STAT2005 PROJECT: APPLE OR MICROSOFT?

COMPUTER SIMULATION SEMESTER 1 2023

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Introduction:

Background:

Investing in stocks can be a difficult decision for many, however it is still the most common method of investing one's money for long term growth in wealth. Considering there are many options now available on the stock market, investors can find it quite difficult in choosing where to put their money. This is especially difficult when choosing between the stocks of two of the most well know tech companies in the world: Microsoft and Apple. Each stock has shown a track record of stability and good returns since the companies were listed on the stock market.

Aim/Objectives:

The aim of this report will be to provide an analysis and future prediction in the stocks of two tech giants Apple and Microsoft. This prediction will be done to help in decision making in what stock to invest in. Through analysis and future prediction, this report aims to illustrate different market trends and future growth and predictability of each company, providing a basis for informed decisions to be made, providing an accurate and reliable resource for people to look at in their investment journey.

Literature Review:

1. https://www.fool.com/investing/2023/03/24/better-growth-stock-apple-vs-microsoft/#:~:text=Then%20when%20considering%20both%20companies,stock%20to%20buy%20right%20now.

2. https://www.thestreet.com/apple/stock/apple-vs-microsoft-which-tech-stock-to-own-in-2023

Both these articles/sources provide insight and recommendations on which stock to invest in. The first source, published on The Motley Fool compares Apple and Microsoft's stocks growth in 2023. It dives into each company's revenue and their strong financial performance, but it concludes that Microsoft is the better recommendation out of the two. It states this due to its more diverse and expansive business model, as Microsoft is more diverse in terms of where it operates compared to Apple. This is benefitted by the fact that Microsoft has been investing in Artificial Intelligence, which could see its stocks grow at a fast rate.

The second source compares the results of Apple and Microsoft stocks as technology stocks in 2023. It is stated that both companies have very large cash reserves and strong balance sheets, but concludes that Apple is the better choice to invest in. This is due to the fact that its customer are extremely loyal to the brand and that the company has a history of continuously innovating and coming up with new ideas to keep its audience intrigued. It also makes evident that Apple has been expanding its business, which in turn would make its stocks give a higher return, and states that the company's stock is undervalued, meaning if an investor buys the stock at its current price, it could be worth a lot more in the future.

It is important to note however, that it is practically impossible to predict the outcome and result of the stock market, as it is a very volatile environment; one which is constantly changing, so investors should keep in mind although recommendations do exist, it is

important to know that there is always a risk involved, and that they should make informed and calculated decisions to avoid being at the receiving end of huge loss.

The Data:

The data that will be used for this project is derived from yahoo finance and provides historical prices of the respective stocks on a daily basis, ranging from the 1st of Jan 2010 to the 1st of Jan 2023. The datasets for both Apple and Microsoft stocks contain several variables that give several details about the stock on a particular day. These variables are:

- ***Open***: this refers to the initial or "opening" price of the financial security. It is the price at which the stock opens at on the stock market when trading begins on a given day.
- ***High***: refers to the highest trading price of the respective stock on a given day.
- ***Low***: refers to the lowest trading price of the respecting stock on a given day.
- ***Close***: refers to the closing trading price of the respective stock when the stock market closes on the given day.
- ***Adjusted Close:*** refers to the adjusted close price after the stock market closes on a given day. The close price is adjusted to better illustrate the stock's value after accounting in certain factors.
- ***Volume***: refers to the total number of shares that were bought of the respective stock on the given day.

Methodology:

Two methods have been chosen to aid in modelling a prediction to recommend readers/investors on which stock to invest in. A time series model will be implemented along with Monte Carlo simulation techniques to forecast the respective share prices of both companies one month into the future, with the forecasting illustrating daily data for each stock.

Historical share price data for the respective companies was obtained through Yahoo finance and various variables are present in the data set as shown in the previous section. As we are using models to forecast the share price, we will disregard the open, high, low and volume variables as they are not relevant in our simulation. The main variable that will be used to predict against time is the adjusted close price. This is chosen over Close price as it considers other factors that affect a shares price such as dividends and company actions. The adjusted close price therefore presents a much more reliable and accurate representation of what the stock is actually worth and would therefore make our simulation models more efficient and accurate in provide high quality predictions.

Using this raw data, will conduct a time series analysis to illustrate specific trends, patterns, and behaviours in the stock prices of the respective stocks. This will be shown through the analysis of different plots, correlation graphs and other components of the ARIMA model. Using the initial analysis, including the trends observed, the favourable parameters for the ARIMA time series model will be determined.

