

# Stock Price Analysis and Predictions

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*A Day in the Life of a Data Scientist  
at a Prestigious Investment Firm*



*Presented by Dr. Monday Oshoikpor*

CANOJOPA  
INC.

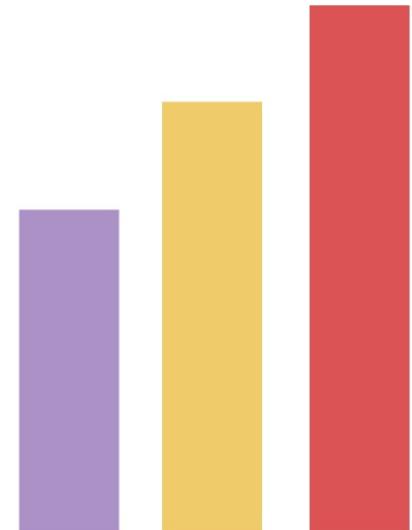
## Problem Statement

I am a data scientist at CANOJOPA Inc., a renowned investment brokerage firm in the Bay Area of California. This company specializes in buying and selling securities like stocks on an exchange market for individuals as well as businesses. One of my many daily tasks at CANOJOPA Inc. is to run a series of analysis on a 5-year historical data of Amazon Inc., Adobe Inc., Microsoft Corporation and Square Inc. and come up with recommendations for our client.

# Problem Statement

I have decided to draft metrics which can measures the performance of the stocks as well as run predictions on adjusted closing prices. The metrics include:

- To determine the change in price of the stock over time.
- To determine the daily return of the stock on average.
- To determine the moving average of the various stocks.
- To determine the correlation between different stocks.
- To determine how much value we put at risk by investing in a particular stock.
- To determine how we can attempt to predict future stock behavior.



# Stock Price Analysis and Predictions

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What was the  
change in  
price of the  
stock over  
time?

Historical  
View of  
Closing  
Price

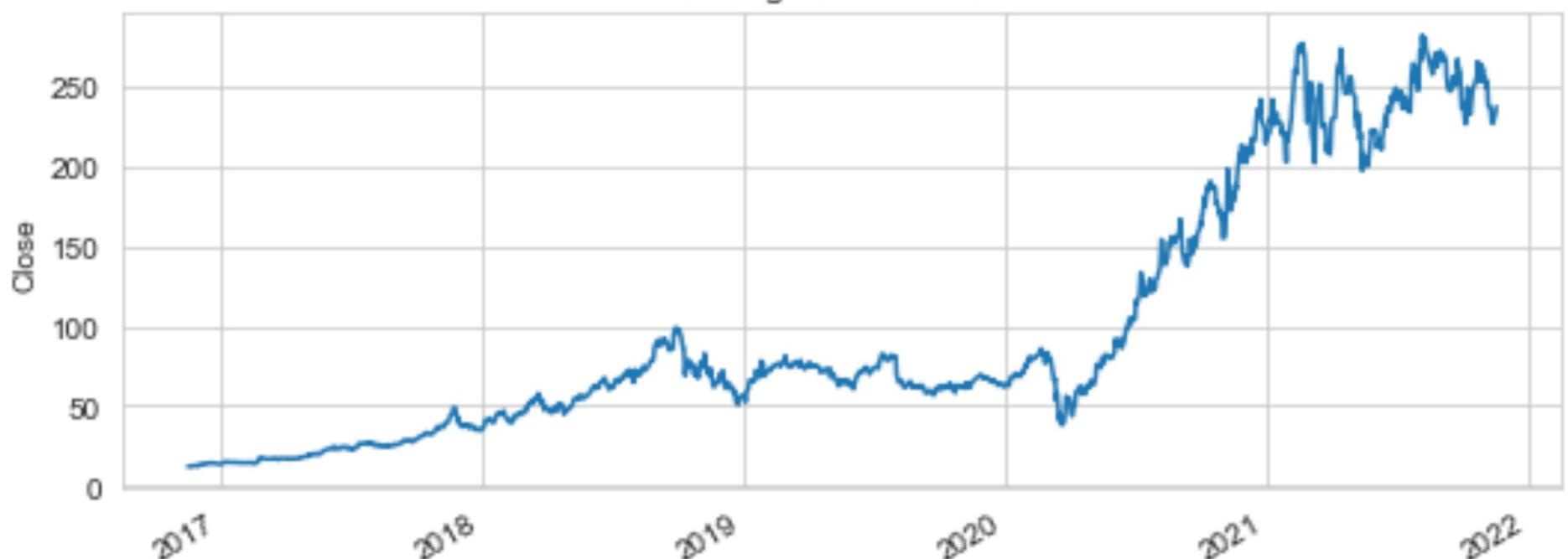
Total  
Volume of  
Stocks  
Traded

We plotted graphs for  
the closing price  
for four stocks: Adobe (ADBE),  
Amazon (AMZN), Microsoft  
(MSFT), and Square (SQ)

View  
Graphs



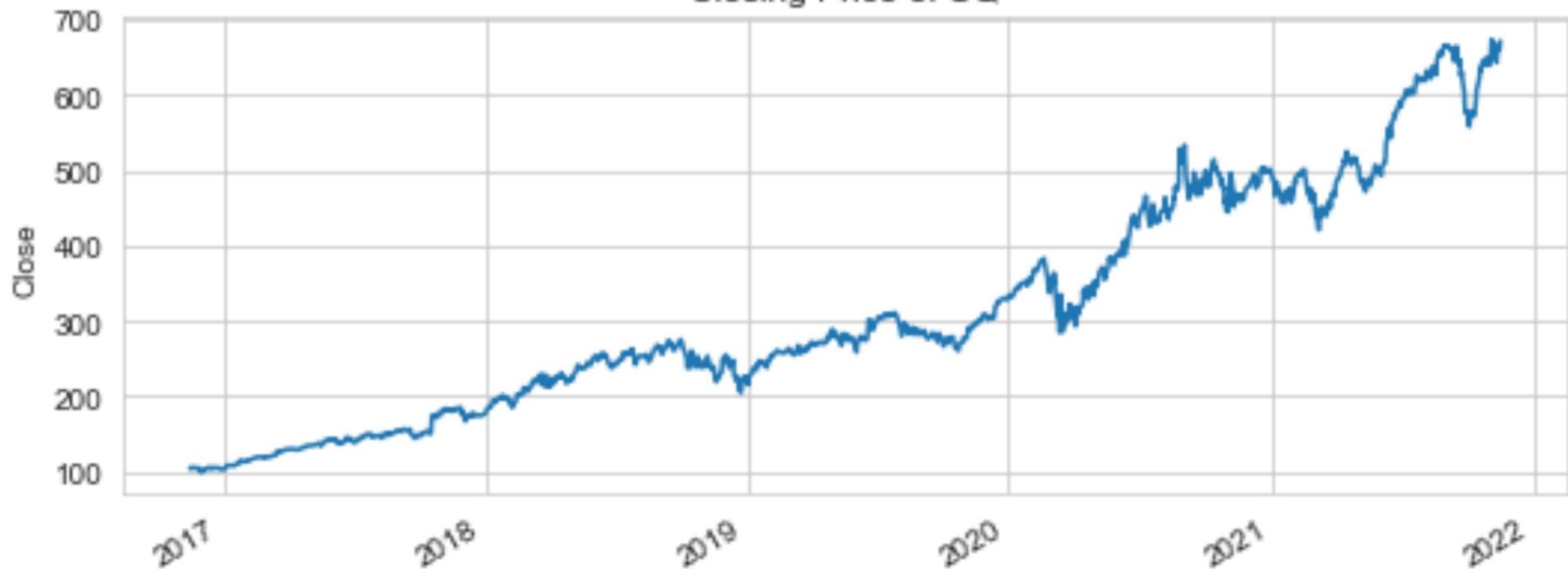
Closing Price of ADBE



Closing Price of MSFT



Closing Price of SQ



Closing Price of AMZN

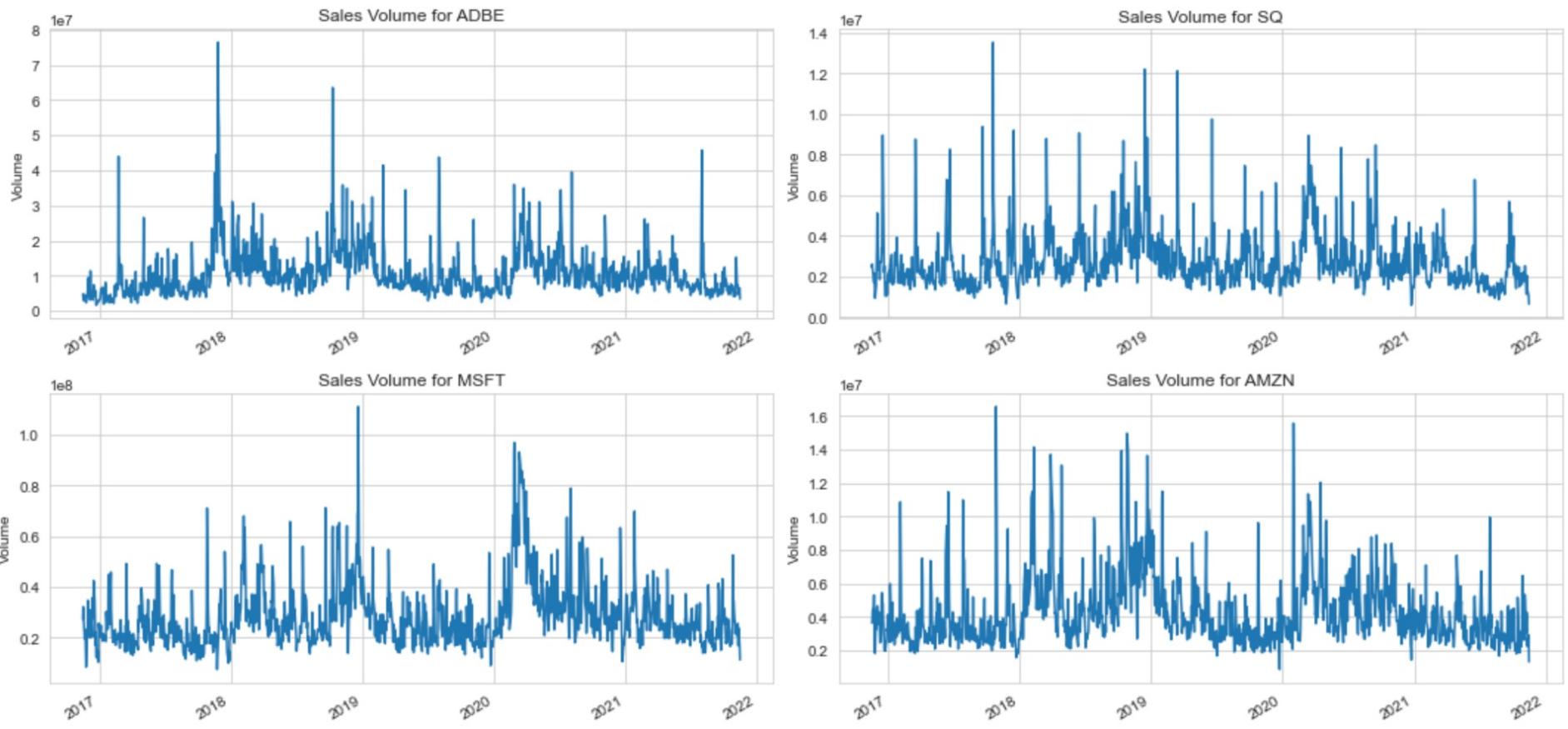


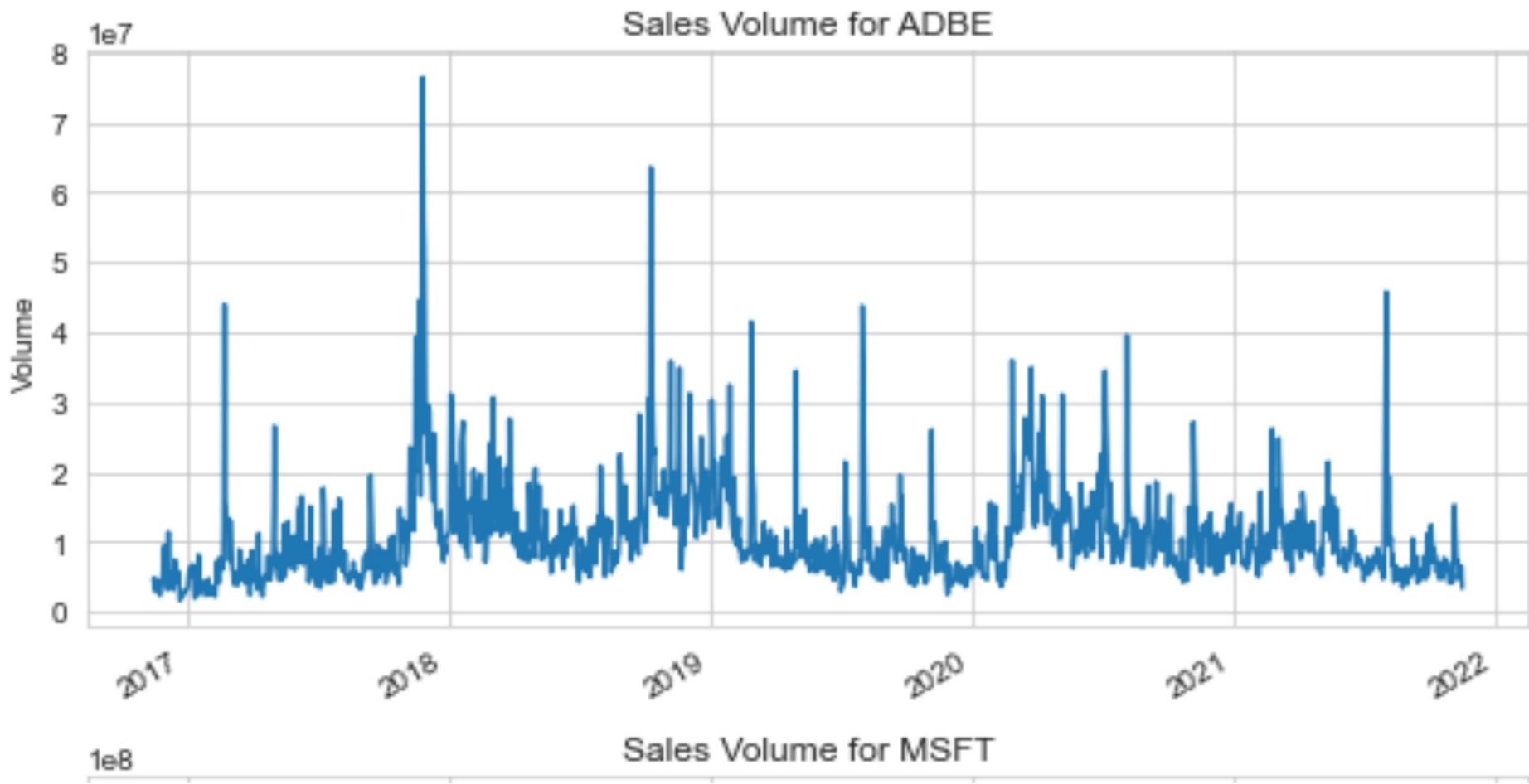


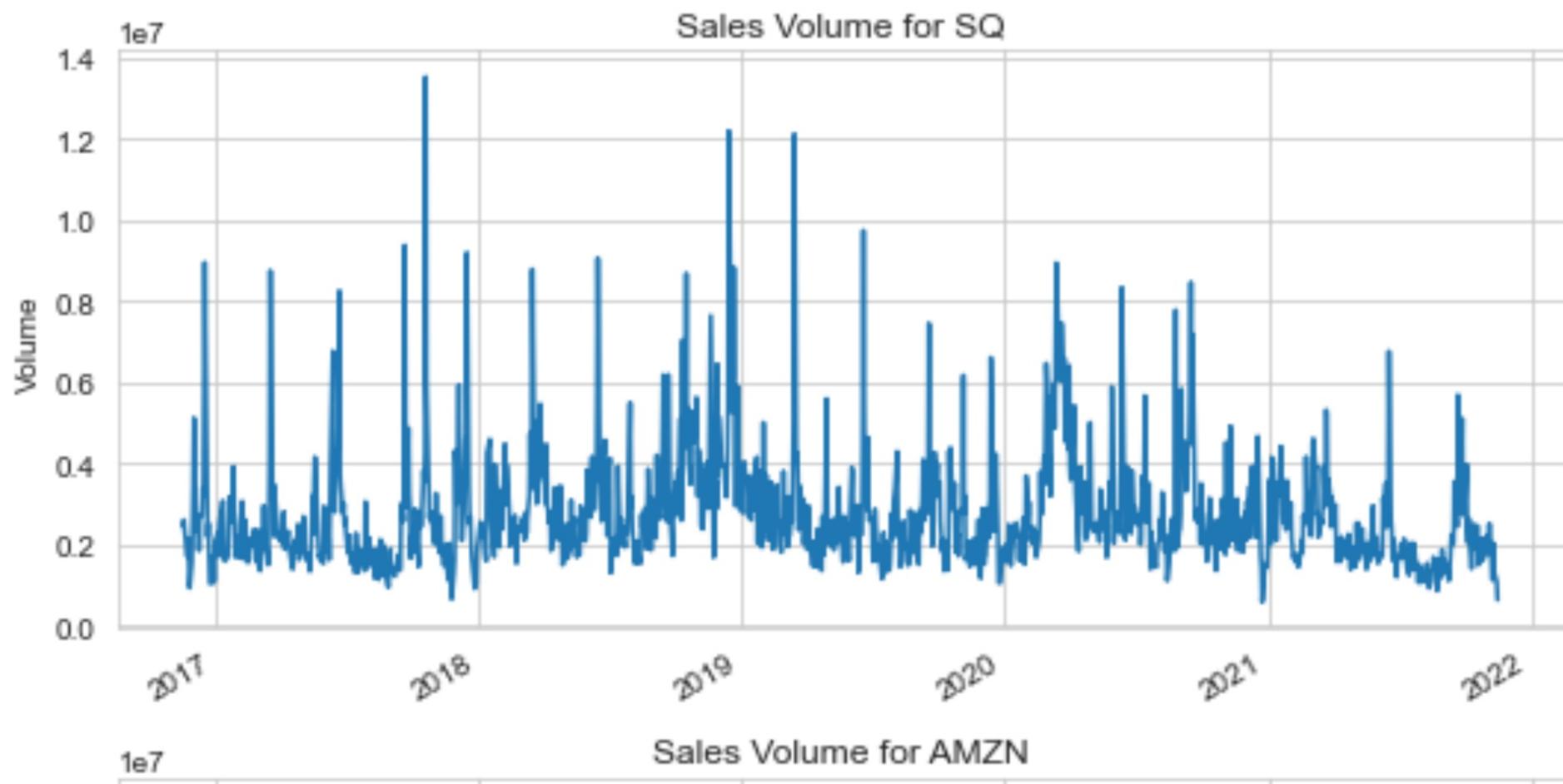


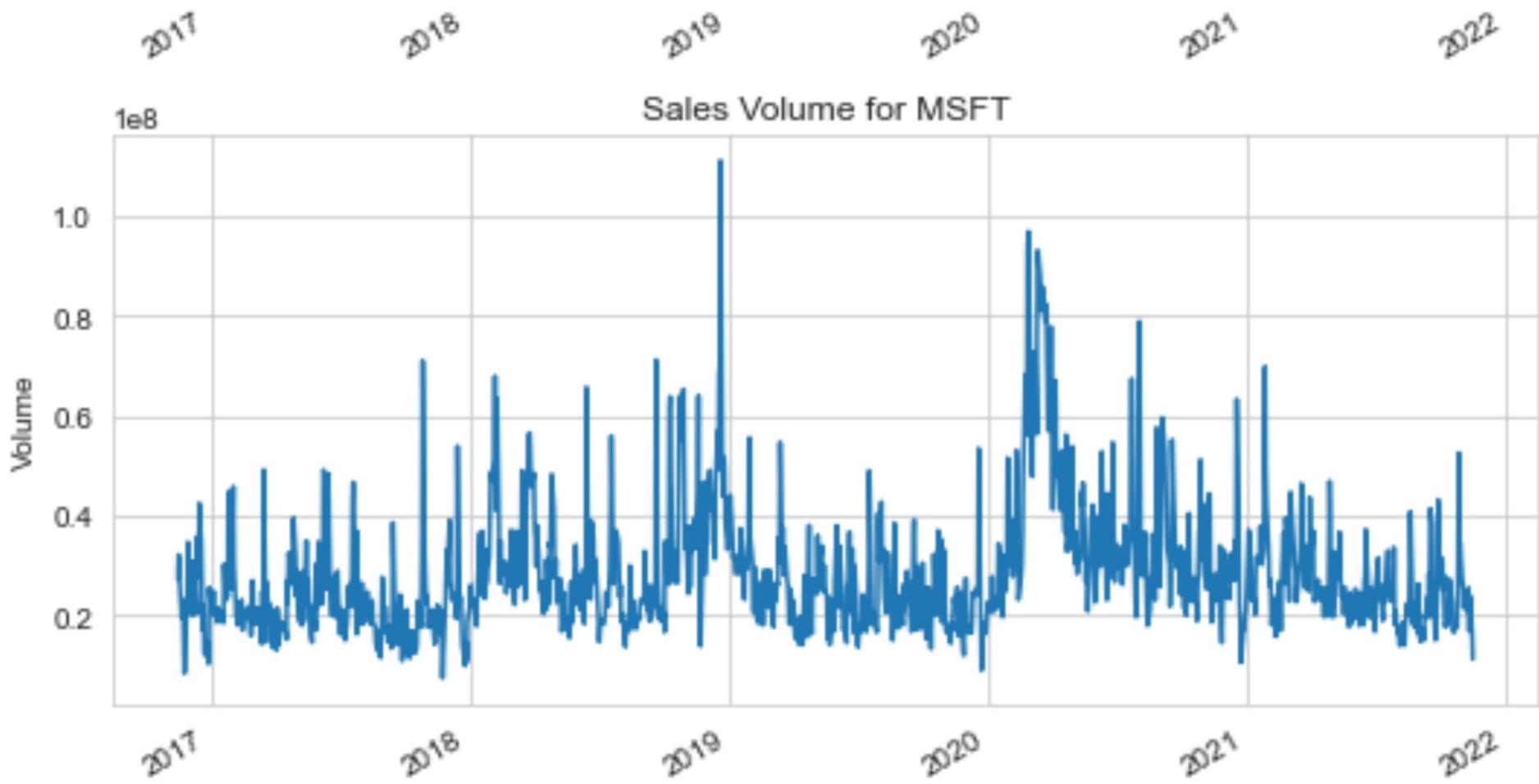
**Next, we plotted  
graphs of the total  
volume of each of the  
stocks traded each day**

