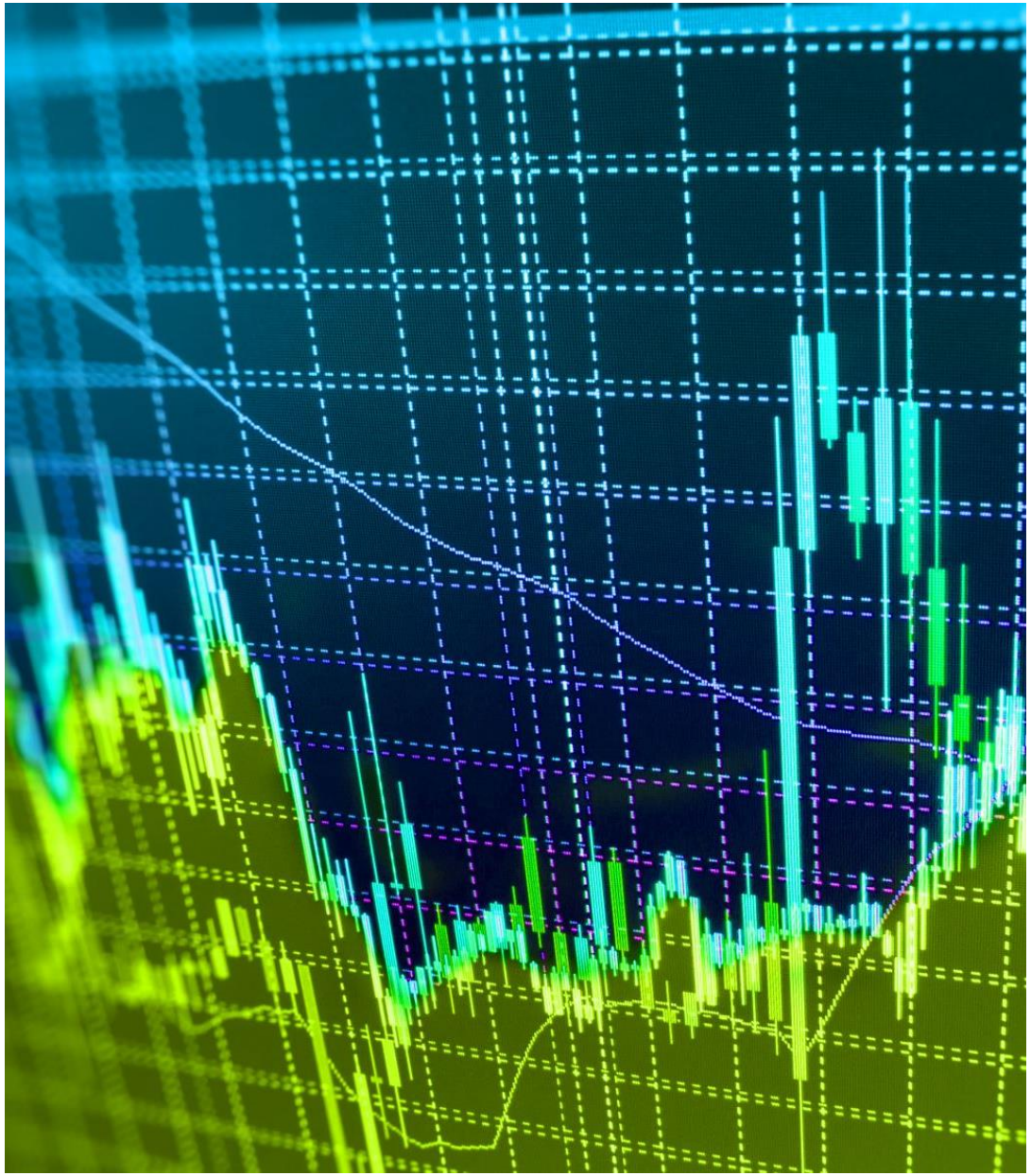
Stock Analysis & Portfolio Management

By –

Sakshi Agarwal



Business Case

- With lack of skill or shortage of time, a need to identify right investment opportunity for individual/business to get maximum returns has given rise to dedicated individuals called Portfolio Managers investing on their behalf with commission.
- The main objective of Portfolio Manager is to realize the investor needs and suggest a suitable portfolio that meets all the expectations. They are responsible for establishing the best investment strategy, selecting appropriate investments along with right allocation.
- I am working at an investment firm that manages accounts for private clients and my role is to analyze a portfolio of stocks to provide consultation on investment management based on client's requirement.
- Our investor is Ms. Alexandra Koslishnyick who is a potential client, and we are required to create a portfolio for her which gives decent returns and involves low risk.
- Here, we are provided with 12 different stock price data that belongs to 4 Industry Groups – Aviation, Finance, Healthcare & Technology along with price of Market Index S&P500.
- The dataset contains 10 years of data from 1st Oct 2010 to 30th Sep 2020.

Process Steps

Business Case – Structured Problem Solving

Preliminary Steps - Data loading

Data Exploration

Stock Analysis and Portfolio Management - CAPM

Stock Price Prediction - Validation

Reporting

Preliminary Step - Data Loading

Understanding the Domain/Variables

Read/Load the Dataset

Inspect/Check the structure of dataframe

Data Cleaning

Merge the different stock files

Keep the required attributes

Data Cleaning/Merging

- Convert/Fix Incorrect Datatypes – Date Column.
- Set The Date column as Index.
- Handling Missing Values.
- No outliers present.
- Merge the stock files into single dataset.
- Removing extra records from few datasets.
- Keep only the required columns – Close Price & Volume.

The screenshot shows NULL records in one of the stock file which has been removed from the dataset.

```
## Check the last few rows of the dataset

alk.tail(10)
```

Date	Open	High	Low	Close	Adj Close	Volume
2020-09-28	37.590000	38.259998	36.740002	37.540001	37.540001	2922800.0
2020-09-29	37.400002	37.419998	36.279999	36.669998	36.669998	1743500.0
2020-09-30	37.590000	38.270000	36.480000	36.630001	36.630001	1921600.0
NaT	NaN	NaN	NaN	NaN	NaN	NaN
NaT	NaN	NaN	NaN	NaN	NaN	NaN
NaT	NaN	NaN	NaN	NaN	NaN	NaN
NaT	NaN	NaN	NaN	NaN	NaN	NaN
NaT	NaN	NaN	NaN	NaN	NaN	NaN
NaT	NaN	NaN	NaN	NaN	NaN	NaN
NaT	NaN	NaN	NaN	NaN	NaN	NaN

Data Exploration

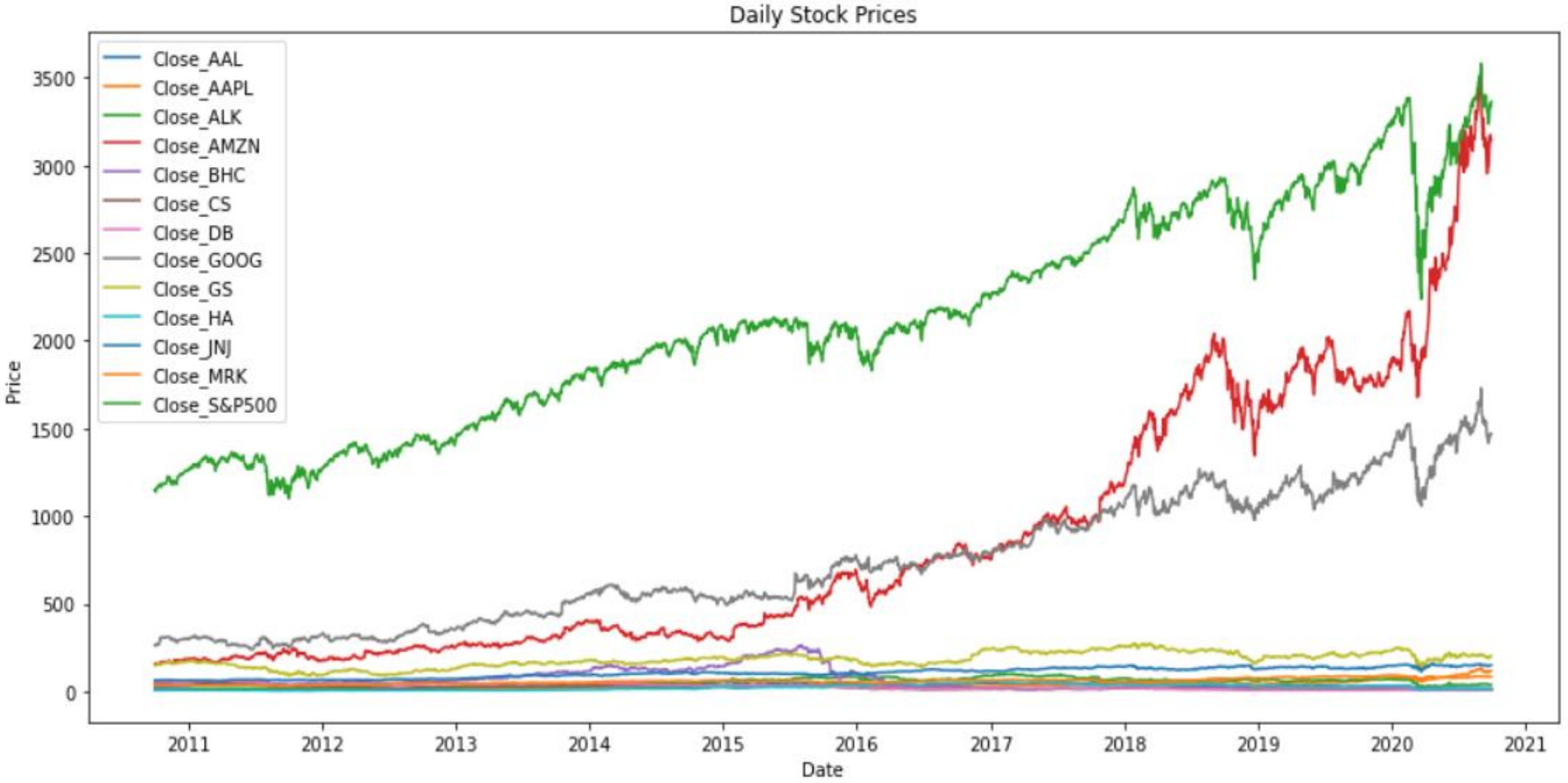
Daily and Normalized Stock Price Visualization

Perform calculation of various metrics –

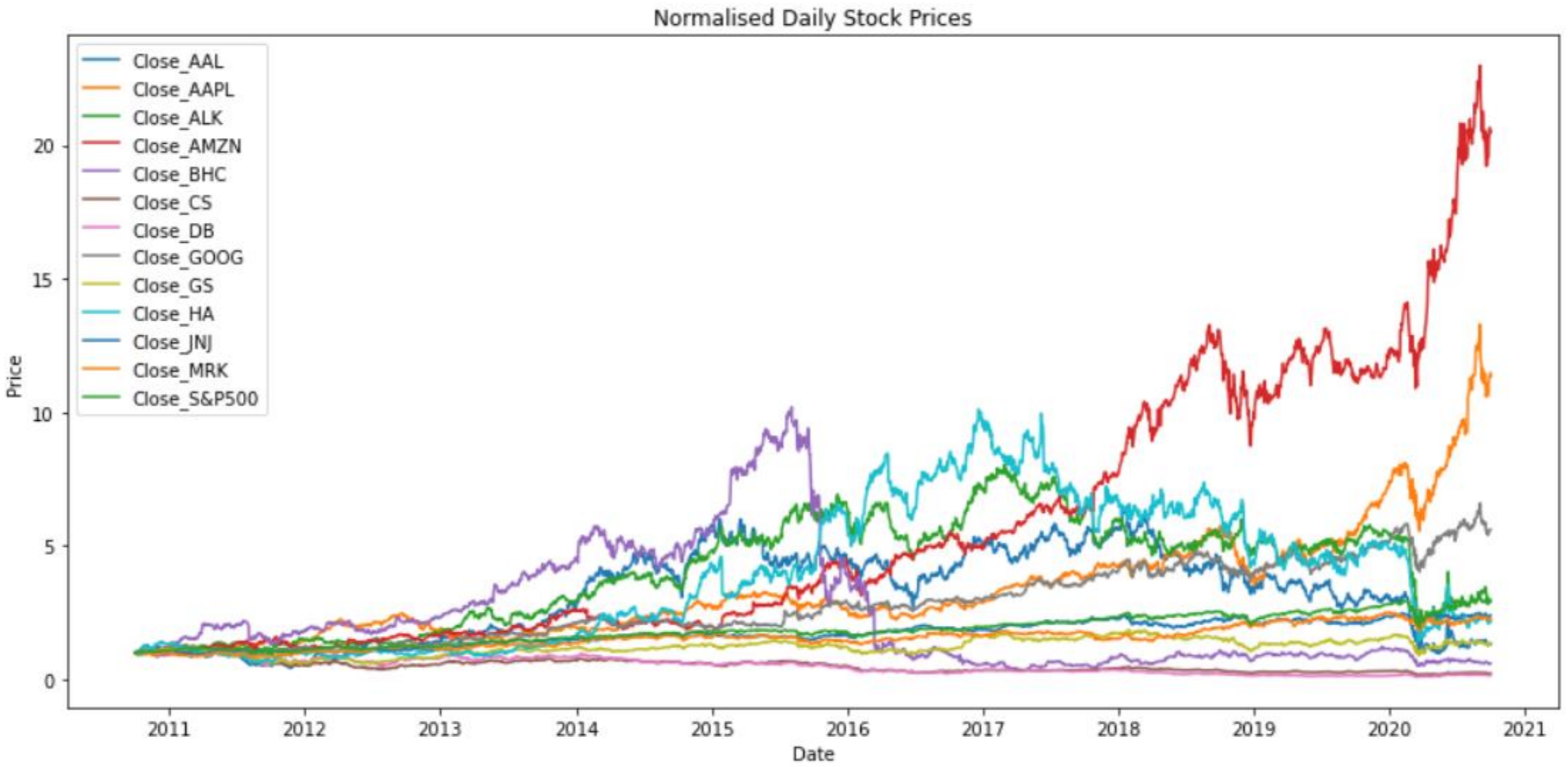
- Returns – Daily Returns, Mean of Returns, Annualized Returns
- Statistical Summary
- Risk/Volatility – Standard Deviation
- Cumulative Returns
- Correlation among stocks and different industry Groups

