Forecast from Holt-Winters

- 2021 :

Sep	Oct	Nov	Dec
96.70420	95.55149	96.87569	91.25565

- 2022 :

Jan	Feb	Mar	Apr
95.08210	97.54202	94.67059	93.71342

May	Jun	Jul	Aug
93.95899	94.68307	96.55776	94.30499

Forecasts from HoltWinters
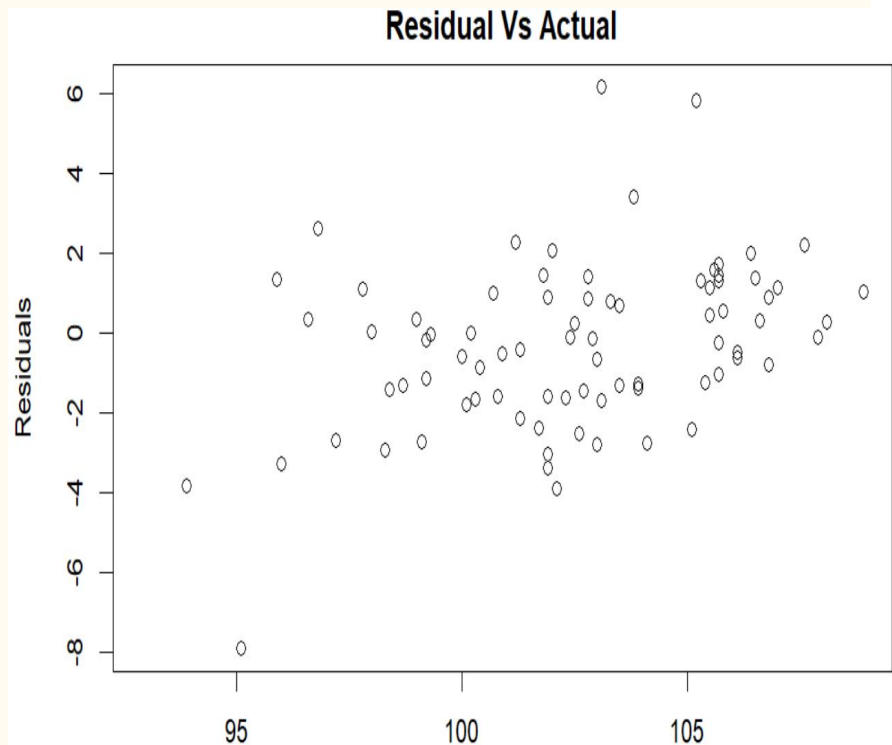
Residual Analysis of Holt-Winters
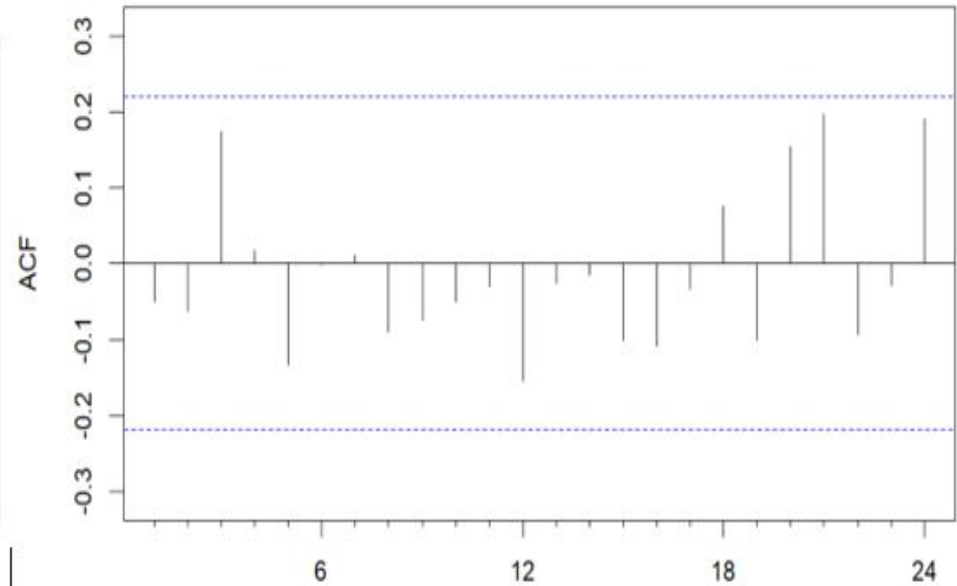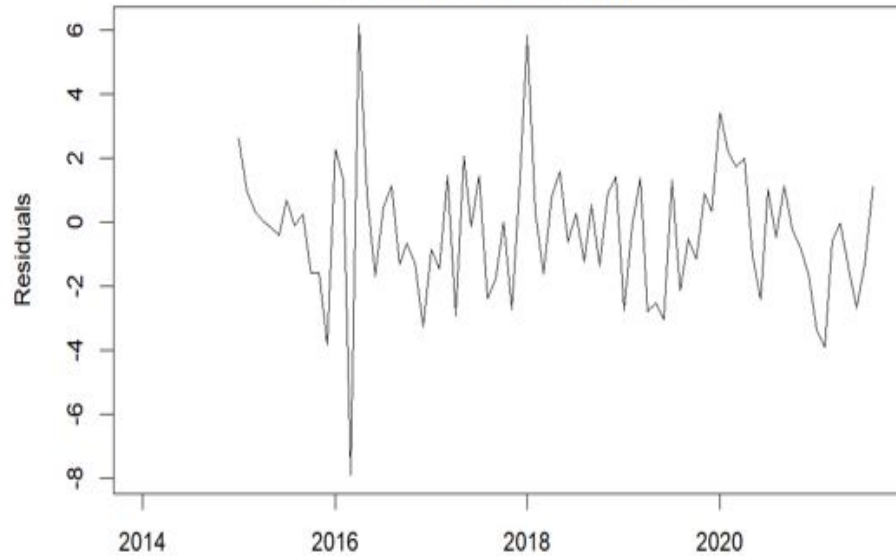
Histogram of Holt-winters Residuals
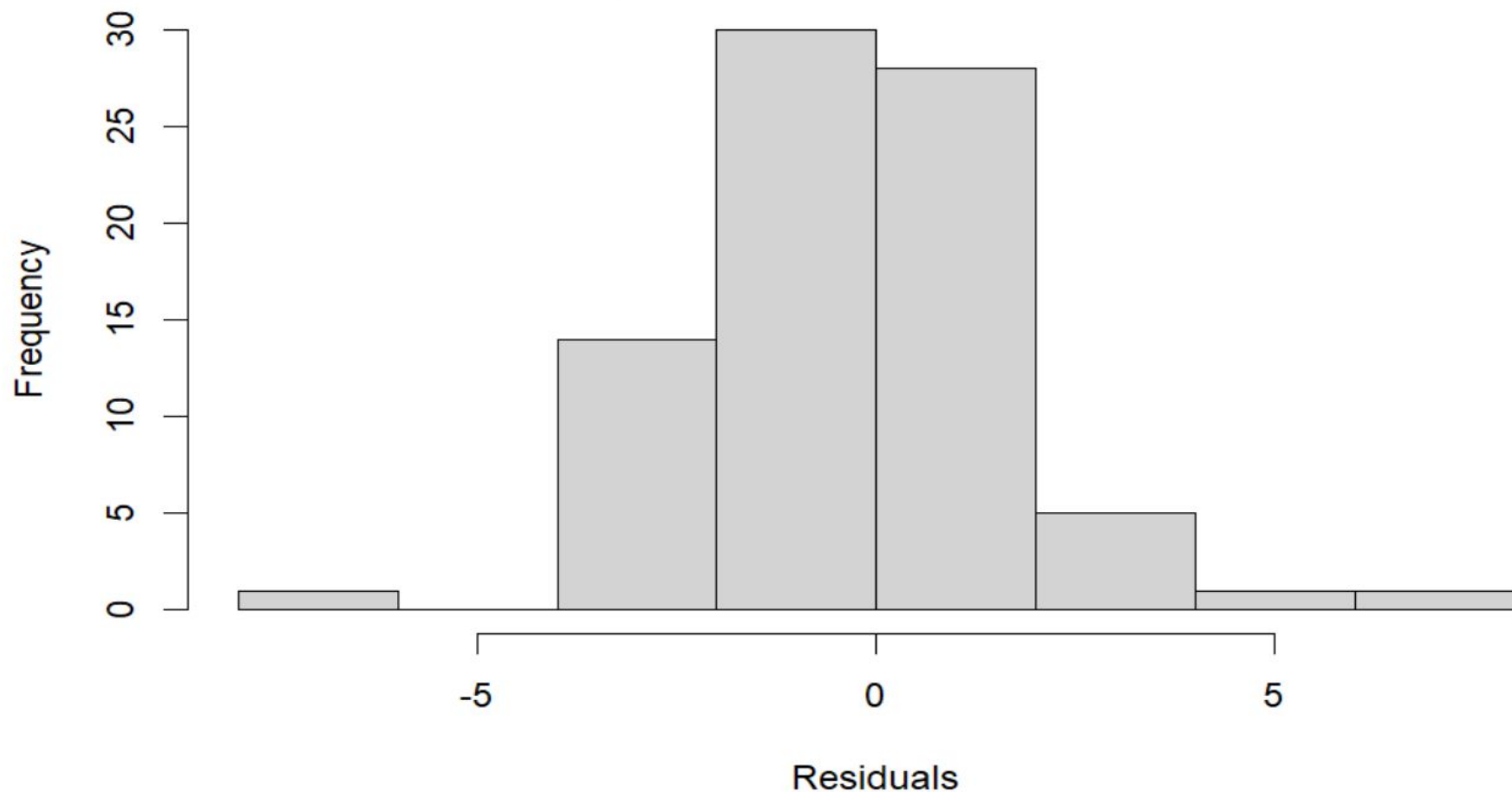
Residual Vs Actual

