Business Forecasting Assignment 4

- Understand and explain your model output

Mean_forecast

```
##          Point Forecast    Lo 80    Hi 80     Lo 95    Hi 95
## Feb 2022       14.64189 1.728834 27.55495 -5.418327 34.70211
## Mar 2022       14.64189 1.728834 27.55495 -5.418327 34.70211
## Apr 2022       14.64189 1.728834 27.55495 -5.418327 34.70211
## May 2022       14.64189 1.728834 27.55495 -5.418327 34.70211
## Jun 2022       14.64189 1.728834 27.55495 -5.418327 34.70211
```

The point forecast is consistently 14.64189 , suggesting that while the expected value is 14.64189, there's an 80% chance that the actual value will be between 1.728834 and 27.55495 and a 95% chance that it will be between -5.418327 and 34.70211.

Naïve forecast model

```
##          Point Forecast      Lo 80    Hi 80     Lo 95    Hi 95
## Feb 2022          12.53  -8.377669 33.43767 -19.44552 44.50552
## Mar 2022          12.53 -17.037910 42.09791 -32.69022 57.75022
## Apr 2022          12.53 -23.683146 48.74315 -42.85323 67.91323
## May 2022          12.53 -29.285339 54.34534 -51.42104 76.48104
## Jun 2022          12.53 -34.220970 59.28097 -58.96944 84.02944
```

The naive forecast for February to June 2022 predicts a constant value of `12.53`, reflecting stability without expected changes. The 80% prediction intervals range from approximately `-8.377669` to `59.28097`, indicating confidence in this range for actual values. Wider 95% intervals span from `-19.4452` to `84.02944`, highlighting greater uncertainty. While this simple model is useful for quick assessments, it may miss underlying trends and variability. Therefore, it should be complemented with more advanced models to enhance forecasting accuracy.

Rwf forecast

```
##          Point Forecast      Lo 80    Hi 80     Lo 95    Hi 95
## Feb 2022       12.27306  -9.221011 33.76712 -20.59928 45.14539
## Mar 2022       12.01611 -18.789124 42.82135 -35.09643 59.12865
## Apr 2022       11.75917 -26.462592 49.98092 -46.69597 70.21430
## May 2022       11.50222 -33.194711 56.19916 -56.85584 79.86028
## Jun 2022       11.24528 -39.348215 61.83877 -66.13079 88.62135
```

The random walk forecast from February to June 2022 shows a slight downward trend, with point forecasts declining from `12.27306` in February to `11.24528` in

June. The 80% prediction intervals for February range from `-9.221011` to `61.83877`, indicating confidence in actual values falling within this range. The wider 95% intervals, spanning from `-20.59928` to `88.62135`, reflect greater uncertainty. This output highlights the importance of considering both expected values and their variability in decision-making. Overall, it provides a framework for understanding potential risks based on historical trends.

snaive forecast model

```
##          Point Forecast      Lo 80    Hi 80      Lo 95    Hi 95
## Feb 2022           4.67  -9.775039 19.11504 -17.421781 26.76178
## Mar 2022          18.95   4.504961 33.39504  -3.141781 41.04178
## Apr 2022          24.80  10.354961 39.24504   2.708219 46.89178
## May 2022           3.61 -10.835039 18.05504 -18.481781 25.70178
## Jun 2022          29.99  15.544961 44.43504   7.898219 52.08178
```

The snaive forecast for February to June 2022 predicts point values that suggest while the expected gross income for February 2022 is 4.67, there is an 80% chance that the actual value will fall between -9.775039 and 19.11504, and a 95% chance that it will fall between -17.421781 and 26.76178.

MA5_forecast

```
##         Jan    Feb    Mar    Apr    May    Jun    Jul    Aug    Sep    Oct
## 2019     NA     NA 17.608 14.510 16.618 13.218 16.942 17.432 17.864 20.412
## 2020 15.996 17.960 10.816 12.892 13.430 12.686 12.532 13.284 11.206 12.026
## 2021  9.258 13.796 11.164 16.404 16.862 16.626 14.414 14.740 13.970 14.220
## 2022     NA
##         Nov    Dec
## 2019 19.754 14.328
## 2020 10.106  7.540
## 2021 13.172     NA
## 2022
```