Comparison & Findings

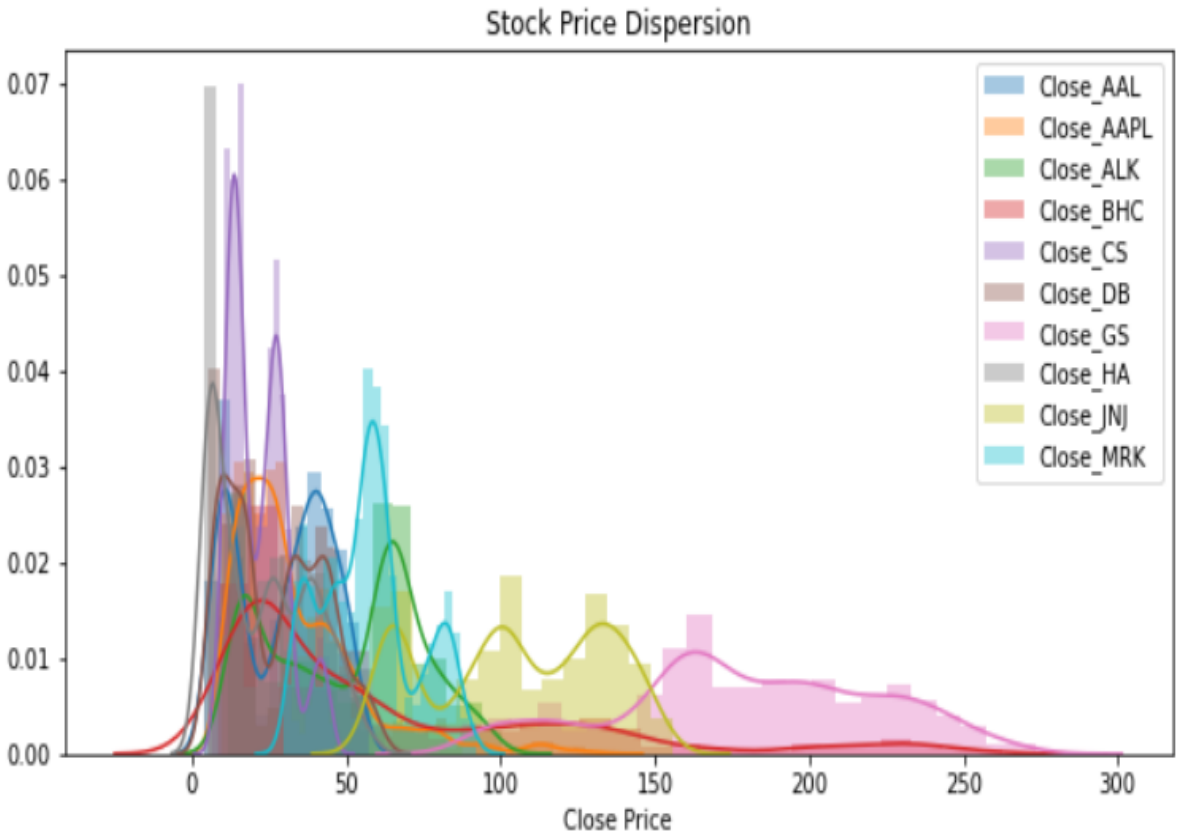
Daily Stock Prices

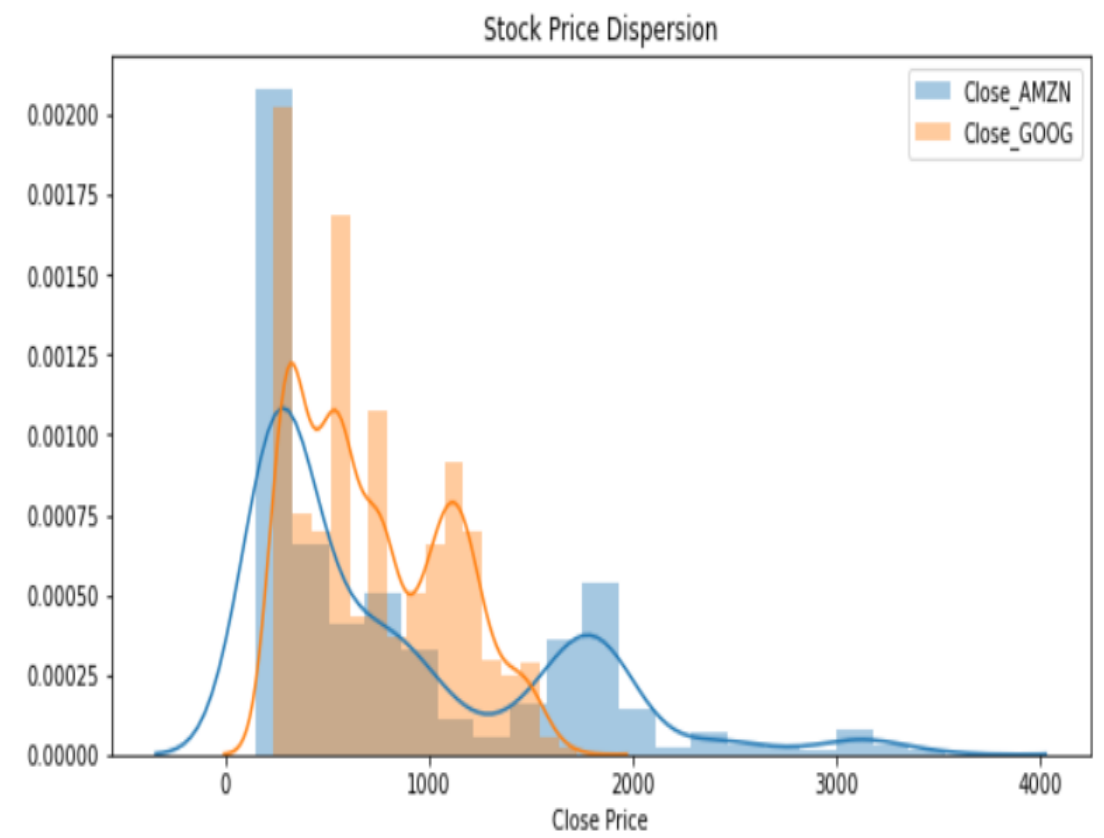


Daily Stock Prices - Normalized



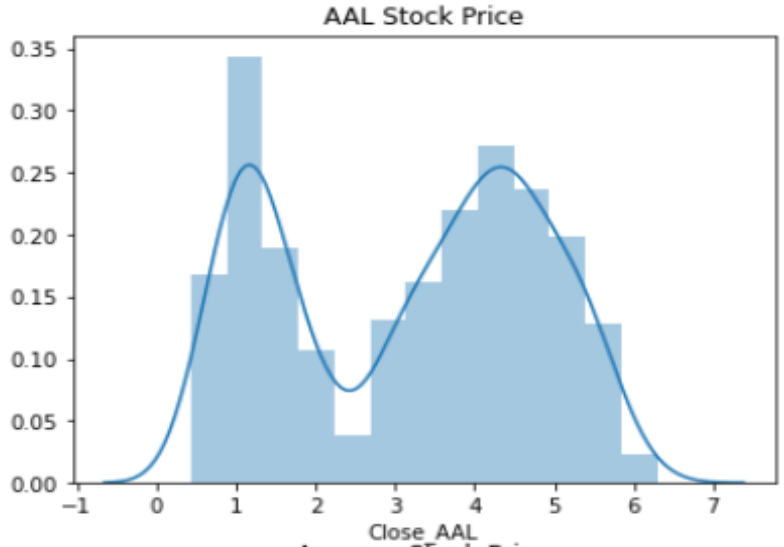
Distribution – Stock Prices

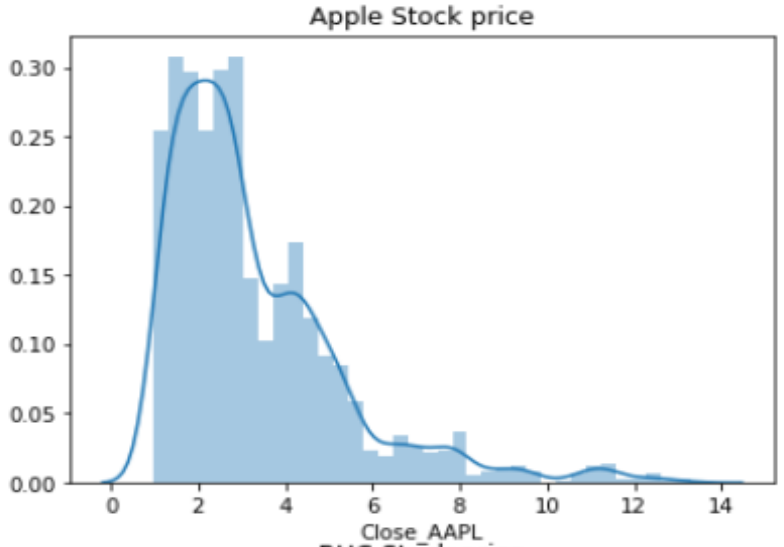


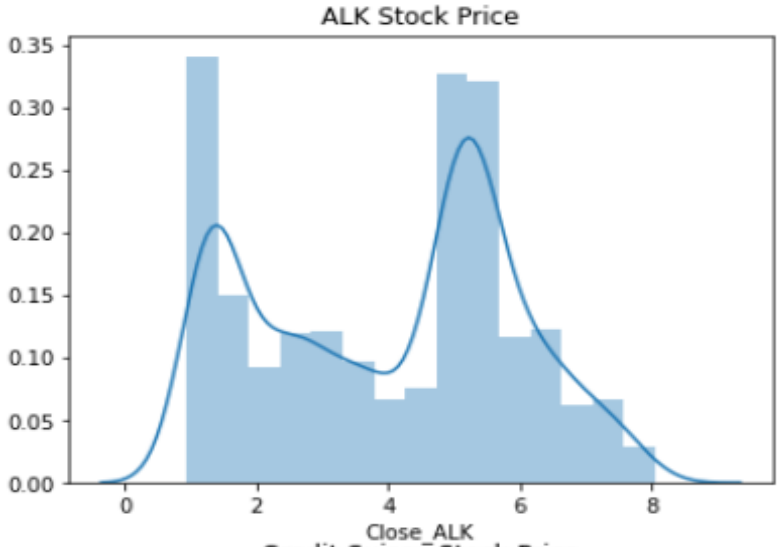


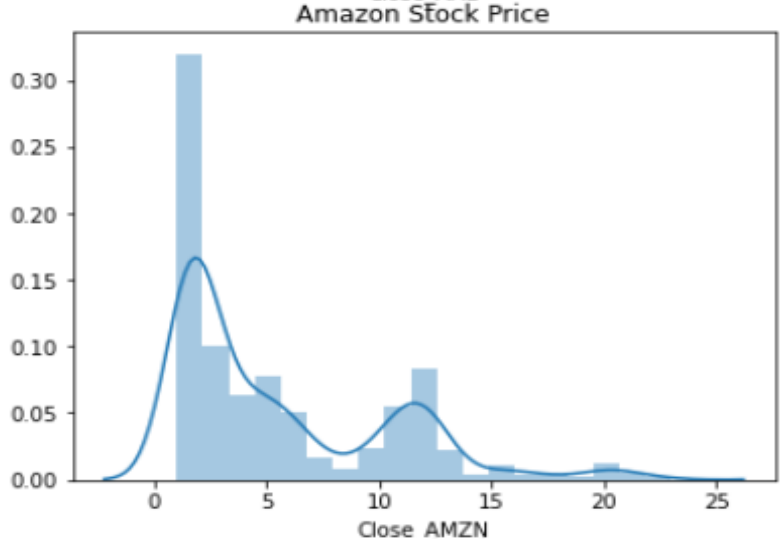
Distribution Plot for various stocks provided.