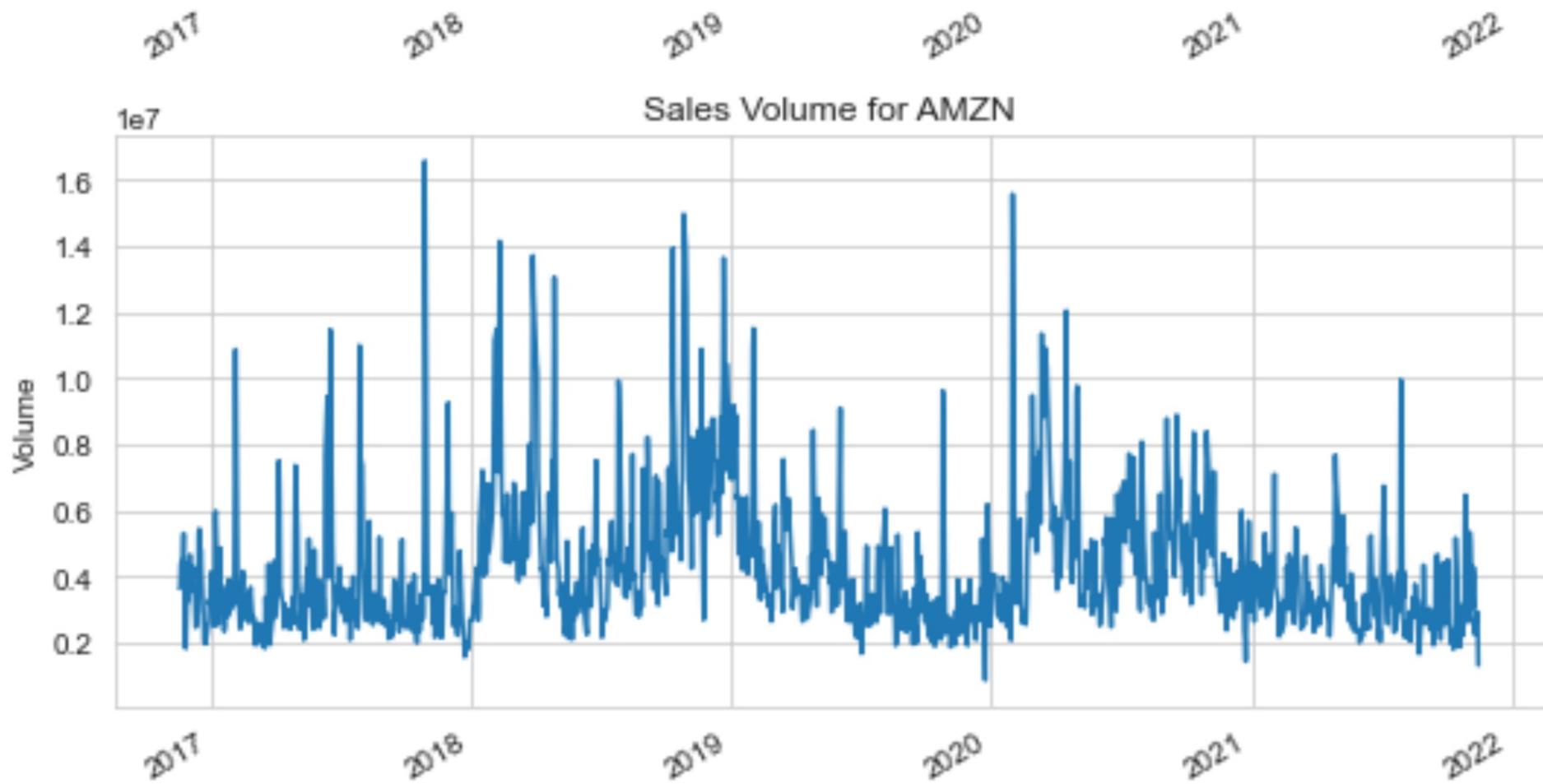
**View  
Graphs**











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What is  
the  
Average  
Return?

What was the  
daily return  
for each of  
the stocks on  
average?

Moving  
Average  
for All  
Stocks

## Definition of Average Return

The average return is the simple mathematical average of a series of returns generated over a specified period of time. This is part of an attempt to analyze the risk of the stocks hence we will take a closer look at the daily changes of the stock, and not just its absolute value.

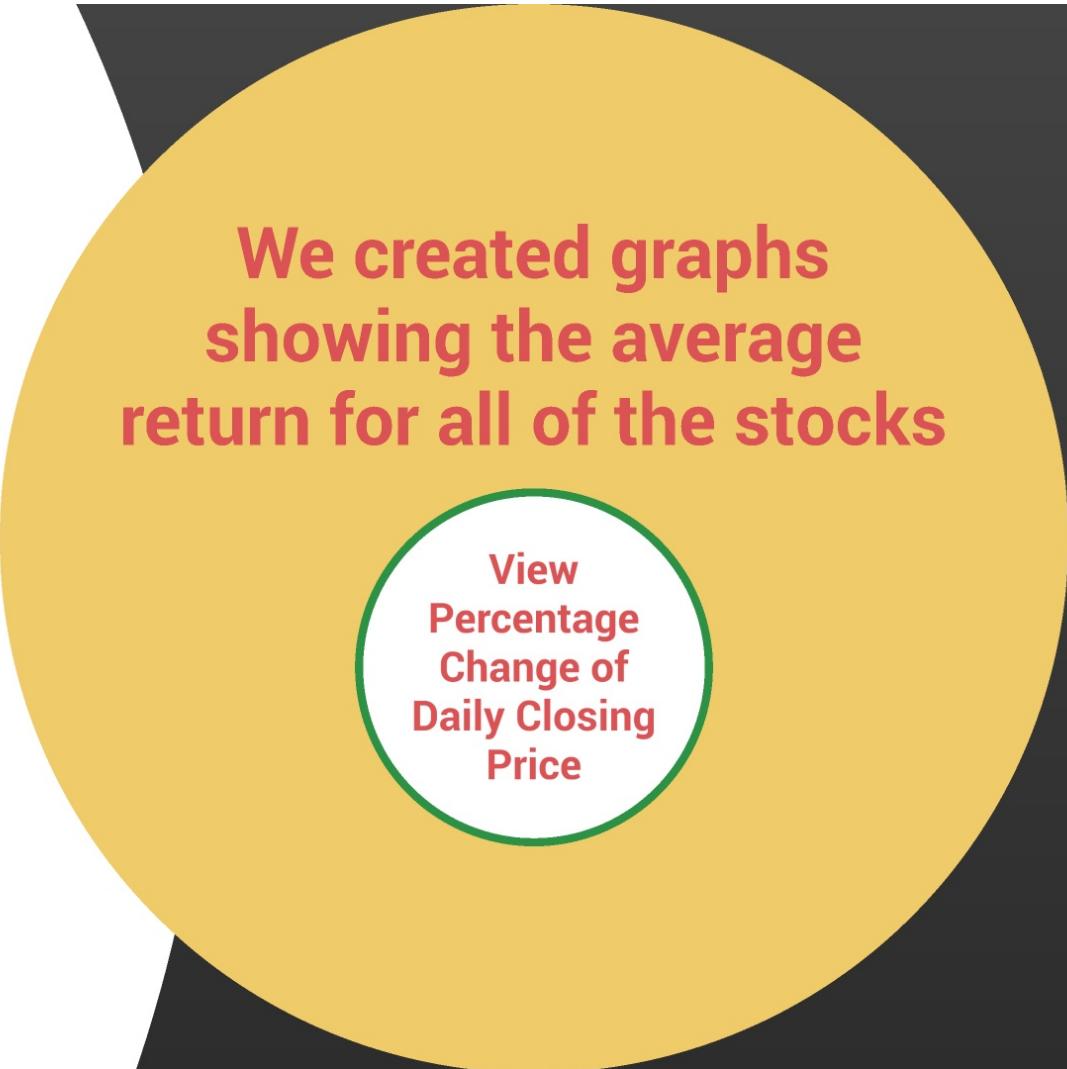
*Source: "Average Return" (Investopedia, 2021)*



What is  
the  
Average  
Return?

What was the  
daily return  
for each of  
the stocks on  
average?

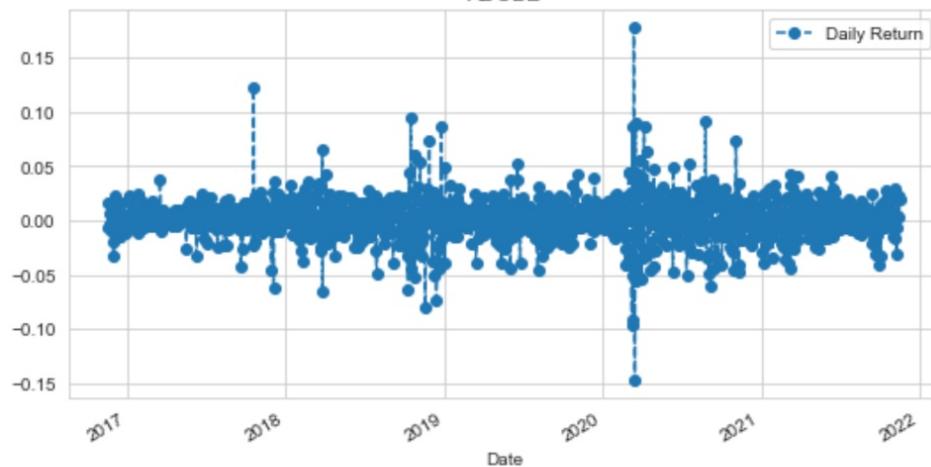
Moving  
Average  
for All  
Stocks



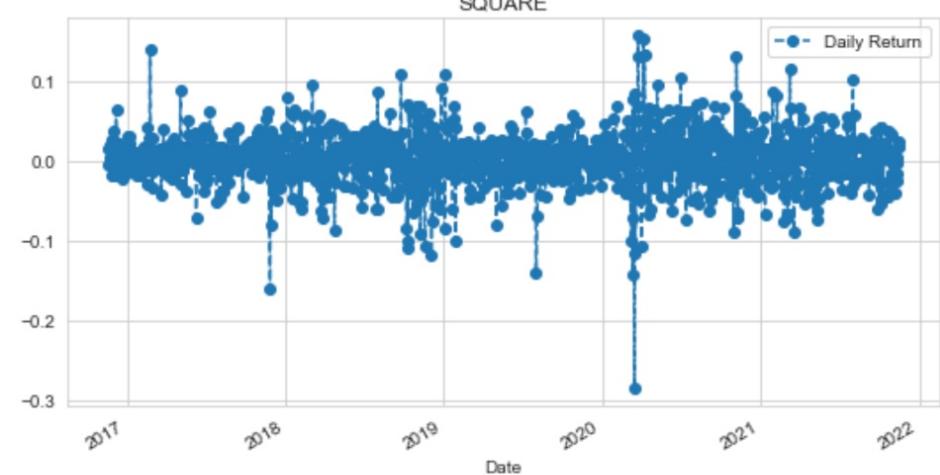
We created graphs  
showing the average  
return for all of the stocks