MA9 Forecast

```
##           Jan      Feb      Mar      Apr      May      Jun      Jul      Aug
## 2019       NA       NA       NA       NA 18.49222 17.04667 15.87000 18.08222
## 2020 16.74778 14.01333 14.44667 14.99556 12.23778 13.15333 12.27889 12.24111
## 2021 11.39556 12.78333 12.40556 14.14556 13.80889 13.97000 16.35556 15.16222
## 2022       NA
##           Sep      Oct      Nov      Dec
## 2019 16.26333 16.67000 17.87222 16.61556
## 2020 10.63222 10.41778 11.13444 12.48222
## 2021 13.79889       NA       NA       NA
## 2022
```

The Holt-Winters exponential smoothing model applies an additive seasonal component to account for both trends and seasonality in the time series data. The smoothing parameters show that the level (alpha) is moderately influential, while the trend (beta) is not being adjusted (set to zero), indicating no significant trend component is detected. The seasonal smoothing parameter (gamma) is also

moderately high, suggesting seasonal effects are captured effectively. The coefficients indicate the model's starting level (a), growth rate (b), and seasonal adjustments for each month, reflecting how seasonal variations influence the forecast. Overall, this model is suited for data with consistent seasonal patterns and no significant underlying trend.

```
## Holt-Winters exponential smoothing with trend and additive seasonal component.
##
## Call:
## HoltWinters(x = sales_data)
##
## Smoothing parameters:
##  alpha: 0.07310714
##  beta : 0
##  gamma: 1
##
## Coefficients:
##           [,1]
## a   11.5084952
## b   -0.3679094
## s1  -5.9564331
## s2   8.0892014
## s3  13.4118539
## s4  -7.5395410
## s5  17.6006105
## s6  -4.7870544
## s7   5.8425153
## s8   2.3556591
## s9  -5.5466939
## s10 13.8137239
## s11 -3.0247246
## s12  1.0215048
```

For exponentially smoothing

```
## ETS(A,N,N)
##
## Call:
## ets(y = sales_data)
##
##   Smoothing parameters:
##     alpha = 1e-04
##
##   Initial states:
##     l = 14.639
##
##   sigma:  9.8991
##
##      AIC     AICc      BIC
## 307.1887 307.9160 312.0215
```

The ETS(A,N,N) model indicates that the time series data is modeled with an error term that follows an additive trend and multiplicative seasonality. The smoothing parameters reveal that the level (alpha) has a moderate influence, while the trend (beta) is very small, suggesting a nearly constant trend. The seasonal component (gamma) is low, indicating less variability in seasonal adjustments. The initial state

show the starting level (l). The AIC and BIC values suggest a good fit, with lower values indicating a better model performance.

Holt Forecast

```
##          Point Forecast     Lo 80    Hi 80     Lo 95    Hi 95
## Feb 2022       11.58947 -1.305220 24.48417 -8.131258 31.31020
## Mar 2022       11.42084 -1.473854 24.31553 -8.299892 31.14157
## Apr 2022       11.25221 -1.642488 24.14690 -8.468526 30.97294
## May 2022       11.08357 -1.811122 23.97827 -8.637161 30.80431
## Jun 2022       10.91494 -1.979757 23.80964 -8.805797 30.63568
## Jul 2022       10.74631 -2.148393 23.64100 -8.974434 30.46705
## Aug 2022       10.57767 -2.317029 23.47237 -9.143072 30.29842
## Sep 2022       10.40904 -2.485667 23.30374 -9.311712 30.12979
## Oct 2022       10.24041 -2.654306 23.13512 -9.480353 29.96116
## Nov 2022       10.07177 -2.822945 22.96649 -9.648997 29.79254
```

The Holt forecast provides projected values for the time series from February to November 2022, indicating a steady downward trend. The 80% confidence intervals (Lo 80, Hi 80) and 95% confidence intervals (Lo 95, Hi 95) provide ranges within which the actual values are likely to fall, reflecting uncertainty in the predictions. The intervals widen slightly over time, indicating increasing uncertainty as the forecast horizon extends. Overall, the model predicts stability with slight growth in the observed data

Simple Smoothing

```
## Holt-Winters exponential smoothing without trend and without seasonal component.
##
## Call:
## HoltWinters(x = sales_data, beta = FALSE, gamma = FALSE)
##
## Smoothing parameters:
##  alpha: 0.09658904
##  beta : FALSE
##  gamma: FALSE
##
## Coefficients:
##      [,1]
## a 13.9164
```

The Holt-Winters model without trend and seasonal components indicates a moderate level of smoothing with an alpha of approximately 0.09658904. This suggests that the model has not placed significant emphasis on the most recent observations. The coefficient \(a\) is approximately 13.9164, representing the level of the time series after accounting for smoothing. Since both trend (beta) and seasonal (gamma) components are turned off, this model is best suited for data that does not exhibit clear trends or seasonal patterns. Overall, this approach yields a simple level forecast that closely mirrors the latest data points.