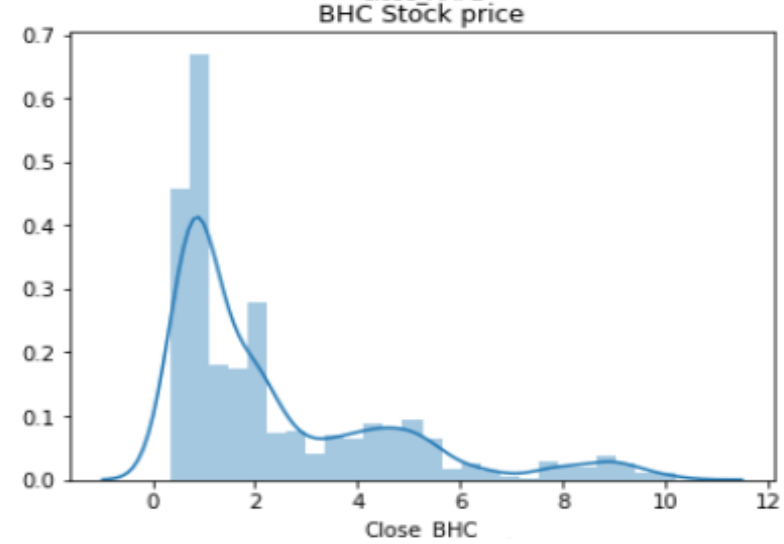
Distribution – Stock Prices

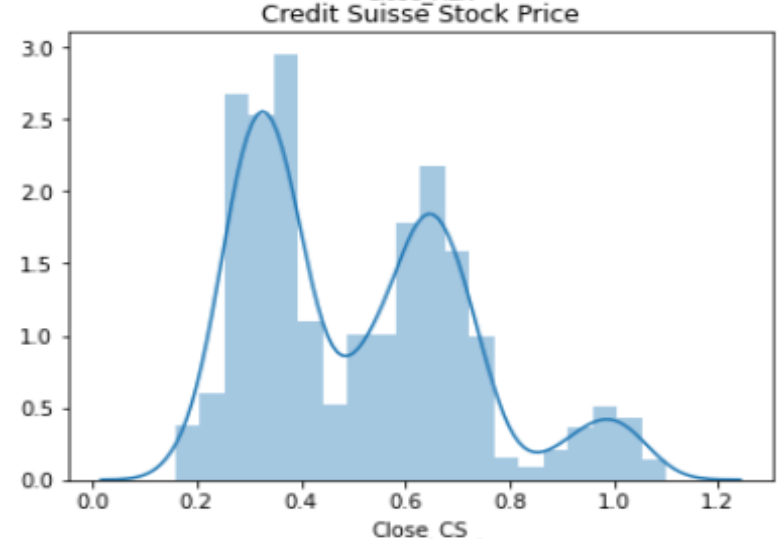




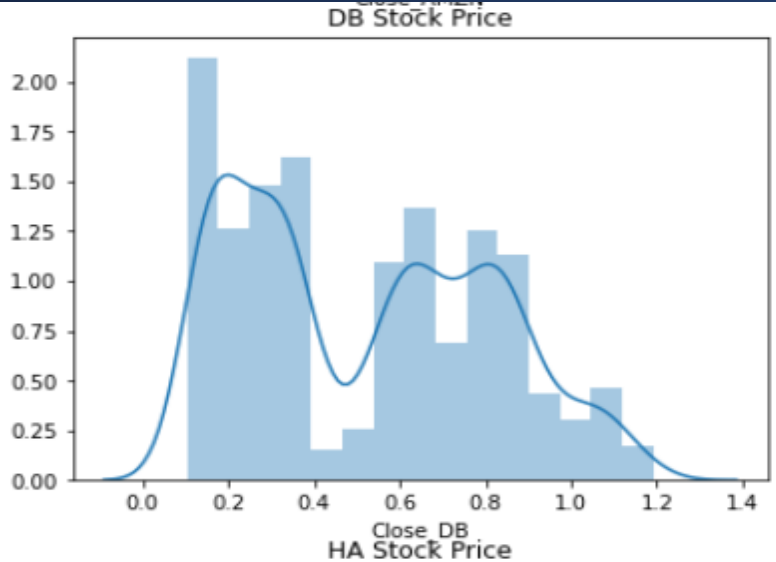


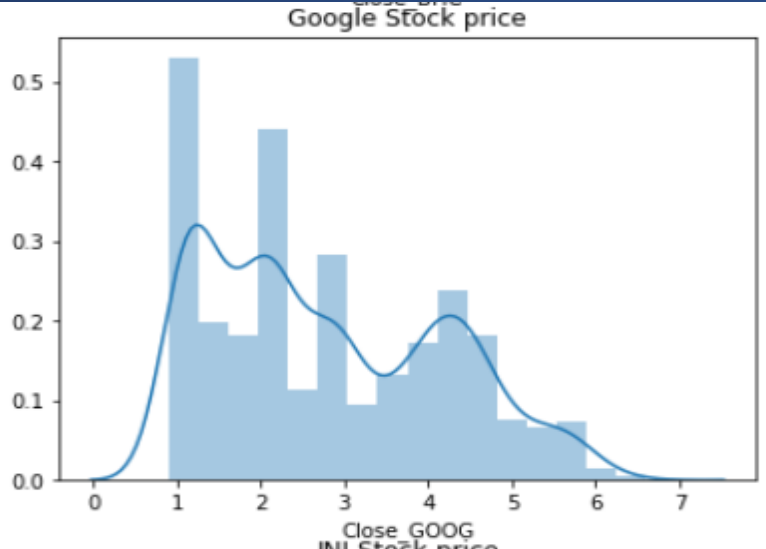


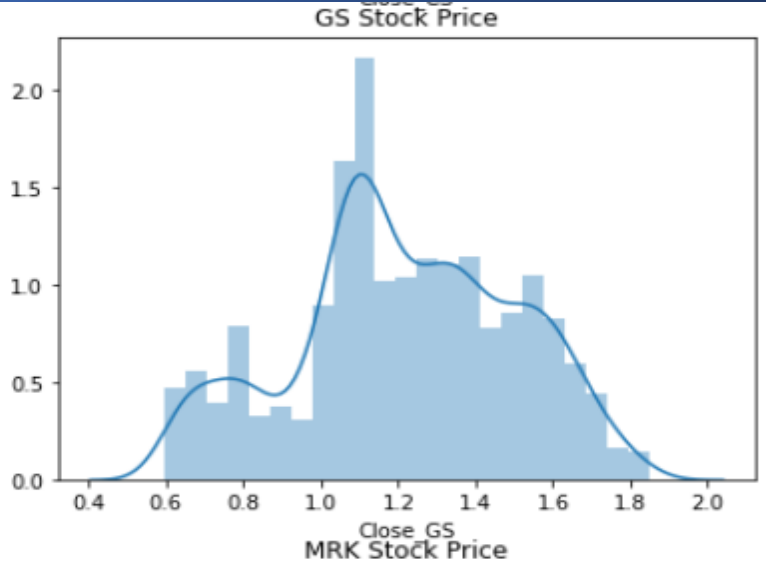


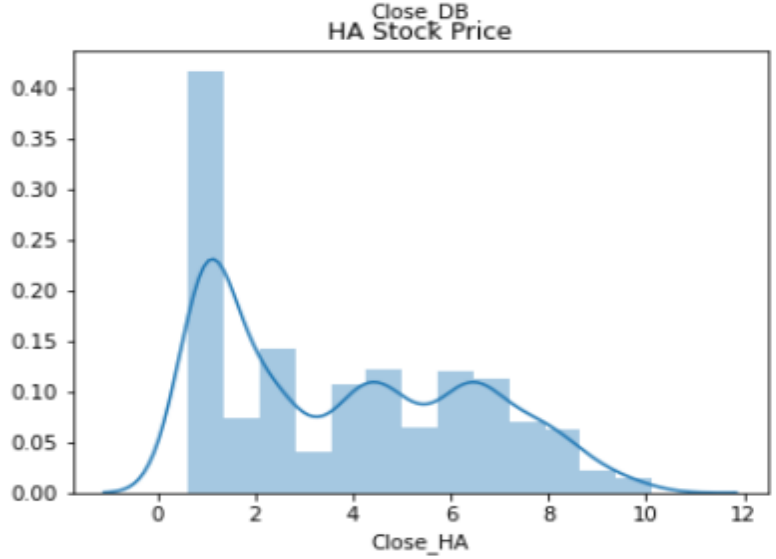


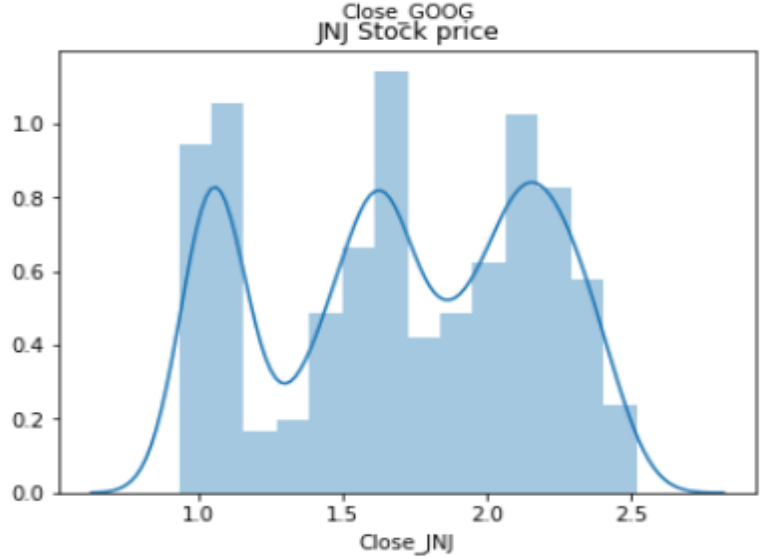
Distribution – Stock Prices

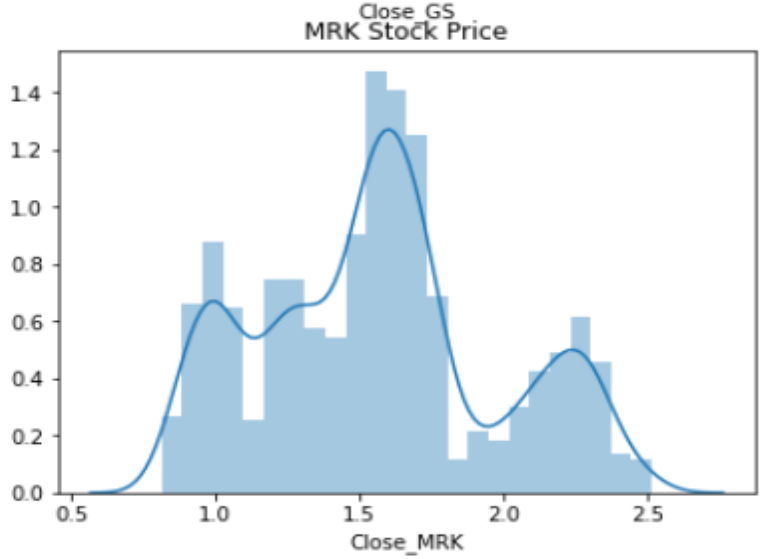




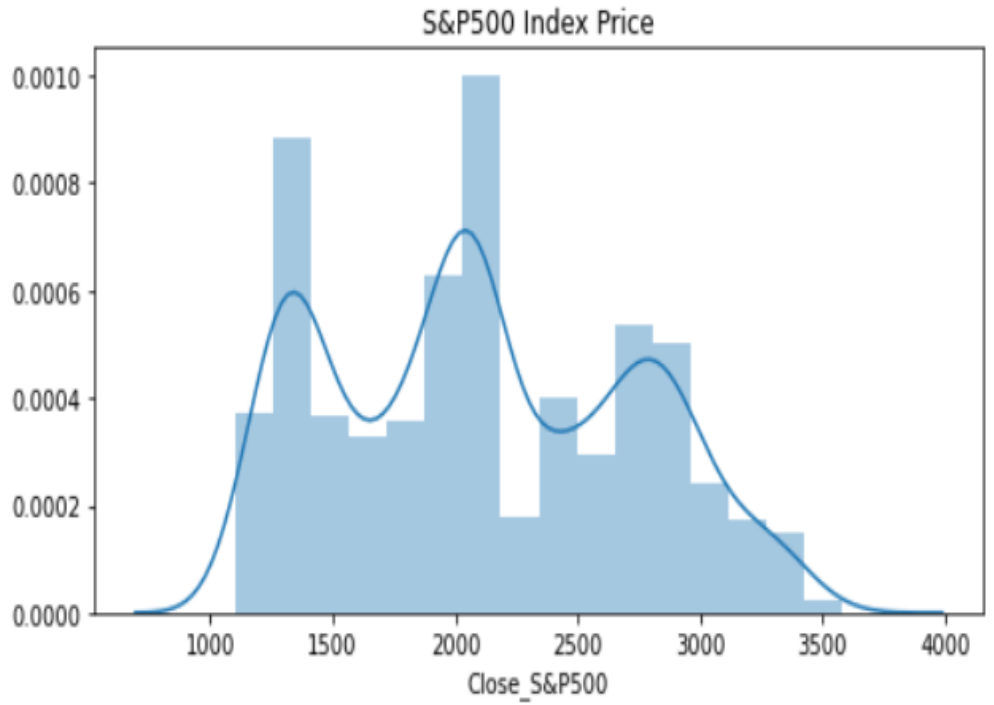


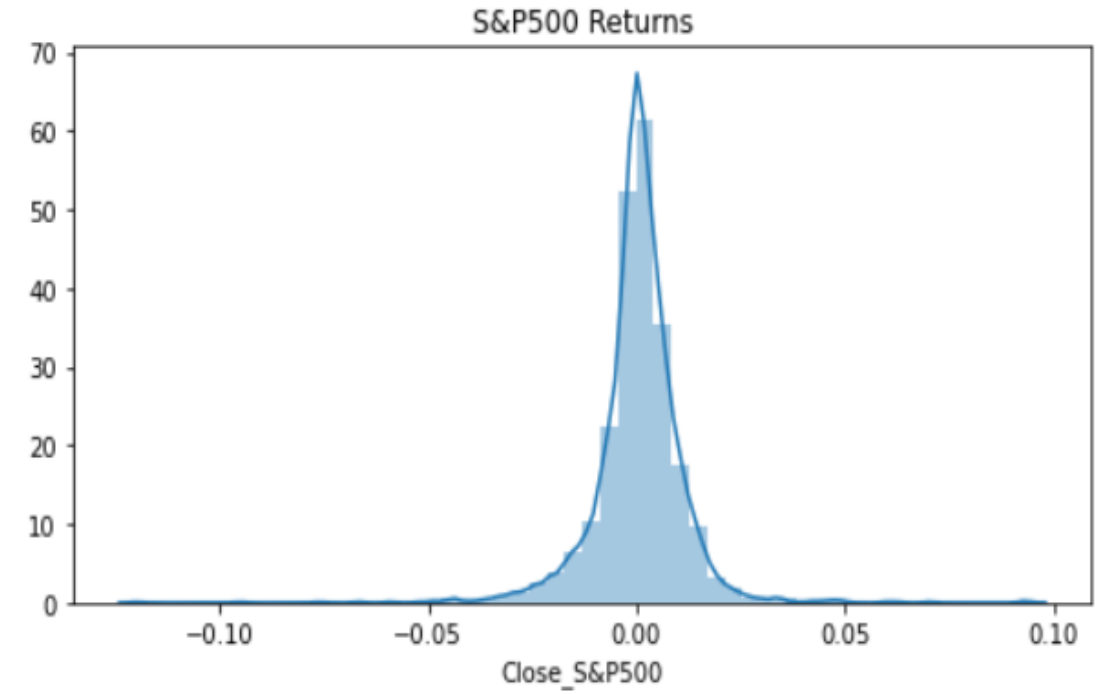






Distribution – Market Index S&P500 Price & Returns



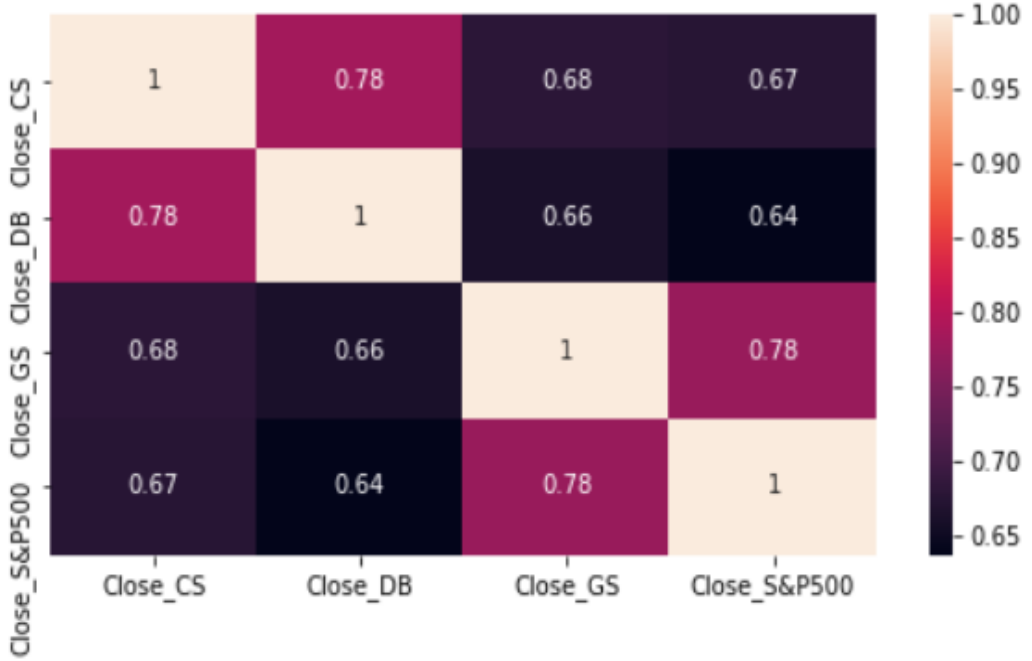


S&P500 Returns is normally distributed while Price is more dispersed.

Correlation Heatmap – Industry Groups

Aviation

Finance



In Aviation – none of the stocks are correlated with Market Index.
In Finance – Goldman Sachs, Deutsche Bank & Credit Suisse have correlation with S&P500.

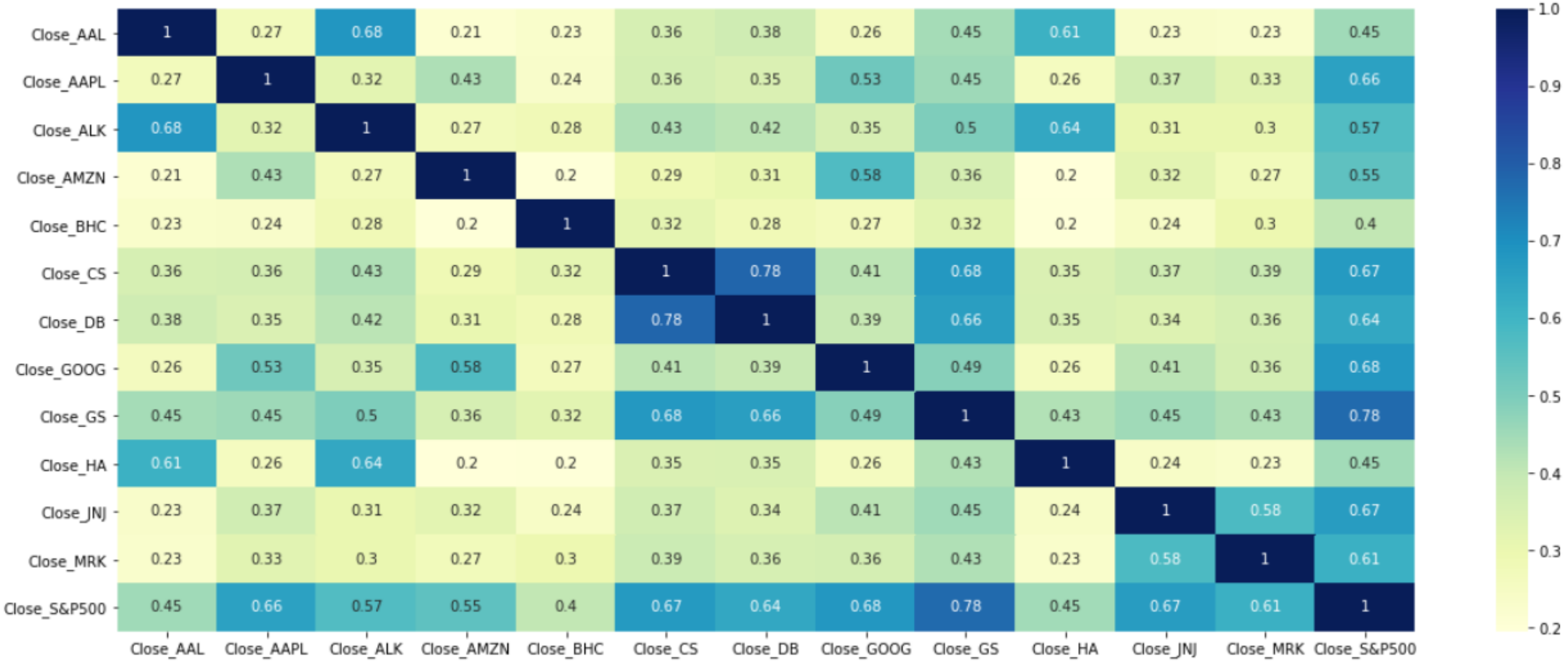
Correlation Heatmap – Industry Groups

Healthcare

Technology

In Healthcare – Johnson & Johnson and Merck and CO are correlated with Market Index.
In Technology – Google & Apple are correlated with S&P500.

Correlation Heatmap



Comparisons & Findings – I

Daily Stock Prices –

- Highest Stock prices - Amazon , Apple and Google.