View  
Percentage  
Change of  
Daily Closing  
Price

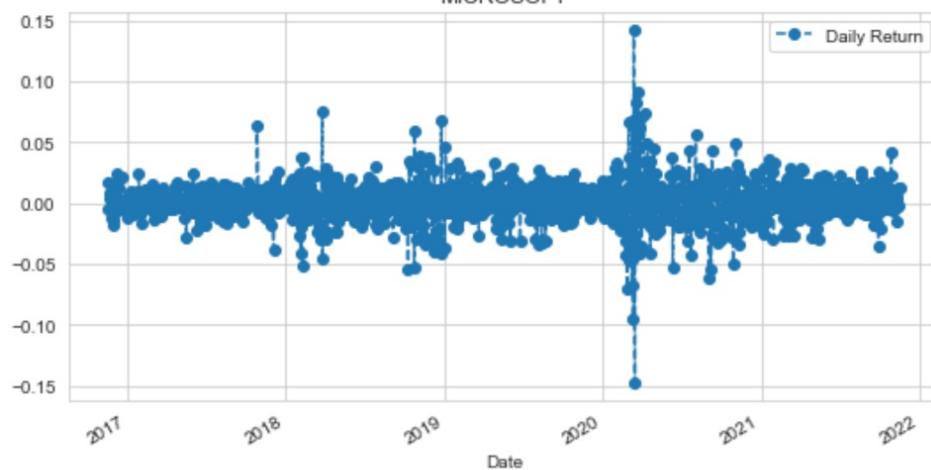
ADOBE



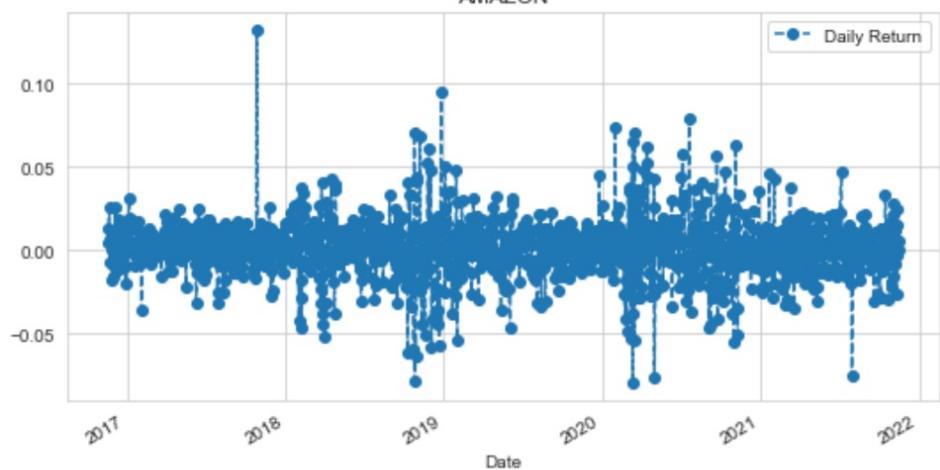
SQUARE



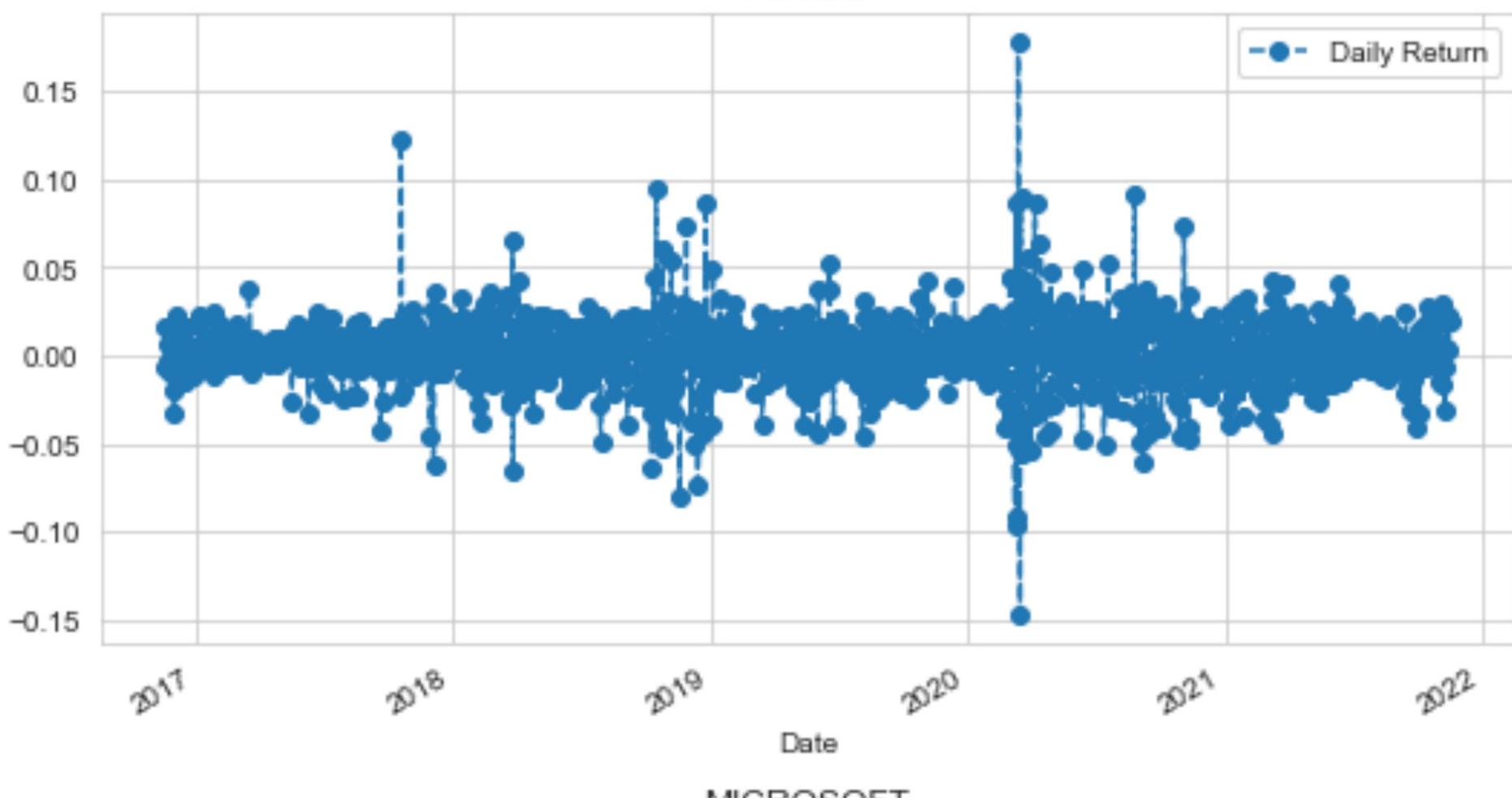
MICROSOFT



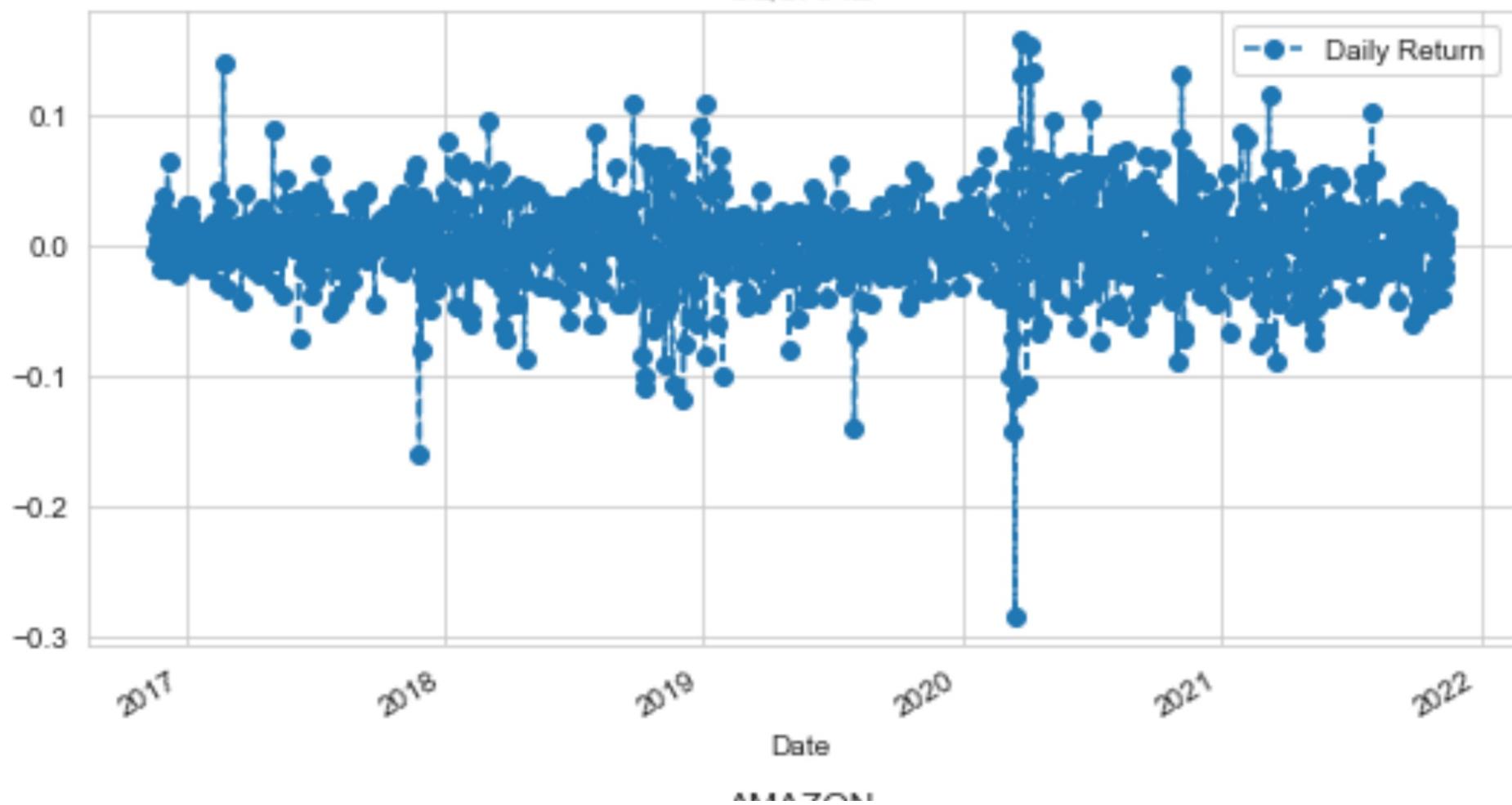
AMAZON



## ADOBE

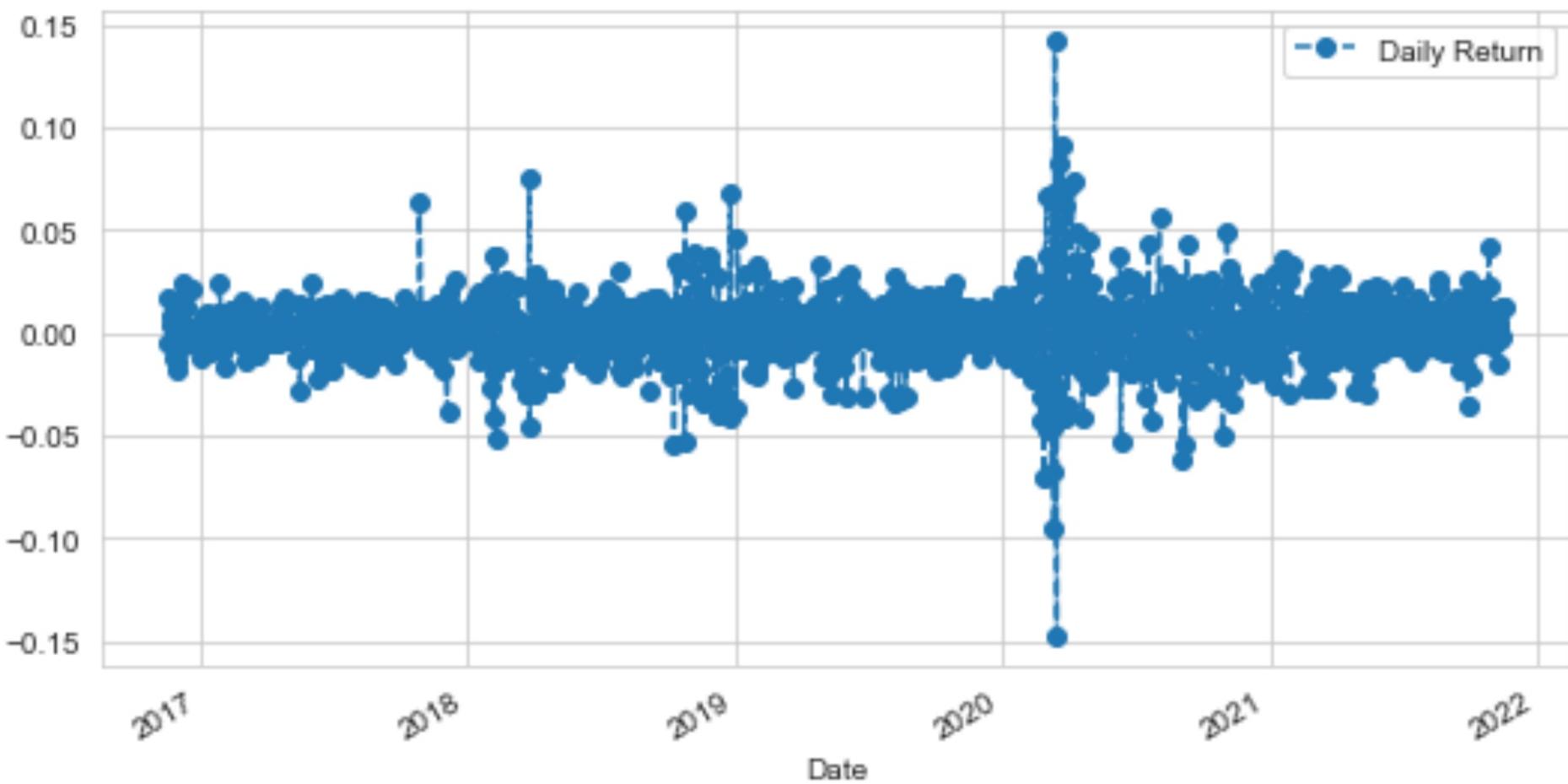


## SQUARE

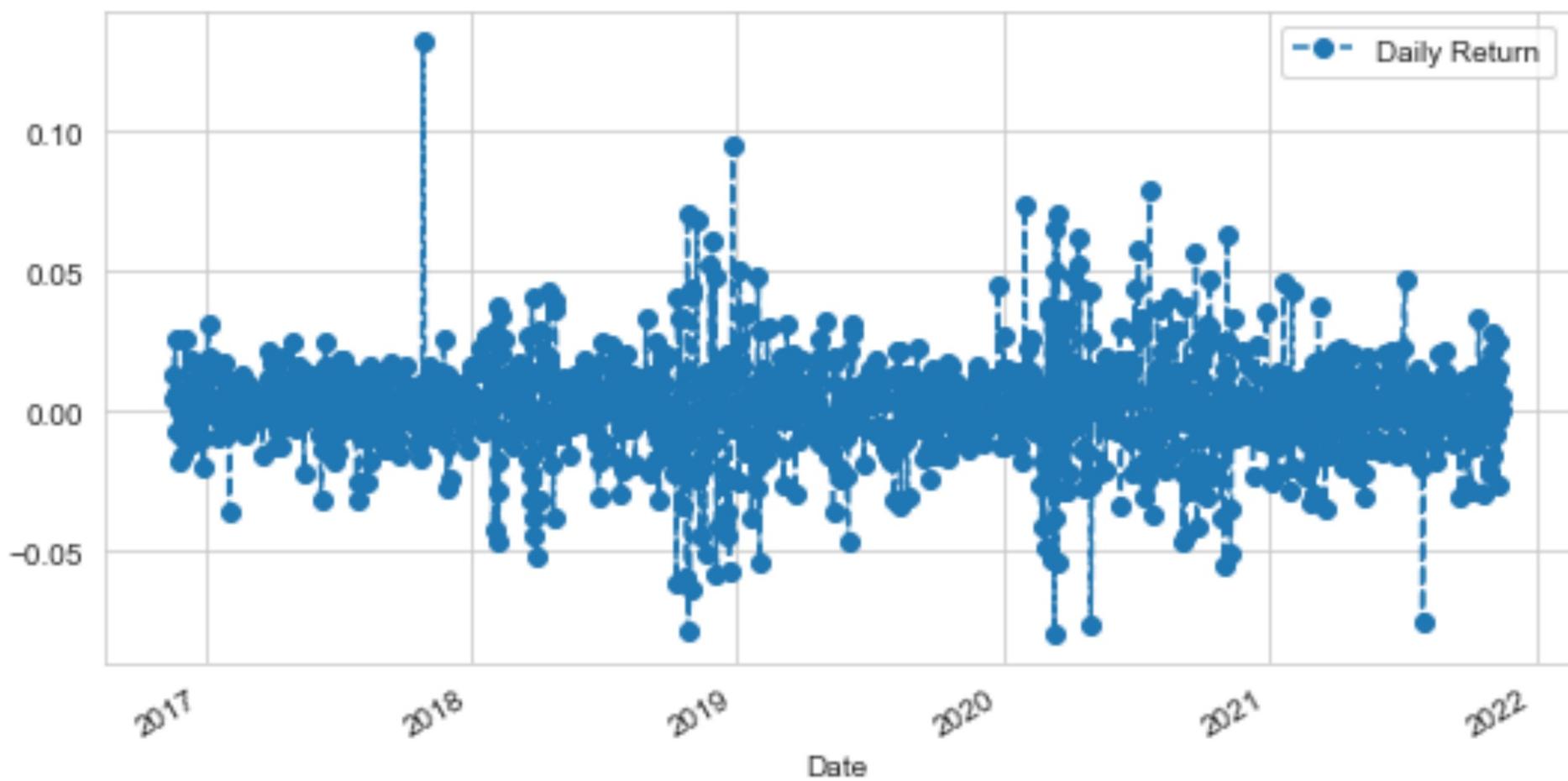


AMAZON

## MICROSOFT



## AMAZON



We created graphs  
showing the average  
return for all of the stocks

View  
Percentage  
Change of  
Daily Closing  
Price

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What was the  
moving  
average of  
the various  
stocks?

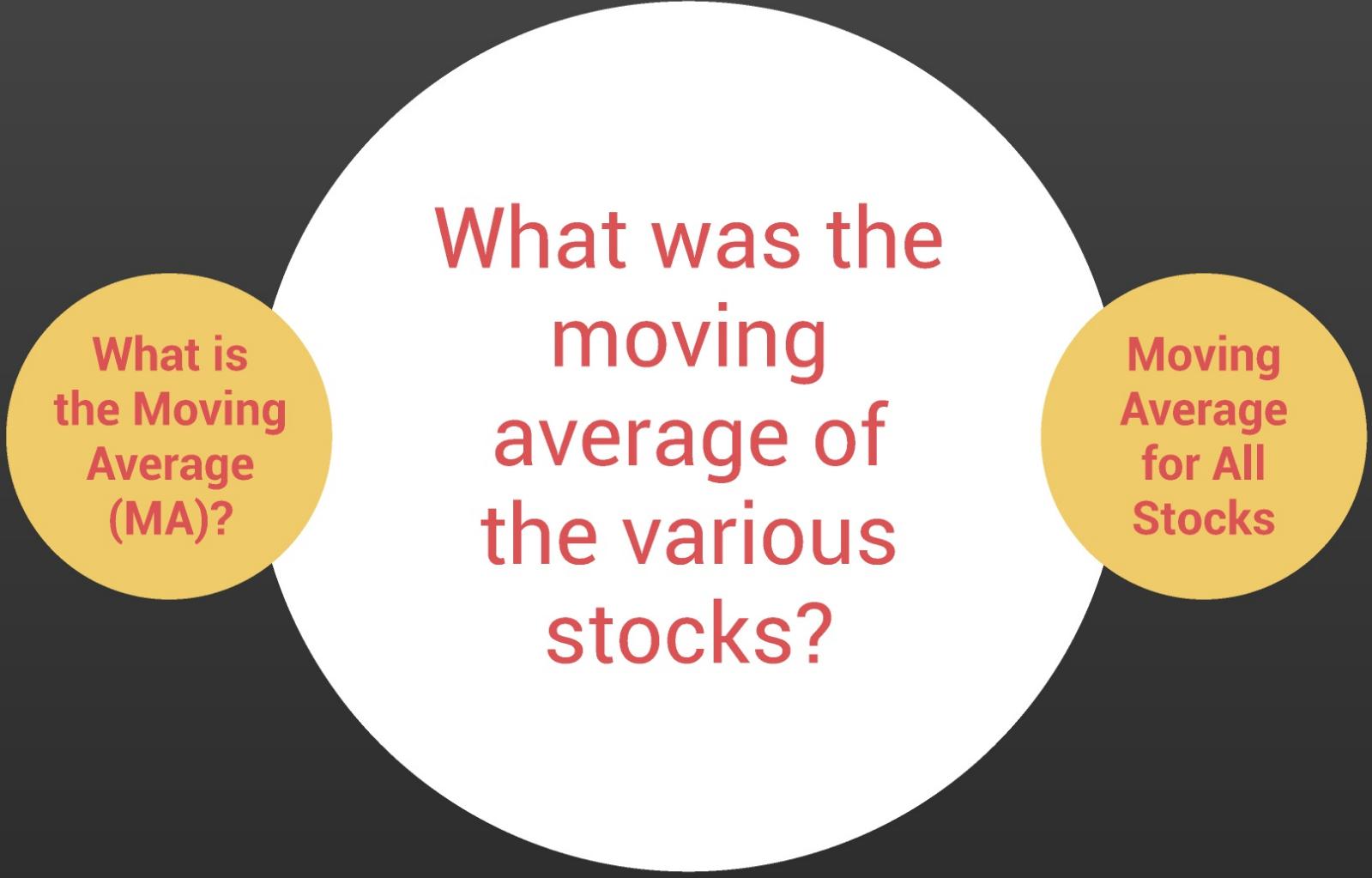
What is  
the Moving  
Average  
(MA)?

Moving  
Average  
for All  
Stocks

## Definition of Moving Average (MA)

A moving average (MA) is a widely used technical indicator that smooths out price trends by filtering out the “noise” from random short-term price fluctuations. We will need the MA in this project to identify trend direction and to determine support and resistance levels.

*Source: "How to Use a Moving Average to Buy Stocks" (Investopedia, 2021)*



What was the  
moving  
average of  
the various  
stocks?

What is  
the Moving  
Average  
(MA)?

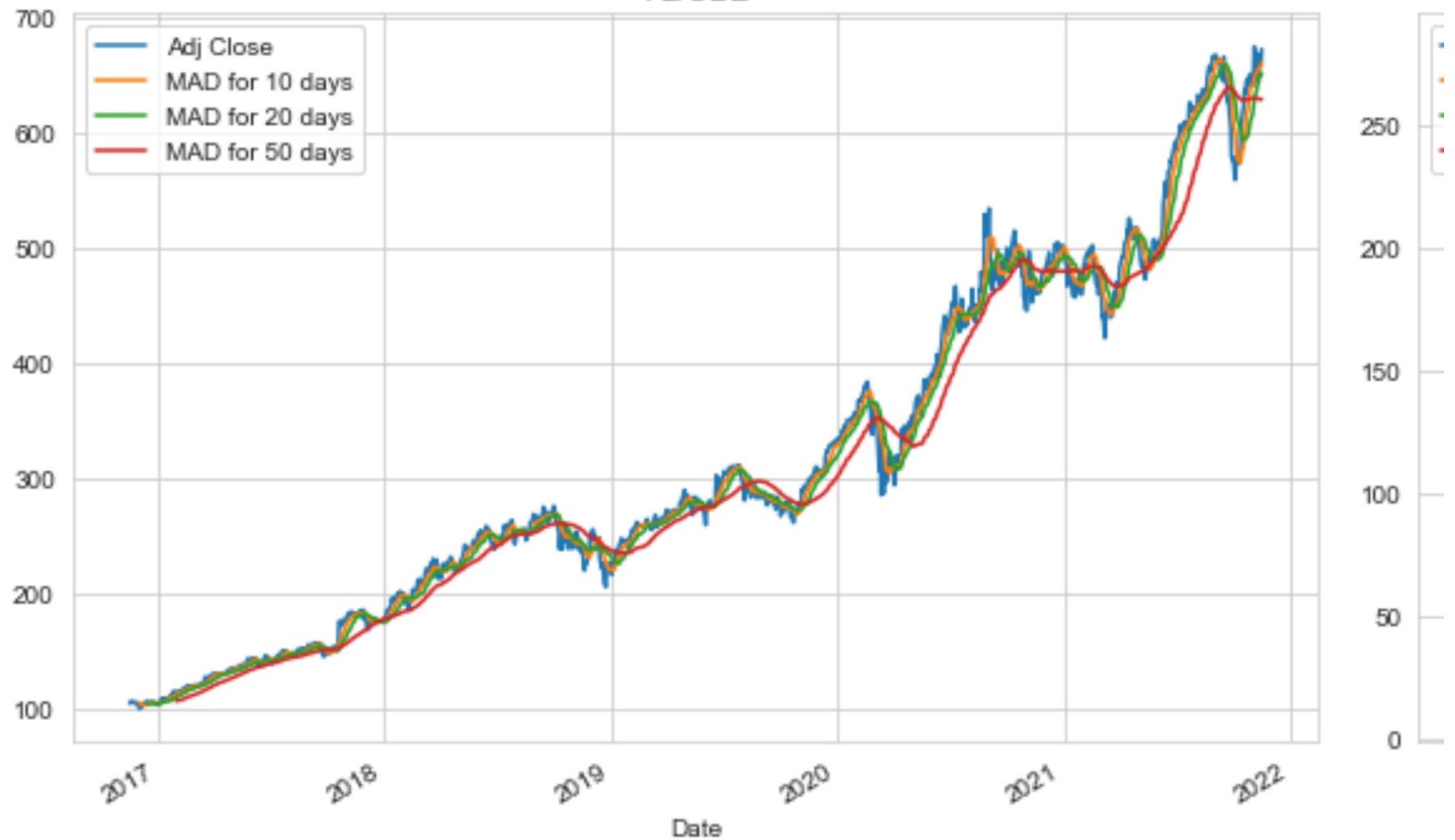
Moving  
Average  
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We plotted graphs for  
the moving average  
for all stocks