Residuals Vs Fitted
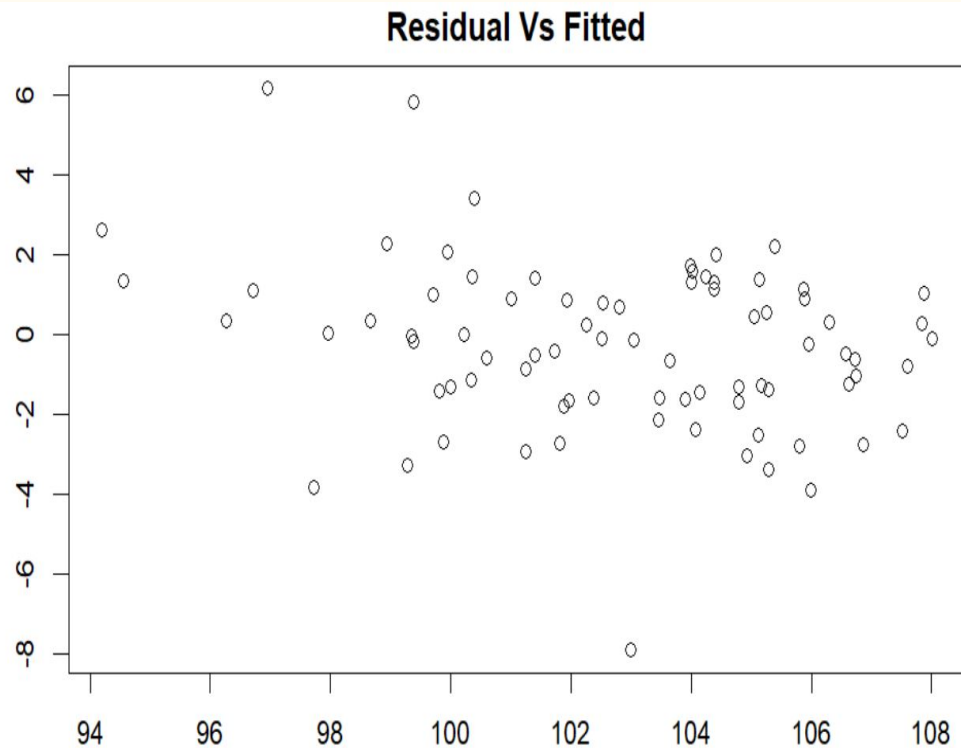
Accuracy Measures (Holt-Winters)