- Prices of Bausch Health, Hawaiian Holdings, American Airlines have dropped in recent years.
- Apple & Goldman Sachs seems to be normally distributed with S&P500
- S&P500 Index Price is more dispersed from mean.

Daily Returns –

- S&P500 Returns is normally distributed.
- All the stock returns are normally distributed.

Average Daily Returns, Annualized and Cumulative Returns –

- Amazon has highest Returns followed by Apple & Google.
- Deutsche Bank has lowest Returns.

Comparisons & Findings – II

Risk and Annualized Risk –

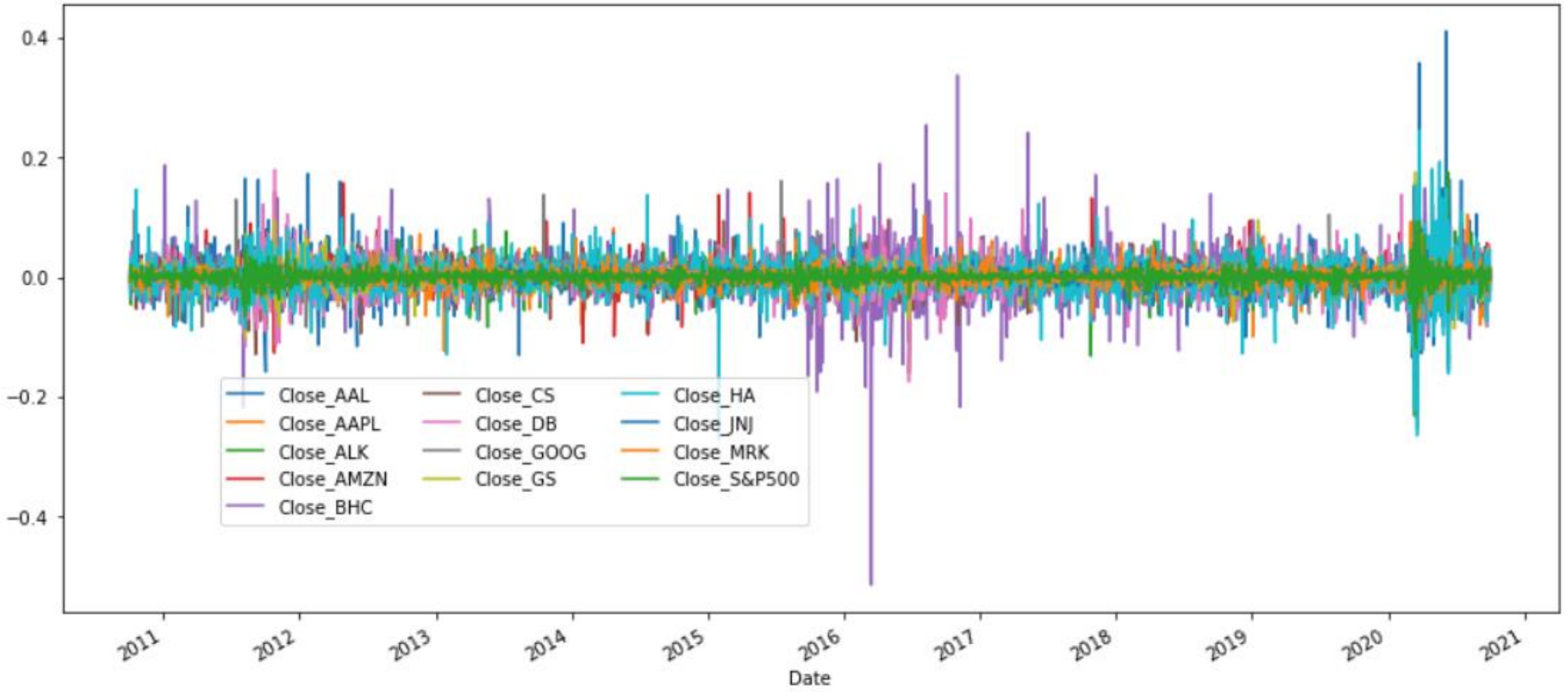
- Most Risky Assets - Bausch Health, American Airlines Group & Hawaiian Holdings.
- Johnson & Johnson is least risky asset.

Correlation Analysis –

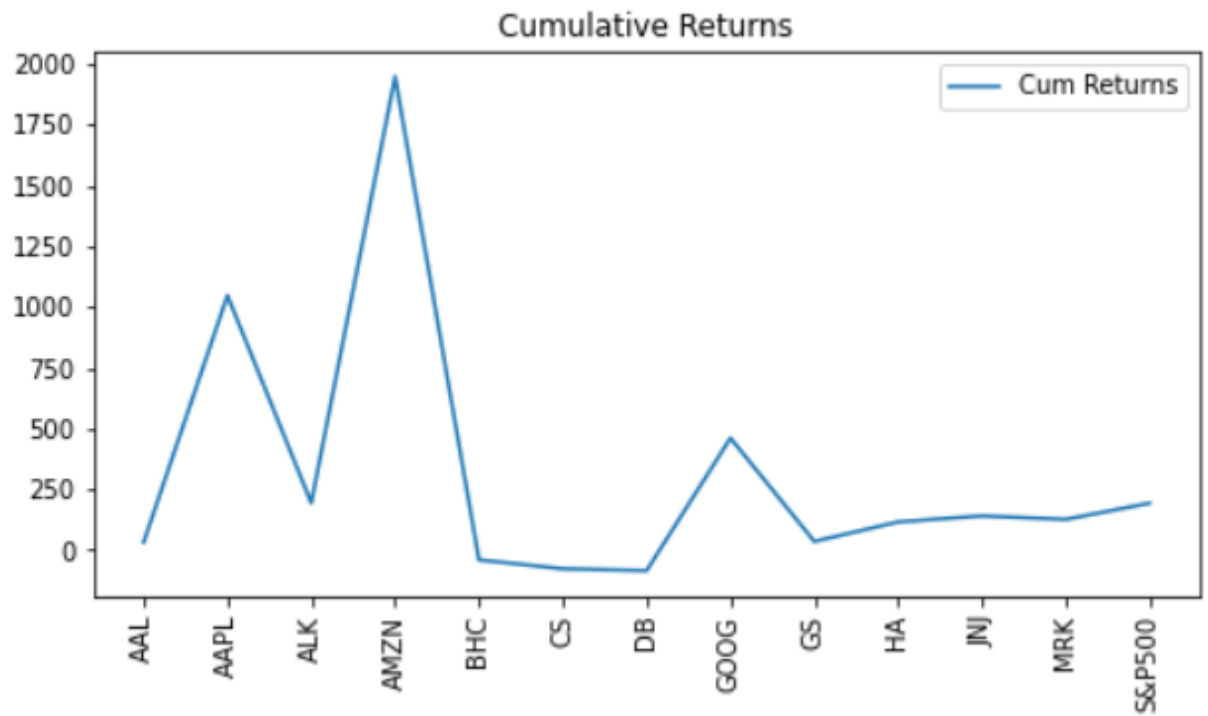
- Aviation – none of the stocks are correlated with Market Index.
- Finance – Goldman Sachs, Deutsche Bank & Credit Suisse have correlation with S&P500.
- Healthcare – Johnson & Johnson and Merck and CO are correlated with Market Index.
- Technology – Google & Apple are correlated with S&P500.
- Among each other – Deutsche Bank & Credit Suisse have strong correlation with each other, and American Airlines & Alaska Air Group are also correlated with each other along with Hawaiian Holdings.