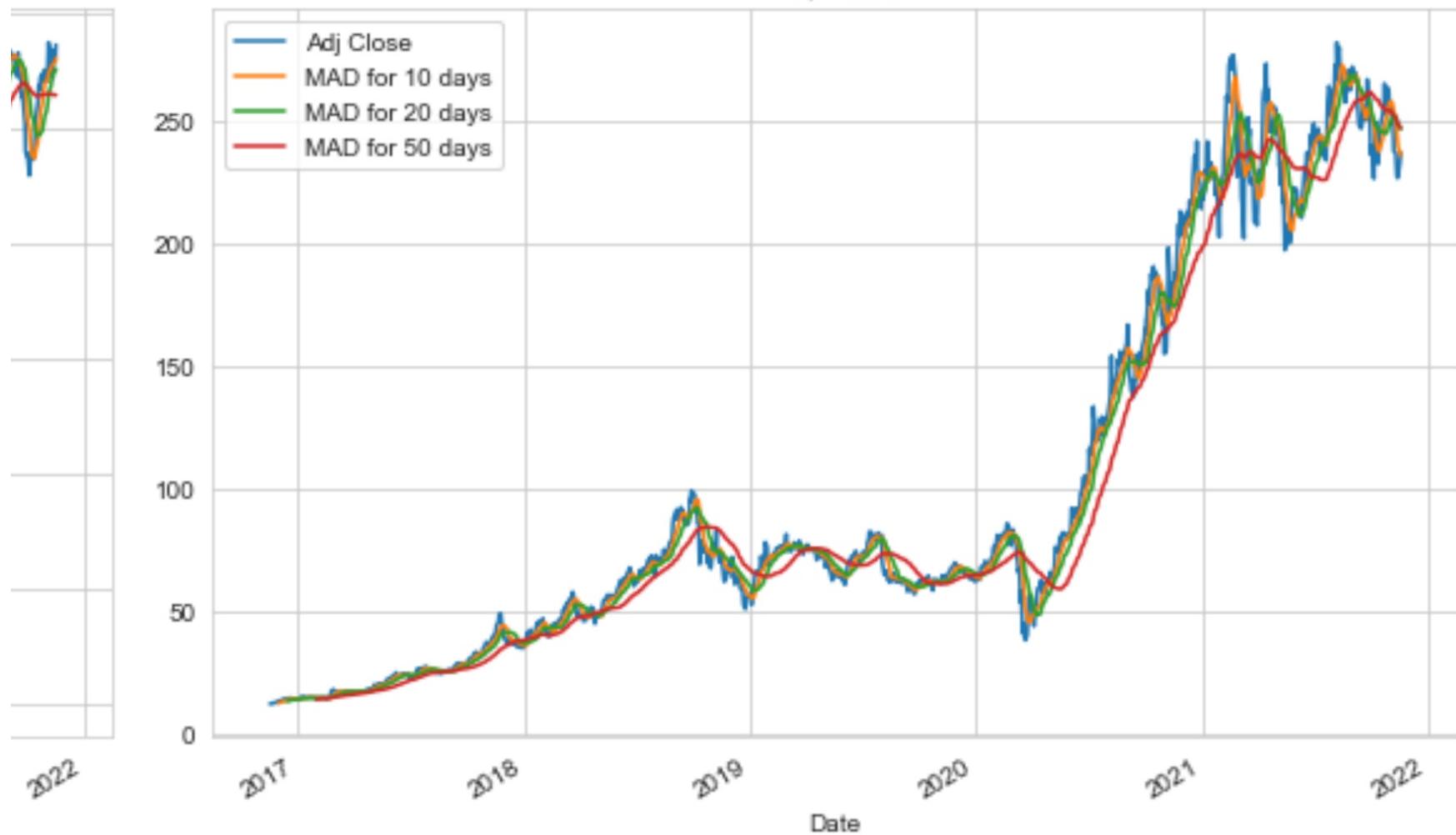
View  
Graphs



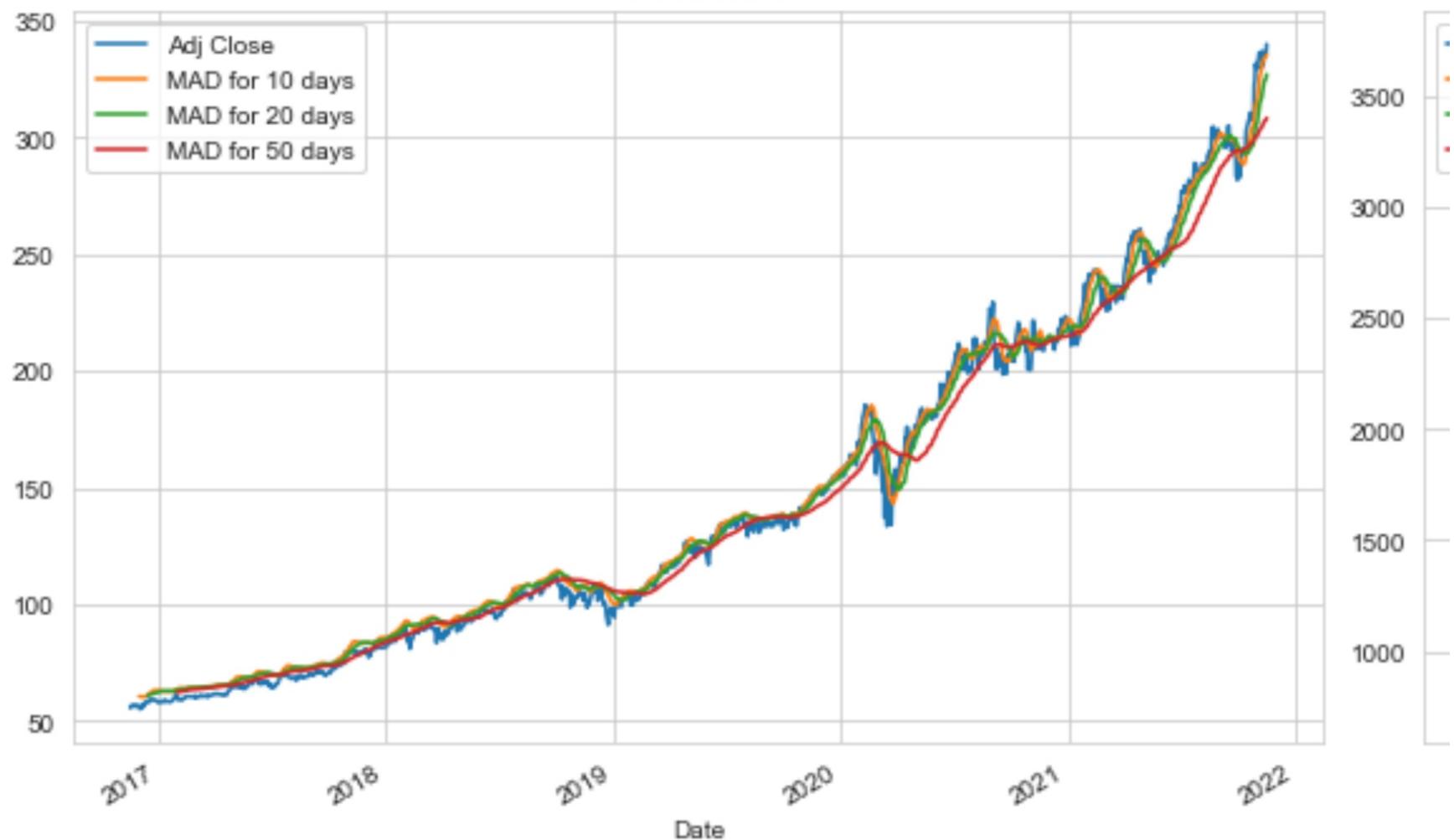
## ADOBE



## SQUARE



## MICROSOFT



## AMAZON



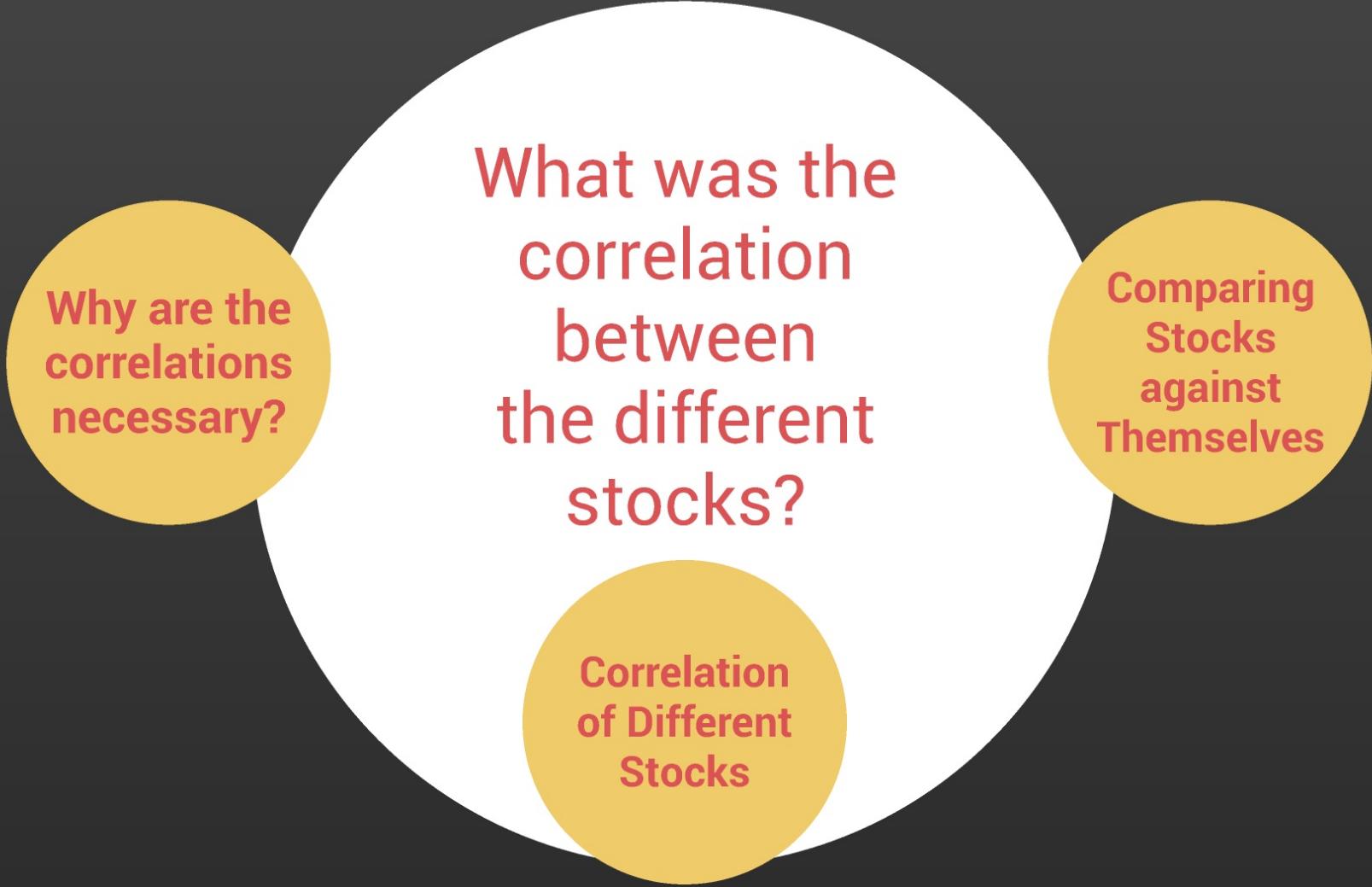
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What was the  
correlation  
between  
the different  
stocks?

Why are the  
correlations  
necessary?

Comparing  
Stocks  
against  
Themselves

Correlation  
of Different  
Stocks

## Why Find the Correlation?

Correlation measures the amount of co-movement between two investment securities (stocks). CANOJOPA is interested in calculating the correlations between the different stocks in view because understanding correlations can help investors (our clients) build diversified portfolios.

*Source: "Can I use the correlation coefficient to predict stock market returns?"  
(Investopedia, 2020)*



We are comparing stocks  
against themselves to  
make sure that the  
covariance equals  
the variance

Adobe  
ADBE

Square  
SQ

Amazon  
AMZN

Microsoft  
MSFT



We are comparing stocks  
against themselves to  
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Adobe  
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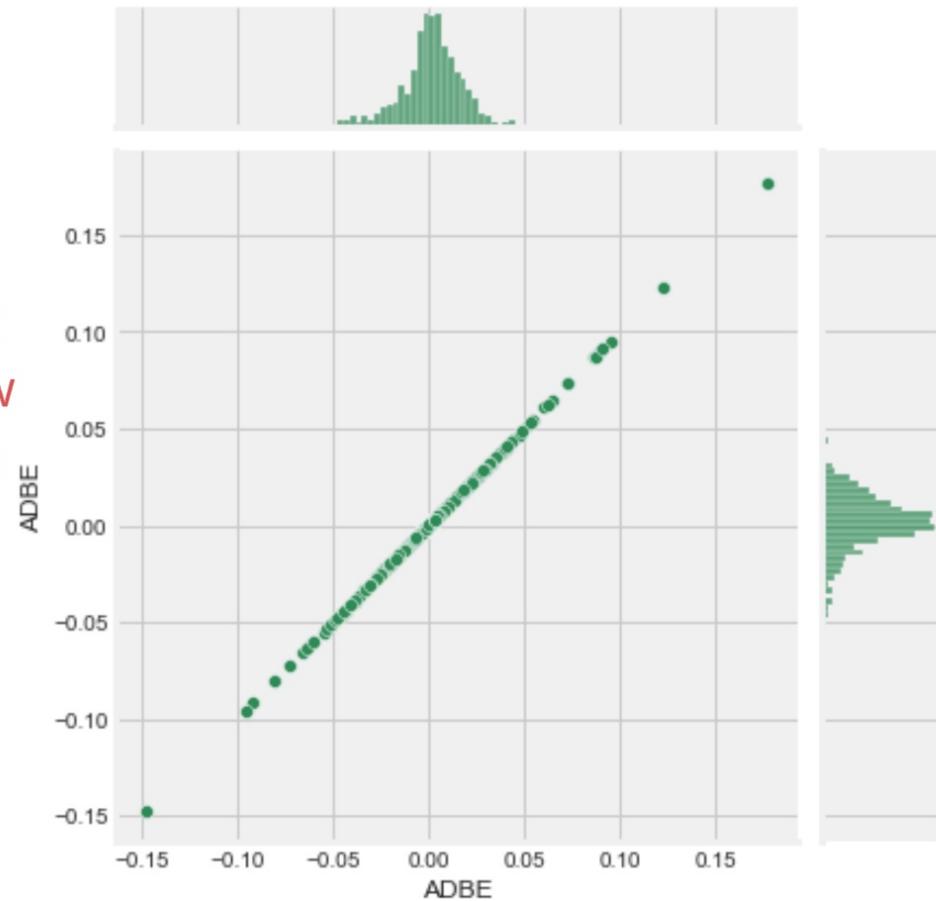
Square  
SQ

Amazon  
AMZN

Microsoft  
MSFT

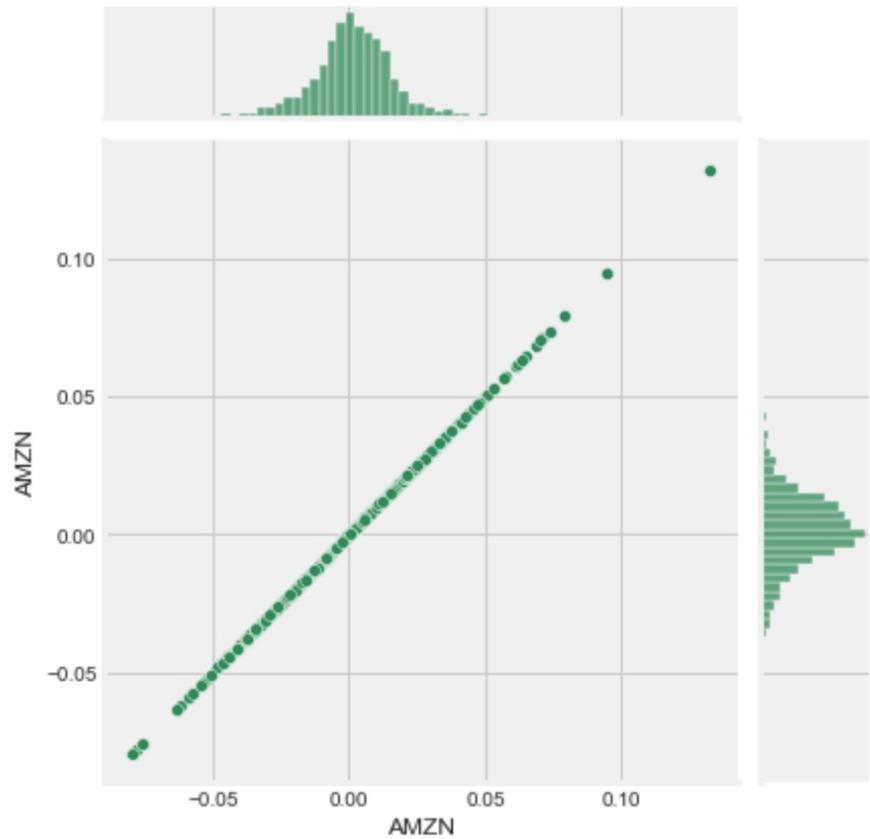
## Adobe (ADBE) Stock

The focus of this visual is majorly on the two histograms. We want to show that the standard deviation given an asset (Adobe stock price), if multiplied by itself (Adobe stock price), the value is equal to Adobe stock price squared.



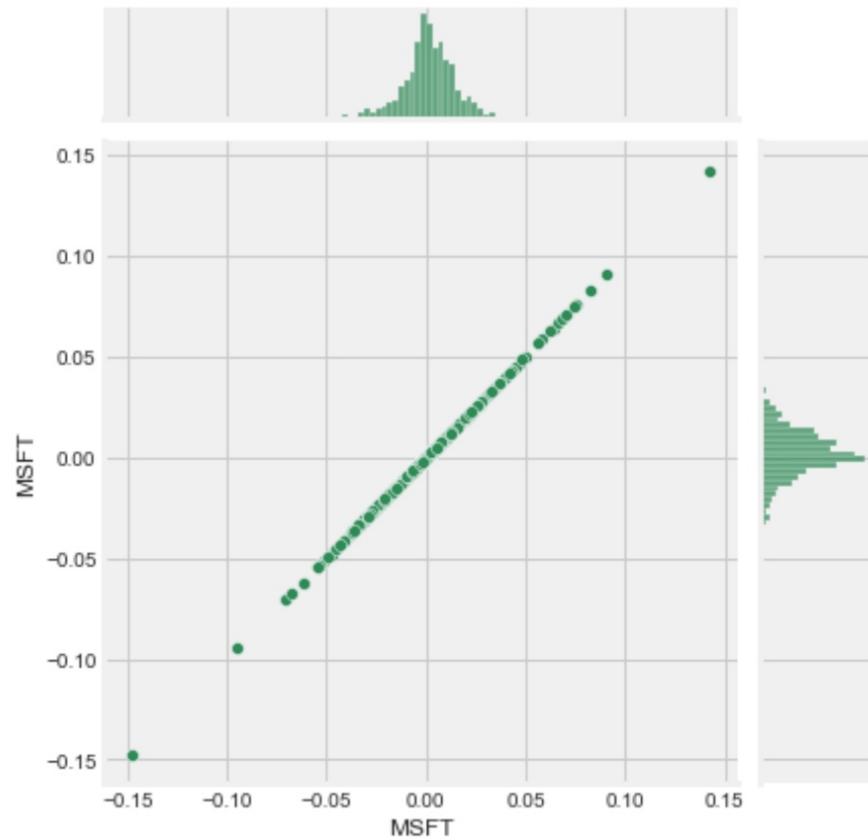
## Amazon (AMZN) Stock

The focus of this visual is majorly on the two histograms. We want to show that the standard deviation given an asset (Amazon stock price), if multiplied by itself (Amazon stock price), the value is equal to Amazon stock price squared.



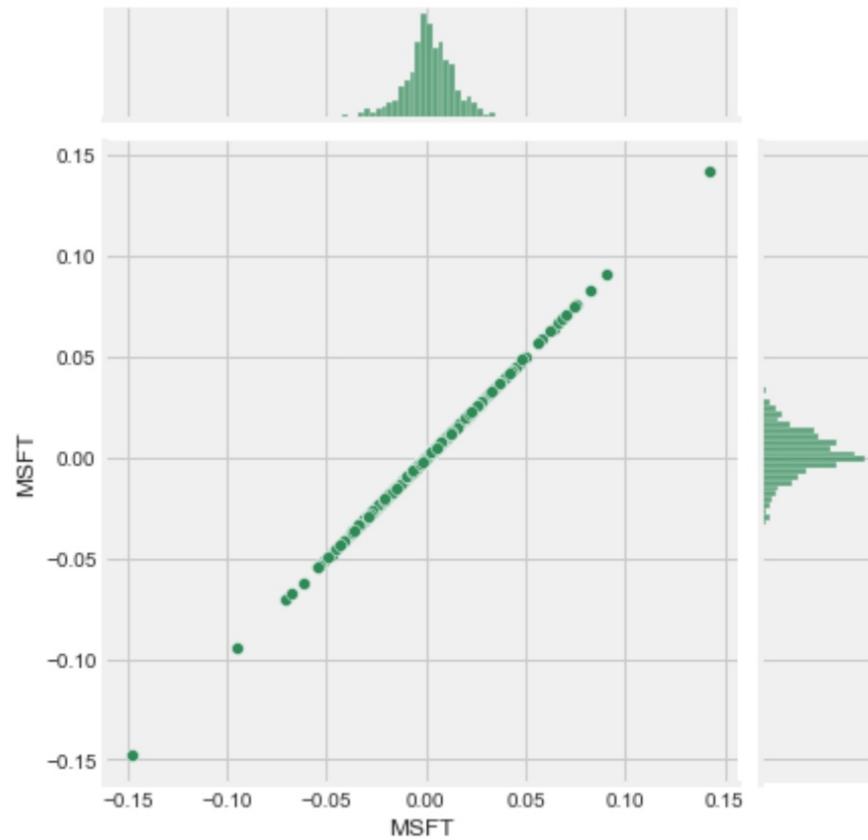
## Microsoft (MSFT) Stock

The focus of this visual is majorly on the two histograms. We want to show that the standard deviation given an asset (Microsoft stock price), if multiplied by itself (Microsoft stock price), the value is equal to Microsoft stock price squared.



## Square (SQ) Stock

The focus of this visual is majorly on the two histograms. We want to show that the standard deviation given an asset (Square stock price), if multiplied by itself (Square stock price), the value is equal to Square stock price squared.