	ME	RMSE	MAE	MPE	MAPE	MASE
Training set	-0.3041817	2.109948	1.591239	-0.3230801	1.566045	0.4118379

- RMSE and MAE look much better than Naive but could be better when compared to ETS
- The ACF looks much better than ETS and Naive

Simple Moving Averages

- Order 3 (Red) plot follows the actual data (Grey) closely
- Order 6 (Orange) plot is somewhat smoother compared to Order 3
- Order 9 (Purple) is smoothest.

Time Series Plot for HICP - Norway
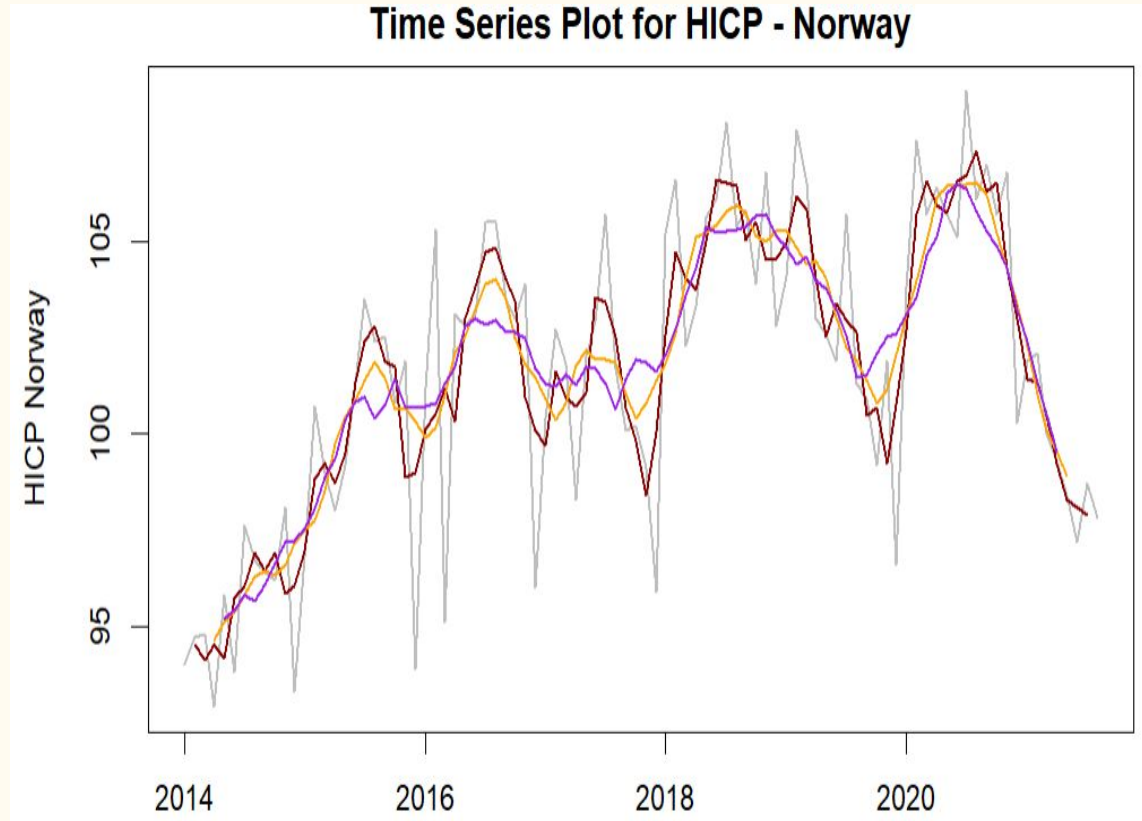
Forecast Using Moving Averages

- 2021:

May	Jun	Jul	Aug
98.86074	98.33009	97.90444	97.56299
Sep	Oct	Nov	Dec
97.28911	97.06941	96.89318	96.75181

- 2022:

