Business forecasting

Assignment 4

Q. Understand and Explain your model output

Mean Forecast:

```
##          Point Forecast    Lo 80    Hi 80    Lo 95    Hi 95
## Jan 2023       7.764007 4.907189 10.62082 3.390606 12.13741
## Feb 2023       7.764007 4.907189 10.62082 3.390606 12.13741
## Mar 2023       7.764007 4.907189 10.62082 3.390606 12.13741
## Apr 2023       7.764007 4.907189 10.62082 3.390606 12.13741
## May 2023       7.764007 4.907189 10.62082 3.390606 12.13741
```

The forecast provides a stable point estimate of approximately 7.76 for each month from January to May 2023, with 80% confidence intervals ranging from 4.91 to 10.62 and 95% confidence intervals from 3.39 to 12.14. This indicates a consistent prediction with a notable range of uncertainty around the expected values.

Naïve Forecast:

```
##          Point Forecast    Lo 80    Hi 80    Lo 95    Hi 95
## Jan 2023            5.1 4.374623 5.825377 3.990631 6.209369
## Feb 2023            5.1 4.074161 6.125839 3.531115 6.668885
## Mar 2023            5.1 3.843609 6.356391 3.178516 7.021484
## Apr 2023            5.1 3.649245 6.550755 2.881262 7.318738
## May 2023            5.1 3.478007 6.721993 2.619375 7.580625
```

The naive forecast maintains a constant point estimate of 5.1 for each month from January to May 2023, suggesting that future values are expected to remain unchanged. The 80% confidence intervals range from approximately 4.37 to 6.72, and the 95% intervals range from about 2.62 to 7.32, indicating some variability and uncertainty in the predictions despite the constant forecast.

Random walk:

```
##          Point Forecast    Lo 80    Hi 80    Lo 95    Hi 95
## Jan 2023       5.089165 4.362631 5.815699 3.978028 6.200303
## Feb 2023       5.078330 4.049946 6.106715 3.505552 6.651109
## Mar 2023       5.067496 3.806873 6.328118 3.139539 6.995452
## Apr 2023       5.056661 3.599734 6.513588 2.828483 7.284838
## May 2023       5.045826 3.415496 6.676156 2.552452 7.539200
```

The random walk forecast shows a gradually decreasing point estimate, starting at approximately 5.09 in January 2023 and declining slightly each month. The 80% confidence intervals range from about 4.36 to 6.68, and the 95% intervals range from approximately 2.55 to 7.54, reflecting uncertainty in the predictions while suggesting that future values will closely follow past trends with some random variation.

Seasonal naive:

```
##          Point Forecast    Lo 80     Hi 80    Lo 95     Hi 95
## Jan 2023           7.6 4.740595 10.459405 3.226917 11.973083
## Feb 2023           6.9 4.040595  9.759405 2.526917 11.273083
## Mar 2023           6.3 3.440595  9.159405 1.926917 10.673083
## Apr 2023           5.9 3.040595  8.759405 1.526917 10.273083
## May 2023           5.5 2.640595  8.359405 1.126917  9.873083
```

The seasonal naive forecast (snaive) predicts a declining trend in point estimates, starting at 7.6 in January 2023 and decreasing to 5.5 by May 2023, reflecting seasonal patterns in the data. The 80% confidence intervals range from approximately 4.74 to 10.46, and the 95% intervals range from about 1.13 to 11.97, indicating considerable uncertainty in the predictions while capturing seasonal variations.

Moving Averages:

- **MA5**

The 5-month moving average (MA 5) forecast smooths the data by averaging the values from the previous five months to predict future values, providing a clearer trend over time. The forecasts show a gradual decline in values from the late 1970s to early 2020, with a notable spike in mid-2020, likely reflecting significant changes or events during that period. As a result, this model helps reduce noise and highlight underlying trends while indicating variability in historical data.

- **MA10:**

The moving average (MA 10) for the unemployed population shows the average unemployment rate over a ten-month period, providing a smoother trend of the unemployment data. The values indicate fluctuations over the years, with significant peaks during economic downturns, notably in 2020 due to the COVID-19 pandemic, and gradual declines in unemployment rates in subsequent years.

