Q. Understand and Explain your model output

Mean Forecast

```
print(mean_forecast)
```

```
##     Point Forecast    Lo 80   Hi 80    Lo 95    Hi 95
## 477       136.3954 93.05179 179.739 70.03017 202.7606
## 478       136.3954 93.05179 179.739 70.03017 202.7606
## 479       136.3954 93.05179 179.739 70.03017 202.7606
## 480       136.3954 93.05179 179.739 70.03017 202.7606
## 481       136.3954 93.05179 179.739 70.03017 202.7606
```

The output represents a forecast for beer production over the next few periods (rows 477 to 481).

Point Forecast: This is the most likely estimate of beer production for that period. The model predicts that production will be around 136.3954 megaliters for each of these future periods.

-Lo 80 and Hi 80: These numbers show the range within which the true production value is expected to fall with 80% confidence. In this case, the model is 80% sure that production will be between 93.05179 and 179.739 megaliters.

-Lo 95 and Hi 95: This is a wider range where the model is 95% confident the actual production will fall. The model predicts the production could be as low as 70.03017 or as high as 202.7606 megaliters.

The model expects beer production to be around 136.4 megaliters, but there's some uncertainty. There's an 80% chance that production will be between 93 and 179 megaliters, and a 95% chance it will be between 70 and 203 megaliters.

Naïve Forecast

```
print(naive_forecast)
```

```
##     Point Forecast     Lo 80    Hi 80     Lo 95    Hi 95
## 477            153 127.83894 178.1611 114.51948 191.4805
## 478            153 117.41689 188.5831  98.58033 207.4197
## 479            153 109.41977 196.5802  86.34979 219.6502
## 480            153 102.67788 203.3221  76.03896 229.9610
## 481            153  96.73816 209.2618  66.95495 239.0451
```

The model is predicting that beer production will be 153 megaliters for each of the future periods (rows 477 to 481).

The 80% confidence interval shows that production will likely be between 127.8 and 178.2 megaliters for row 477, with increasing uncertainty in later periods.

The 95% confidence interval shows an even wider range, with production expected to fall between 114.5 and 191.5 megaliters for row 477, and again, the range gets wider for future periods.

The model predicts 153 megaliters of beer production, but as time goes on, there's more uncertainty, with production possibly falling between 127 and 239 megaliters across these periods.

Exponential smoothing

```
print(ets_forecast)
```

```
## ETS(M,A,N)
##
## Call:
## ets(y = Monthlybeerproduction)
##
##   Smoothing parameters:
##     alpha = 0.7427
##     beta  = 1e-04
##
##   Initial states:
##     l = 87.482
##     b = 1.1808
##
##   sigma:  0.1303
##
##      AIC     AICc      BIC
## 5660.876 5661.004 5681.703
```

This output represents the result of an ETS (Error, Trend, Seasonality) model used to forecast beer production. The model type is ETS(M,A,N), which means:

- M: Multiplicative error term.
- A: Additive trend component.
- N: No seasonality.

Here's a simple breakdown:

Smoothing parameters:

- alpha = 0.7427: This controls how much weight is given to recent observations. A higher alpha means the model places more emphasis on recent data.
- beta = 1e-04: This is related to the trend and shows how quickly the trend can change. A low beta indicates a more stable trend over time.

Initial states:

- l = 87.482: This is the initial level of beer production, an estimate of the baseline value.
- b = 1.1808: This is the initial trend, showing how fast production is increasing over time.

sigma = 0.1303: This represents the standard deviation of the error term, which gives an indication of how much random noise or variability is in the data.

Finally, there are model performance metrics:

AIC, AICc, BIC: These are measures of model quality, with lower values indicating a better fit to the data. In this case, the AIC value is 5660.876, suggesting how well this model fits your data compared to other possible models.

This model uses past data to predict future beer production, giving more importance to recent observations and assuming a steadily increasing trend, without accounting for any seasonal patterns.

Holts-Winter

```
print(HW_forecast)
```

```
## Holt-Winters exponential smoothing without trend and without seasonal component.
##
## Call:
## HoltWinters(x = Monthlybeerproduction, beta = FALSE, gamma = FALSE)
##
## Smoothing parameters:
##  alpha: 0.6777264
##  beta : FALSE
##  gamma: FALSE
##
## Coefficients:
##       [,1]
## a 143.7039
```

This output shows the results from a Holt-Winters Exponential Smoothing model applied to the data. This model does not include trend or seasonality, meaning it assumes the data has a consistent level over time without major changes in trend or seasonal patterns.

alpha = 0.6777: This parameter controls how much weight is given to recent observations when smoothing the data. A value close to 1 means recent data points have more influence on the forecast.

beta = FALSE: This indicates that the model is not accounting for a trend in the data.

gamma = FALSE: This means the model does not account for seasonality.