Jan	Feb	Mar	Apr
96.63842	96.54746	96.47450	96.41597

Forecasts from ETS(A,Ad,N)
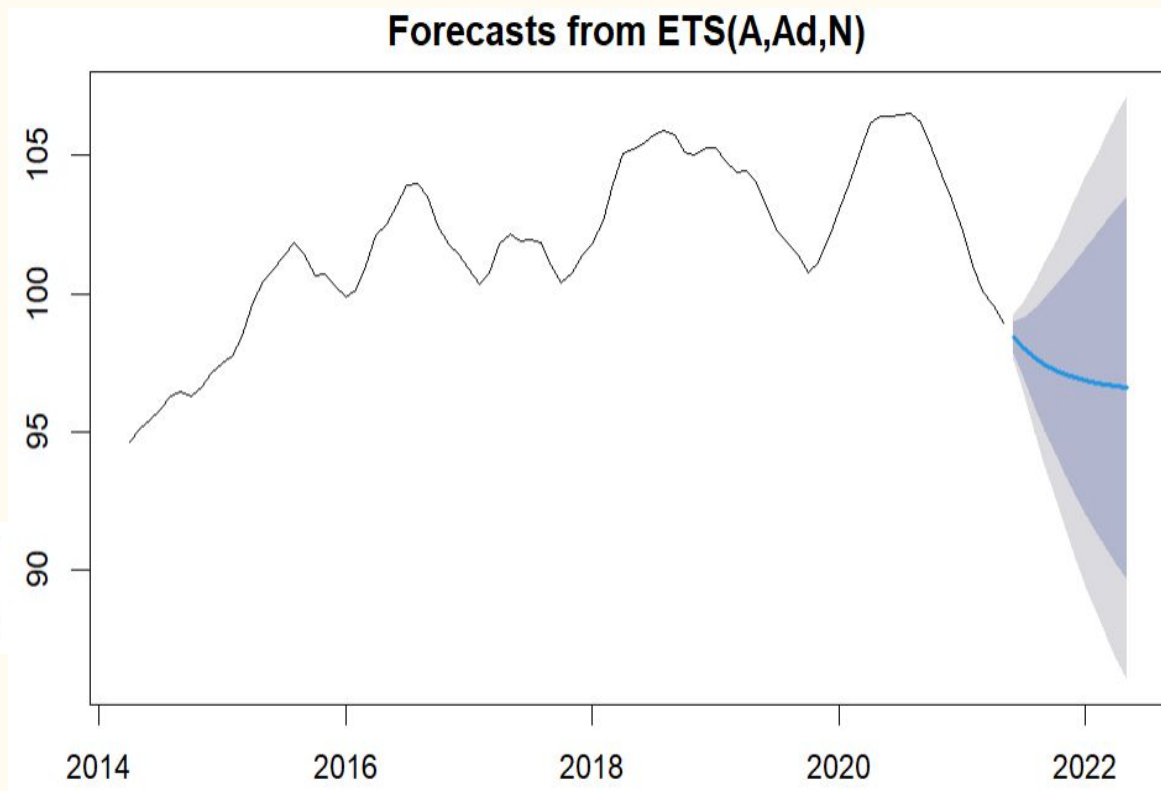
Residual Analysis of Moving Averages
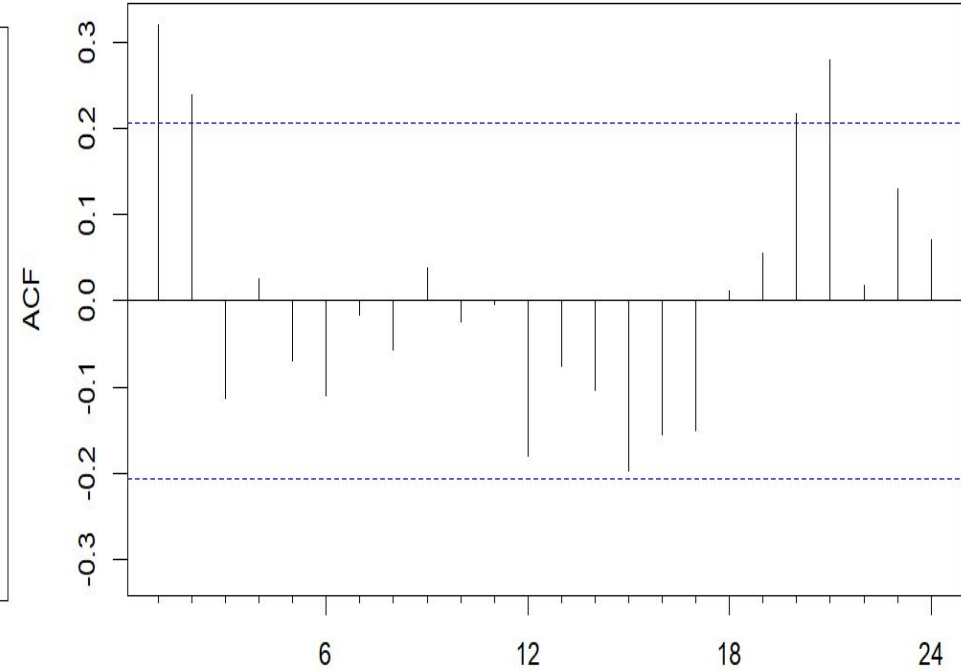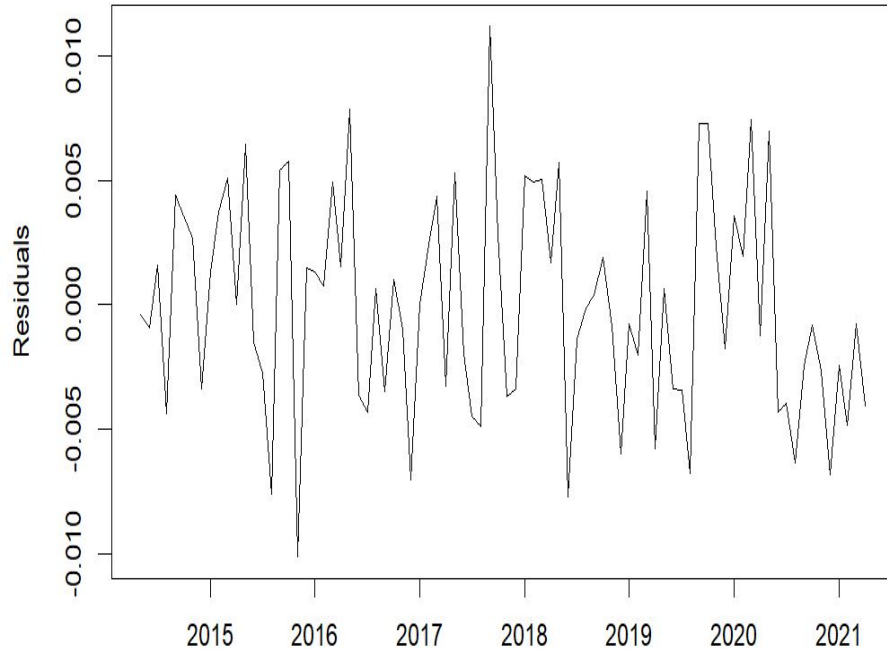
Histogram of Residuals for Simple MA (order=6)