Stock Analysis and Portfolio Management – CAPM

Distribution – Daily Returns

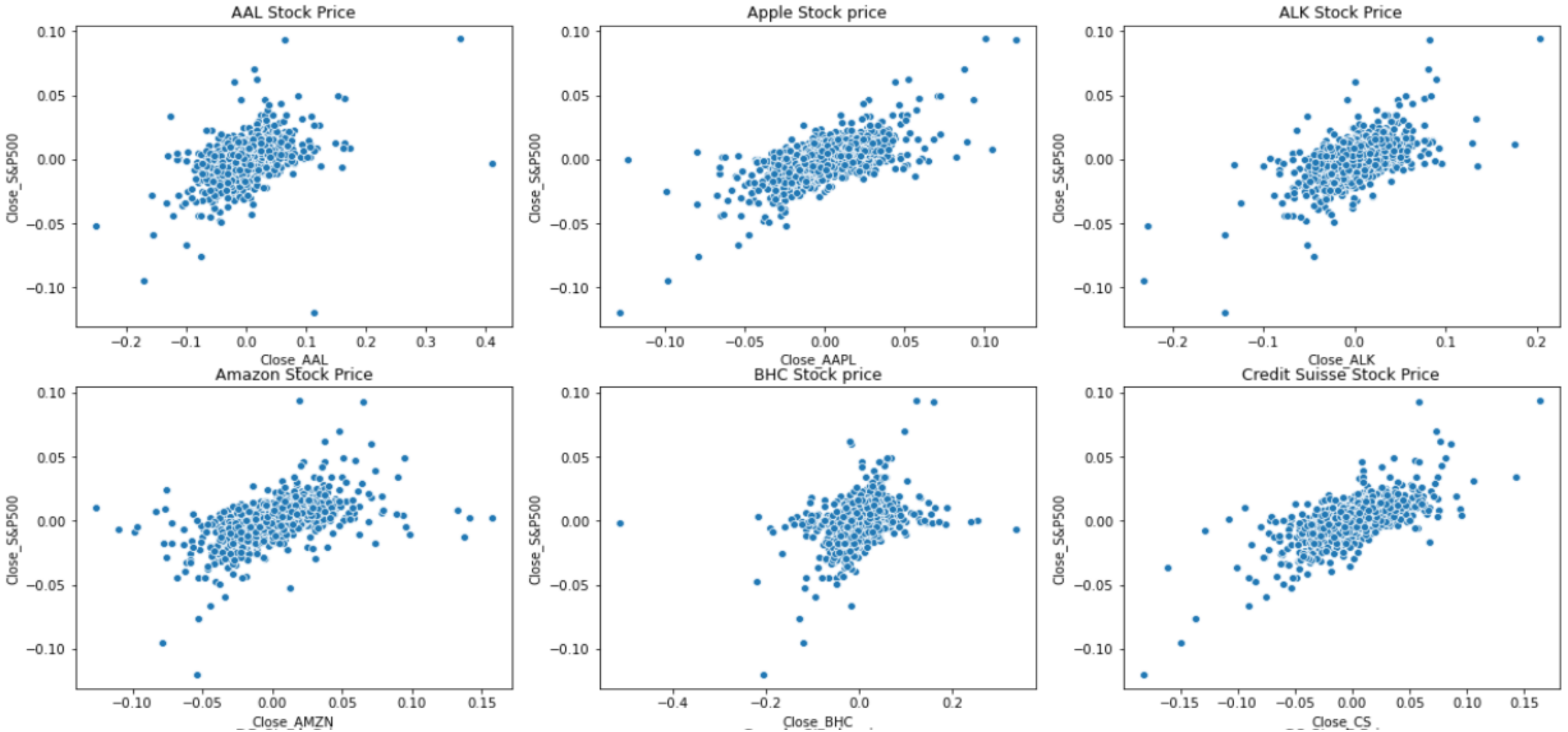


Annualized Risk, Annualized Returns & Cumulative Returns

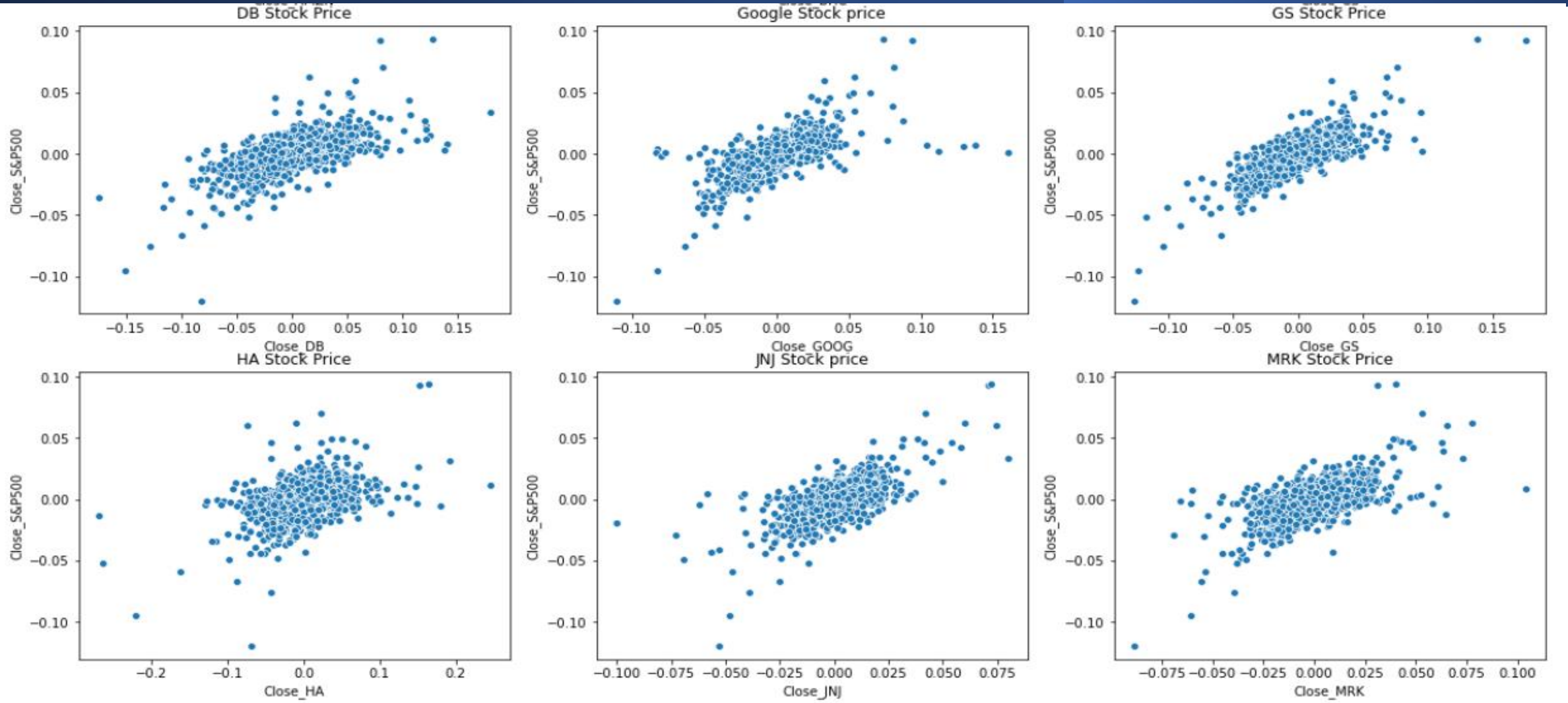


Annualized & Cumulative Returns are high for Amazon and low for Deutsche Bank while Annualized Risk is high for Bausch Health and low for Johnson & Johnson.

Stock vs Market Returns – Scatter Plot



Stock vs Market Returns – Scatter Plot



Beta Coefficient – Linear Regression

Stock – American Airlines Group Inc

Industry – Aviation

Beta Value – 1.3536

Adj R-square – 20.5%

OLS Regression Results

Dep. Variable:	Close_AAL	R-squared:	0.205
Model:	OLS	Adj. R-squared:	0.204
Method:	Least Squares	F-statistic:	646.4
Date:	Wed, 29 Dec 2021	Prob (F-statistic):	4.19e-127
Time:	12:10:06	Log-Likelihood:	5322.0
No. Observations:	2516	AIC:	-1.064e+04
Df Residuals:	2514	BIC:	-1.063e+04
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	-2.365e-05	0.001	-0.041	0.968	-0.001	0.001
Close_S&P500	1.3536	0.053	25.425	0.000	1.249	1.458

Omnibus:	1331.358	Durbin-Watson:	1.882
Prob(Omnibus):	0.000	Jarque-Bera (JB):	63518.565
Skew:	1.777	Prob(JB):	0.00
Kurtosis:	27.357	Cond. No.	91.5

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.

Beta Coefficient – Linear Regression

Stock – Apple Inc

Industry – Technology

Beta Value – 1.0633

Adj R-square – 43.1%

OLS Regression Results

Dep. Variable:	Close_AAPL	R-squared:	0.431
Model:	OLS	Adj. R-squared:	0.430
Method:	Least Squares	F-statistic:	1901.
Date:	Wed, 29 Dec 2021	Prob (F-statistic):	8.93e-310
Time:	12:10:06	Log-Likelihood:	7286.3
No. Observations:	2516	AIC:	-1.457e+04
Df Residuals:	2514	BIC:	-1.456e+04
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	0.0006	0.000	2.281	0.023	8.55e-05	0.001
Close_S&P500	1.0633	0.024	43.602	0.000	1.016	1.111

Omnibus:	394.018	Durbin-Watson:	1.902
Prob(Omnibus):	0.000	Jarque-Bera (JB):	6676.516
Skew:	-0.057	Prob(JB):	0.00
Kurtosis:	10.980	Cond. No.	91.5

Warnings:

[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.

Beta Coefficient – Linear Regression

Stock – Merck and CO inc.

Industry – Healthcare

Beta Value – 0.7335

Adj R-square – 37.8%

OLS Regression Results

Dep. Variable:	Close_MRK	R-squared:	0.378
Model:	OLS	Adj. R-squared:	0.378
Method:	Least Squares	F-statistic:	1526.
Date:	Wed, 29 Dec 2021	Prob (F-statistic):	2.67e-261
Time:	12:10:06	Log-Likelihood:	7944.3
No. Observations:	2516	AIC:	-1.588e+04
Df Residuals:	2514	BIC:	-1.587e+04
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	5.235e-05	0.000	0.255	0.799	-0.000	0.000
Close_S&P500	0.7335	0.019	39.066	0.000	0.697	0.770

Omnibus:	455.549	Durbin-Watson:	1.942
Prob(Omnibus):	0.000	Jarque-Bera (JB):	7756.989
Skew:	0.336	Prob(JB):	0.00
Kurtosis:	11.576	Cond. No.	91.5

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.

Beta Coefficient – Linear Regression

Stock – Goldman Sachs

Industry – Finance

Beta Value – 1.3013

Adj R-square – 60.2%

OLS Regression Results

Dep. Variable:	Close_GS	R-squared:	0.602
Model:	OLS	Adj. R-squared:	0.602
Method:	Least Squares	F-statistic:	3810.
Date:	Wed, 29 Dec 2021	Prob (F-statistic):	0.00
Time:	12:10:06	Log-Likelihood:	7652.9
No. Observations:	2516	AIC:	-1.530e+04
Df Residuals:	2514	BIC:	-1.529e+04
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	-0.0003	0.000	-1.493	0.136	-0.001	0.000
Close_S&P500	1.3013	0.021	61.727	0.000	1.260	1.343

Omnibus:	363.838	Durbin-Watson:	2.009
Prob(Omnibus):	0.000	Jarque-Bera (JB):	2662.419
Skew:	0.464	Prob(JB):	0.00
Kurtosis:	7.953	Cond. No.	91.5

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.

