Module 5 Assignment: Forecasting Demand for Shoe Laces and Blouses

Part 1 - Forecasting Demand for Laces

Chart

Description automatically generated

Chart

Description automatically generated with low confidenceChart

Description automatically generated with medium confidence

The time series plot shows seasonal patterns without obvious changing trend, while the significant ACF and PACF at higher lags indicates this series might have seasonal behavior. Thus, we assume this series should fit with Holt-Winters’ Additive model to incorporate seasonality and potential trend and compare with Seasonal Exponential Smoothing model (to see the result if we don’t include the trend component).

Model Comparison

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Model** | **RMSE** | **MAPE** | **Residuals** | **|Forecast - Actual|** |
| *Simple Exponential Smoothing* | 954.6948 | 11.15584 | White Noise | Oct 2359.47  Nov 794.134  Dec 1295.034 |
| *Holt-Winters’ Additive* | 499.9297 | 5.768398 | Not White Noise | Oct 768.018  Nov 768.187  Dec 1171.917 |
| *Seasonal Exponential Smoothing* | 507.5075 | 5.693469 | Not White Noise | Oct 854.465  Nov 635.841  Dec 993.271 |
| *AUTO.ARIMA(0,0,1)(1,1,0)[12]* | 606.7496 | 5.88871 | White Noise | Oct 1565.66  Nov 202.555  Dec 352.489 |

Four models were built for forecasting laces demand. The Simple Exponential Smoothing model forecasts a flat result with three same demands for October, November, and December, which is not acceptable. Comparing among the rest three models, Seasonal Exponential Smoothing model performs the best with lowest MAPE, relatively lower RMSE, and the second lowest overall forecast error (compared with actual demands). With a MAPE of 5.693469 means that the model only generates 5.69% of forecast errors. From the forecast plot below, we can tell that the forecast correctly picks up the seasonal pattern of the historical data, which demonstrates that this model is able to capture the seasonality of the time series and precisely forecast laces demand.

However, the Ljung-Box test result rejects the null hypothesis as its p-value is less than 0.05, stating that the residuals are not white noise. This is probably due to the significant lags in the ACF and there might be potential autocorrelations or patterns existing in the residuals. We need to identify those components and add to our model for further refinement.

Forecast Plot of Seasonal Exponential Smoothing Model

Chart, histogram

Description automatically generated

Text

Description automatically generated

Forecast Result of Seasonal Exponential Smoothing Model

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Point Forecast** | **Lo 80** | **Hi 80** | **Lo 95** | **Hi 95** | **Actual** |
| *Oct 1998* | 8875.335 | 8126.508 | 9624.162 | 7730.102 | 10020.568 | 9729.8 |
| *Nov 1998* | 7212.041 | 6398.455 | 8025.628 | 5967.768 | 8456.315 | 6576.2 |
| *Dec 1998* | 7068.571 | 6195.013 | 7942.129 | 5732.579 | 8404.563 | 6075.3 |

As we can see, all actual demands of laces are within the 95% confidence level of the forecast value. The result implies that we are 95% confident that all the actual demands will fall in the forecast range of the best model.

Chart

Description automatically generated

Part 2 - Forecasting Demand for Blouses

Chart, line chart

Description automatically generated

Chart

Description automatically generatedChart

Description automatically generated

The time series plot shows an obvious increasing trend with seasonality, while ACF decays slowly with repeating patterns and PACF cuts off quickly. Therefore, we assume that this model should fit with Holt-Winters’ Multiplicative model to incorporate potential seasonality and changing trend.

Model Comparison

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Model** | **RMSE** | **MAPE** | **Residuals** | **|Forecast - Actual|** |
| *Simple Exponential Smoothing* | 3496.529 | 15.47029 | Not White Noise | Oct 7305.41  Nov 2097.41  Dec 890.41 |
| *Holt-Winters’ Additive* | 1062.155 | 5.022268 | Not White Noise | Oct 2179.37  Nov 3223.23  Dec 896.18 |
| *Holt-Winters’ Multiplicative* | 902.73 | 4.654127 | Not White Noise | Oct 925.00  Nov 4207.15  Dec 1138.66 |
| *Seasonal Exponential Smoothing* | 742.4161 | 3.389703 | Not White Noise | Oct 394.08  Nov 3895.62  Dec 1424.67 |
| *AUTO.ARIMA(1,0,1)(0,1,0)[12]* | 1106.891 | 4.280318 | White Noise | Oct 42.79  Nov 3712.33  Dec 698.59 |

Five models were built for comparison. The Simple Exponential Smoothing model generates three same forecast results for October, November, and December – which is not acceptable. Overall, the Seasonal Exponential Smoothing model outperforms the others with the lowest RMSE of 742.4161 and the lowest MAPE of 3.389703, indicating that the average percentage difference between forecast value and actual target is 3.39%. In addition, this model also generates the second lowest overall forecast errors (right after auto.arima) compared with the actual demands. The forecast plot below shows that the model correctly picks up the potential trend, the multiplicative error and seasonality from past data, which suggests that this model is the most predictive forecasting tool.

However, the Ljung-Box test result rejects the null hypothesis as its p-value < 0.05, concluding that the residuals are not white noise. This is probably due to the potential seasonality component left in the residuals. For further refinement, we need to keep improving the model to address those varieties.

Forecast Plot of Seasonal Exponential Smoothing Model

Chart

Description automatically generated

Text, letter

Description automatically generated

Text

Description automatically generated with medium confidence

Forecast Result of Seasonal Exponential Smoothing Model

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Point Forecast** | **Lo 80** | **Hi 80** | **Lo 95** | **Hi 95** | **Actual** |
| *Oct 1998* | 28064.92 | 26214.60 | 29915.24 | 25235.10 | 30894.74 | 28459 |
| *Nov 1998* | 19355.38 | 17804.88 | 20905.88 | 16984.10 | 21726.67 | 23251 |
| *Dec 1998* | 20619.33 | 18720.76 | 22517.90 | 17715.72 | 23522.94 | 22044 |

According to the forecast result, the actual demands for blouses in October and December fall in the 80% confidence level of the forecast value, which is the best performance out of five models.

Graphical user interface, chart

Description automatically generated