Next, we will check for correlation between the different stocks

MSFT  
and  
AMZN

SQ  
and  
ADBE

Pair Plot  
of  
Correlation  
for Returns

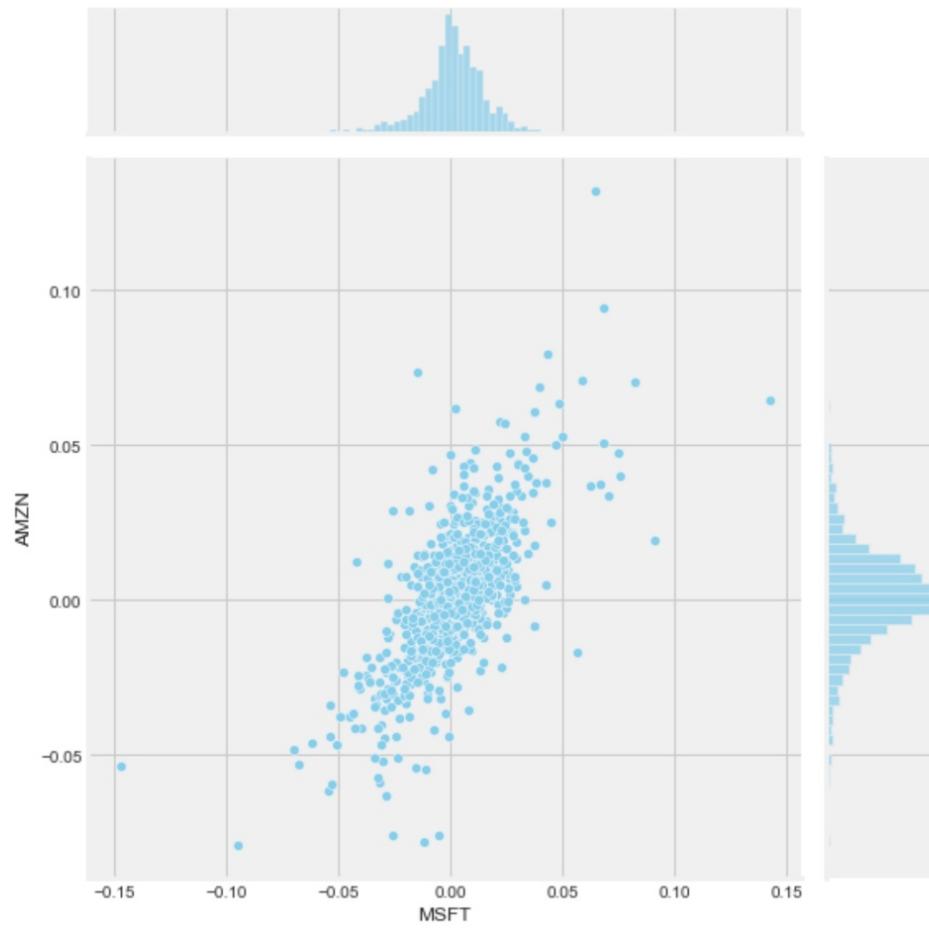
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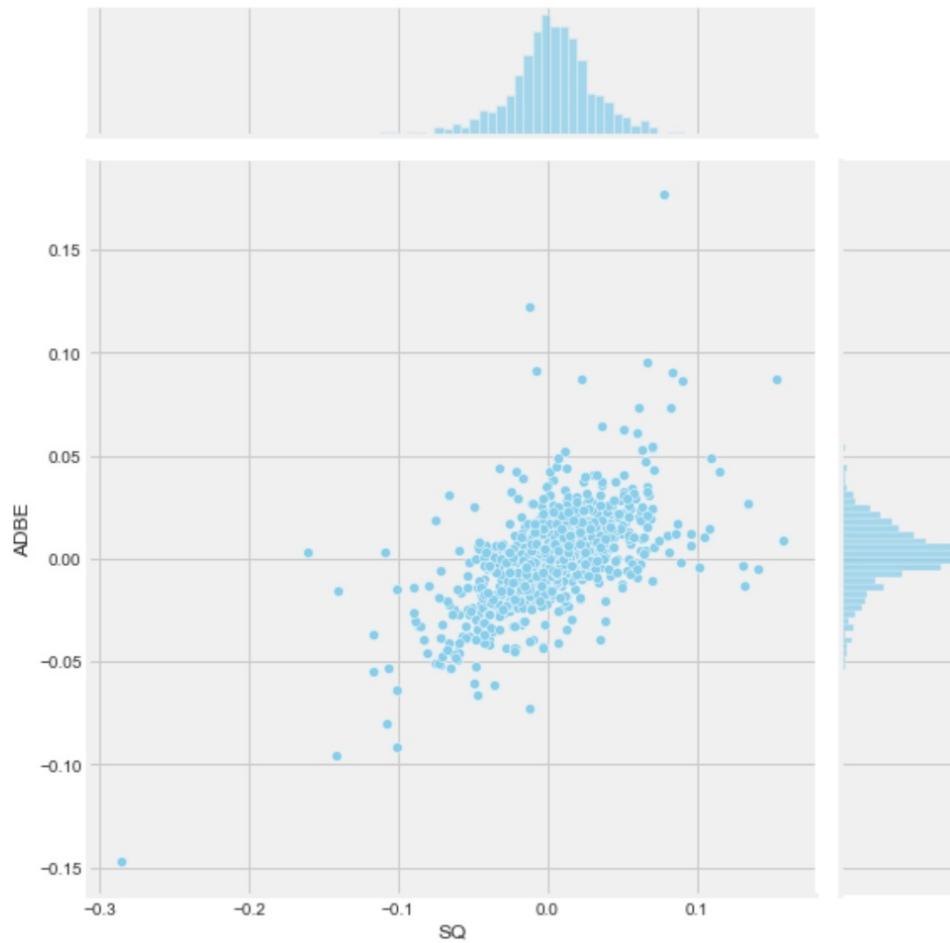
SQ  
and  
ADBE

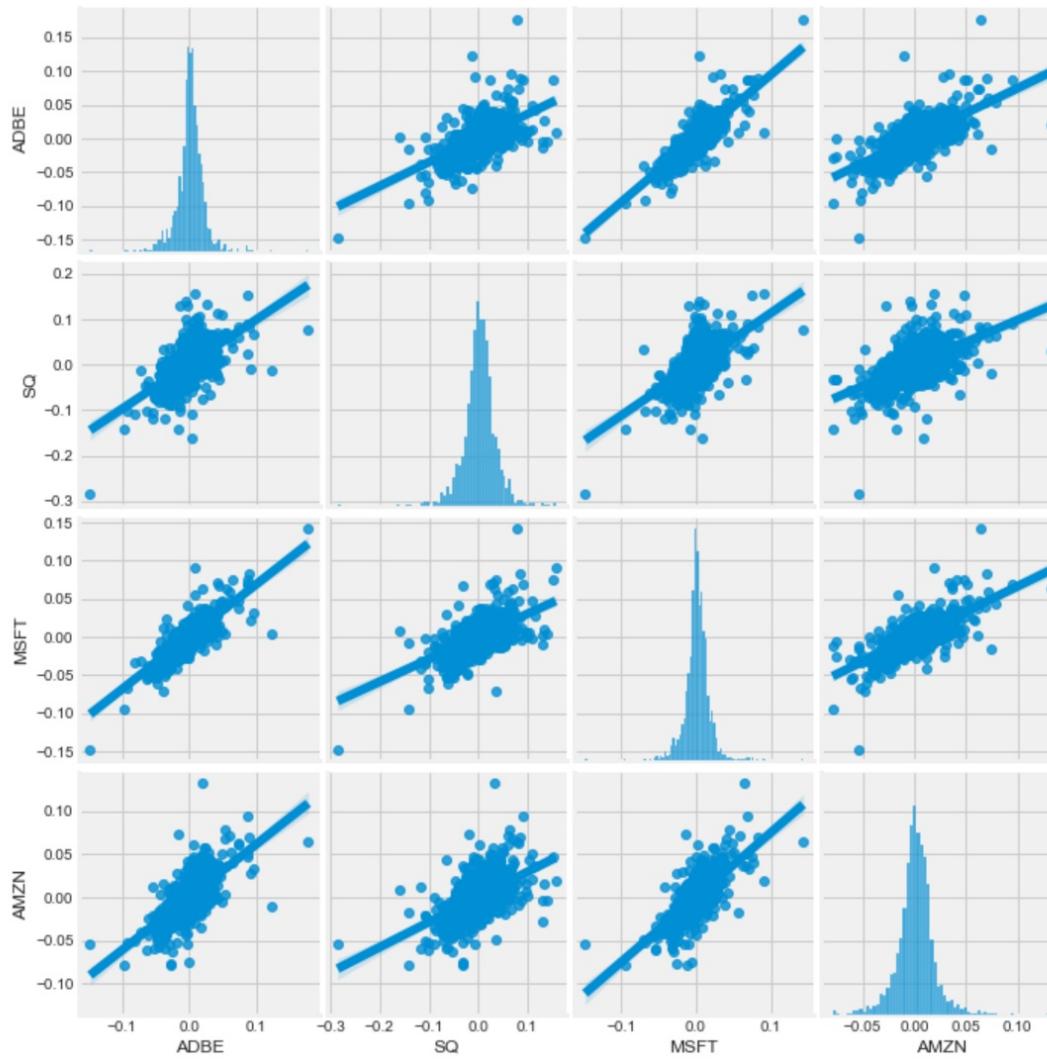
Pair Plot  
of  
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# Correlation between Amazon (AMZN) and Microsoft (MSFT)



## Correlation between Adobe (ADBE) and Square (SQ)





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How much  
value do we  
put at risk by  
investing in a  
particular  
stock?

Risk  
Analysis  
Definition

Three  
Methods of  
Risk  
Analysis

## Risk Analysis Definition

Risk analysis is the study of the underlying uncertainty of a given course of action and refers to the uncertainty of forecasted cash flow streams, the variance of portfolio or stock returns, the probability of a project's success or failure, and possible future economic states.

*Source: "Risk Analysis"  
(Investopedia, 2021)*

## The Three Methods Used for Risk Analysis

Expected  
Return Vs.  
 $SD(Risk)$

Bootstrap  
Method

Monte  
Carlo

## The Three Methods Used for Risk Analysis

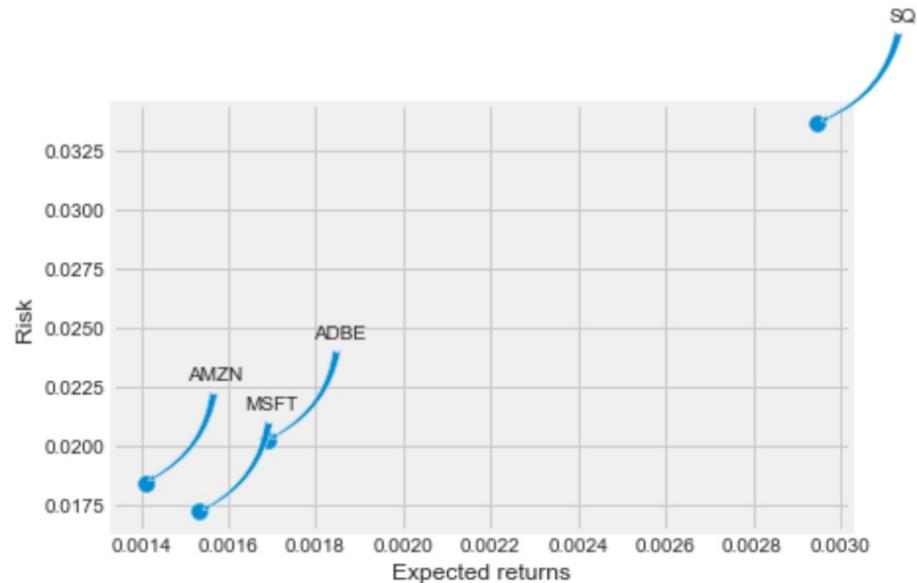
Expected  
Return Vs.  
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Method

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Carlo

## Compare Expected Returns with Standard Deviation of Daily Returns (Risk)

All the stocks have positive expected returns. Amazon, Microsoft and Adobe, have lower risk under 2.1% and Square stock with a little higher risk compare to the other 3 at a little above 3.3%



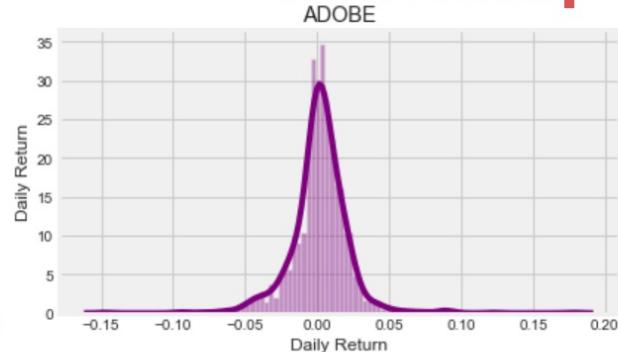
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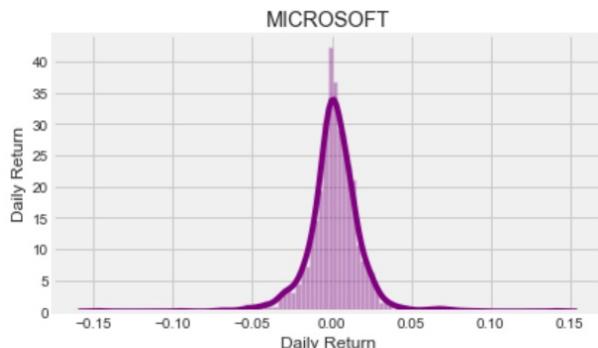
# Bootstrap Method Risk Analysis



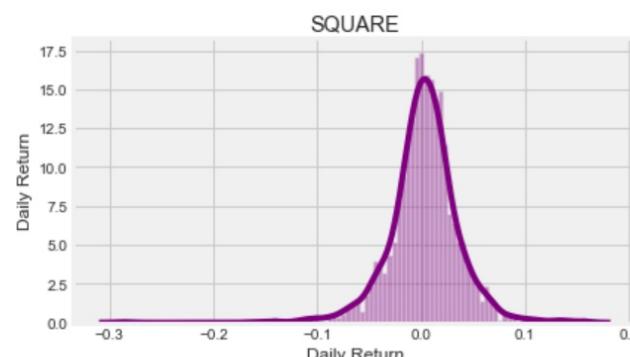
The 0.05 empirical quantile of daily returns is at  $-0.031982344218764$ . That means that with 95% confidence, our worst daily loss will not exceed 3.2%. If we have a 1 million dollar investment on ADOBE stock for instance, our one-day 5% VaR is  $0.032 * 1,000,000 = \$32,000$ .



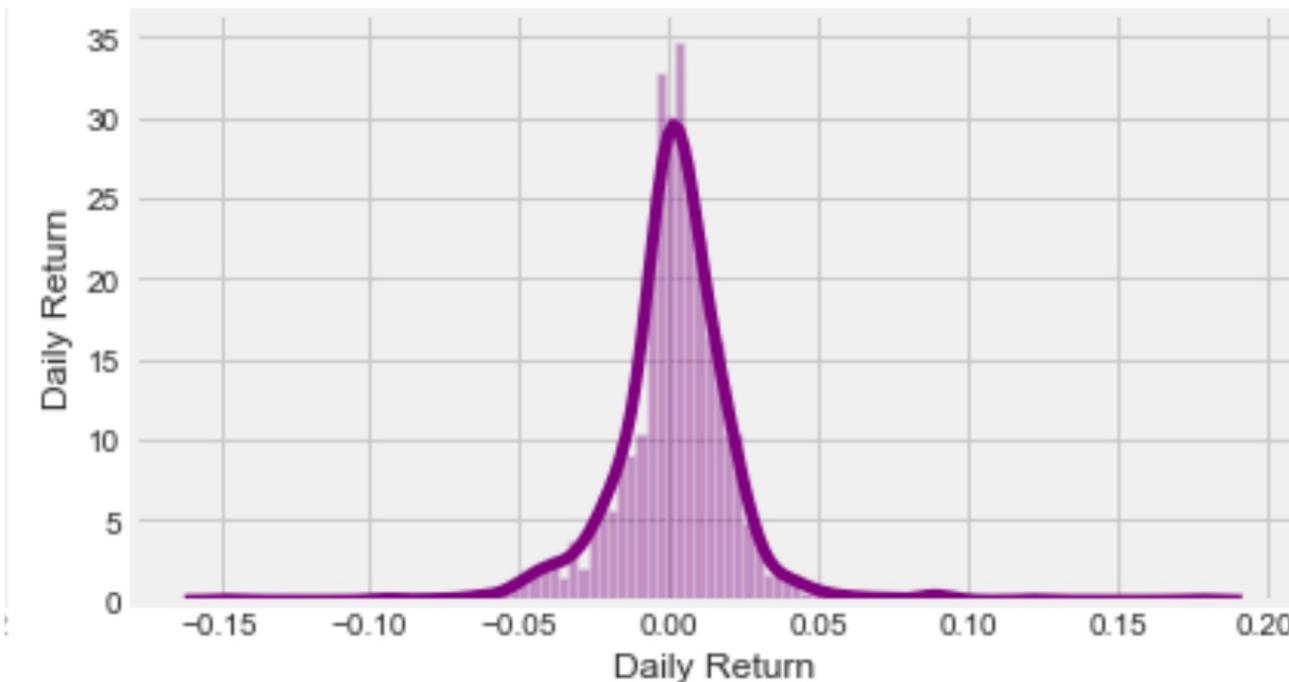
The 0.05 empirical quantile of daily returns is at  $-0.04778899243477372$ . That means that with 95% confidence, our worst daily loss on a square stock will not exceed 4.7%. If we have a 1 million dollar investment of AMAZON for instance, our one-day 5% VaR is  $0.047 * 1,000,000 = \$47,000$ .



The 0.05 empirical quantile of daily returns is at  $-0.02589709145787561$ . That means that with 95% confidence, our worst daily loss will not exceed 2.6%. If we have a 1 million dollar investment on MICROSOFT stock for instance, our one-day 5% VaR is  $0.026 * 1,000,000 = \$26,000$ .



The 0.05 empirical quantile of daily returns is at  $-0.04778899243477372$ . That means that with 95% confidence, our worst daily loss on a square stock will not exceed 4.7%. If we have a 1 million dollar investment of SQUARE for instance, our one-day 5% VaR is  $0.047 * 1,000,000 = \$47,000$ .