After we have investigated the data, the model that is chosen needs to be validated to ensure there are no unusual trends present. This is implemented by splitting the datasets

into a training and test set. From this, the ability to accurately forecast future share prices will be determined through methods of an ARIMA time series model as well as certain metrics (i.e. MSE & RMSE). This will be known as the fitted model, and once validated it will be utilised to forecast future share prices of Apple and Microsoft stocks through the use of the auto.arima() function and time series methods.

Monte Carlo simulation methods will then be implemented using the fitted model to forecast share prices by simulating the "stock market" using multiple random scenarios. This simulation comprises of a random sample from probability distributions based on the data we have obtained. It involves stock market trends and factors such as volatility, i3nflation, economy rates and other external events that may affect the stock prices of the respective stocks, either positively or negatively. The simulation generates a large number of random scenarios to forecast share prices, making the overall predictions much more accurate as they consider many different scenarios. Each scenario for each day is random and represents random factors that affect the adjusted close price of the respective company's stock.

The Monte Carlo simulation will be conducted using historical data from approximately 23 years and will project one month into the future. The data is daily, so the forecast that the Monte Carlo simulation will produce is daily predictions for one month. At each given step, i.e. daily, random variables/factors are implemented to account for external factors so that the prediction is relevant to the real world and is as accurate as possible.

Using the forecasting and prediction of future stock prices from the time series model and Monte Carlo simulation techniques, a comparison will be implemented to compare the two methods of simulation. This comparison will be shown through visualisations (graphs, correlation plots, trends etc) and metrics such as mean squared error (MSE) and root mean squared (RMSE). Using this comparison, a conclusion will be made the more accurate and reliable model will be suggested.

After all the simulation methods are implemented, the report aims to discuss factors that cannot be "predicted" in a prediction/simulation model. This is done so readers/investors have a better understanding on how stocks work and what factors can influence share prices going up or down. Factors include natural disasters, politics, world wars along with many other factors that humans cannot predict. Using these factors along with the predictions the simulation models suggested, a recommendation will be made on which stock an individual should invest in to maximise one's return. By combining a time series model with Monte Carlo simulation techniques, a more accurate and reliable prediction is illustrated given the fact that the stock market is a highly volatile and unpredictable environment, and even through the use of models it is still extremely difficult to predict for certain the outcome of a stock and thus only recommendations can be made.

Code and relation to methodology:

Data Wrangling:

The data cleaning and wrangling process was not as extensive as first thought, as when initially examining the data, there were not many anomalies and things to be concerned over, as the data obtained from Yahoo Finance was already quite well put together. However, when checking for missing values, we found that there were quite a few missing values for

the adjusted close price data. This is illustrated below with the last 500 values of the dataset for apple and Microsoft being plotted.