Residual Vs Actual
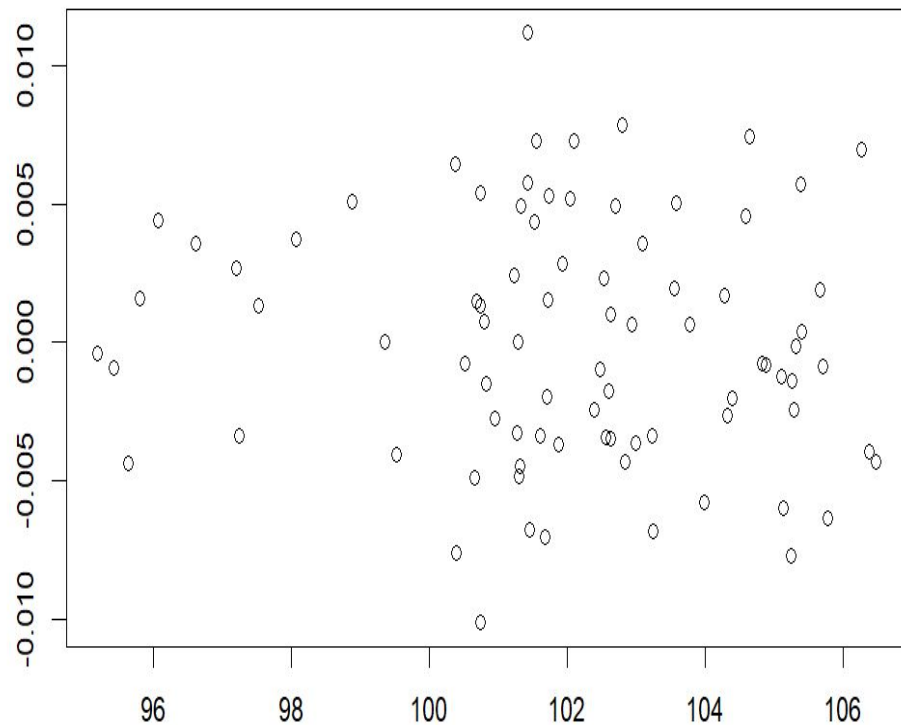
Residuals Vs Fitted
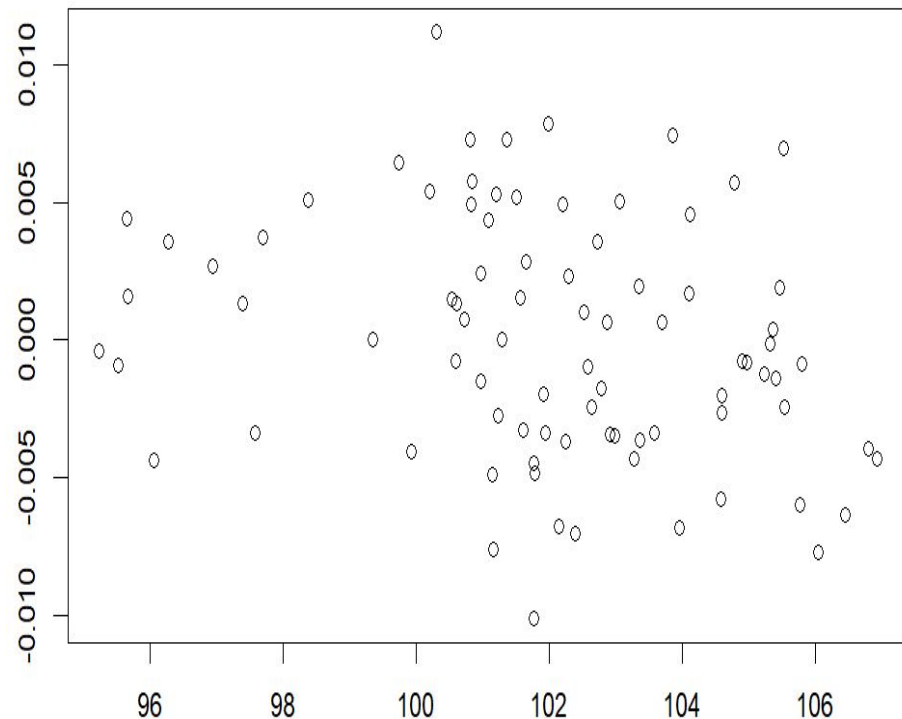
Accuracy Measures for MA

- Order= 9

	ME	RMSE	MAE	MPE	MAPE	MASE
Training set	-0.002987679	0.4463498	0.370536	-0.001905518	0.3628843	0.1488484