Beta Coefficient – Linear Regression

Other Stocks –

Alaska Air Group Inc – 1.231512

Amazon – 0.998802

Bausch Health Companies Inc – 1.315971

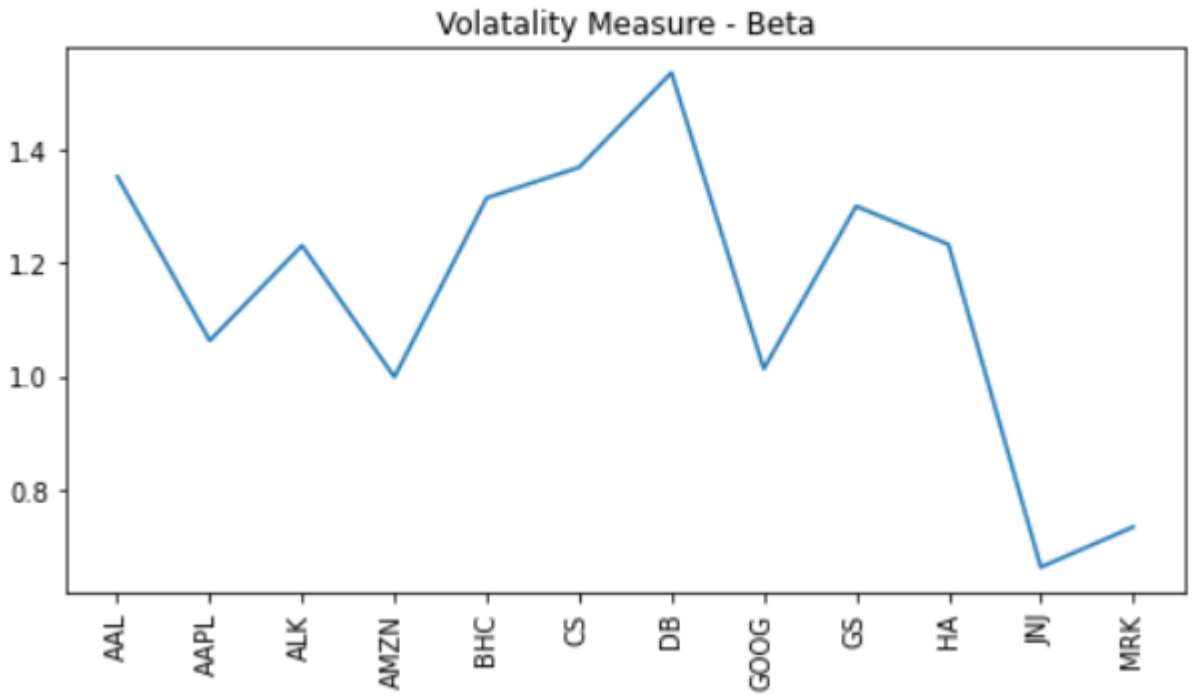
Credit Suisse – 1.370002

Deutsche Bank – 1.537546

Google – 1.013338

Hawaiian Holdings Inc – 1.233534

Johnson & Johnson – 0.662233



Stocks – Volatility/Beta Plot

Comparisons & Findings – I

- On observing the Scatter Plots of stocks with Market Index, we can see that Apple , Goldman Sachs and Deutsche Bank seems to be correlated with the market index.
- Beta Values for American Airlines, Alaska Air, Bausch Health, Credit Suisse, Deutsche Bank, Goldman Sachs, Hawaiian Holdings are depicting high volatility with respect to Market.
- Beta values for Apple, Amazon, Google are correlated with the market.
- Beta values for Johnson & Johnson and Merck and CO are less volatile than the market.
- The Annualized Market Returns S&P500 is **12.3%**.
- Risk Free Rate given is **0.75%**.
- Expected Returns are hence calculated based on above metrics.
- We will now compare the stocks with respect to below parameters for selection –
    - Beta Value
    - Annualized Risk
    - Cumulative Returns
    - Annualized Returns

Comparisons & Findings – II

Comparing the Beta values for different stocks as -

- **Beta ~1:**
  - Google, Apple, Amazon - Low Risk, High Returns
- **Beta >1:**
  - Deutsche Bank, Credit Suisse, Bausch Health - Negative Cumulative Returns, High Risk
  - American Airlines Group - Good Returns, High Risk
  - Goldman Sachs - Good Returns, Low Risk
  - Alaska Air Group - Good Returns, Less Risk
  - Hawaiian Holdings - High Returns, High Risk
- **Beta <1:**
  - Johnson & Johnson, Merck and CO - High Returns, Less Risk

Stock Selection

Based on the analysis using Beta Value, Risk & Returns of stocks along with the Investor Persona, we are choosing below stocks for our portfolio –

- **Google**
- **Apple Inc**
- **Goldman Sachs**
- **Alaska Air Group Inc**

	Ann Returns	Ann Risk	Cum Returns	Beta
AAL	16.048889	51.950444	32.292788	1.353609
AAPL	28.416386	28.127302	1047.770050	1.063349
ALK	17.879160	37.404274	194.275967	1.231512
AMZN	35.220120	31.573504	1948.487305	0.998802
BHC	11.697321	56.671428	-39.650485	1.315971
CS	-8.188845	35.250863	-76.389269	1.370002
DB	-9.610244	41.867595	-84.029028	1.537546
GOOG	20.602336	25.856093	461.283184	1.013338
GS	7.321234	29.099614	36.066354	1.301286
HA	19.282441	47.857323	116.275168	1.233534
JNJ	10.300879	17.218738	141.101223	0.662233
MRK	10.338527	20.714241	126.639348	0.733475
S&P500	12.296594	17.357439	193.394056	NaN

Portfolio Beta

Portfolio Beta – For a portfolio, the overall risk can be calculated as the weighted average of the risk of all the securities.

$$Portfolio\ \beta = \sum_{i=1}^{N} w_i \beta_i$$

where i represents the security I
w_i represents the weights of security i in the portfolio

```
## Portfolio Beta

portfolio_beta = sum(portfolio['Beta Total'])
portfolio_beta
```

```
1.1523710892778851
```

Result:- For our portfolio, Portfolio Beta is **1.1524**

Portfolio Returns

Portfolio Returns – is the measure of returns of the Portfolio and calculated using Portfolio Beta times market returns and risk-free return.

$$r_i = r_f + \beta_i(r_m - r_f)$$

Where:

r_i = expected return of security i

r_f = risk-free rate of return

β_i = beta between the stock and the market

r_m = market returns

```
## Portfolio Returns Calculation

portfolio_returns = Rf + portfolio_beta * (Rm - Rf)
portfolio_returns
```

```
14.055961625663196
```

Result:- For our portfolio, Portfolio Returns is **14.1%.**

Portfolio Risk – Standard Deviation

Portfolio Risk – is the measure of risk in the portfolio and calculated using

- Portfolio Weight Array
- Portfolio Covariance Matrix
- Transpose of Portfolio Weight Array

```
# Standard deviation (risk of portfolio)

portfolio_risk = np.sqrt(portfolio_variance)
portfolio_risk
```

```
0.22910379914496606
```

$$\sigma_p^2 = \begin{bmatrix} w_1 & \cdots & w_n \end{bmatrix} \begin{bmatrix} \sigma_{11} & \cdots & \sigma_{1n} \\ \vdots & & \vdots \\ \sigma_{n1} & \cdots & \sigma_{nn} \end{bmatrix} \begin{bmatrix} w_1 \\ \vdots \\ w_n \end{bmatrix} = w'\Sigma w$$

Result:- For our portfolio, Portfolio Risk is **22.91%.**

Sharpe Ratio

Sharpe Ratio - helps the investor to realize the excess returns earned to endure the extra volatility of a riskier asset.

$$Sharpe\ Ratio = \frac{R_p - R_f}{\sigma_p}$$

Where:

R_f = Risk-free rate of return

R_p = Return from the portfolio

σ_p = Risk of the portfolio

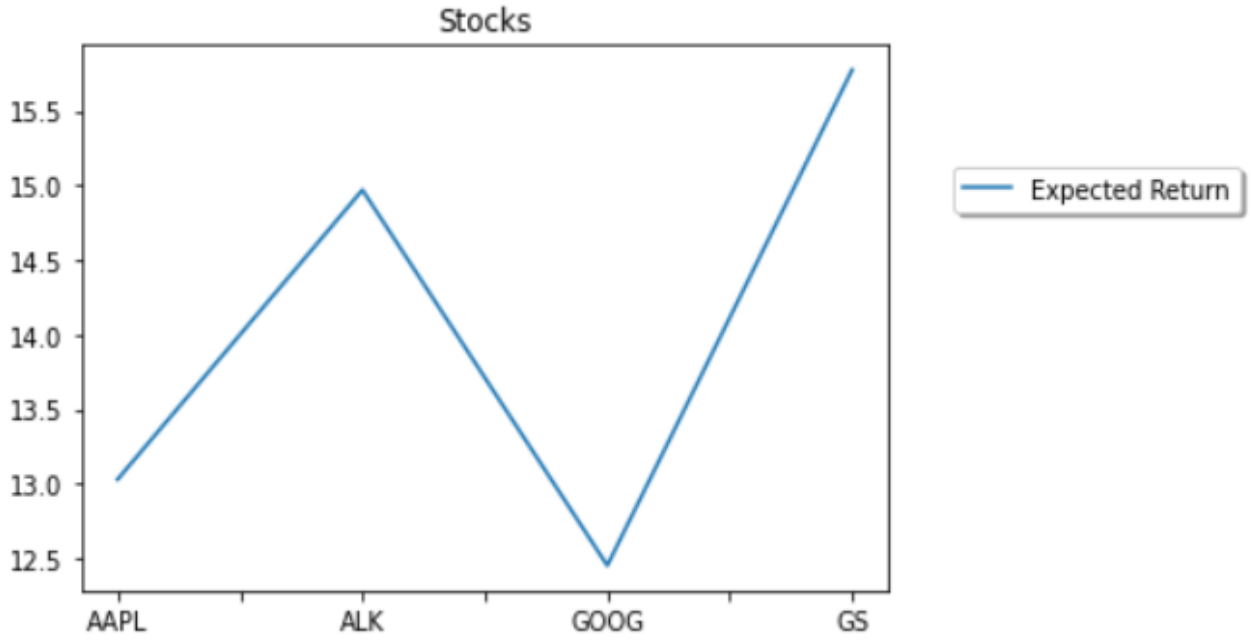
```
## Calculating the Sharpe Ratio to validate

Sharpe_Ratio = (portfolio_returns - Rf) / (portfolio_risk * 100)
Sharpe_Ratio
```

