Forecasting Models

Assignment 4

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# Forecasting models

Mean Forecast:

A forecasting method that predicts future values in a time series by taking the historical average (mean) of the data as the expected value for upcoming periods. Mean forecast using the "meanf" function is applied to a time series data represented by the "Time Series" variable, and the forecast is generated for 5 time points into the future.

A graph of a number of years

Description automatically generated

The mean forecast for Coffee Imports in Brazil, projected for July to November 2022, consistently stands at 111,300.4 units. This point forecast provides a central value, and the accompanying confidence intervals (Lo 80, Hi 80, Lo 95, and Hi 95) offer insights into forecast uncertainty. The narrow confidence intervals in this case signify a high level of confidence in the forecasted values, suggesting stability in coffee imports during the specified months. Decision-makers can use this information to assess risk and make informed choices for their business. However, it's crucial to consider external factors, such as economic conditions and global market dynamics, which could impact coffee imports. In summary, the mean forecast and confidence intervals provide valuable insights, indicating a stable trend in coffee imports, but comprehensive decision-making should encompass external factors and industry trends to navigate the dynamic coffee market effectively.

Naive Forecast:

A simple forecasting method that predicts future values by assuming they will be the same as the most recent observed value in a time series. In essence, it doesn't consider any underlying patterns, trends, or seasonality in the data; it simply extrapolates the last observed value into the future.

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Description automatically generatedThe naive forecast for the above dataset indicates a simple and straightforward approach to predicting future coffee import levels. Based on the naive forecast for the next 5 months, it is evident that the forecasted point estimate for July 2022, and the subsequent months (August to November 2022), remains constant at 181,707 units. The prediction does not take into account any underlying patterns or seasonality in the data but merely assumes that future imports will be the same as the most recent observation. The prediction intervals (Lo 80, Hi 80, Lo 95, Hi 95) provide an estimate of the range within which the actual import levels are likely to fall. These intervals widen as we move further into the future, reflecting the increasing uncertainty associated with naive forecasts. It's evident that this method does not capture potential fluctuations or trends in coffee imports that may be influenced by factors such as global market conditions, domestic consumption, or changes in trading policies.

In summary, the naive forecast may be useful for very short-term predictions or as a benchmark for more sophisticated forecasting methods. However, it should be used cautiously for long-term planning and decision-making, as it oversimplifies the complexity of the coffee import market in Brazil and does not provide insights into the driving factors behind import fluctuations.

Random walk without drift:

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Description automatically generatedRandom walk with drift:

A "random walk" is a simple forecasting model that assumes that the best prediction for a future value in a time series is the most recent observed value. By including drift in the random walk model, it accommodates the possibility that the time series exhibits a trend.

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Description automatically generated with medium confidence

The random walk forecast with drift (rwf) for "Coffee Imports in Brazil" suggests that there's a linear trend in the data, and this trend is considered for forecasting. Here are the key insights drawn from the rwf\_forecast with drift: The point forecasts show a gradual and consistent increase in coffee imports over the forecasted months, with the values steadily rising from 182,447.9 in July 2022 to 185,411.7 in November 2022. This trend suggests that coffee imports into Brazil are on an upward trajectory, possibly influenced by factors like increased demand, favorable market conditions, or changes in trade policies.

The key insight drawn from this RWF forecast with drift is that the model acknowledges and captures the underlying linear trend in coffee imports. This suggests that over the next few months, Brazil is likely to experience an increase in coffee imports. This information can be invaluable for supply chain planning, inventory management, and financial forecasting, as it recognizes and incorporates the systematic upward movement in import values. However, it is crucial to remember that this forecast assumes that the trend will continue as it has historically, and unforeseen factors or events could influence the actual values.

Seasonal Naive Forecast:

Seasonal Naive is a simple but effective forecasting method that considers seasonal patterns in time series data. The Seasonal Naive method makes forecasts based on the last observed value from the same season in the previous year. It's particularly useful for data that exhibits strong seasonality.

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Description automatically generated

The Seasonal Naive forecast for "Coffee Imports in Brazil" takes into account seasonality and historical patterns to predict future imports. The results indicate a clear seasonality in the data, with fluctuations in coffee imports over the forecast horizon: In July 2022, the Point Forecast predicts coffee imports to be approximately 81,897 units, with an 80% prediction interval ranging from 26,745.56 to 137,048.4 units and a 95% prediction interval spanning from -2,449.849 to 166,243.8 units. The forecast reveals that there is an anticipated increase in coffee imports for August 2022, reaching approximately 98,620 units. This is in line with the historical seasonal pattern, which typically sees a rise in imports during this period. However, the forecast also suggests some fluctuation in the coming months. While September 2022 is expected to see a decrease in imports to approximately 85,452 units, October 2022 shows a significant increase to around 131,631 units, which is a notable departure from the previous months. The November 2022 forecast returns to a value of approximately 120,896 units, reflecting a seasonal trend.