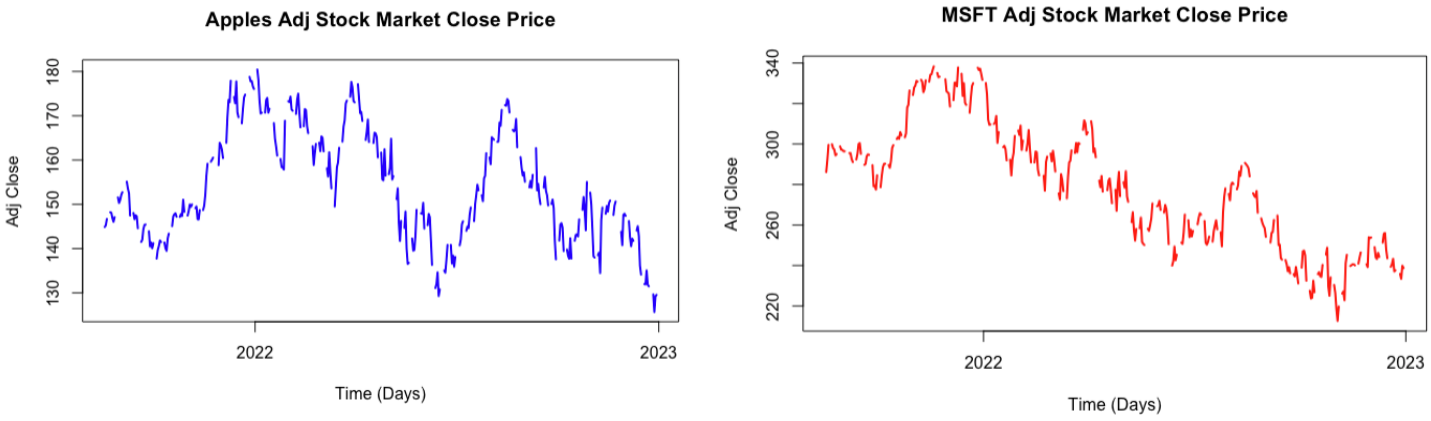


Figure 1: Missing Values Plots

It can be seen through the plots that there are quite a few missing values present. This needed to be addressed as for a time series model to be implemented, the data must be in order and sequential. To solve this problem, a subset of the original dataset was created and the extend function was used to fill in the missing values.

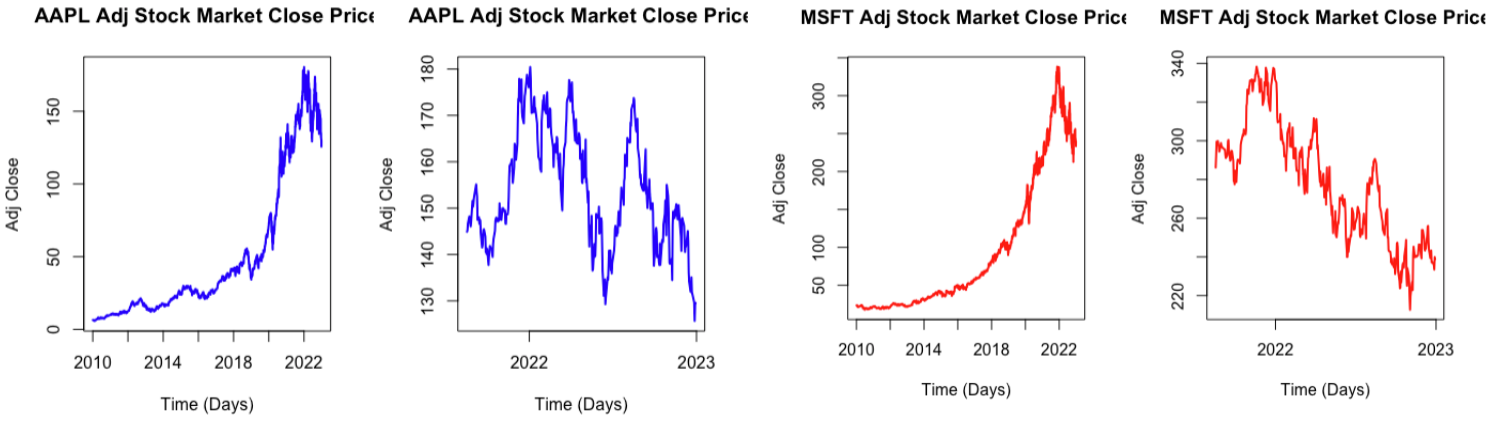


Figure 2: New Dataset plots

The above figures illustrate for both companies the graphs of the dataset with no missing values. As it can be seen, there are no gaps in the dataset and hence a time series model can now be implemented.

ARIMA Time Series Model:

The first step of the implementing a time series model is to transform the class of the dataset into a timeseries class. This is done so it can be used to forecast and plot the data using functions such as autoplot() and forecast().

After examining the forecast plot of the adjusted dataset, we split the dataset into a training and test set. The training set is used to build and "train" the time series model, and the splitting of the dataset ensures a more accurate and efficient prediction.