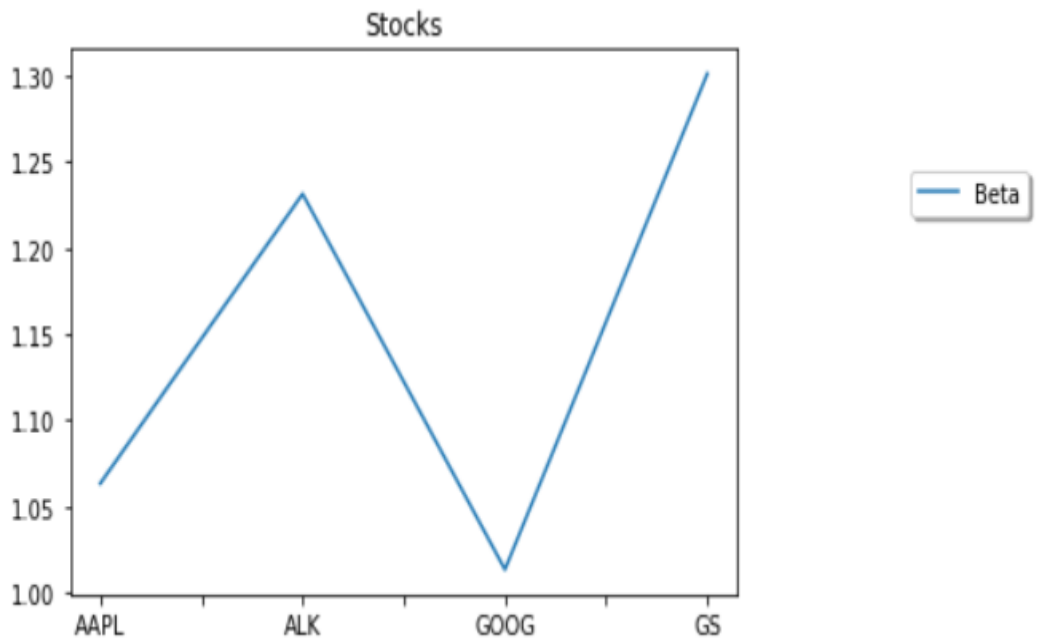
```
0.5807831068416204
```

Result:- For our portfolio, Sharpe Ratio comes is **0.58**

Stock Price Prediction – Validation

Selected Stocks – Returns & Beta Plot

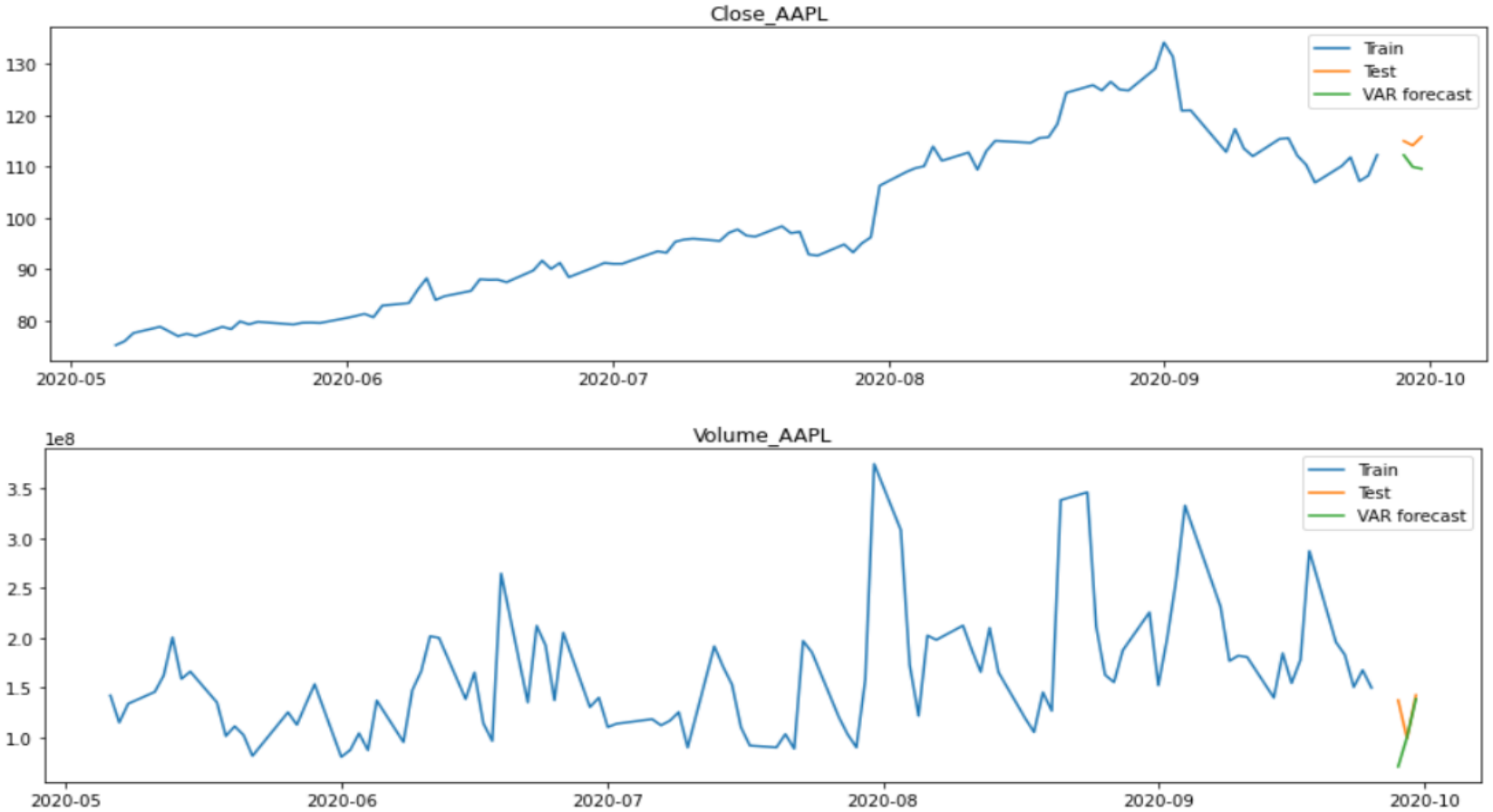




Expected Returns & Beta value for Google is less among all selected stocks while Goldman Sachs has the highest value.

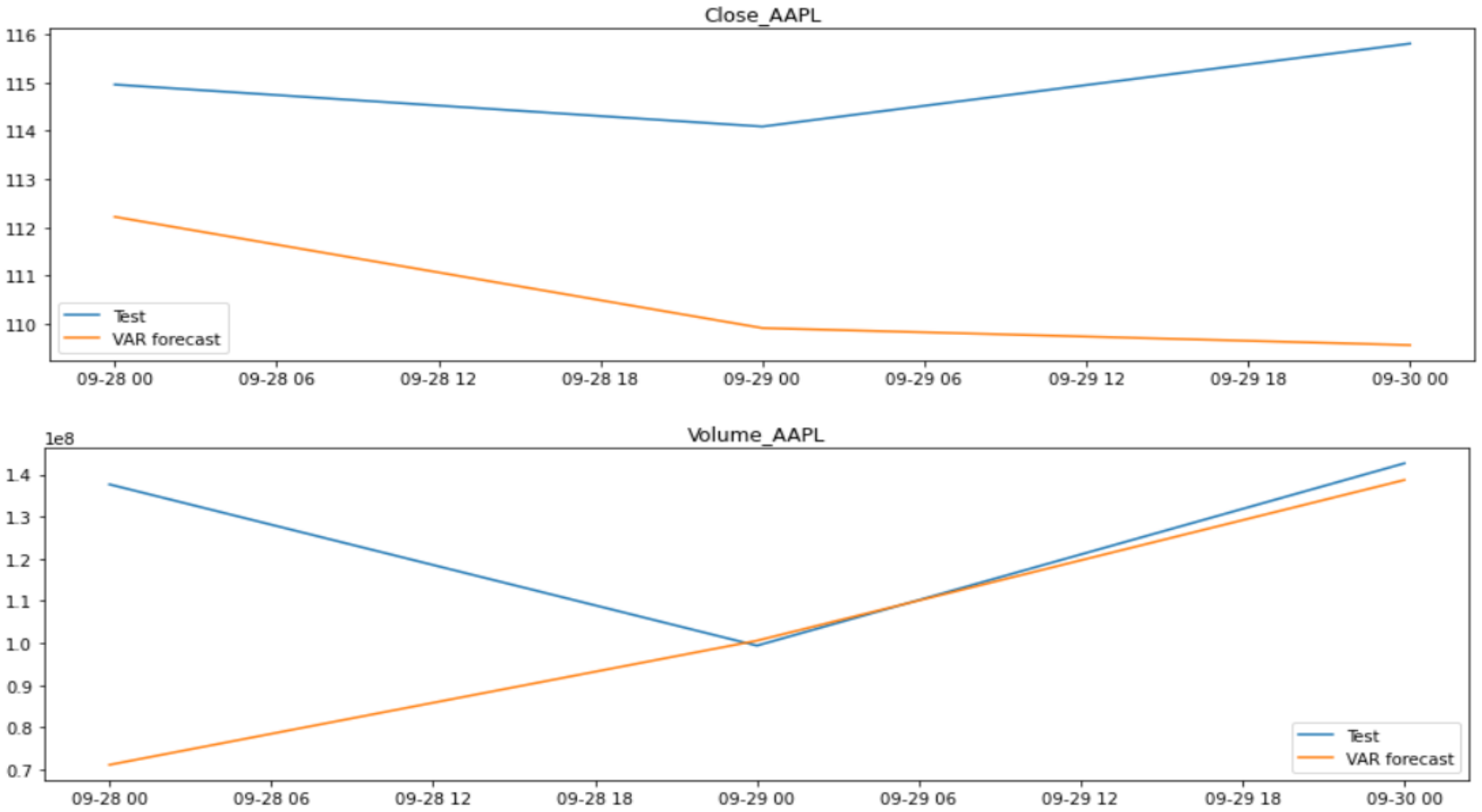
Model Building & Forecasting

Apple Close Price and Volume Prediction – Train, Test and Forecast



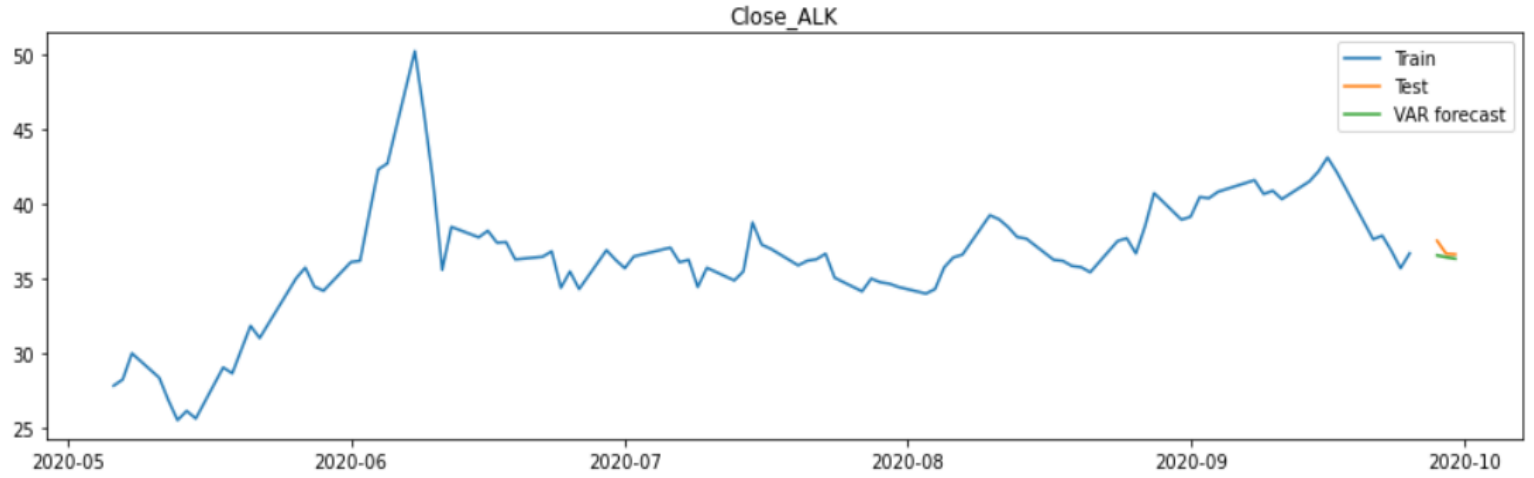
Model Building & Forecasting

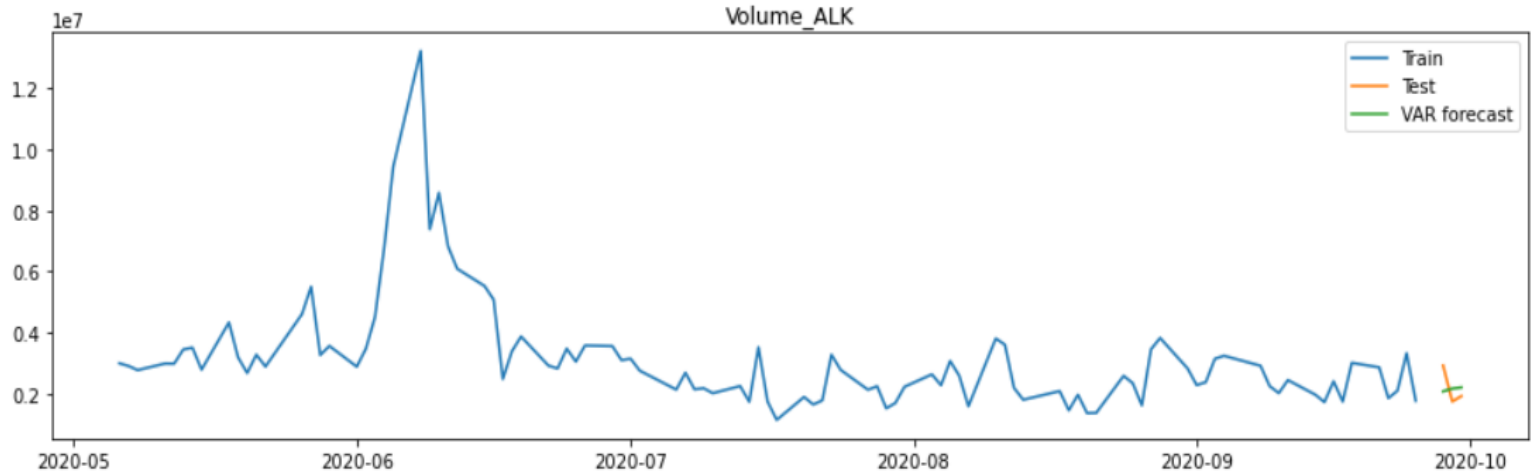
Apple Close Price and Volume Prediction – Test and Forecast



Model Building & Forecasting

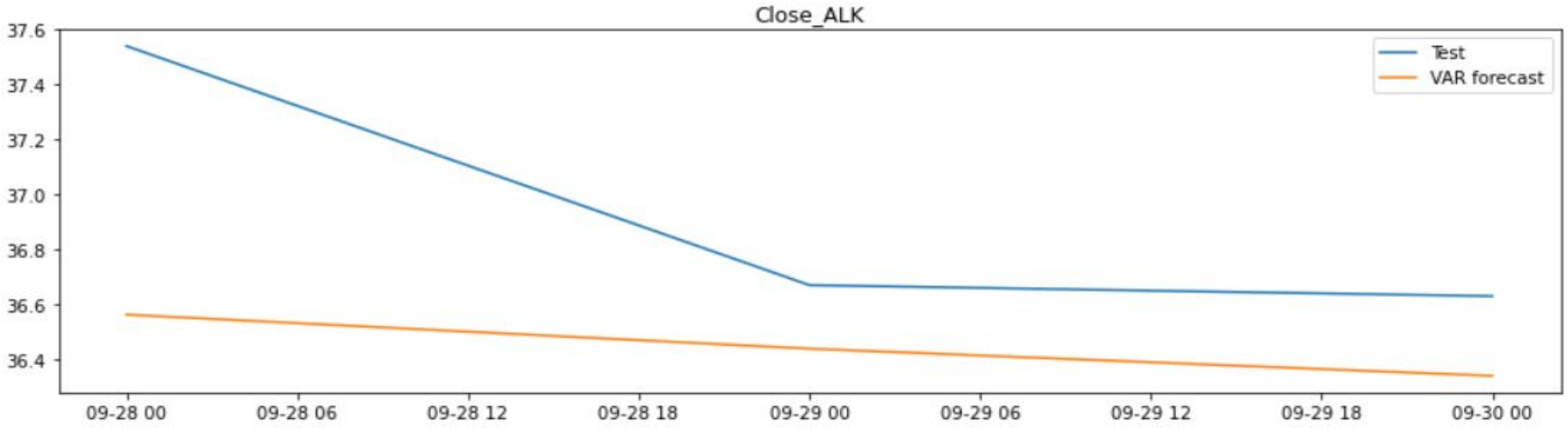
Alaska Air Group Close Price and Volume Prediction – Train, Test and Forecast