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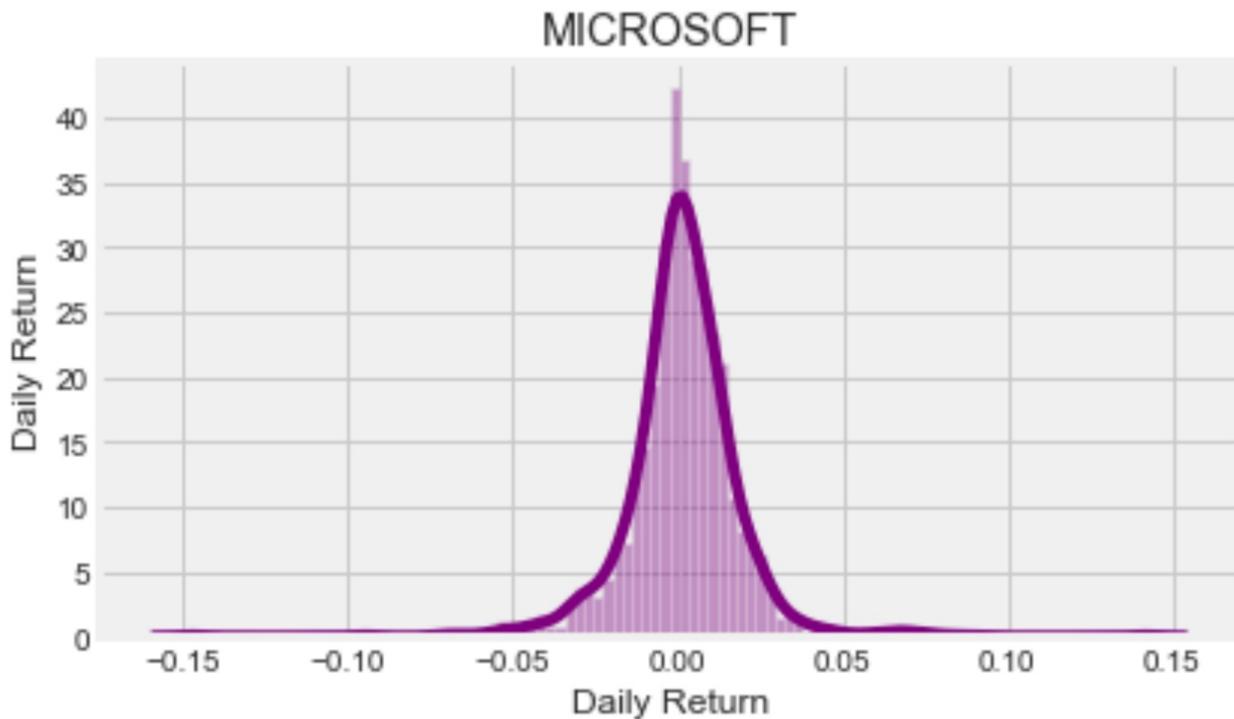
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# סיכון וניתוח

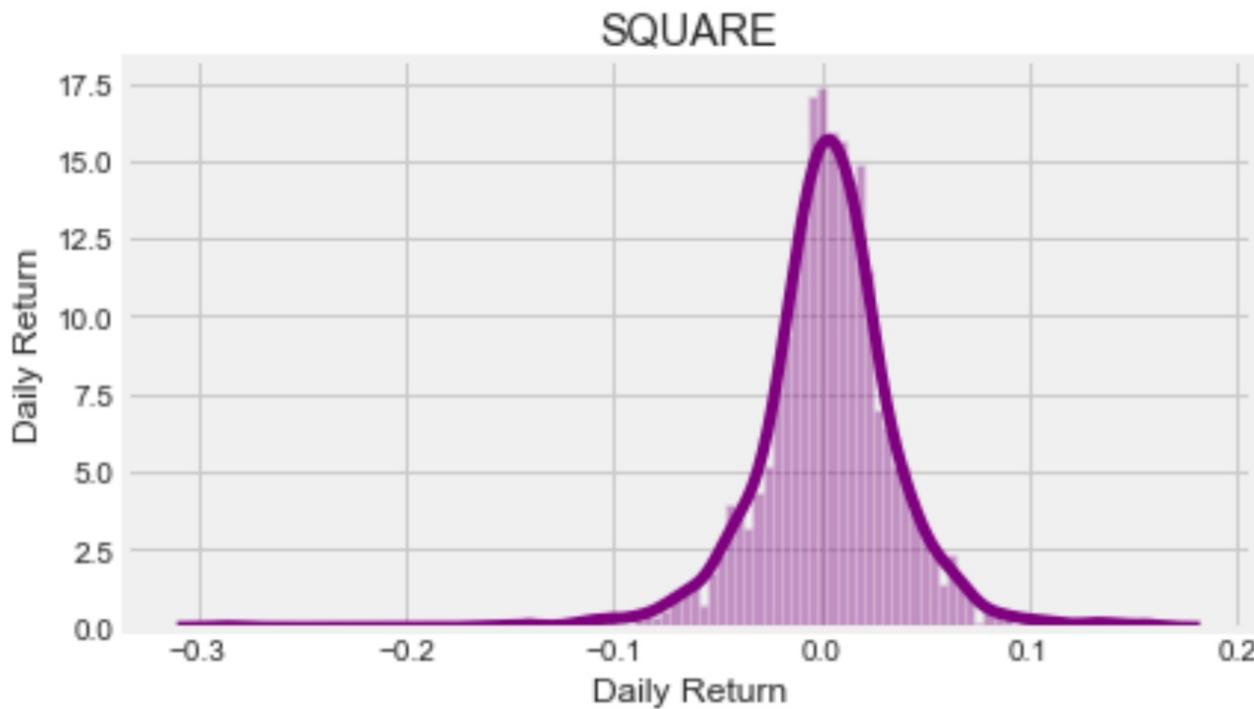


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סונדרס



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The 0.05 empirical quantile of daily returns is at -0.04778899243477372. That means that with 95% confidence, our worst daily loss on a square stock will not exceed 4.7%. If we have a 1 million dollar investment of SQUARE for instance, our one-day 5% VaR is  $0.047 * 1,000,000 = \$47,000$ .

## The Three Methods Used for Risk Analysis

Expected  
Return Vs.  
 $SD(Risk)$

Bootstrap  
Method

Monte  
Carlo

# Monte Carlo Risk Analysis

## Monte Carlo Method Description

The Monte Carlo method is suitable for a great range of risk measurement problems, especially when dealing with complicated factors. It assumes that there is a known probability distribution for risk factors. Firstly, use the geometric Brownian motion (GBM), which is technically known as a Markov process. This means that the stock price follows a random walk and is consistent with (at the very least) the weak form of the efficient market hypothesis (EMH): past price information is already incorporated and the next price movement is "conditionally independent" of past price movements.

## Open Price Definition

We want to predict the price of the stock today. We know the price of the stock yesterday. So, what's missing? We obviously do not know the daily return that the stock is going to yield today. This is where Monte Carlo comes in.

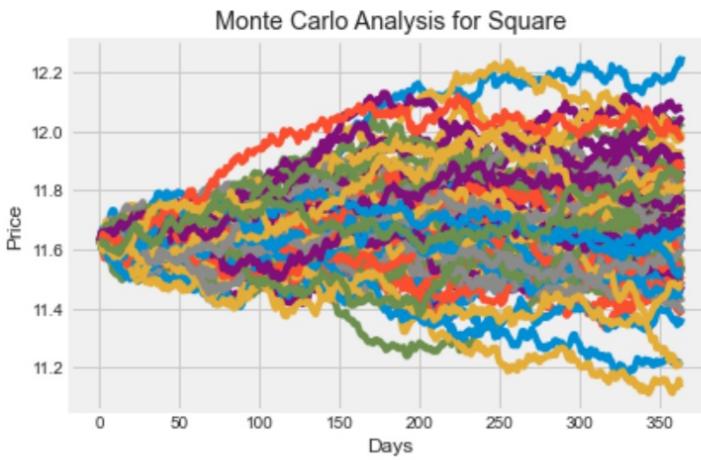
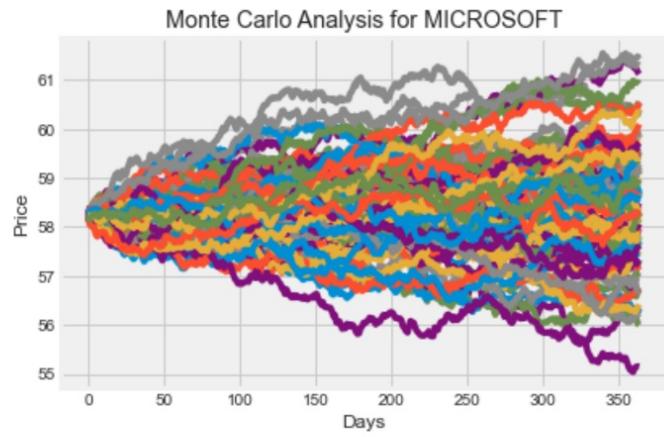
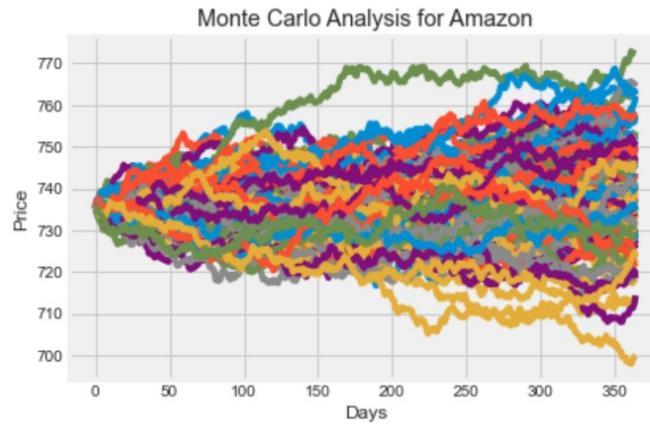
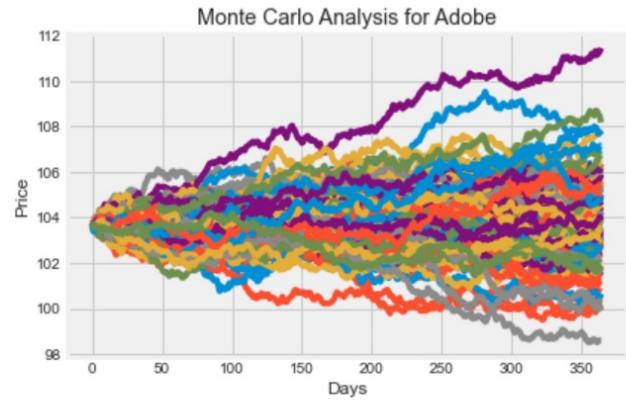
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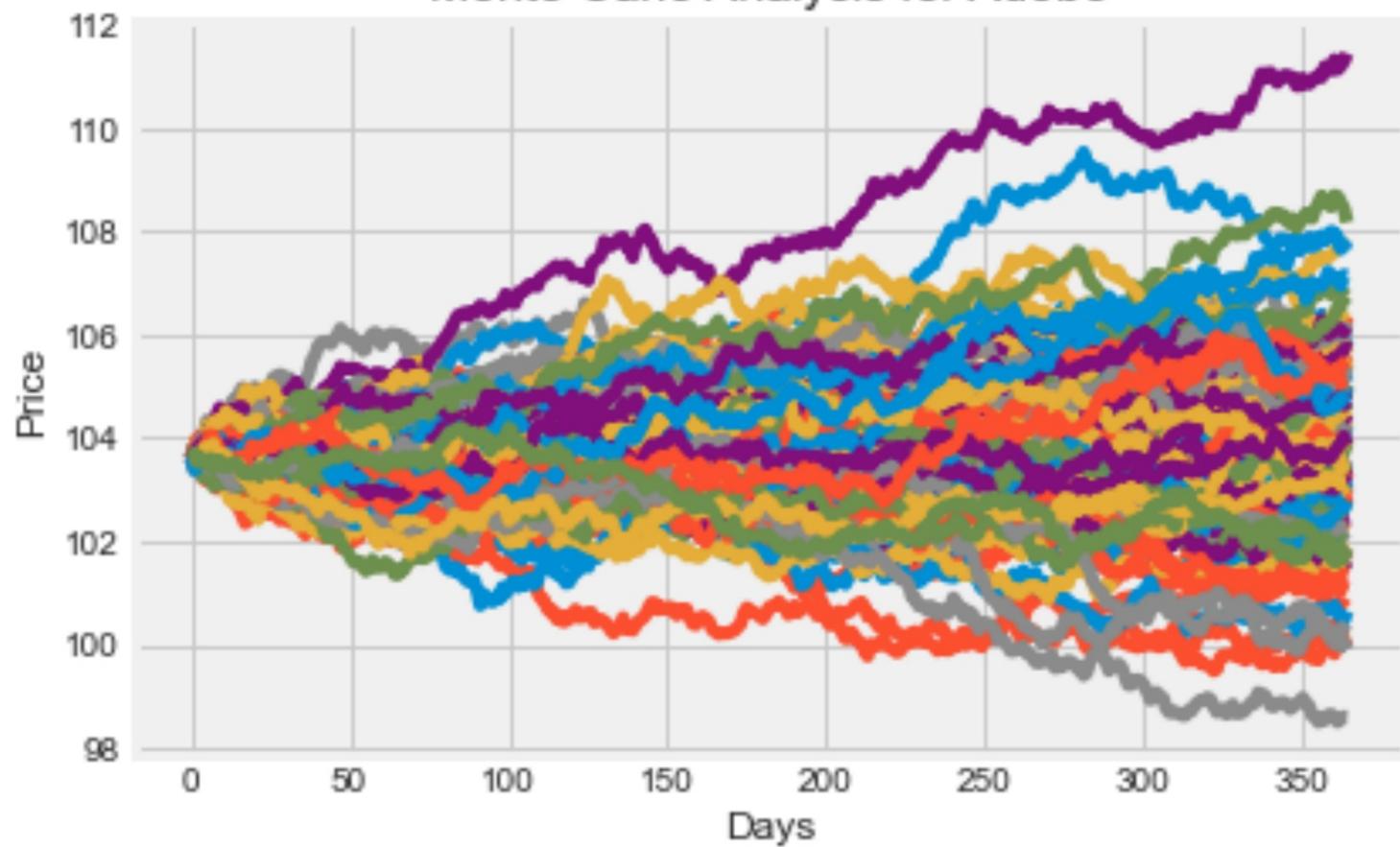
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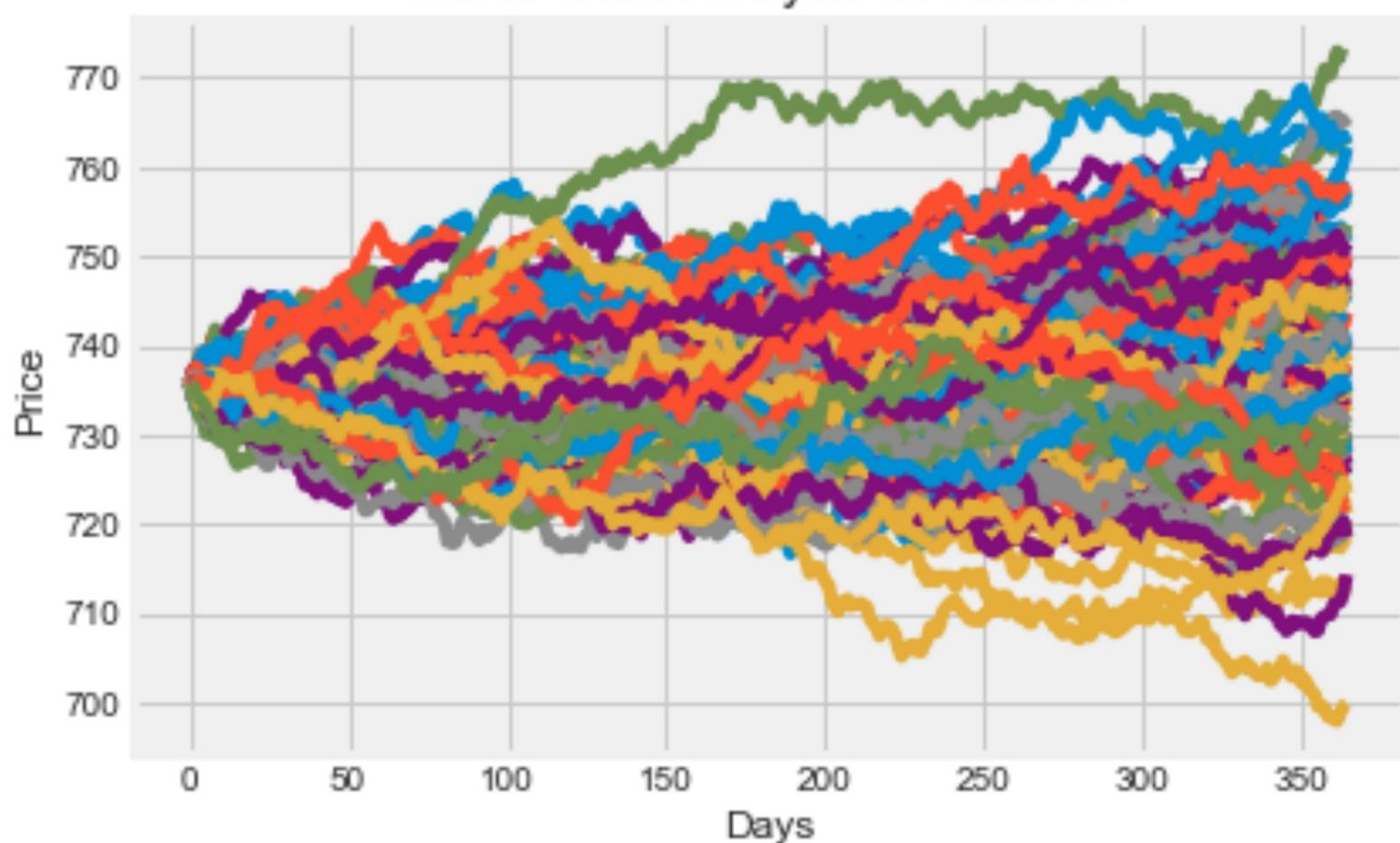
# Monte Carlo Analysis Graphs



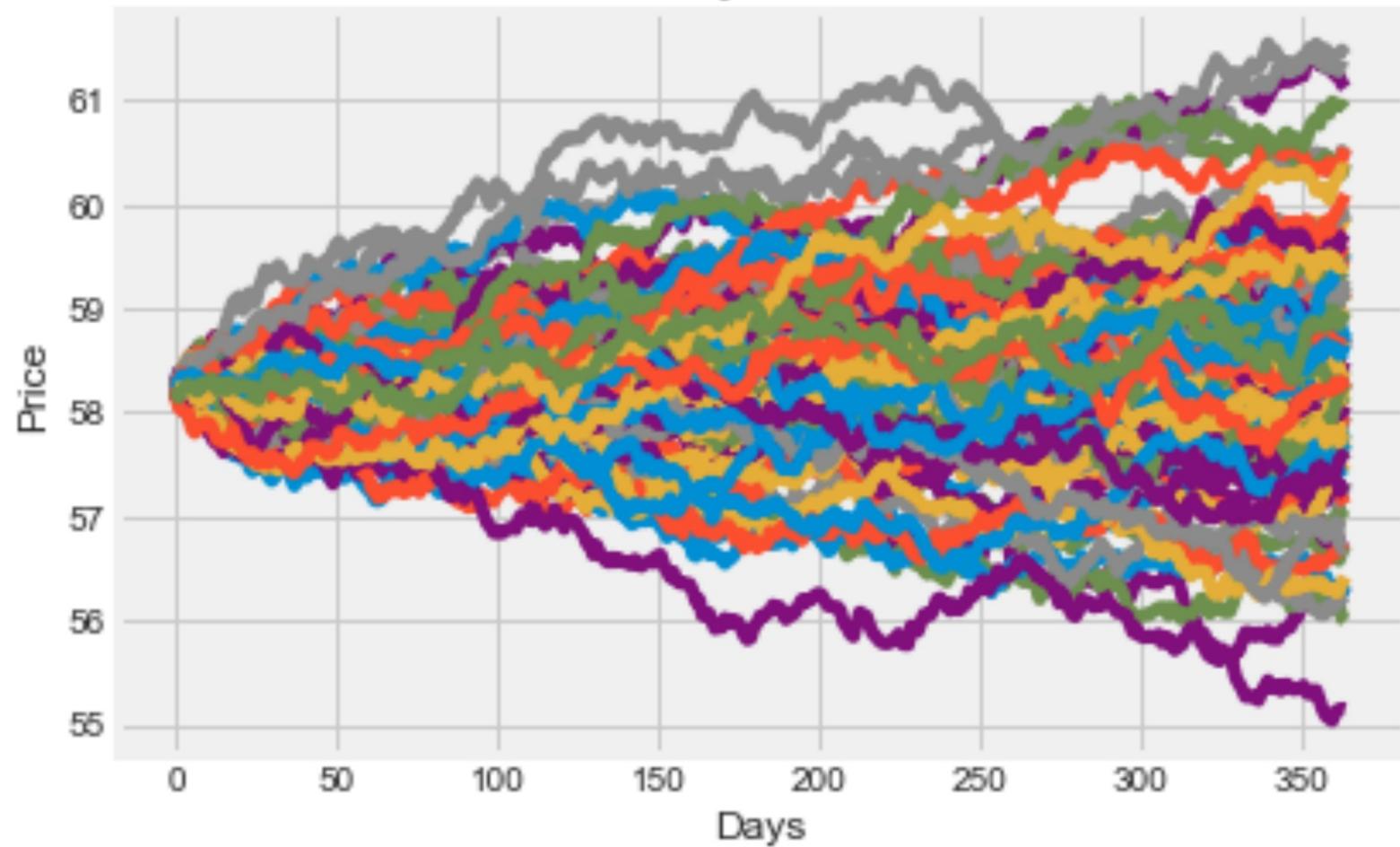
## Monte Carlo Analysis for Adobe



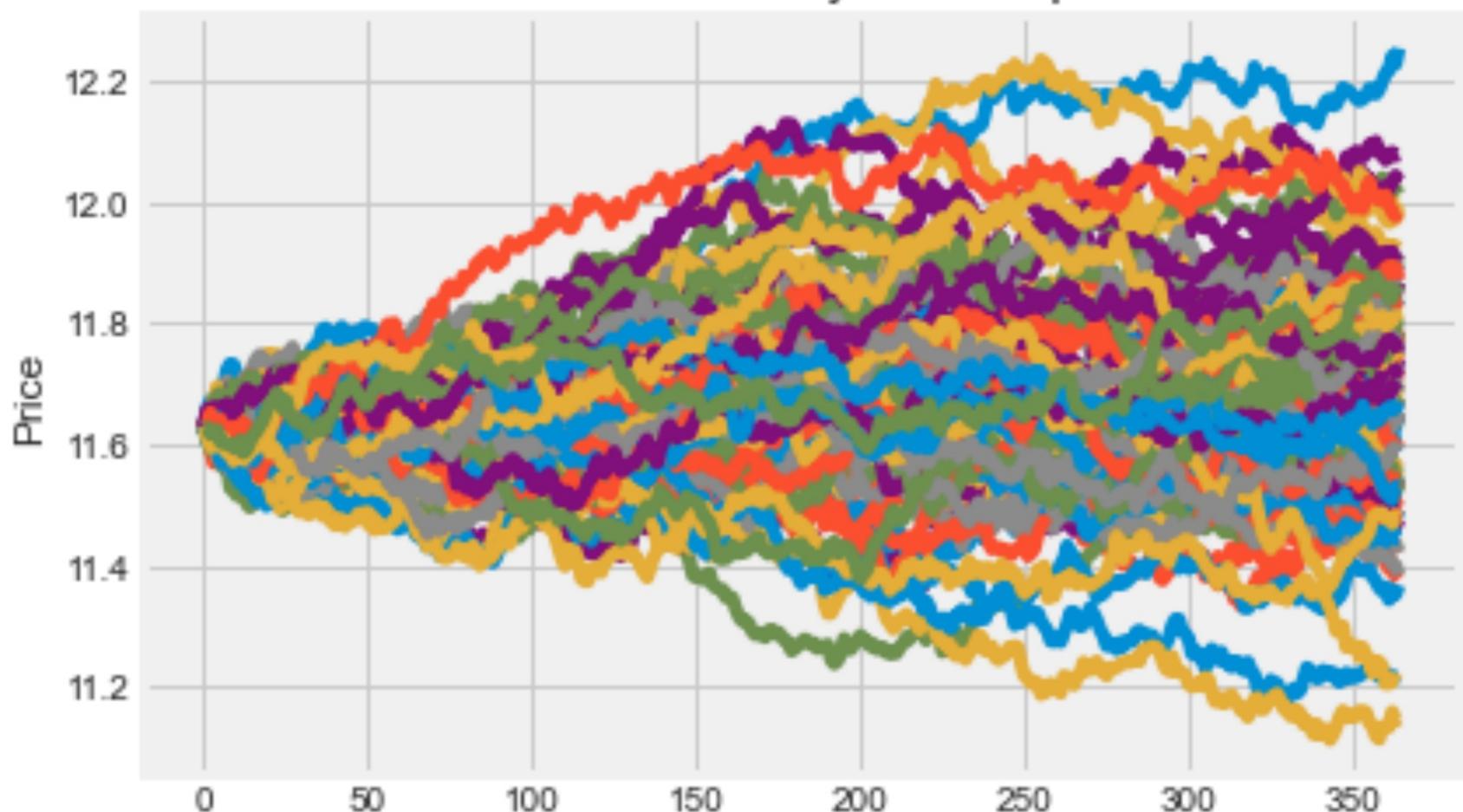
## Monte Carlo Analysis for Amazon



## Monte Carlo Analysis for MICROSOFT



## Monte Carlo Analysis for Square



# Monte Carlo Final Price Distributions

Final price distribution for ADOBE Stock(Adobe) after 365 days



For every initial ADOBE stock, you are putting about \$4.10 at risk of investment of \$104.12 99% of the time from our Monte Carlo Simulation.