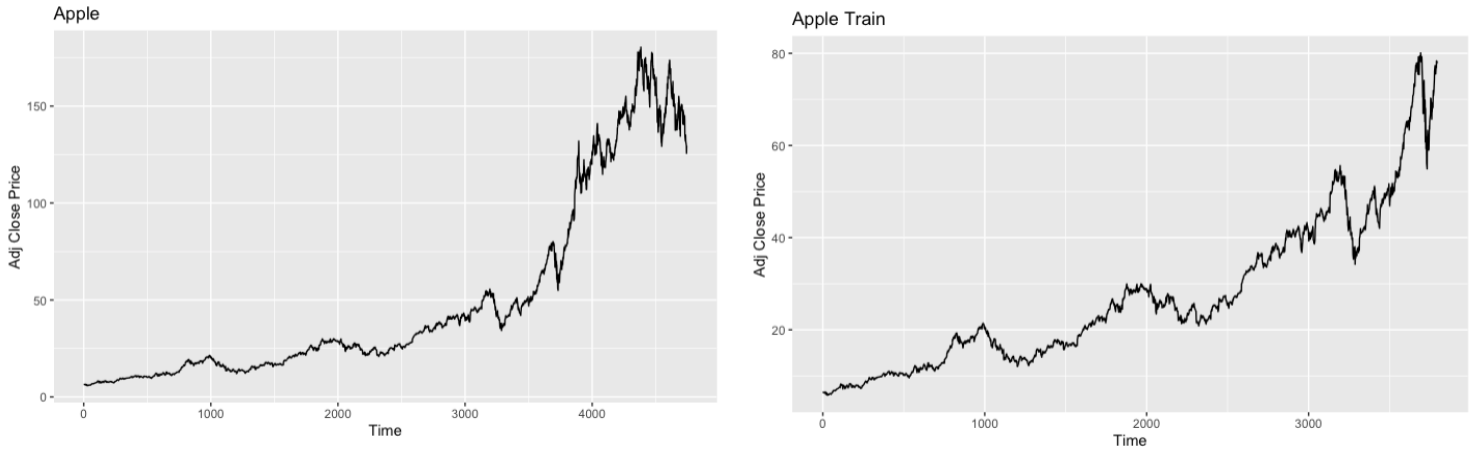


Figure 3: Apple Time Series & Apple Train Plot

As we can see from the above visualisations, the training set has split, as the observations are fewer than from before. The same was done for Microsoft and its datasets. We can identify that the data has an increasing pattern over time, with adjusted close price have a positive relationship with time. Therefore, we decided to fit an ARIMA time series model, as the graphs above show a seasonal pattern.

ARIMA models are best used when the data is non-stationary; this is applicable to our data as the stock market is quite an unpredictable place, with stock prices constantly fluctuating with time. This confirmed through an Augmented Dickey-Fuller Test, where we get a p-value of 0.99 & 0.9323 respectively. This means we fail to reject H0; that is data is not stationary. This is shown below.

Augmented Dickey-Fuller Test for Microsoft Train Set

data: MSFTTrain
Dickey-Fuller = 0.098076, Lag order = 15, p-value = 0.99
alternative hypothesis: stationary

Augmented Dickey-Fuller Test for Apple Train Set

data: AppleTrain
Dickey-Fuller = -1.0399, Lag order = 15, p-value = 0.9323
alternative hypothesis: stationary

Using the training set, we implement the ARIMA model using the auto.arima() function for both Apple and Microsoft. We decided to Implement the ARIMA time series model to predict stock growth as it is an effective model to identify and forecast specific trends and fluctuations, that of which are common in stocks.

Series: AppleTrain
ARIMA(0,1,1) with drift

Coefficients:
ma1 drift
-0.0529 0.0188
s.e. 0.0161 0.0073

sigma^2 = 0.2256: log likelihood = -2557.43
AIC=5120.85 AIC=5120.86 BIC=5139.58

Series: MSFTTrain
ARIMA(5,2,0)

Coefficients:
ar1 ar2 ar3 ar4 ar5
-1.0082 -0.8468 -0.6053 -0.3347 -0.1453
s.e. 0.0161 0.0223 0.0243 0.0223 0.0161

sigma^2 = 1.175: log likelihood = -5685.78
AIC=11383.55 AIC=11383.57 BIC=11421

Above are the summaries of the ARIMA models created for the respective stocks training sets. We can see that the variable, adjusted close price is quite significant due to the high s.e values. Comparing the AIC values for each model, we evaluate that Apple stocks have lower AIC values than MSFT. This indicates that Apple has a better fitted model than MSFT, as the lower the AIC value the better the fitted model is. However, we can also see that the variance for Microsoft is larger than the variance for Apple (sigma^2) value. In stocks, the higher the variance the higher the risk and higher the return. However, the opposite is also true; lower the variance the lower the risk and lower the return (Investopedia, 2022)