Holt-Winters:

```
## Holt-Winters exponential smoothing with trend and additive seasonal co
mponent.
##
## Call:
## HoltWinters(x = ts_data)
##
## Smoothing parameters:
##  alpha: 1
##  beta : 0.003708204
##  gamma: 2.116835e-16
##
## Coefficients:
##             [,1]
## a     5.01250000
## b    -0.02073021
## s1    0.07083333
## s2    0.05833333
## s3   -0.05000000
## s4   -0.15833333
## s5   -0.16666667
## s6   -0.17500000
## s7   -0.01250000
## s8    0.02500000
## s9    0.07500000
## s10   0.13750000
## s11   0.10833333
## s12   0.08750000
```

The output presents the results of applying Holt-Winters exponential smoothing with a trend and additive seasonal component to a time series dataset. The smoothing parameters (alpha, beta, and gamma) indicate the level of responsiveness to changes in the data, with alpha set to 1, suggesting the model heavily weights the most recent observations. The coefficients represent the estimated values for the level (a), trend (b), and seasonal effects (s1 to s12) for each month, capturing the underlying patterns in the data.

Holts:

```
##          Point Forecast    Lo 80    Hi 80    Lo 95    Hi 95
## Jan 2023       5.084433 4.354815 5.814050 3.968579 6.200286
## Feb 2023       5.068857 4.037022 6.100691 3.490802 6.646911
## Mar 2023       5.053281 3.789505 6.317057 3.120502 6.986059
## Apr 2023       5.037705 3.578361 6.497048 2.805831 7.269578
## May 2023       5.022129 3.390460 6.653798 2.526706 7.517552
## Jun 2023       5.006553 3.219065 6.794040 2.272827 7.740279
## Jul 2023       4.990977 3.060178 6.921776 2.038074 7.943879
## Aug 2023       4.975401 2.911190 7.039612 1.818463 8.132339
## Sep 2023       4.959825 2.770293 7.149358 1.611224 8.308426
## Oct 2023       4.944249 2.636166 7.252332 1.414341 8.474157
```

The output displays the forecasts generated by Holt's method for the time period from January to October 2023. The "Point Forecast" column indicates the predicted values for each month, while the

"Lo" and "Hi" columns provide the lower and upper bounds of the 80% and 95% prediction intervals, respectively, reflecting the uncertainty in the forecasts. This allows for assessing the range within which the actual values are expected to fall, giving insights into potential variability in future observations.

Winters:

```
##          Point Forecast    Lo 80    Hi 80       Lo 95     Hi 95
## Jan 2023       5.167662 4.412097 5.923227  4.01212553  6.323199
## Feb 2023       5.142006 4.093601 6.190411  3.53860945  6.745403
## Mar 2023       5.105368 3.829618 6.381118  3.15427656  7.056459
## Apr 2023       5.356503 3.888159 6.824847  3.11086505  7.602141
## May 2023       5.354360 3.715873 6.992847  2.84851044  7.860210
## Jun 2023       4.891182 3.098598 6.683766  2.14966157  7.632702
## Jul 2023       4.878536 2.944064 6.813009  1.92001585  7.837057
## Aug 2023       4.785936 2.719267 6.852605  1.62523807  7.946634
## Sep 2023       4.754629 2.563699 6.945558  1.40389155  8.105366
## Oct 2023       4.740390 2.431856 7.048925  1.20979196  8.270989
## Nov 2023       4.796287 2.375832 7.216741  1.09452087  8.498053
## Dec 2023       4.910405 2.382960 7.437851  1.04501068  8.775800
## Jan 2024       4.978068 2.339841 7.616294  0.94324816  9.012887
## Feb 2024       4.952411 2.215654 7.689169  0.76690198  9.137921
## Mar 2024       4.915773 2.083891 7.747655  0.58478316  9.246762
## Apr 2024       5.166908 2.242976 8.090840  0.69513991  9.638676
## May 2024       5.164765 2.151575 8.177955  0.55648885  9.773041
## Jun 2024       4.701587 1.601690 7.801483 -0.03929578  9.442470
## Jul 2024       4.688941 1.504681 7.873202 -0.18096481  9.558847
## Aug 2024       4.596341 1.329878 7.862804 -0.39928322  9.591965
## Sep 2024       4.565034 1.218370 7.911698 -0.55324707  9.683314
## Oct 2024       4.550795 1.125792 7.975799 -0.68729512  9.788886
## Nov 2024       4.606692 1.105085 8.108298 -0.74855302  9.961937
## Dec 2024       4.720810 1.144226 8.297395 -0.74910388 10.190724
```

The output presents the forecasts generated by the Holt-Winters method, which includes a trend and an additive seasonal component, for the period from January 2023 to December 2024. The "Point Forecast" column indicates the predicted values for each month, while the "Lo" and "Hi" columns provide the lower and upper bounds for both the 80% and 95% prediction intervals, allowing for an understanding of the forecast's uncertainty and potential variability in future observations. The forecast shows a slight declining trend over the initial months, followed by fluctuations in subsequent periods, reflecting seasonal patterns and adjustments.

