



Northeastern University
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Module 3-Project: Forecasting Financial Time Series

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ALY6050 - Introduction to Enterprise Analytics

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Introduction

This report examines Apple Inc. (AAPL) and Honeywell International Inc. (HON) past stock prices during a one-year period, comprising 252 market days. This study aims to estimate stock prices using several approaches for time series forecasting: linear regression, weighted moving averages, and exponential smoothing. Three sections comprise the report: regression analysis, long-term, and short-term forecasts. The findings lead to a portfolio allocation plan that balances the investment between AAPL and HON.

Analysis

Part 1: Short-term Forecasting

1. Time Series Plots

Interpretation: The plot of AAPL stock prices and the plot of HON stock prices show an overall upward tendency with some fluctuations. AAPL exhibits higher volatility compared to HON, which appears to be more consistent. Both stocks show no obvious seasonal trends.

2. Exponential smoothing

Interpretation: The stock prices of AAPL and HON were subjected to exponential smoothing with α values of 0.15, 0.35, 0.55, and 0.75. In contrast to HON, which had MAPE values of 3.06, 2.35, 2.03, and 1.90, respectively, AAPL had MAPE values of 3.87, 2.47, 2.08, and 1.97. For both stocks, the most accurate predictions were obtained when $\alpha = 0.75$. This variation is due to the fact that a larger α value assigns more weight to recent data, which is crucial for identifying both subtle trends in HON's stock price and quick changes in AAPL's stock price. The findings imply that current data is crucial for predicting both firms' stock values.

-> Best MAPE for AAPL: 1.969072

-> Best MAPE for HON: 1.895824

3. Adjusted exponential smoothing

Interpretation: The stock prices of AAPL and HON were subjected to adjusted exponential smoothing with $\alpha = 0.55$ and β values of 0.15, 0.25, 0.45, and 0.85. In contrast to HON, which had MAPE values of 2.06, 2.08, 2.17, and 2.28 correspondingly, AAPL had MAPE values of 2.03, 2.05, 2.17, and 2.30. For both stocks, the most accurate predictions were obtained when $\beta = 0.15$. This variation is due to the fact that a smaller β value eliminates noise and prevents overfitting to short-term movements, both of which are critical for capturing the general trend in steady (HON) and high-volatility (AAPL) equities. The findings imply that prediction accuracy is increased by flattening the trend component.

Part 2: Long-term Forecasting

1. 3-period weighted moving averages

For periods 1 through 100, the stock prices of AAPL and HON were subjected to a 3-period weighted moving average. The weights for the third most recent, second most recent, and most recent periods were 0.2, 0.3, and 0.5, respectively. Forecasts were created using the linear trend that was fitted to the observed data beginning with period 101 for periods 101 through 257.

The following displays the predicted values for periods 253-257:

Period	Forecasted AAPL Price	Actual AAPL Price	Forecasted HON Price	Actual HON Price
253	128.0162	116.32	176.0496	196.99
254	128.4151	114.13	176.3539	201.98
255	128.8139	116.44	176.6582	199.29
256	129.2128	118.57	176.9625	197.24

257	129.6117	117.87	177.2668	201.54
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How accurate this method of forecasting has been by comparing the forecasted values for periods 253-257 with their actual “Close” values on those specific days:

1. AAPL Forecasts:

For AAPL, the predicted values were always higher than the "Close" price. For instance:

- The actual price for period 253 was 116.32 when the estimate was 128.0162.
- The actual price for period 257 was 117.87, compared to the expectation of 129.6117.

Interpretation: Because the approach significantly overstated the real prices, the AAPL estimates were not particularly accurate. This is probably because AAPL's stock price is so volatile that it is difficult to forecast using a simple weighted moving average and linear trend.

2. HON Forecasts:

The "close" prices were always higher than the predicted values for HON. For instance:

- The actual price for period 253 was 196.99, when the expectation was 176.0496.
- The actual price for period 257 was 201.54, compared to the expectation of 177.2668.

Interpretation: Additionally, the HON forecasts were not particularly accurate since the approach significantly underestimated the real costs. This conclusion implies that the increased trend in HON's stock price during this period may not have been well represented by the linear trend.

2. MAPEs calculation and comparison.

- AAPL (Linear Trend Forecasting): 4.778476
- HON (Linear Trend Forecasting): 3.052453

Comparison and Analysis:

AAPL:

Best MAPE in Part 1 (Exponential Smoothing): 1.969072

MAPE in Part 2.2 (Linear Trend Forecasting): 4.778476

Interpretation: The MAPE in Part 2.2 (4.778476) is much higher than the best MAPE for AAPL in Part 1 (1.969072). This finding suggests that the most accurate prediction for AAPL was produced using the exponential smoothing approach, which had an alpha of 0.75.

HON:

Best MAPE in Part 1 (Exponential Smoothing): 1.895824

MAPE in Part 2.2 (Linear Trend Forecasting): 3.052453

Interpretation: Likewise, the MAPE in Part 2.2 (3.052453) is higher than the best MAPE for HON in Part 1 (1.895824). This result implies that the most accurate prediction for HON was likewise produced using the exponential smoothing approach, which had an alpha of 0.75.

Part 3: Regression

1. Simple Regression

MAPE Values Summary:

AAPL:

Part 1 (Exponential Smoothing): Best MAPE = 1.969072

Part 2 (Linear Trend Forecasting): MAPE = 4.778476

Part 3.1 (Simple Regression): MAPE = 10.56076

HON:

Part 1 (Exponential Smoothing): Best MAPE = 1.895824

Part 2 (Linear Trend Forecasting): MAPE = 3.052453

Part 3.1 (Simple Regression): $MAPE = 9.758568$

Comparison and Analysis:

AAPL:

Compared to the MAPE of part 1 (1.969072) and the MAPE of part 2 (4.778476), the MAPE of part 3.1 (10.56076) is much greater. This result suggests that, in comparison to the techniques used in Parts 1 and 2, the basic regression approach is less successful in forecasting AAPL stock prices.