Final price distribution for MICROSOFT Stock(MRST) after 365 days



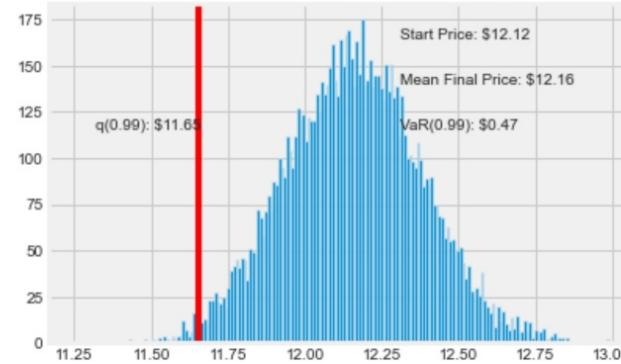
For every initial MICROSOFT stock one purchase, you are putting about \$2.34 at risk 99% of the time from our Monte Carlo Simulation.

Final price distribution for AMAZON Stock(AMZN) after 365 days



For every initial AMAZON stock one purchase, you are putting about \$29.49 at risk 99% of the time from our Monte Carlo Simulation.

Final price distribution for SQUARE Stock(SQ) after 365 days



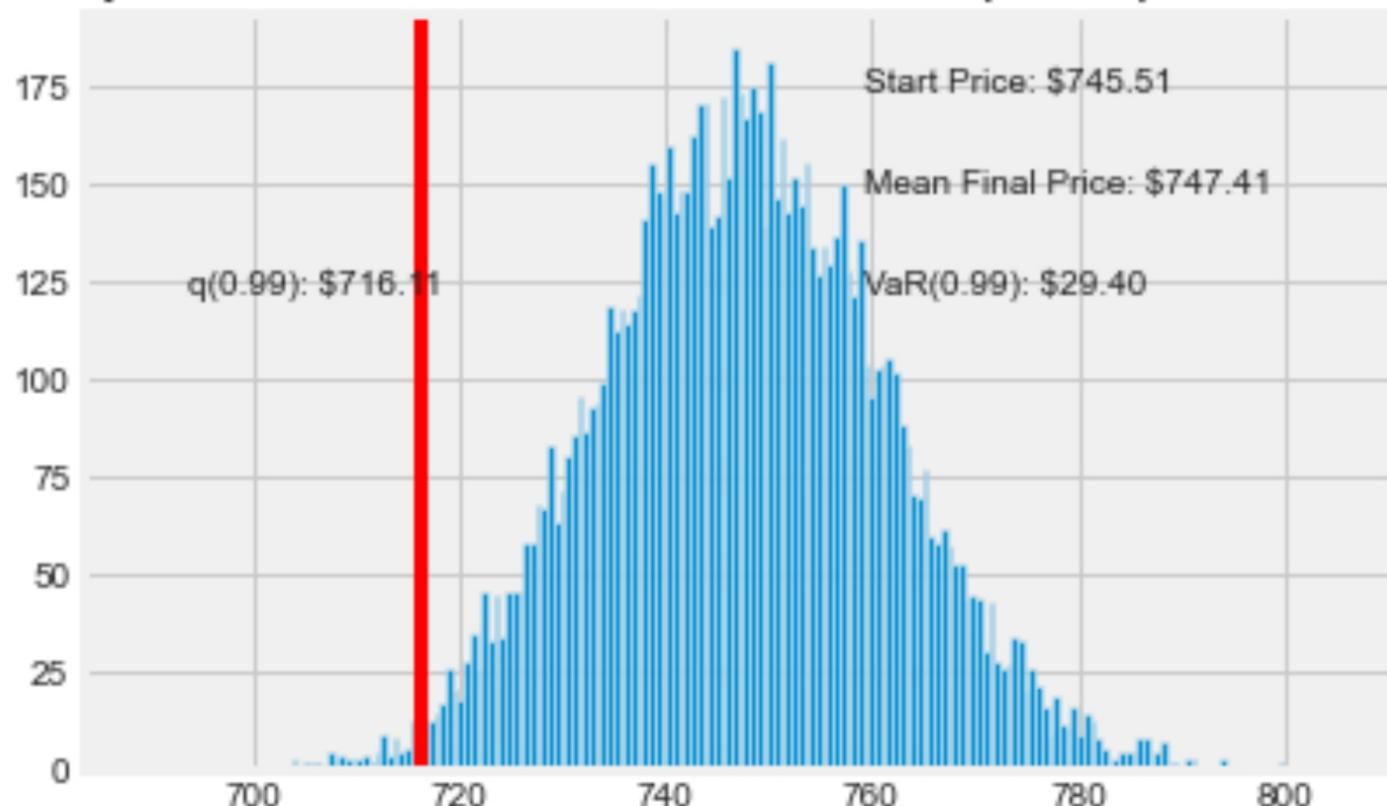
For every initial SQUARE stock one purchase, you are putting about \$0.48 at risk 99% of the time from our Monte Carlo Simulation.

## Final price distribution for ADOBE Stock(Adobe) after 365 days



For every initial ADOBE stock, you are putting about \$4.10 at risk of investment of \$104.12 99% of the time from our Monte Carlo Simulation.

## Final price distribution for AMAZON Stock(AMZN) after 365 days



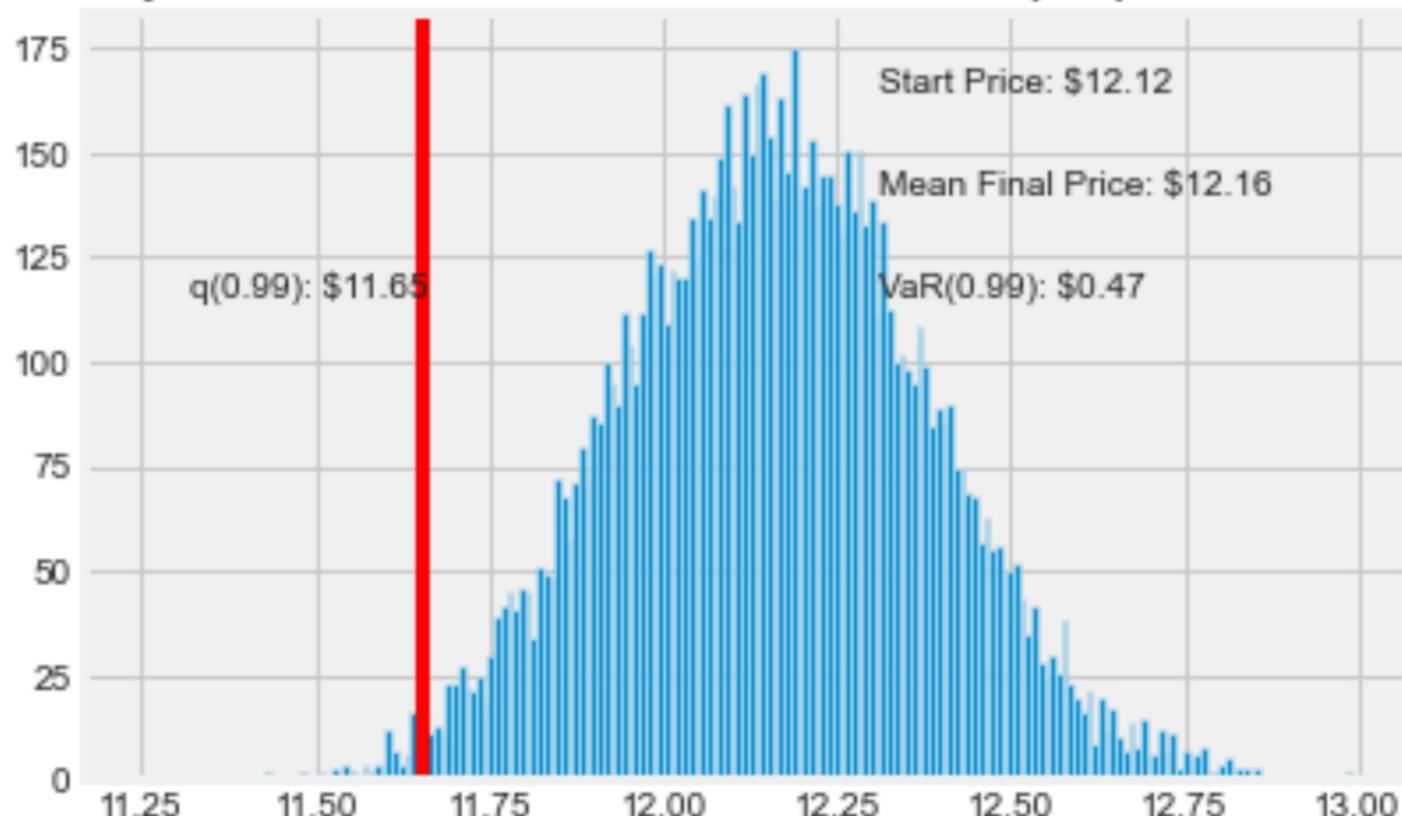
For every initial AMAZON stock one purchase, you are putting about \$29.49 at risk 99% of the time from our Monte Carlo Simulation.

## Final price distribution for MICROSOFT Stock(MRST) after 365 days



For every initial MICROSOFT stock one purchase, you are putting about \$2.34 at risk 99% of the time from our Monte Carlo Simulation.

## Final price distribution for SQUARE Stock(SQ) after 365 days



For every initial SQUARE stock one purchase, you are putting about \$0.48 at risk 99% of the time from our Monte Carlo Simulation.

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# How can we predict future stock behavior?

Predictions  
for Adobe  
ADBE

Predictions  
for Microsoft  
MSFT

Predictions  
for Amazon  
AMZN

Using a  
Linear  
Regression  
Model

Predictions  
for Square  
SQ

## Model Building

We tried to predict the closing price of the stocks by training and evaluating a linear regression model to determine the best fit linear line between the independent and dependent variable.

*Source: "All you need to know about your first Machine Learning model - Linear Regression" (Analytics Vidhya, 2021)*

# How can we predict future stock behavior?

Predictions  
for Adobe  
ADBE

Predictions  
for Amazon  
AMZN

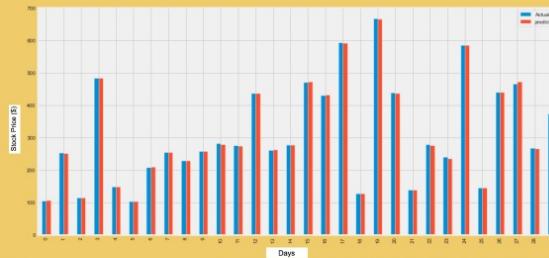
Using a  
Linear  
Regression  
Model

Predictions  
for Microsoft  
MSFT

Predictions  
for Square  
SQ

# Linear Regression Model Evaluation Metrics for Adobe (ADBE)

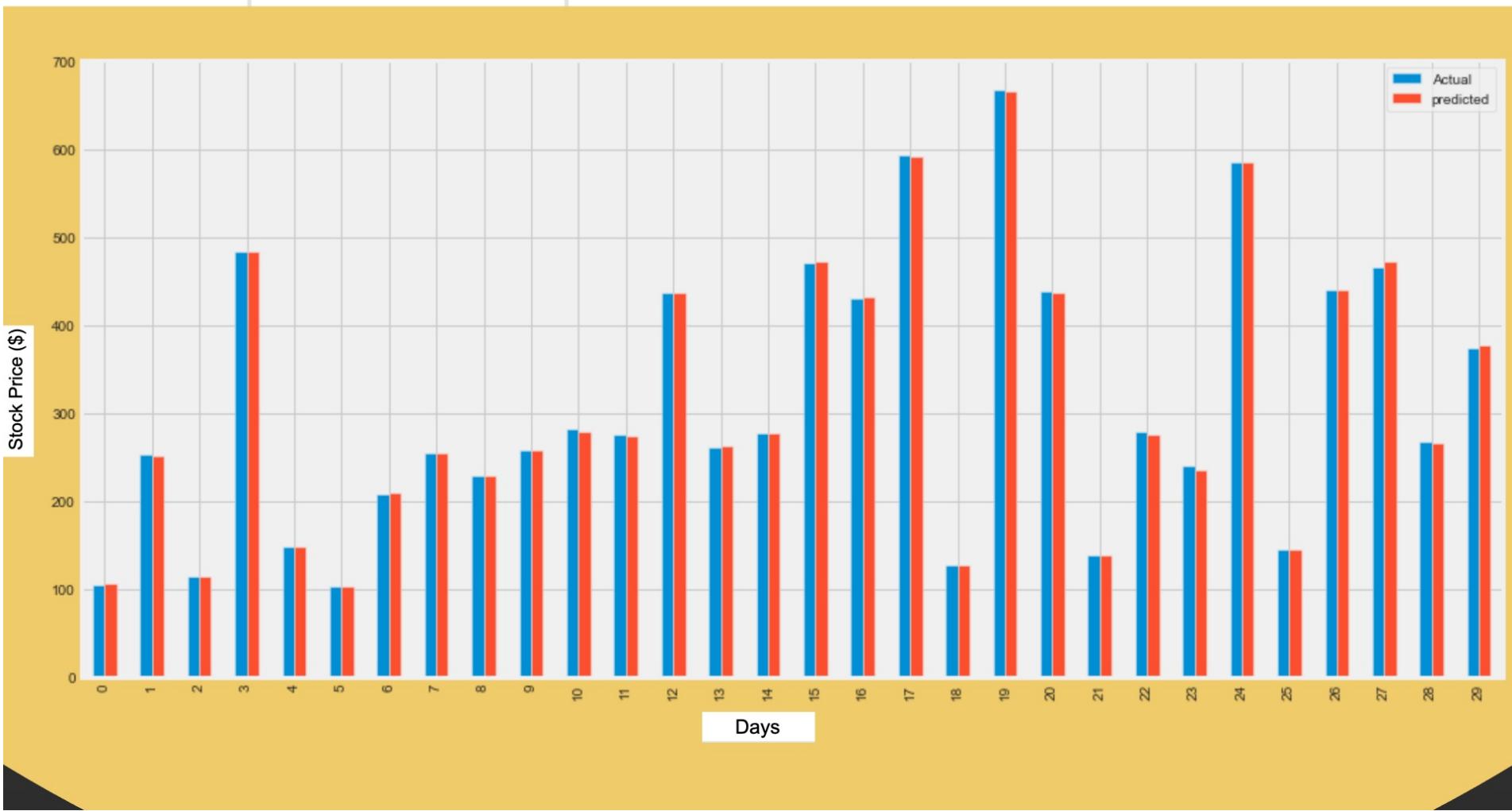
Evaluation Metrics	Scores	Interpretation
Mean Absolute Error (MAE)	1.51	On average, we expect to make a 1.51 error on forecast.
Mean Squared Error (MSE)	4.36	The MSE has a value of 4.36 that tells us how close we are to finding the line of best fit.
Root Mean Squared Error (RMSE)	2.1	Our RMSE has a value of 2.1 standard deviation of the unexplained variance, which is a good score compared to the average mean of our actual closing price of \$315.85.
R-Square ( $R^2$ )	99.98%	This means that 99.98% of the data fits the regression line which is a fantastic fit for the model.
Cross Validation Score	99.98%	The cross validation shows that our model can evaluate the performance of unseen data at 99.98% validation score. This usually assist with preventing overfitting.



# (ADBE)

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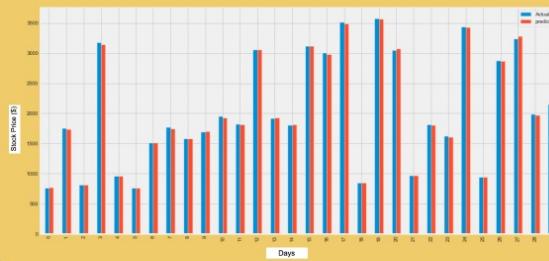
Using a  
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Regression  
Model

Predictions  
for Microsoft  
MSFT

Predictions  
for Square  
SQ

# Linear Regression Model Evaluation Metrics for Amazon (AMZN)

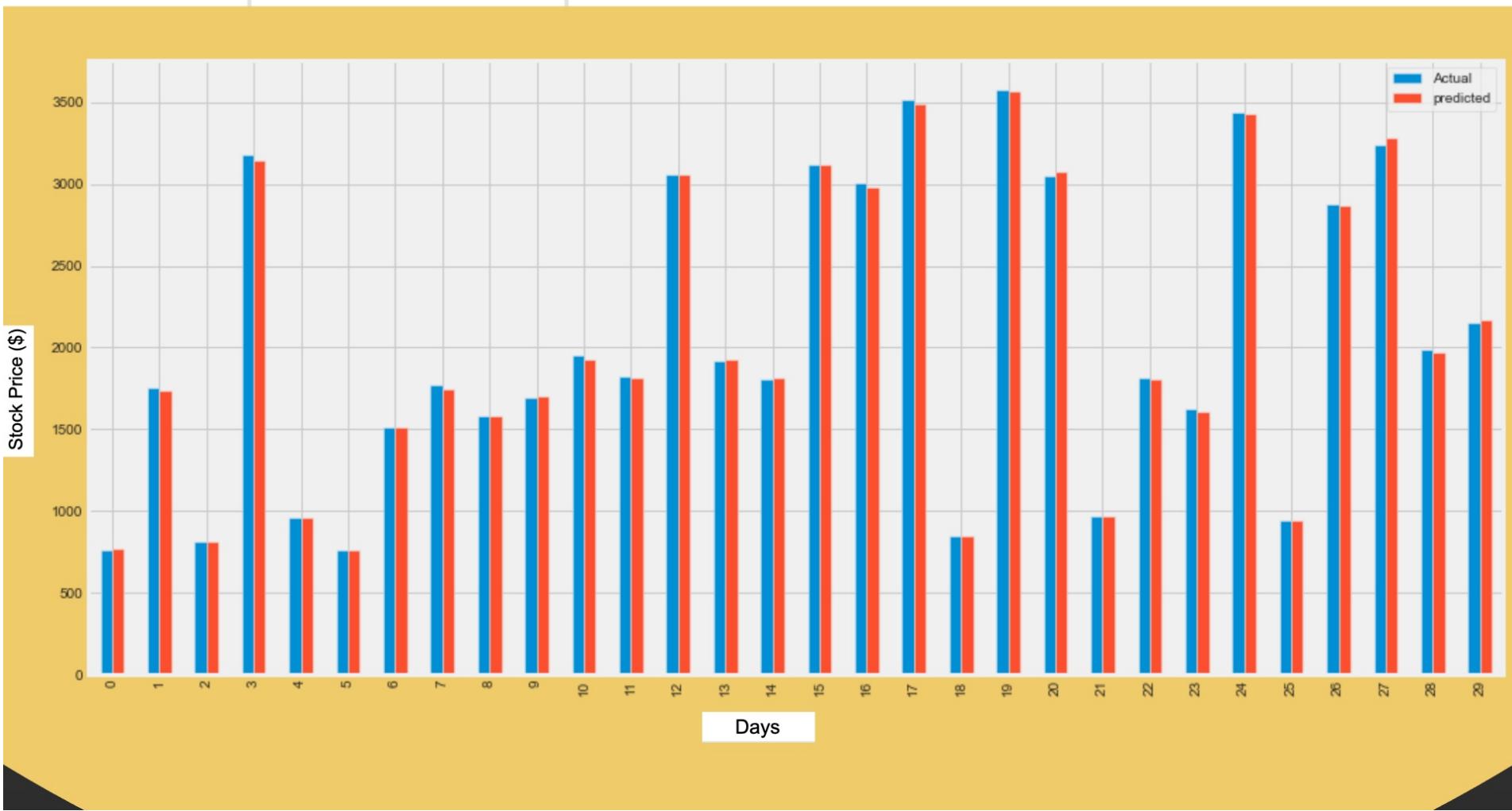
Evaluation Metrics	Scores	Interpretation
Mean Absolute Error (MAE)	9.75	On average, we expect to make a 9.75 error on forecast.
Mean Squared Error (MSE)	219.5	The MSE has a value of 219.5 that tells us how close we are to finding the line of best fit.
Root Mean Squared Error (RMSE)	14.8	Our RMSE has a value of 14.8 standard deviation of the unexplained variance, which is a good score compared to the average mean of our actual closing price of \$2026.86.
R-Square ( $R^2$ )	99.97%	This means that 99.97% of the data fits the regression line which is a fantastic fit for the model.
Cross Validation Score	99.97%	The cross validation shows that our model can evaluate the performance of unseen data at 99.97% validation score. This usually assist with preventing overfitting.