Exponential Smoothing:

```
## ETS(M,A,N)
##
## Call:
## ets(y = timeSeriesData)
##
##   Smoothing parameters:
##     alpha = 0.8979
##     beta  = 0.8979
##
##   Initial states:
##     l = 11.2626
##     b = -0.1155
##
##   sigma:  0.0758
##
##      AIC     AICc      BIC
## 2931.286 2931.393 2952.961
```

The output describes the results of the Exponential Smoothing State Space Model (ETS) with a multiplicative error, additive trend, and no seasonality (ETS(M,A,N)). The smoothing parameters alpha and beta are both set at approximately 0.898, indicating strong responsiveness to recent observations. The model's initial level (l) is 11.263, and the initial trend (b) is -0.116, with a residual standard deviation (sigma) of 0.0758. The Akaike Information Criterion (AIC), corrected AIC (AICc), and Bayesian Information Criterion (BIC) values suggest a good fit for the model, as lower values indicate better performance.

Simple Smoothing:

```
## Holt-Winters exponential smoothing without trend and without seasonal component.
##
## Call:
## HoltWinters(x = timeSeriesData, beta = FALSE, gamma = FALSE)
##
## Smoothing parameters:
##  alpha: 0.9999542
##  beta : FALSE
##  gamma: FALSE
##
## Coefficients:
##       [,1]
## a 5.100005
```

This output indicates the results of the Holt-Winters exponential smoothing model applied without trend or seasonal components (Holt-Winters (M,N,N)). The smoothing parameter (alpha) is approximately 0.99995, suggesting that the model places a high weight on the most recent observations. The coefficient (a) (the level) is estimated at 5.100, indicating the model's predicted baseline value for the time series data. Since both (beta) and (gamma) are set to FALSE, the model does not account for any trend or seasonal effects.

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

```
accuracy(mean_forecast)
```

```
##                         ME     RMSE      MAE       MPE    MAPE    MASE
## Training set -2.984247e-18 2.222627 1.803226 -9.125461 26.7602 1.34275
##                   ACF1
## Training set 0.9642393
```

```
accuracy(naive_forecast)
```

```
##                       ME     RMSE       MAE       MPE     MAPE      MASE
## Training set -0.01083481 0.566015 0.1571936 -0.260081 1.822557 0.1170523
##                   ACF1
## Training set 0.2870979
```

```
accuracy(rwf_forecast)
```

```
##                        ME      RMSE       MAE        MPE     MAPE      MASE
## Training set 2.003483e-16 0.5659113 0.1582521 -0.1076958 1.838588 0.1178405
##                   ACF1
## Training set 0.2870979
```

```
accuracy(snaive_forecast)
```

```
##                      ME     RMSE      MAE       MPE     MAPE MASE      ACF1
## Training set -0.1193841 2.231206 1.342935 -4.711159 16.89369    1 0.9305874
```

```
accuracy(ets_forecast)
```

```
##                        ME      RMSE       MAE        MPE     MAPE       MASE
## Training set -5.77345e-07 0.6731741 0.1116492 0.07488355 1.202059 0.08313824
##                     ACF1
## Training set -0.08833626
```

```
accuracy(holt_forecast)
```

```
##                       ME      RMSE       MAE         MPE     MAPE     MASE
## Training set 0.002992048 0.5673008 0.1604176 -0.05519606 1.860303 0.119453
##                   ACF1
## Training set 0.2852483
```

```
accuracy(winters_forecast)
```

```
##                       ME      RMSE       MAE         MPE     MAPE      MASE
## Training set 0.005347043 0.5811476 0.1874316 -0.03797169 2.228681 0.1395687
##                   ACF1
## Training set 0.3138823
```

In comparing the forecasting models using Mean Absolute Error (MAE), the ETS Forecast emerges as the best model, exhibiting the lowest MAE of 0.1116492. The Naive and Random Walk Forecasts follow closely behind with MAEs of 0.1571936 and 0.1582521, respectively. In contrast, the Mean Forecast and Seasonal Naive Forecast perform poorly, showing significantly higher MAE values, indicating they are less accurate. Overall, the results suggest that the ETS model provides the most reliable predictions for this dataset.