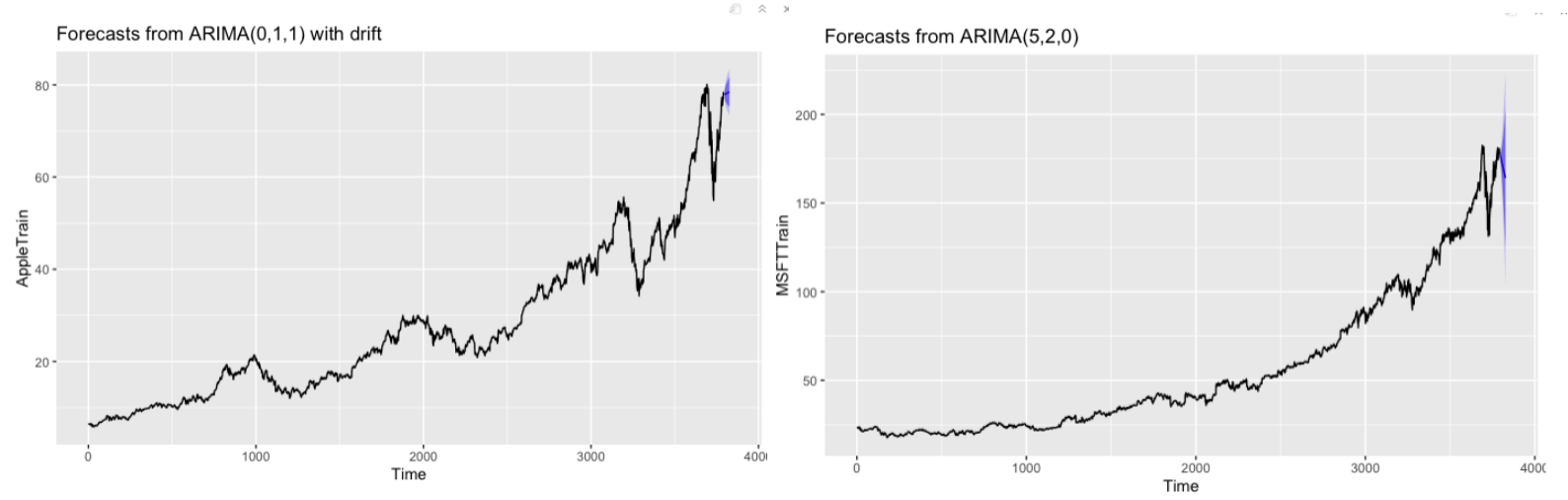


Figure 4: Forecast plots for Apple and Microsoft

The above are forecast plots that illustrate the projected growth of each respective stock, with Apple being on the left and Microsoft on the right. It can be seen that Microsoft has a much more consistent growth over a period of time, whereas Apple has many fluctuations and dips in its share price, indicating that is not as stable and volatile as its rival stock.

Monte Carlo Simulation:

Using the fitted models created in time series modelling, we implemented a Monte Carlo simulation to predict future population growth. MC simulation was chosen as it simulated random events with random factors in relation to the events. This fits well with predicting stocks, as predicted the future growth of stocks is quite difficult and near impossible due to the nature of how the stock market works. We first needed to confirm whether or not the data was normal or not.

Shapiro-Wilk normality test for Apple

data: AAPL_forecast$mean.
W = 0.95728, p-value = 0.2468

Shapiro-Wilk normality test for Microsoft

data: MSFT_forecast$mean.
W = 0.9585, p-value = 0.2661

Using the result of Shapiro test, we can conclude that the data is indeed normally distributed due to the large p-value (assuming significance @ 5%). Now that we have concluded that the data is normal, we implement a MC simulation to predict the mean and statistical significance of the forecasted stocks. We simulated 10,000 iterations for the next month (31 days) and obtained these values:

- Mean (Apple): **78.12255**
- Sig (Apple): **36.10117**
- Mean (MSFT): **170.3851**
- Sig (MSFT): **51.43407**

We then constructed confidence (credible) intervals to predict what range the forecasted values will be in, as illustrated below:

Apple : 2.5% 97.5%
66.83701 89.56883
2.5% 97.5%
0.05641351 194.78530246

MSFT: 2.5% 97.5%
159.0996 181.8314
2.5% 97.5%
11.33106 212.86665

This means that on average, the forecasted adjusted close price values for Apple lie between $66.8 - $89.6 US dollars, while for Microsoft they lie between $159.1 - $194.8 US dollars.