- Order= 6
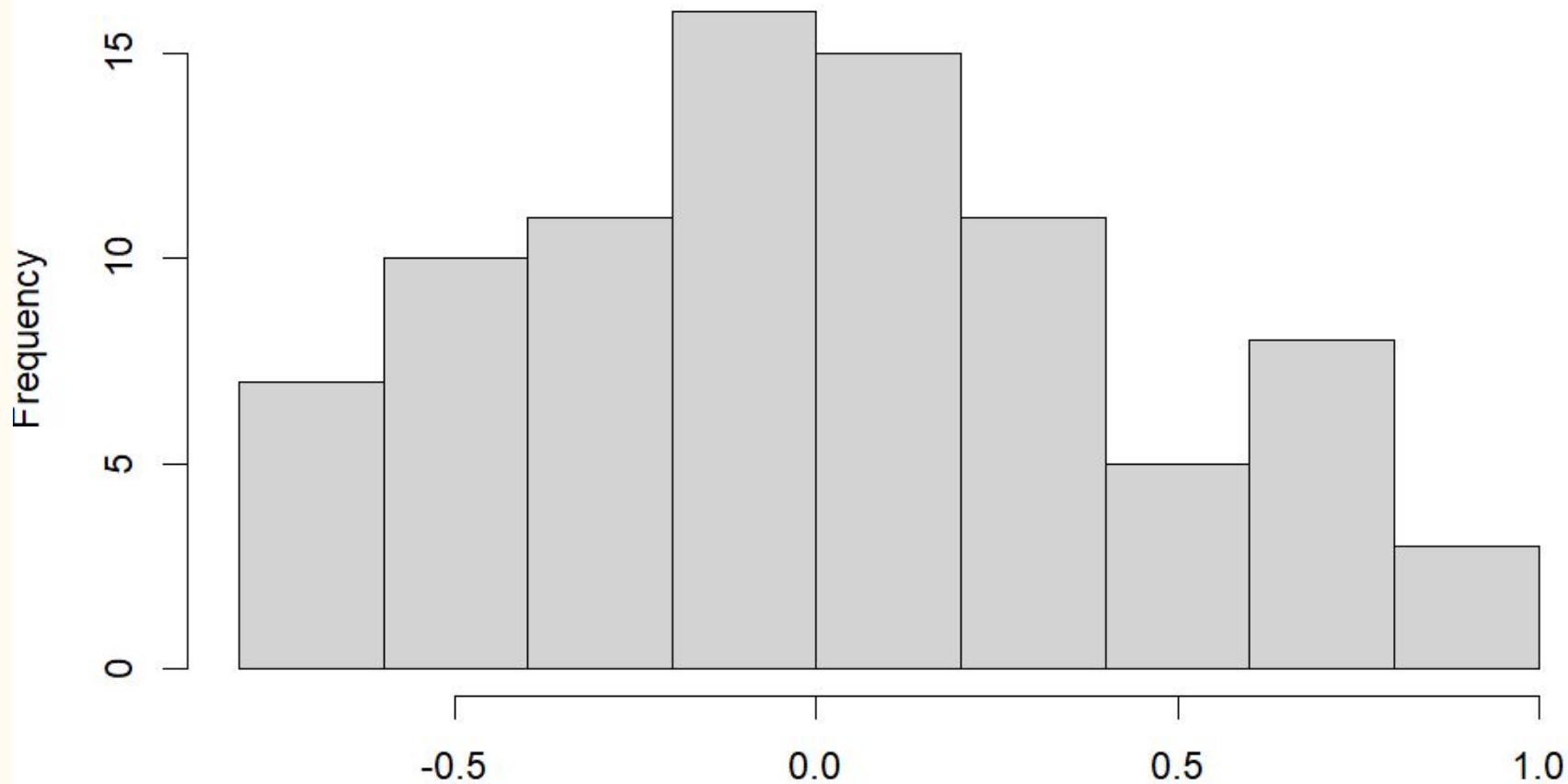
	ME	RMSE	MAE	MPE	MAPE	MASE
Training set	0.01095049	0.4166802	0.344412	0.01351231	0.3381337	0.1193141

- Order= 3

	ME	RMSE	MAE	MPE	MAPE	MASE
Training set	-0.008960104	0.768153	0.6041846	-0.009421314	0.5951015	0.1793014

ARIMA

```
> ndiffs(hicp_ts_recent)
[1] 1
> nsdiffs(hicp_ts_recent)
[1] 0
>
```

- Differences needed to make data stationary = 1
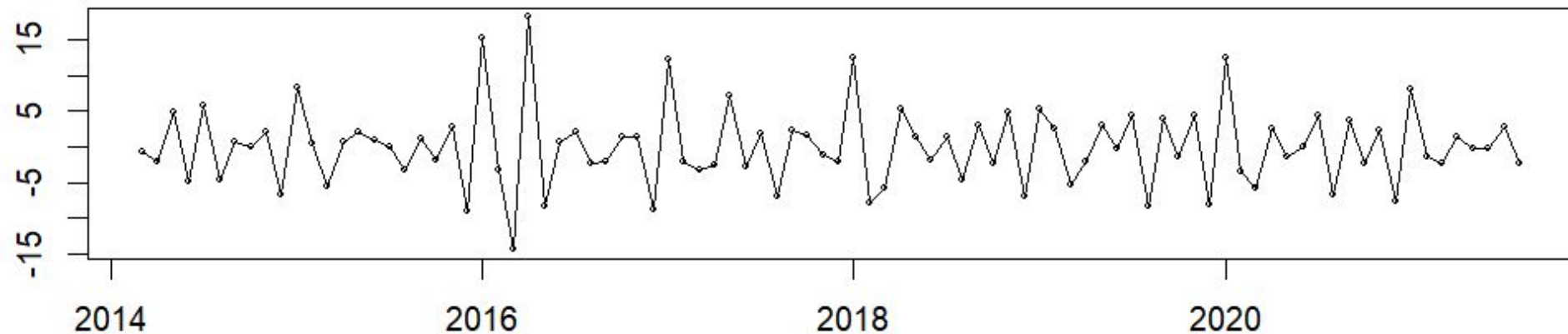- Seasonal difference required = 0
- d=1