The model is focusing only on the level of beer production and not adjusting for any trend or seasonal patterns.

Coefficient a = 143.7039: This is the model's estimate of the base level of beer production, which is around 143.7 megaliters.

This model assumes the beer production stays relatively stable over time (no upward or downward trend, no seasonal effects), and it smooths the data based on recent observations. The base level of production is estimated to be around 143.7 megaliters.

Simple Smoothing

```
plot(SSE_Simple)
print(SSE_Simple)
```

```
## Holt-Winters exponential smoothing without trend and without seasonal component.
##
## Call:
## HoltWinters(x = Monthlybeerproduction, beta = FALSE, gamma = FALSE)
##
## Smoothing parameters:
##  alpha: 0.6777264
##  beta : FALSE
##  gamma: FALSE
##
## Coefficients:
##       [,1]
## a 143.7039
```

This output shows a Holt-Winters Exponential Smoothing model that forecasts beer production. The model is not considering trend or seasonal patterns, meaning it assumes the beer production remains stable over time.

alpha = 0.6777: Recent observations are given more weight (67.77%) when smoothing the data.

beta = FALSE: No trend is included in the model.

gamma = FALSE: No seasonal effects are included.

Coefficient a = 143.7039: The base level of beer production is estimated to be 143.7 megaliters.

This model predicts beer production assuming a stable production level of around 143.7 megaliters, with no trend or seasonality considered

Q. Pick an accuracy measure, compare your models, and state the best model based on the accuracy comparison

```
##                        ME     RMSE      MAE       MPE     MAPE     MASE
## Training set 1.696866e-15 33.70327 27.52386 -7.224373 23.03646 1.851346
##                   ACF1
## Training set 0.8287035
```

```
accuracy(naive_forecast)
```

```
##                     ME     RMSE      MAE       MPE     MAPE MASE       ACF1
## Training set 0.1258947 19.63328 14.86695 -0.829328 10.81055    1 -0.2276534
```

```
accuracy(rwf_forecast)
```

```
##                        ME     RMSE      MAE        MPE     MAPE     MASE
## Training set 6.192904e-15 19.63287 14.86118 -0.9282214 10.81053 0.999612
##                    ACF1
## Training set -0.2276534
```

```
accuracy(snaive_forecast)
```

```
##                     ME     RMSE      MAE       MPE     MAPE MASE       ACF1
## Training set 0.1258947 19.63328 14.86695 -0.829328 10.81055    1 -0.2276534
```

```
accuracy(ets_forecast)
```

```
##                     ME     RMSE      MAE       MPE     MAPE      MASE
## Training set -1.384217 18.97159 14.82623 -2.175087 10.89679 0.9972614
##                     ACF1
## Training set -0.01723298
```

The output shows the accuracy metrics for different forecasting models, which tell you how well each model fits the data. Here’s a breakdown of the metrics:

ME (Mean Error): The average difference between the forecasted and actual values. Close to zero indicates a better fit.

RMSE (Root Mean Squared Error): The square root of the average squared differences between forecasted and actual values. Lower values mean a better model.

MAE (Mean Absolute Error): The average of the absolute differences between forecasted and actual values. Like RMSE, lower is better.

MPE (Mean Percentage Error): The average percentage difference between the forecasted and actual values. Negative values suggest underestimation, while positive values suggest overestimation.

MAPE (Mean Absolute Percentage Error): Similar to MPE but focuses on the absolute percentage differences. Lower values indicate more accurate forecasts.

MASE (Mean Absolute Scaled Error): This metric is scaled by the errors from a naïve forecast, making it easier to compare. A value close to 1 means the model is similar to a simple forecasting method.

ACF1: The first autocorrelation of the forecast errors. Values close to zero indicate that the forecast errors are not autocorrelated, which is desirable.

Interpretation:

Naive and RW Forecasts: These have relatively higher errors (RMSE ~19.63, MAE ~14.86), meaning they aren’t the best-performing models.

ETS Forecast: This has slightly better error metrics (RMSE ~18.97, MAE ~14.82), indicating it might be performing slightly better than the naïve models.

SNaive Forecast: Similar to naïve and RW forecasts in performance, suggesting that it’s not significantly better or worse.

The ETS model seems to be performing slightly better than the others, but the differences between models aren't huge. Lower error values (like RMSE and MAE) indicate better-fitting models.