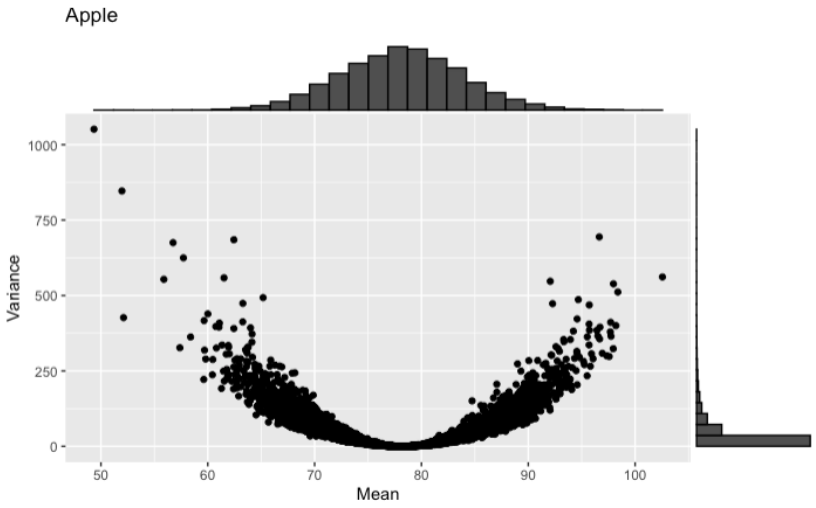
Findings and interpretation:

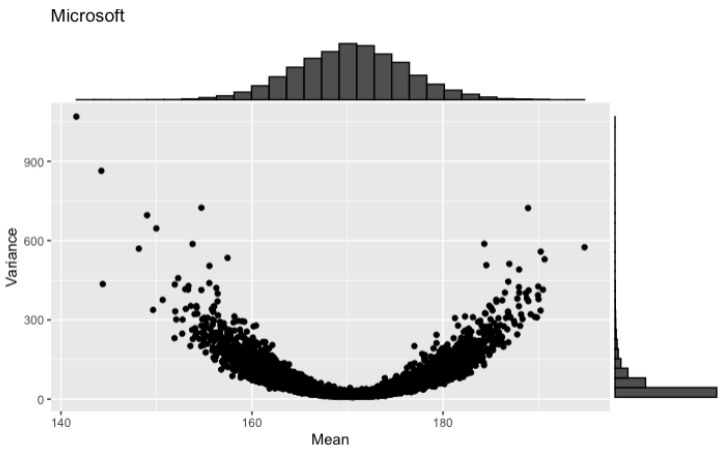
From the above findings, we can conclude on several different things. Firstly, before implementing analysis we hypothesised that we predicted Apple to be the better choice for investors to put their money in for maximum reward in the future against MSFT, however through further analysis we can say that this is not entirely true as our analysis predicts otherwise.

For instance, in the time series model the forecasted adjusted close price values for Microsoft are much higher than Apple's. This is backed up by the fact that Microsoft has a higher variance indicating higher risk but also higher return. Also in the forecast plots for the

time series model, it illustrated that Apple and many dips and variations over time, whereas Microsoft was much more consistent in its growth and did not show a large number of changes over the course of a month.

In our final model, a Monte Carlo simulation was implemented. We found from our randomised simulations, that Apple's adjusted close price values for the next month range between $66.8 and $89.5 Us dollars, whereas Microsoft's ranges from $159.1 - $ 181.8 US dollars. We can clearly see that the returns for Microsoft are projected to be much greater than Apple's. This is confirmed by the graphs below.





We can visualise from the above plots that the mean for Microsoft is situated between 160-180, whereas the mean for Apple is situated at a much lower price; approximately between 70-85.

From our findings and interpretations, we can advise investors to put their money in Microsoft stocks rather than Apple stocks. This is because even though both stocks show growth over the course of the future, Microsoft is seen to be the more stable stock, giving higher returns as well as stability, whereas Apple is seen to be more volatile and is seen to have many changes in its growth over time. This could be down to many factors. Microsoft operates in many different areas of technology whereas Apple is mainly focused on the smartphone and electronic devices area of the tech industry. This could be a factor as to why it is volatile as it is in more of a specific domain compared to Microsoft making more susceptible to change and volatility. Microsoft, on the other hand operates in a large number of areas and hence makes it less susceptible to changes and drastic changes in its stock price, making it a better stock for growth while also guaranteeing investors security and stability. It is important to note that the stock market is an incredibly unpredictable environment and predictions should only be used as a guide, as practically anything could happen and hence educated, informed investment decisions should be made.

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