# (AMZN)

Evaluation Metrics	Scores	Interpretation
Mean Absolute Error (MAE)	9.75	On average, we expect to make a 9.75 error on forecast.
Mean Squared Error (MSE)	219.5	The MSE has a value of 219.5 that tells us how close we are to finding the line of best fit.
Root Mean Squared Error (RMSE)	14.8	Our RMSE has a value of 14.8 standard deviation of the unexplained variance, which is a good score compared to the average mean of our actual closing price of \$2026.86.
R-Square ( $R^2$ )	99.97%	This means that 99.97% of the data fits the regression line which is a fantastic fit for the model.
Cross Validation Score	99.97%	The cross validation shows that our model can evaluate the performance of unseen data at 99.97% validation score. This usually assist with preventing overfitting.





# How can we predict future stock behavior?

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ADBE

Predictions  
for Microsoft  
MSFT

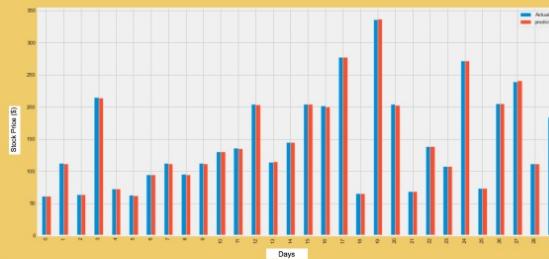
Predictions  
for Amazon  
AMZN

Using a  
Linear  
Regression  
Model

Predictions  
for Square  
SQ

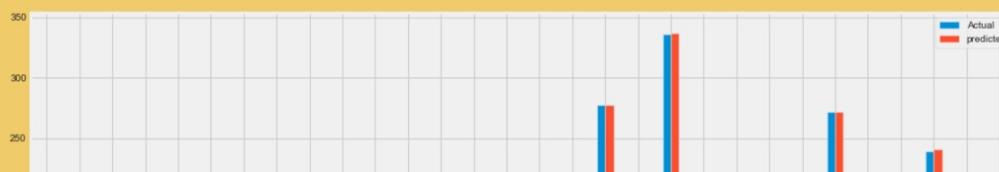
# Linear Regression Model Evaluation Metrics for Microsoft (MSFT)

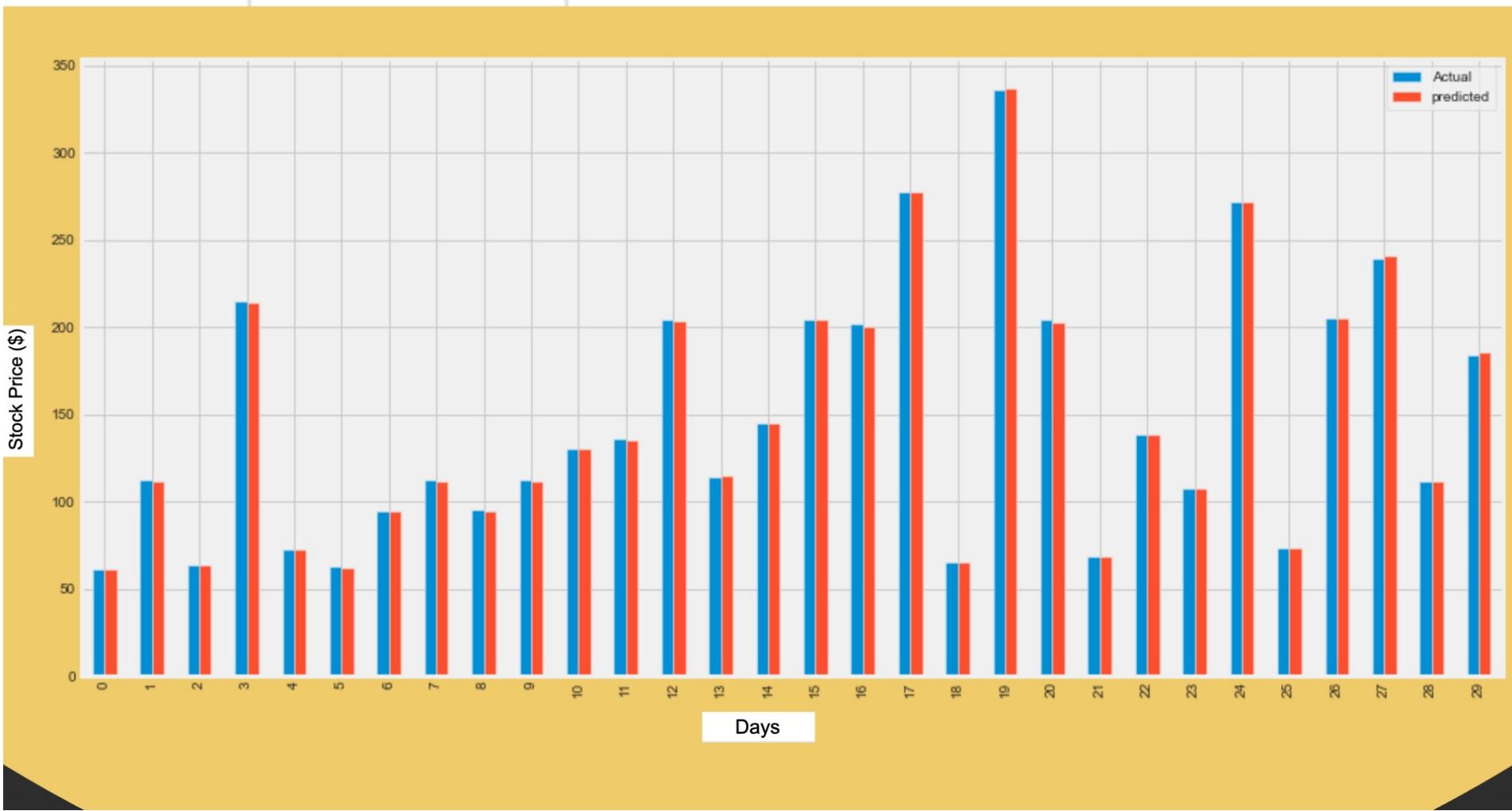
Evaluation Metrics	Scores	Interpretation
Mean Absolute Error (MAE)	0.61	On average, we expect to make a 0.61 error on forecast.
Mean Squared Error (MSE)	0.81	The MSE has a value of 0.81 that tells us how close we are to finding the line of best fit.
Root Mean Squared Error (RMSE)	0.90	Our RMSE has a value of 0.90 standard deviation of the unexplained variance, which is a good score compared to the average mean of our actual closing price of \$148.57.
R-Square ( $R^2$ )	99.98%	This means that 99.98% of the data fits the regression line which is a fantastic fit for the model.
Cross Validation Score	99.98%	The cross validation shows that our model can evaluate the performance of unseen data at 99.98% validation score. This usually assist with preventing overfitting.



# Microsoft (MSFT)

Evaluation Metrics	Scores	Interpretation
Mean Absolute Error (MAE)	0.61	On average, we expect to make a 0.61 error on forecast.
Mean Squared Error (MSE)	0.81	The MSE has a value of 0.81 that tells us how close we are to finding the line of best fit.
Root Mean Squared Error (RMSE)	0.90	Our RMSE has a value of 0.90 standard deviation of the unexplained variance, which is a good score compared to the average mean of our actual closing price of \$148.57.
R-Square ( $R^2$ )	99.98%	This means that 99.98% of the data fits the regression line which is a fantastic fit for the model.
Cross Validation Score	99.98%	The cross validation shows that our model can evaluate the performance of unseen data at 99.98% validation score. This usually assist with preventing overfitting.





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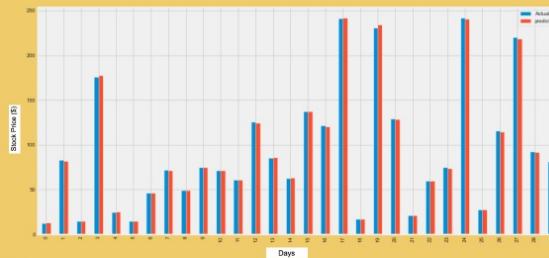
Predictions  
for Amazon  
AMZN

Using a  
Linear  
Regression  
Model

Predictions  
for Square  
SQ

# Linear Regression Model Evaluation Metrics for Square (SQ)

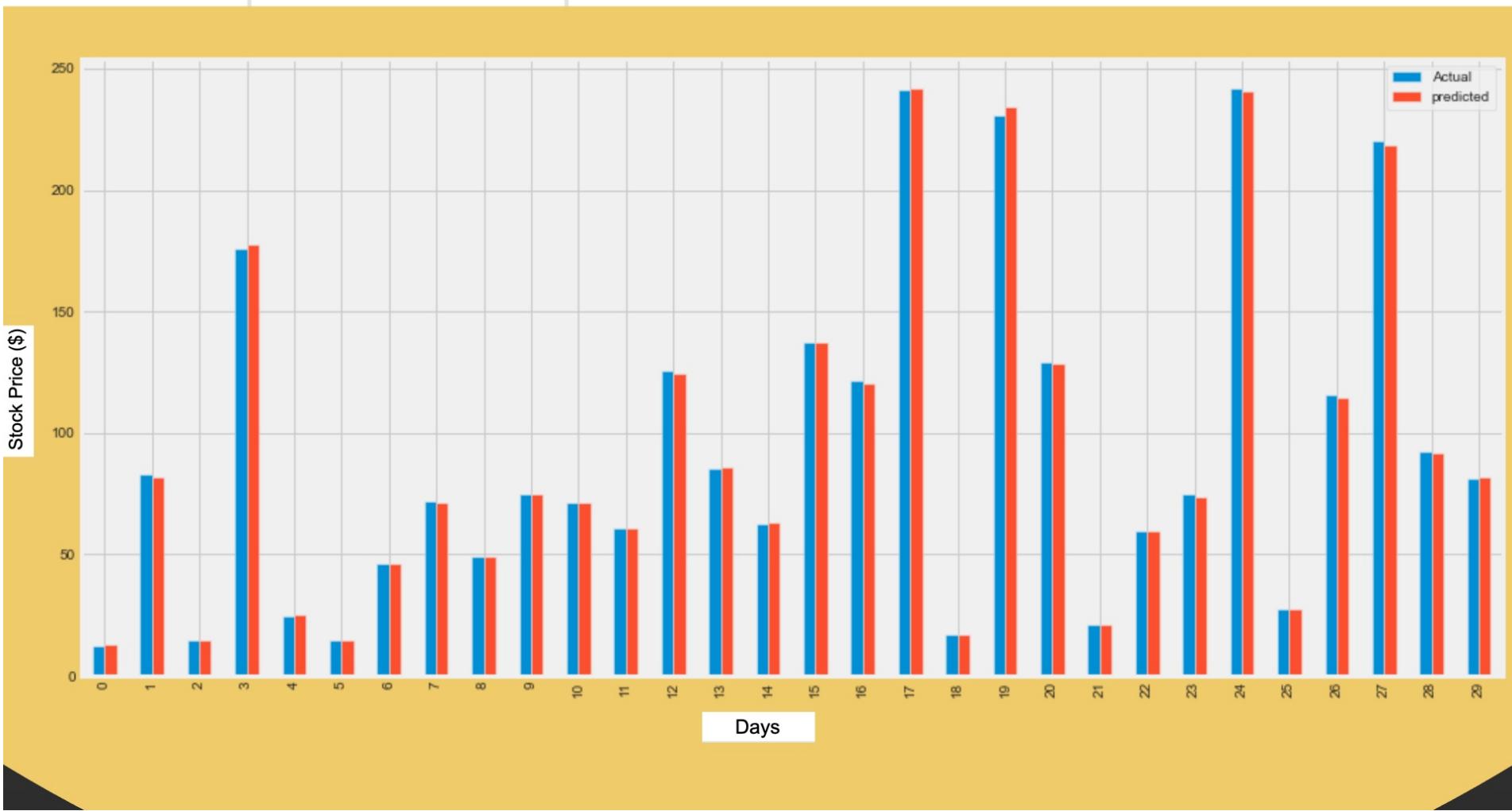
Evaluation Metrics	Scores	Interpretation
Mean Absolute Error (MAE)	0.85	On average, we expect to make a 0.85 error on forecast.
Mean Squared Error (MSE)	1.86	The MSE has a value of 1.86 that tells us how close we are to finding the line of best fit.
Root Mean Squared Error (RMSE)	1.36	Our RMSE has a value of 1.36 standard deviation of the unexplained variance, which is a good score compared to the average mean of our actual closing price of \$98.61.
R-Square ( $R^2$ )	99.97%	This means that 99.97% of the data fits the regression line which is a fantastic fit for the model.
Cross Validation Score	99.97%	The cross validation shows that our model can evaluate the performance of unseen data at 99.97% validation score. This usually assist with preventing overfitting.



# (SQ)

Evaluation Metrics	Scores	Interpretation
Mean Absolute Error (MAE)	0.85	On average, we expect to make a 0.85 error on forecast.
Mean Squared Error (MSE)	1.86	The MSE has a value of 1.86 that tells us how close we are to finding the line of best fit.
Root Mean Squared Error (RMSE)	1.36	Our RMSE has a value of 1.36 standard deviation of the unexplained variance, which is a good score compared to the average mean of our actual closing price of \$98.61.
R-Square ( $R^2$ )	99.97%	This means that 99.97% of the data fits the regression line which is a fantastic fit for the model.
Cross Validation Score	99.97%	The cross validation shows that our model can evaluate the performance of unseen data at 99.97% validation score. This usually assist with preventing overfitting.





# Stock Price Analysis and Predictions

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# Conclusions by Stock

Adobe  
(ADBE)

Amazon  
(AMZN)

Microsoft  
(MSFT)

Square  
(SQ)

## Adobe (ADBE)

- Adobe closing price started very low on November 2016 at 105.65 dollars and grew to 688.37 dollars on November 19th, 2021.
- Adobe stock has an average return that shows right skewness.
- Adobe stock correlated well with itself and other stocks in this project. This is necessary when making investment on different stocks.
- Adobe also shows a positive expected return at slightly above 2.1% risk of investment.
- There is also a quantile daily return that, with 95% confidence, our worst daily loss will not exceed 3.2% using bootstrap method to value the risk of investment.
- A Monte Carlo method was also used to run value at risk analysis on the returns and turns out that for every initial ADOBE stock you purchase, you are putting about 4.10 dollars at risk of investment of 104.12 dollars 99% of the time.

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- A Monte Carlo method was also used to run value at risk analysis on the returns and turns out that for every initial ADOBE stock you purchase, you are putting about 4.10 dollars at risk of investment of 104.12 dollars 99% of the time.

## Amazon (AMZN)

- Amazon closing price started in November 2016 at 743.24 dollars and grew above \$3549.94 in November 2021.
- Amazon stock had an average return that was normally distributed.
- Amazon stock correlated well with itself and other stocks in this project. This is necessary when making investment on different stocks.
- Amazon stock also shows a positive expected return at 1.5 % risk of investment.
- There is also quantile daily return that, with 95% confidence, our worst daily loss will not exceed 2.8% using bootstrap method to value the risk of investment.
- A Monte Carlo method was also used to run risk analysis on the returns and turns out that for every initial Amazon stock you purchase, you are putting about 28.96 dollars at risk of investment of 745.51 dollars 99% of the time.

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- Amazon stock had an average return that was normally distributed.
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- A Monte Carlo method was also used to run risk analysis on the returns and turns out that for every initial Amazon stock you purchase, you are putting about 28.96 dollars at risk of investment of 745.51 dollars 99% of the time.

## Microsoft (MSFT)

- Microsoft stock closing price started in November 2016 at 60.86 dollars and grew to \$343.11 in November 2021. Microsoft stock average return that shows right skewness.
- Microsoft stock correlated well with itself and other stocks in this project. This is necessary when making investment on different stocks.
- Microsoft stock also shows a positive expected return at 1.75% risk of investment.
- There is also quantile daily return that, with 95% confidence, our worst daily loss will not exceed 2.6% using bootstrap method to value the risk of investment.
- A Monte Carlo method was also used to run risk analysis on the returns and turns out that for every initial Microsoft stock you purchase you are putting about 2.34 dollars at risk of investment of \$59.99% of the time.

# Microsoft (MSFT)

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- Microsoft stock correlated well with itself and other stocks in this project. This is necessary when making investment on different stocks.
- Microsoft stock also shows a positive expected return at 1.75% risk of investment.

- There is also quantile daily return that, with 95% confidence, our worst daily loss will not exceed 2.6% using bootstrap method to value the risk of investment.
- A Monte Carlo method was also used to run risk analysis on the returns and turns out that for every initial Microsoft stock you purchase you are putting about 2.34 dollars at risk of investment of \$59 99% of the time.

## Square (SQ)

- Square stock closing price started in November 2016 at 12.22 dollars and grew above 225.14 dollars in November 2021.
- Square stock has an average return that shows right skewness.
- Square stock correlated well with itself and other stocks in this project. This is necessary when making investment on different stocks.
- Square also shows a positive expected return at 3.5 % risk of investment.
- There is also a quantile daily return that, with 95% confidence, our worst daily loss will not exceed 4.7% using bootstrap method to value the risk of investment.
- A Monte Carlo method was also used to run risk analysis on the returns and turns out that for every initial Square stock you purchase, you are putting about 0.48 dollars at risk of investment of 12.12 dollars 99% of the time.

# Square (SQ)

- Square stock closing price started in November 2016 at 12.22 dollars and grew above 225.14 dollars in November 2021.
- Square stock has an average return that shows right skewness.
- Square stock correlated well with itself and other stocks in this project. This is necessary when making investment on different stocks.
- Square also shows a positive expected return at 3.5 % risk of investment.

- There is also a quantile daily return that, with 95% confidence, our worst daily loss will not exceed 4.7% using bootstrap method to value the risk of investment.
- A Monte Carlo method was also used to run risk analysis on the returns and turns out that for every initial Square stock you purchase, you are putting about 0.48 dollars at risk of investment of 12.12 dollars 99% of the time.

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# Recommendations

Based on the series of analysis and evaluations we conducted, we recommend the following:

- All stock has an upward trend showing a consistent rise in closing price( which forms a major consideration investors) with little fluctuations. Value at risk is low on all stocks for risk averse client as well as clients with high level of risk tolerance. Returns on investments though varies across stocks, there seems to be a decent correlation between stocks which means a combination of investment in the stocks we investigated will return a good yield.We recommend for our clients to invest at least 365 days without any interference with the investment for our recommendations to be fully utilized.
- On the part of our model, we were able to show that there is a strong relationship between our predictions and actual price. This means that our trained model can generalize well with unseen but similar data.
- As part of our principles on "growth" and to improve our services to our clients, we planned a good control system where we can build other models such as the AutoRegressive Integrated Moving Average (ARIMA) to try to predict closing price in the future.

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