Non-Stationary TS plot
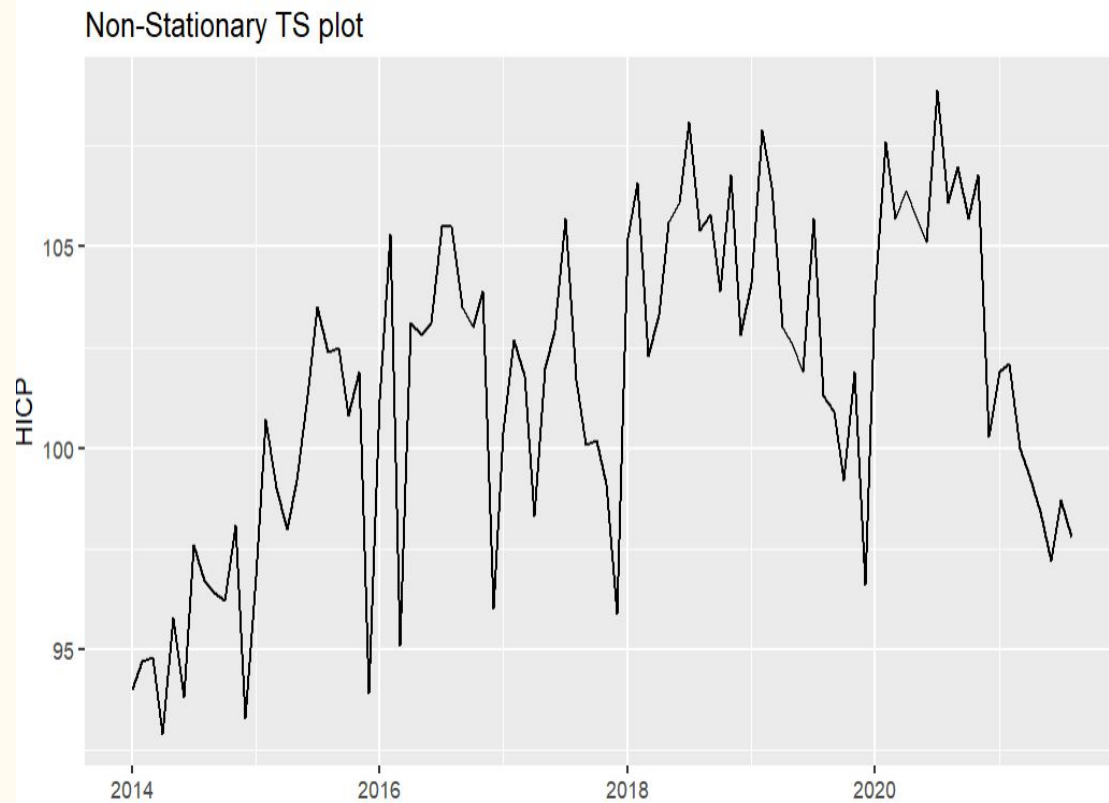
Plot of Stationary Data after Differences

HICP Time Series(Stationary)

- PACF shows significant lag at 12
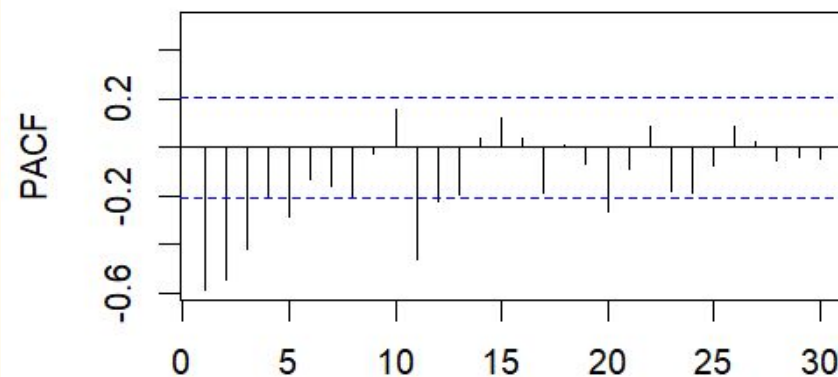
Fitting the ARIMA Model

```
auto_fit <- auto.arima(hicp_ts_recent,trace=TRUE,stepwise=FALSE,approximation=FALSE)
auto_fit
```

```
Series: hicp_ts_recent
ARIMA(0,1,1)(2,0,0)[12]

Coefficients:
          ma1     sar1     sar2
      -0.4680   0.2310   0.5053
s.e.   0.0861   0.0841   0.0938

sigma^2 estimated as 4.759:  log likelihood=-203.71
AIC=415.42    AICc=415.89    BIC=425.47
```

```
Best model: ARIMA(0,1,1)(2,0,0)[12]
```

- Non-seasonal component : MA1 model
- Seasonal component : AR1 and AR2 model
- Significant spike : Lag 12

Forecast Using ARIMA

- 2021 :

	Sep	Oct	Nov	Dec
	97.27438	96.11509	97.73343	93.55385

- 2022 :