The key insight drawn from this Seasonal Naive forecast is that coffee imports in Brazil follow a strong seasonal pattern, with notable fluctuations. While the forecast captures seasonality, it may not account for other external factors affecting imports, such as economic conditions, global coffee prices, or changes in trade policies. Therefore, this model is most effective for short-term planning and should be used in conjunction with additional analyses and domain knowledge for more robust decision-making, particularly for long-term strategic planning.

Moving Averages

* MA5\_forecast:

The moving average method calculates a 5-period moving average forecast for the "Coffee Imports in Brazil" time series data and then plots the results. The plot provides a visual representation of how the moving average smooths out short-term fluctuations, making it easier to identify trends and patterns in the data.

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The Moving Average (MA) forecast with a 5-period order for "Coffee Imports in Brazil" reveals distinct seasonal patterns and trends in import values. Coffee imports demonstrate a consistent seasonality, with peak values typically occurring in July and August, followed by declines in other months. The forecast reflects an overarching trend, with import values gradually increasing until around 2011 and then declining in subsequent years before experiencing a resurgence in 2022. The results underscore the importance of seasonality and the need for complete and up-to-date data for accurate forecasting. Businesses in the coffee industry can use this information for short- to medium-term planning, aiding inventory management, supply chain logistics, and marketing strategies. However, long-term planning should incorporate additional forecasting methods and consider external factors that may impact import trends.

* MA9\_forecast:

The Moving Average method generates a 9-period Moving Average forecast for the "Coffee Imports in Brazil" time series data and then creates a plot to visualize the forecast results. The 9-period Moving Average is often used to capture longer-term trends and patterns in the data, providing insights into the overall import value trends.

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The Moving Average (MA) forecast with a 9-period order for "Coffee Imports in Brazil" offers valuable insights into the historical trends and seasonality of coffee imports. The forecast reveals a consistent seasonal pattern, where import values reach their peak during July and August and decline during other months. This seasonality corresponds to typical coffee consumption and production cycles. Additionally, the forecast highlights a longer-term trend in import values, with a notable upswing until around 2011, followed by a gradual decline in subsequent years. Recent data suggests a resurgence in imports. However, in recent years, there has been a recovery in imports, reaching a new high in 2022. The MA9\_forecast is particularly useful for medium-term planning, aiding inventory management, supply chain logistics, and marketing strategies. For robust long-term planning, it's advisable to combine this analysis with other forecasting methods and consider external factors influencing import trends, such as economic conditions and global coffee market dynamics.

ETS (Error, Trend, Seasonality) forecast:

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Description automatically generated The ETS (Error, Trend, Seasonality) forecast for "Coffee Imports in Brazil," utilizing the ETS (M, Ad, A) model, reveals critical insights into the underlying time series patterns. The model's parameters indicate that it effectively captures the characteristics of the data. The relatively high alpha (0.6608) signifies the substantial influence of historical data in the forecast, highlighting the persistence of past values. The low values for beta and gamma imply minimal impact from trend and seasonality components, indicating that the forecast is primarily driven by the error term. The initial states provide starting points for the forecast, with an initial upward trend in imports. The sigma value (0.1682) suggests that the model can explain a significant portion of the data's variation. Additionally, the AIC value (3711.833) demonstrates a good fit of the model to the data. In summary, the ETS (M, Ad, A) model is well-suited for forecasting coffee imports, with a strong reliance on historical data, making it valuable for businesses to optimize inventory management, logistics, and decision-making in the coffee industry.

Holtwinters Forecast

The Holt-Winters method is an extension of exponential smoothing that considers not only the level (error) and trend (trend component) of the time series but also its seasonality (seasonal component).

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The Holt-Winters exponential smoothing analysis of the coffee import dataset in Brazil reveals critical insights into import patterns. The model's smoothing parameters indicate that recent import data significantly influences forecasts, with a high alpha value, while trend and seasonal components play a relatively smaller role, as suggested by low beta and gamma values. The model successfully captures the seasonality in coffee imports, as shown by the distinct patterns in the seasonal components (s1 to s12). This emphasizes the significance of seasonality in coffee imports in Brazil, with some months witnessing decreases and others increases. Additionally, a minor positive trend suggests gradual growth in coffee imports. These insights are valuable for stakeholders in the coffee industry, aiding them in making informed decisions related to inventory management, production planning, and resource allocation.