-> The simple regression method (Part 3.1) is the least accurate.

HON:

Similarly, the MAPE of part 2 (4.052453) and the MAPE of part 1 (1.895824) have lower MAPEs than the MAPE of part 3.1 (9.758568). This implies that, in comparison to the techniques used in Parts 1 and 2, the basic regression approach is as well less successful for forecasting HON stock prices.

-> The simple regression method (Part 3.1) is the least accurate.

2. Residual analysis

1. Residuals' Independence:

- AAPL Residuals vs. Fitted Plot: There is no clear pattern to the residuals, which are randomly scattered around zero. The residuals seem to be independent based on this.
- HON Residuals vs. Fitted Plot: Similarly, the residuals lack a clear pattern and are randomly scattered around zero. This implies the residuals' independence as well.

In conclusion, the residuals for HON and AAPL are independent.

2. Homoscedasticity

Breusch-Pagan Test for AAPL:

- $p\text{-value} = 0.99054$, $\chi^2 = 0.0001407281$

- We fail to reject the null hypothesis of constant variance since the $p\text{-value} > 0.05$.

This suggests that the residuals have a constant variance, or are homoscedastic.

Breusch-Pagan Test for HON:

- $p\text{-value} = 0.26512$, $\chi^2 = 1.241827$
- We fail to reject the null hypothesis of constant variance since the $p\text{-value} > 0.05$.

This suggests that the residuals have a constant variance, or are homoscedastic.

In conclusion, homoscedasticity (constant variance) is present in the residuals for both AAPL and HON.

3. Residual Normality

a. Normal Q-Q plot

- The residuals seem to be normally distributed based on the points' near alignment with the reference line in the AAPL Q-Q plot.
- The HON Q-Q Plot indicates that the residuals are regularly distributed since the points roughly follow the reference line.

b. Shapiro-Wilk Normality Test

Shapiro-Wilk Test for AAPL:

- $p\text{-value} = 9.674e-05$, $W = 0.97284$.
- We reject the null hypothesis of normality since the $p\text{-value} < 0.05$. This implies a non-normal distribution of the residuals.

Shapiro-Wilk Test for HON:

- $p\text{-value} = 2.591e-10$, $W = 0.92097$,
- We reject the null hypothesis of normality since the $p\text{-value} < 0.05$. This implies a non-normal distribution of the residuals.

In conclusion:

- **The residuals for both AAPL and HON seem to be about normally distributed, according to the Q-Q plots.**
- **The results of the Shapiro-Wilk test, however, show that neither AAPL nor HON's residuals are regularly distributed. The Shapiro-Wilk test's sensitivity to large sample sizes or slight departures from normality might be the cause of this disparity.**

4. Chi-squared test for Normality

Chi-squared test for AAPL:

- Test Statistic (P): 58.786, p-value: 8.372e-07 (< 0.05)
- We reject the null hypothesis of normality since $p < 0.05$. This means that the residuals for AAPL are not normally distributed.

Chi-squared test for HON:

- Test Statistic (P): 133.73, p-value: $< 2.2\text{e-}16$ (< 0.05)
- We reject the null hypothesis of normality since $p < 0.05$. This means that the residuals for HON are not normally distributed.

In conclusion:

- **The residuals for AAPL and HON are not normally distributed, according to the results of the Shapiro-Wilk and Chi-squared tests.**
- **In this instance, both tests strongly reject the null hypothesis of normality, but the chi-squared test is less sensitive to departures from normality than the Shapiro-Wilk test.**

Portfolio Allocation:

In my opinion, I suggest the following portfolio allocation after examining the past stock prices of AAPL and HON as below:

- Apple Inc. (AAPL): 40%

- Honeywell Inc. (HON): 60%

Reasons:

- The time series plots and forecasting errors (MAPE) show that AAPL is more volatile than HON. A lesser portion (40%) is allotted to AAPL to reduce risk.
- Since HON is less erratic, it receives a higher share (60%) to guarantee consistent growth and lower the risk of the whole portfolio.
- With exponential smoothing, both stocks demonstrated improved forecasting accuracy; nevertheless, AAPL's higher MAPE values suggested that its projections were more uncertain. This further supports a smaller allocation to AAPL.
- By ensuring diversity, a balanced portfolio including 40% AAPL and 60% HON lessens the effect of any one stock's underwhelming performance on the portfolio as a whole.
- This allocation is consistent with a strategy that allows for the possibility of bigger returns (AAPL) while prioritizing stable growth (HON).

Conclusion

This report used basic regression, linear trend forecasting, and exponential smoothing to examine the historical stock prices of Apple Inc. (AAPL) and Honeywell International Inc. (HON). The most accurate short-term projections were obtained using exponential smoothing with $\alpha = 0.75$, with MAPE values of 1.895824 (HON) and 1.969072 (AAPL). Weighted moving averages and linear trends were less accurate for long-term predictions, especially for AAPL because of its increased volatility. The least successful approach was simple regression, which produced the highest MAPE values. Although residual analysis refuted normality, it did demonstrate independence and homoscedasticity, indicating that utilizing regression for these stocks may have limits. To balance risk and reward, the study suggests

allocating 40% of the portfolio to AAPL and 60% to HON. This strategy puts HON's stability first while using AAPL's growth potential. Advanced methods like machine learning models or ARIMA might significantly increase predicting accuracy for future study.