	Jan	Feb	Mar	Apr
	97.56136	99.52755	98.08239	98.27435

Forecasts from ARIMA(0,1,1)(2,0,0)[12]
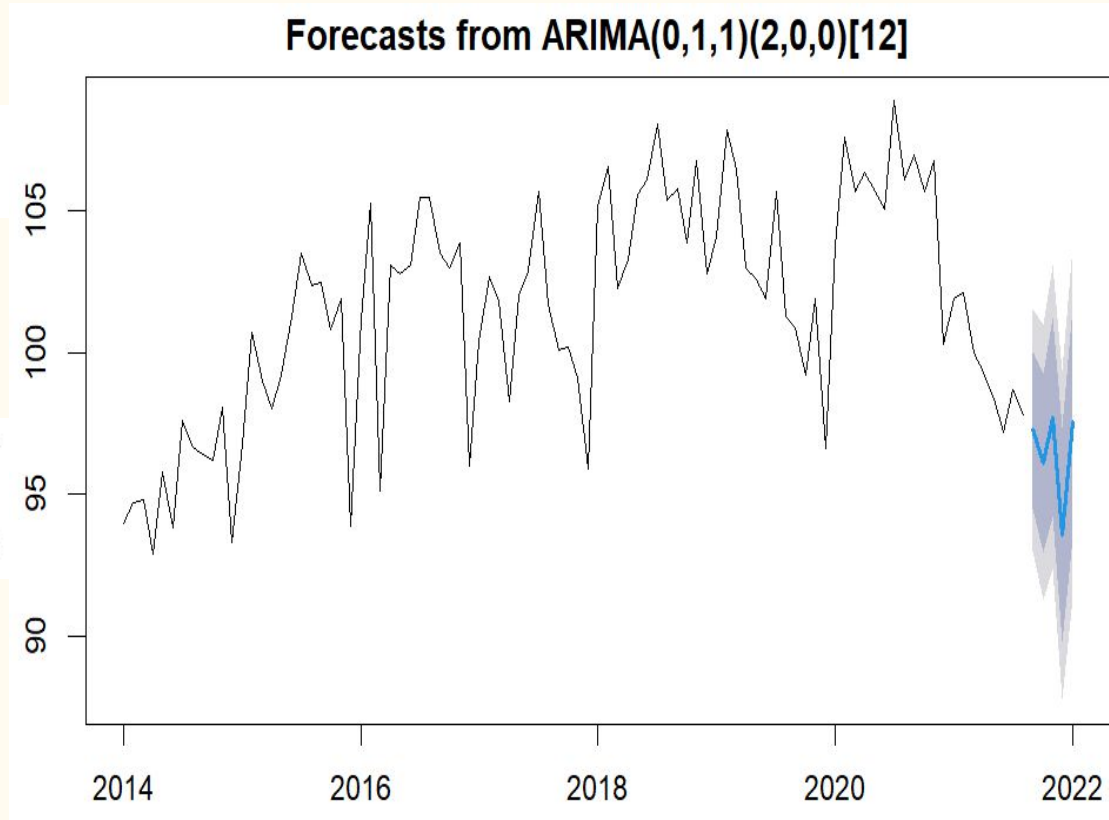
Residual Analysis of ARIMA
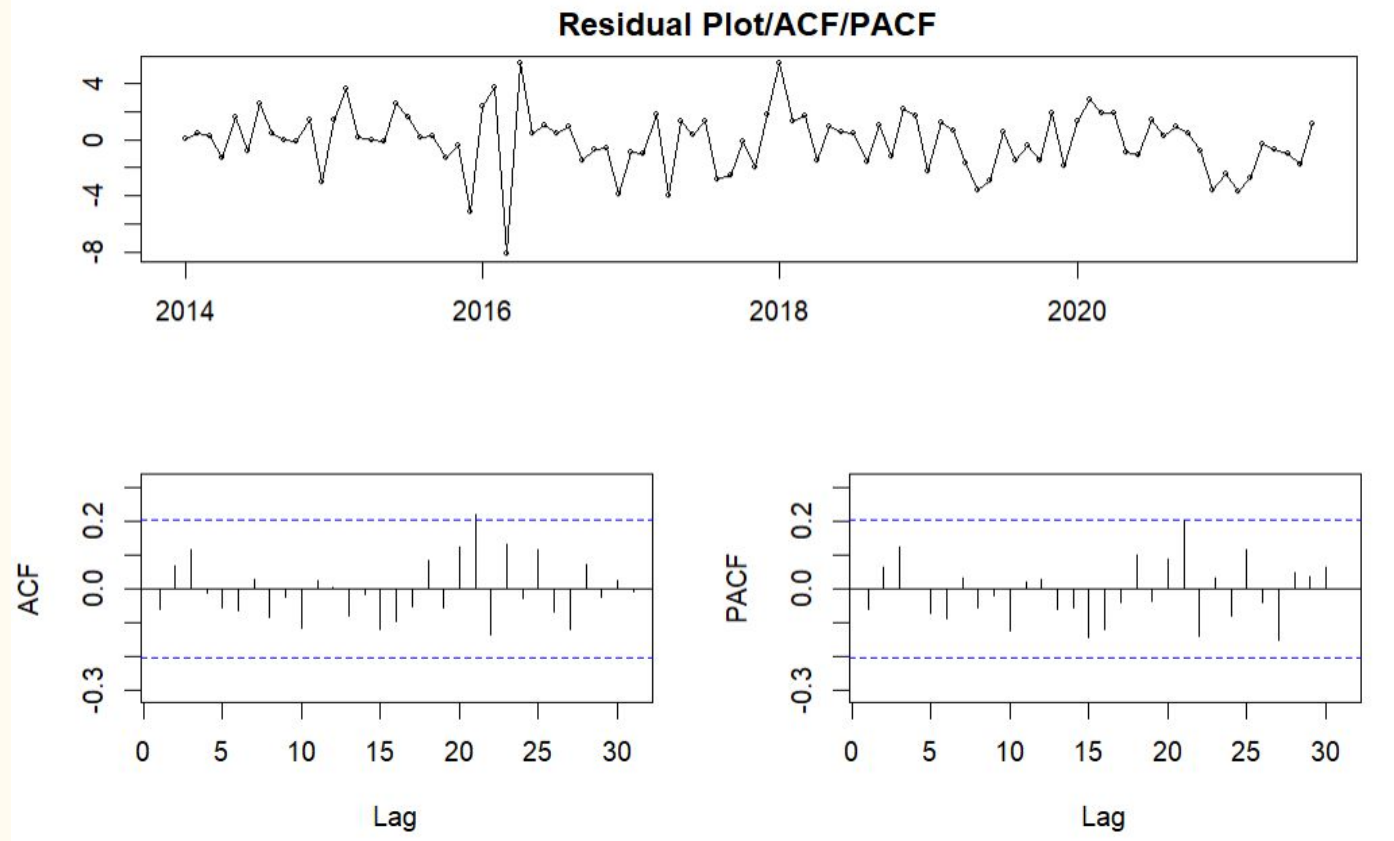
Accuracy Measures for ARIMA

```
                      ME      RMSE       MAE        MPE      MAPE       MASE
Training set -0.1087859  2.133462  1.615173 -0.1367518  1.599689  0.4180325
```

- Accuracy measures are comparable to that of Holt-Winters
- ACF of residuals looks promising

Conclusion

	ME	RMSE	MAE	MPE	MAPE	MASE
Naïve	0.041758	3.281617	2.43956	-0.00985	2.415338	0.631397
ETS	-0.08967	1.794307	1.375361	-0.11099	1.363334	0.355965
HW	-0.30418	2.109948	1.591239	-0.32308	1.566045	0.411838
Moving Avg	-0.0754	0.472928	0.372857	-0.0736	0.365083	0.132861
ARIMA	-0.10879	2.133462	1.615173	-0.13675	1.599689	0.418033

- Moving Averages show the best accuracy measures among all the given models
- But ACF of residuals for MA was not satisfactory
- In comparison, Holt-Winters and ARIMA both show comparable accuracy measures while the ACF of residuals look satisfactory too.
- Going back to the FRED website we could see that HICP for September and October has been updated : 97.6 for September and 96.2 for October. If we look at ARIMA model, we can see that it has made a pretty spot on prediction for Sept 2021 and Oct 2021. This means the ARIMA model is very much reliable

THANK YOU!!