Holtwinters Forecast

(beta=FALSE, gamma=FALSE)

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Description automatically generated with medium confidence

The Holt-Winters forecast results for the coffee import dataset provide insights into the modeling approach and the quality of fit. In this analysis, a Holt-Winters model without trend (beta) or seasonal (gamma) components was selected. This choice implies a primary focus on the level component of the time series data. The sum of squared errors (SSE), which measures the goodness of fit, was calculated and found to be 79,783,724,024. A lower SSE generally indicates a better fit. The fitted values generated by the model closely align with the observed data, signifying a reasonable representation of the dataset. However, it's crucial to note that this simplified model may not capture potential trends or seasonality. The choice of the model should depend on the specific analysis goals and the complexity of the underlying data.

ETS Forecast

A graph showing the results of a forecast

Description automatically generated with medium confidence

The 5-period forecast for the coffee import dataset yields crucial insights into the trajectory of coffee imports in Brazil. Notably, the forecasts indicate a consistent upward trend in coffee imports from July to November 2022. This suggests a potential growth in coffee imports, which can be of significant interest to stakeholders in the coffee industry.

Plot the time series and different model forecasts in one chart!

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Based on the combined forecast plot and the results from various forecasting methods for the "Coffee Imports in Brazil" dataset:

* Stability in Naive Forecasting: The Naive Forecast (shown in red) is relatively stable, maintaining consistent values for the upcoming months in 2022 (July to November) at around 181,707. This method serves as a good "benchmark" for comparison.
* Random Walk with Drift: The Random Walk with Drift (shown in green) predicts slightly increasing import values from July to November in 2022, starting at 182,447.9 and ending at 185,411.7. It acknowledges a mild upward trend.
* Short-Term Variation in Seasonal Naive: The Seasonal Naive Forecast (black) predicts more variable import values in 2022, reflecting seasonal patterns. It anticipates lower values in some months (e.g., September) and higher values in others (e.g., October).
* Moving Averages (MA5 and MA9): Both the 5-period (pink) and 9-period (blue) Moving Averages capture longer-term trends. They exhibit gradual increases, but the 5-period MA is more responsive to short-term fluctuations.
* Holt-Winters: The Holt-Winters Forecast (purple) predicts substantial growth from July to November 2022, reflecting a pronounced upward trend.
* ETS Forecast: The Exponential Smoothing (ETS) Forecast (yellow) also shows growth in import values from July to November 2022, with some seasonal variations along the way.

In conclusion, the combined forecast plot provides a comprehensive view of expected import values for the "Coffee Imports in Brazil" dataset. While different forecasting methods may offer varied perspectives, it's evident that most methods predict an increasing trend in import values from July to November 2022, indicating potential growth soon.

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

There are several accuracy measures commonly used to compare and evaluate time series forecasting models. Each of these measures provides a different perspective on the performance of the models. Here are some common accuracy measures and how to use them for model comparison:

* + - * Mean Absolute Error (MAE): MAE measures the average absolute difference between the forecasted values and the actual values.
      * Root Mean Square Error (RMSE): RMSE is the square root of the average of the squared differences between forecasted and actual values. Lower RMSE values indicate better model accuracy.
      * Mean Absolute Percentage Error (MAPE): MAPE measures the average percentage difference between the forecasted values and the actual values.
      * Mean Squared Error (MSE): MSE is the average of the squared differences between forecasted and actual values.
      * Mean Absolute Scaled Error (MASE): MASE measures the accuracy of the forecast in comparison to a naive forecast (e.g., simple moving average or last observation).
      * Autocorrelation of Residuals (ACF1): ACF1 measures the autocorrelation of the residuals (forecast errors) of the model.

The choice of the best model will depend on the specific goals and requirements of your analysis. Typically, lower values for MAE, RMSE, MAPE, and MASE indicate better model accuracy, and lower ACF1 values indicate less autocorrelation in the residuals.

To compare the models and select the best one based on the accuracy measures provided, let's choose the Mean Absolute Percentage Error (MAPE) as the criterion. Lower MAPE values indicate better forecasting accuracy. Here are the MAPE values for each model:

1. Mean Forecast: MAPE = 23.63%

2. Naive Forecast: MAPE = 16.12%

3. Random Walk Forecast (rwf): MAPE = 16.11%

4. Seasonal Naive Forecast: MAPE = 27.33%

5. Moving Average Order 5 (MA5): MAPE = 4.35%

6. Sum of Squared Errors (SSE): MAPE = 15.64%

7. Holt-Winters (HW): MAPE = 16.26%

8. ETS (Error, Trend, Seasonality): MAPE = 13.21%

Based on MAPE, the "Moving Average Order 5 (MA5)" model has the lowest MAPE value, indicating the best forecasting accuracy in terms of percentage error. Therefore, the "Moving Average Order 5 (MA5)" model is the best model based on the MAPE comparison.