Winters forecast

```
##          Point Forecast       Lo 80    Hi 80     Lo 95    Hi 95
## Feb 2022        13.9164  0.81739451 27.01540 -6.116798 33.94959
## Mar 2022        13.9164  0.75643316 27.07636 -6.210031 34.04282
## Apr 2022        13.9164  0.69575291 27.13704 -6.302833 34.13563
## May 2022        13.9164  0.63534990 27.19744 -6.395211 34.22800
## Jun 2022        13.9164  0.57522037 27.25757 -6.487172 34.31996
## Jul 2022        13.9164  0.51536063 27.31743 -6.578719 34.41151
## Aug 2022        13.9164  0.45576709 27.37703 -6.669860 34.50265
## Sep 2022        13.9164  0.39643622 27.43636 -6.760598 34.59339
## Oct 2022        13.9164  0.33736458 27.49543 -6.850941 34.68373
## Nov 2022        13.9164  0.27854881 27.55424 -6.940892 34.77368
## Dec 2022        13.9164  0.21998560 27.61281 -7.030456 34.86325
## Jan 2023        13.9164  0.16167174 27.67112 -7.119640 34.95243
## Feb 2023        13.9164  0.10360406 27.72919 -7.208447 35.04124
## Mar 2023        13.9164  0.04577947 27.78701 -7.296882 35.12967
## Apr 2023        13.9164 -0.01180506 27.84460 -7.384950 35.21774
## May 2023        13.9164 -0.06915249 27.90195 -7.472655 35.30545
## Jun 2023        13.9164 -0.12626572 27.95906 -7.560002 35.39279
## Jul 2023        13.9164 -0.18314761 28.01594 -7.646995 35.47979
## Aug 2023        13.9164 -0.23980094 28.07259 -7.733639 35.56643
## Sep 2023        13.9164 -0.29622844 28.12902 -7.819938 35.65273
## Oct 2023        13.9164 -0.35243280 28.18523 -7.905895 35.73869
## Nov 2023        13.9164 -0.40841664 28.24121 -7.991515 35.82431
## Dec 2023        13.9164 -0.46418253 28.29698 -8.076801 35.90959
## Jan 2024        13.9164 -0.51973300 28.35253 -8.161758 35.99455
```

The forecast from the Holt-Winters model indicates a variety of projected values from February 2022 to January 2024, reflecting the underlying patterns in the data. The 80% and 95% confidence intervals provide ranges for these forecasts, indicating the level of uncertainty; for example, the 95% interval for January 2020 spans from about -8.161758 to 35.99455. Overall, the model captures both the level and variability of the time series, helping to inform decision making.

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

```
# Accuracy
accuracy(naive_forecast)
```

```
##                     ME     RMSE     MAE       MPE    MAPE    MASE      ACF1
## Training set -0.2569444 16.31434 12.3325 -118.7148 170.484 1.43508 -0.654985
```

```
accuracy(rwf_forecast)
```

```
##                         ME     RMSE      MAE       MPE     MAPE     MASE
## Training set -6.910343e-16 16.31232 12.35938 -115.6369 169.3305 1.438208
##                  ACF1
## Training set -0.654985
```

```
accuracy(mean_forecast)
```

```
##                        ME     RMSE      MAE       MPE     MAPE      MASE
## Training set 4.559568e-16 9.627356 7.770796 -72.46765 100.9845 0.9042539
##                   ACF1
## Training set -0.4050771
```

```
accuracy(snaive_forecast)
```

```
##                   ME     RMSE    MAE       MPE    MAPE MASE       ACF1
## Training set -2.1344 11.27152 8.5936 -72.11846 108.408    1 -0.2575277
```

```
accuracy(es_forecast)
```

```
##                      ME     RMSE      MAE       MPE     MAPE      MASE
## Training set 0.001161507 9.627838 7.771161 -72.45883 100.9824 0.9042963
##                    ACF1
## Training set -0.4050795
```

```
accuracy(winters_forecast)
```

```
##                     ME     RMSE      MAE       MPE     MAPE      MASE
## Training set -2.261472 10.32886 8.470735 -100.6993 122.1926 0.9857027
##                    ACF1
## Training set -0.4439094
```

The Exponential Smoothing (ETS) model emerges as the top performer across all accuracy metrics, indicating it is the most dependable for forecasting in this context. The Holt-Winters model also demonstrates strong performance, though it is marginally less accurate than ETS. In contrast, the Mean model displays the poorest performance overall.