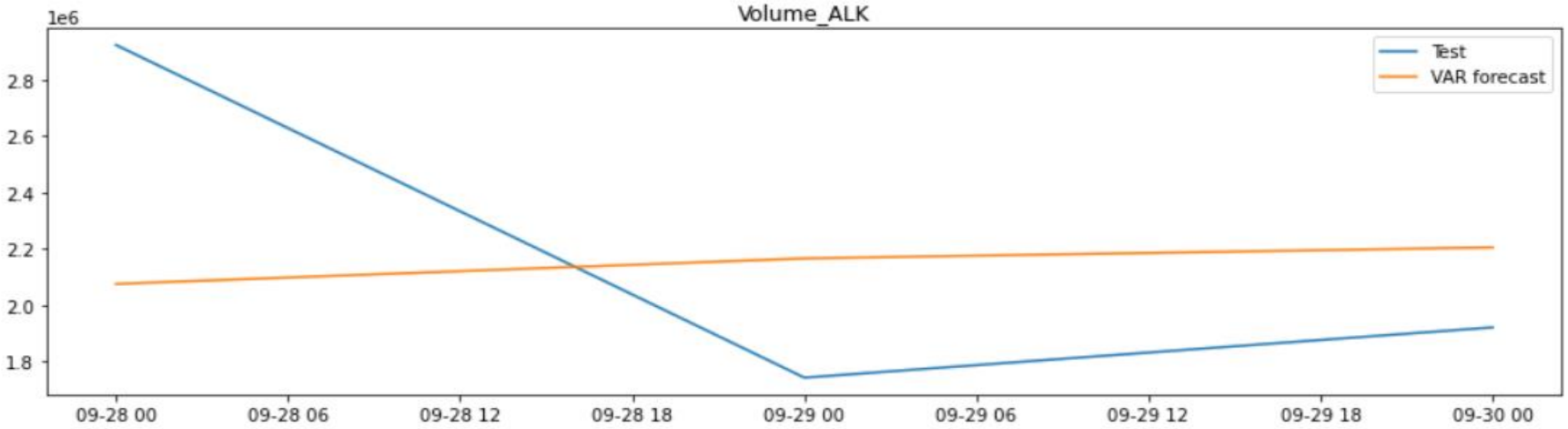




Model Building & Forecasting

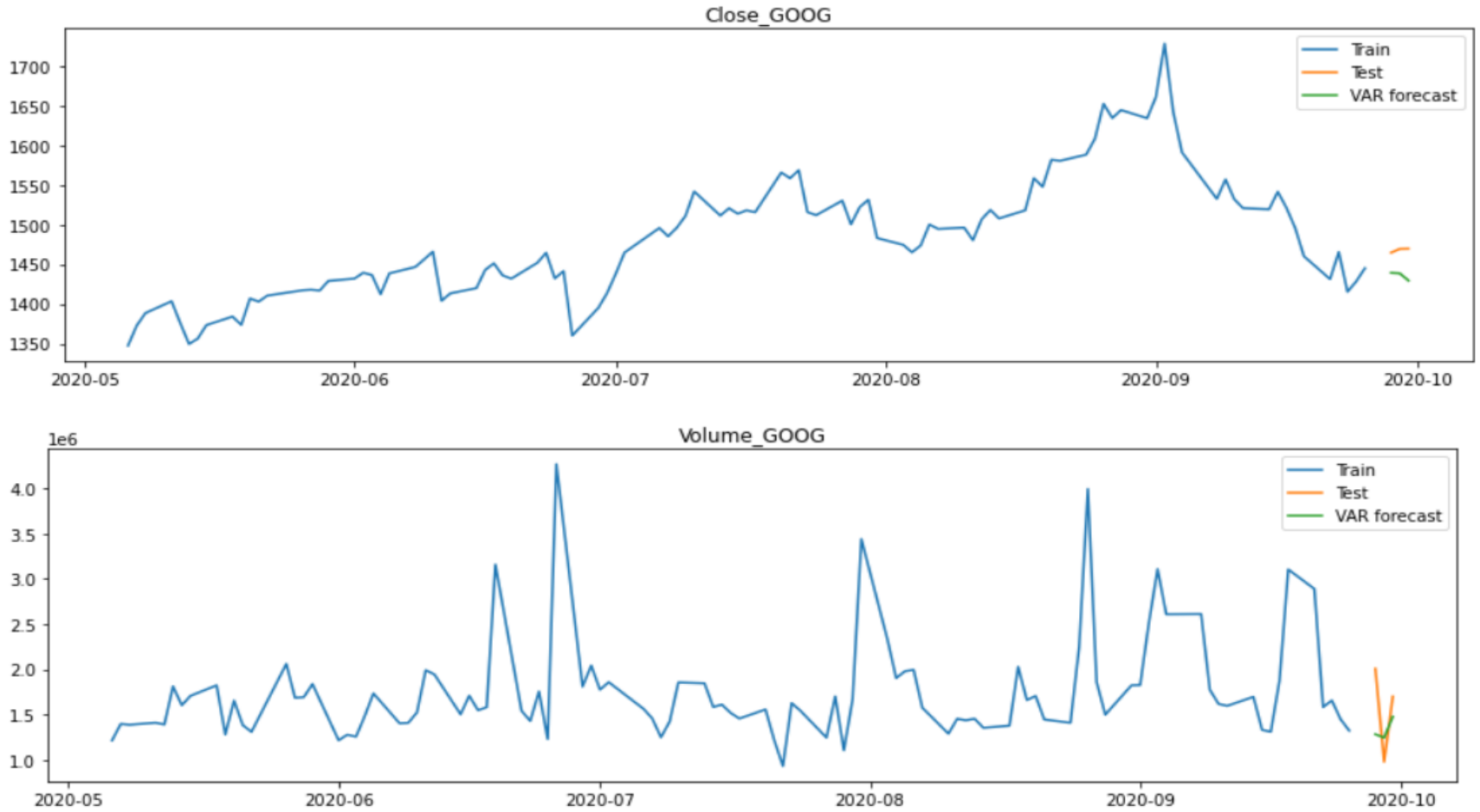
Alaska Air Group Close Price and Volume Prediction – Test and Forecast





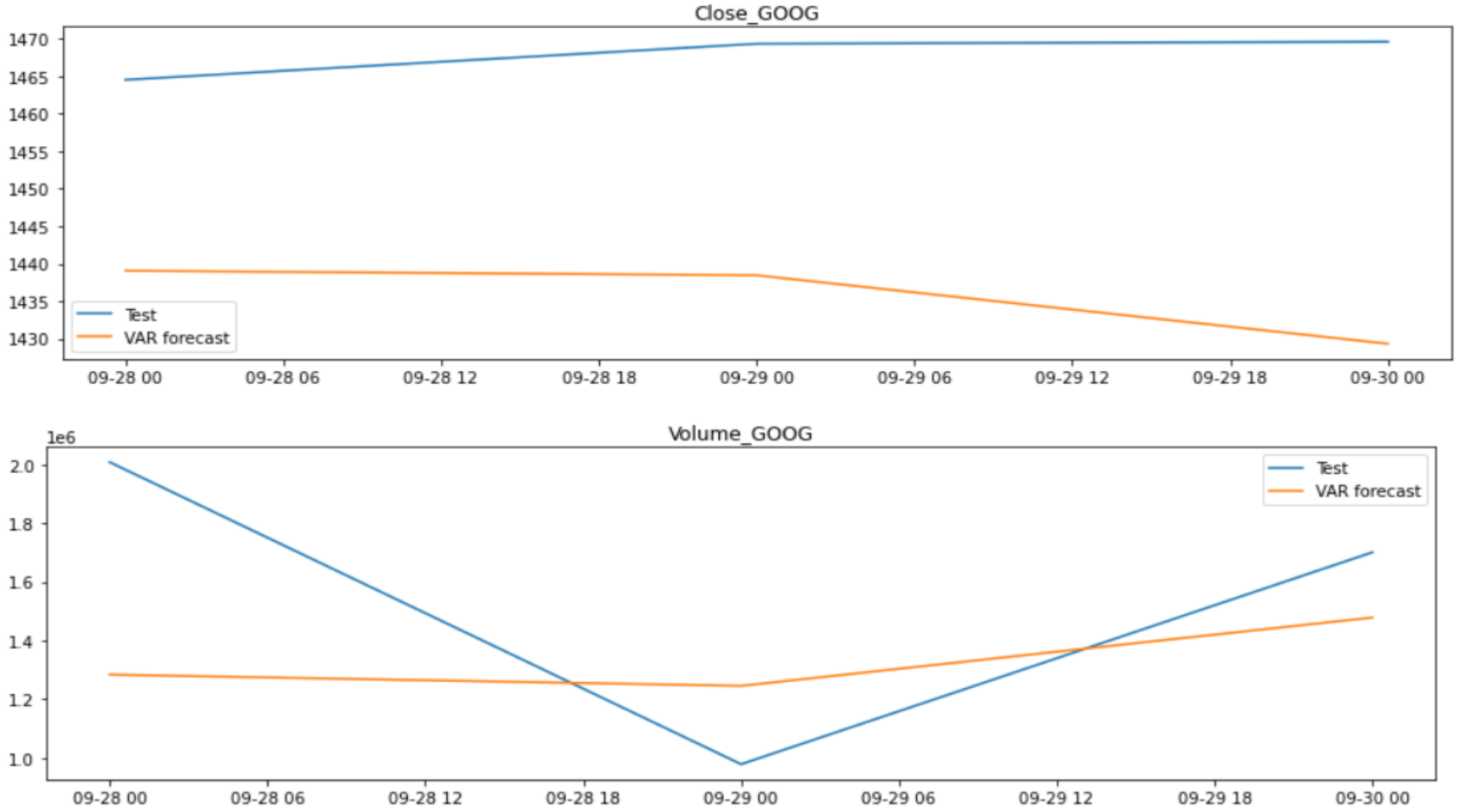
Model Building & Forecasting

Google Close Price and Volume Prediction – Train, Test and Forecast



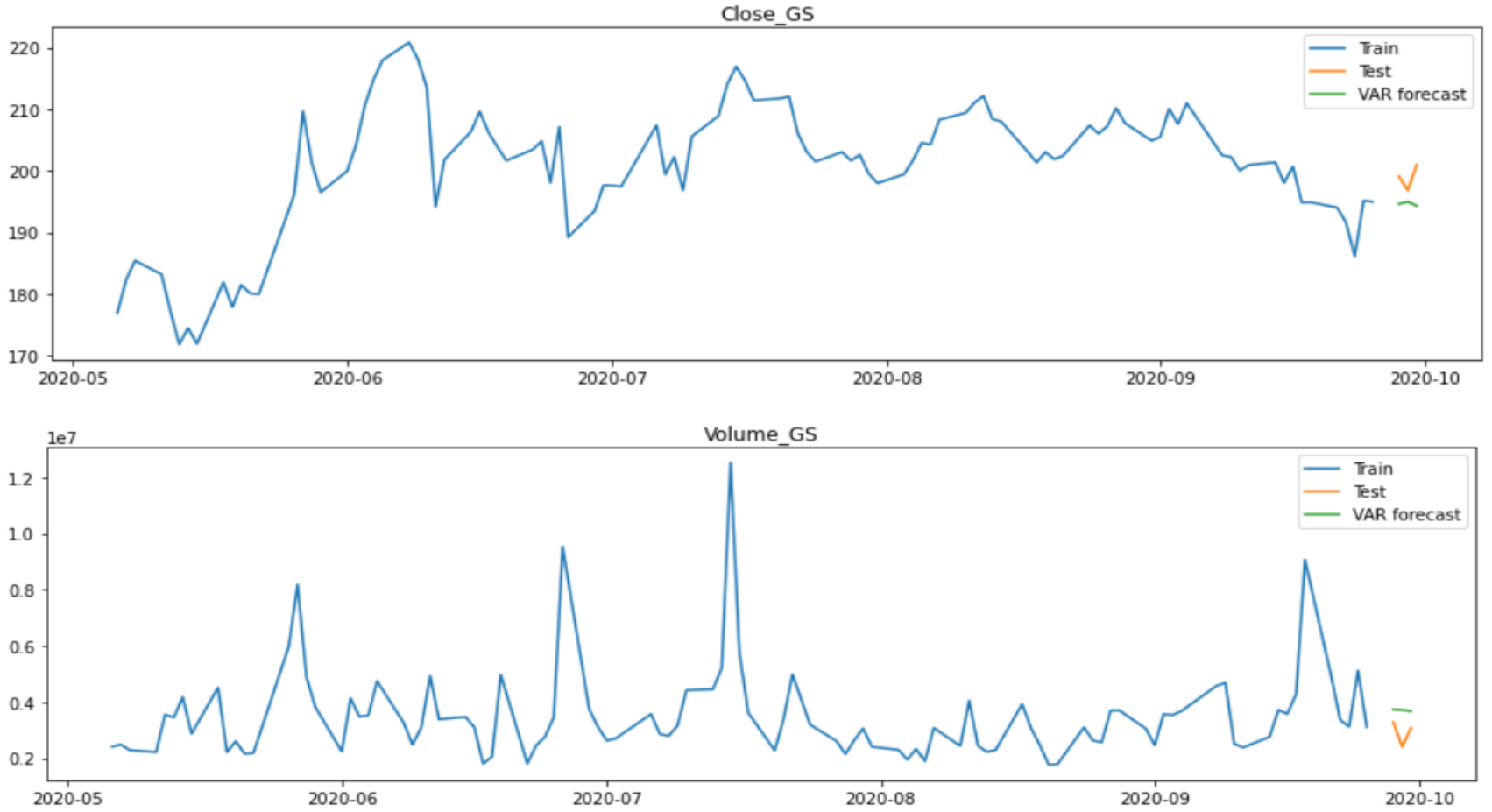
Model Building & Forecasting

Google Close Price and Volume Prediction – Test and Forecast



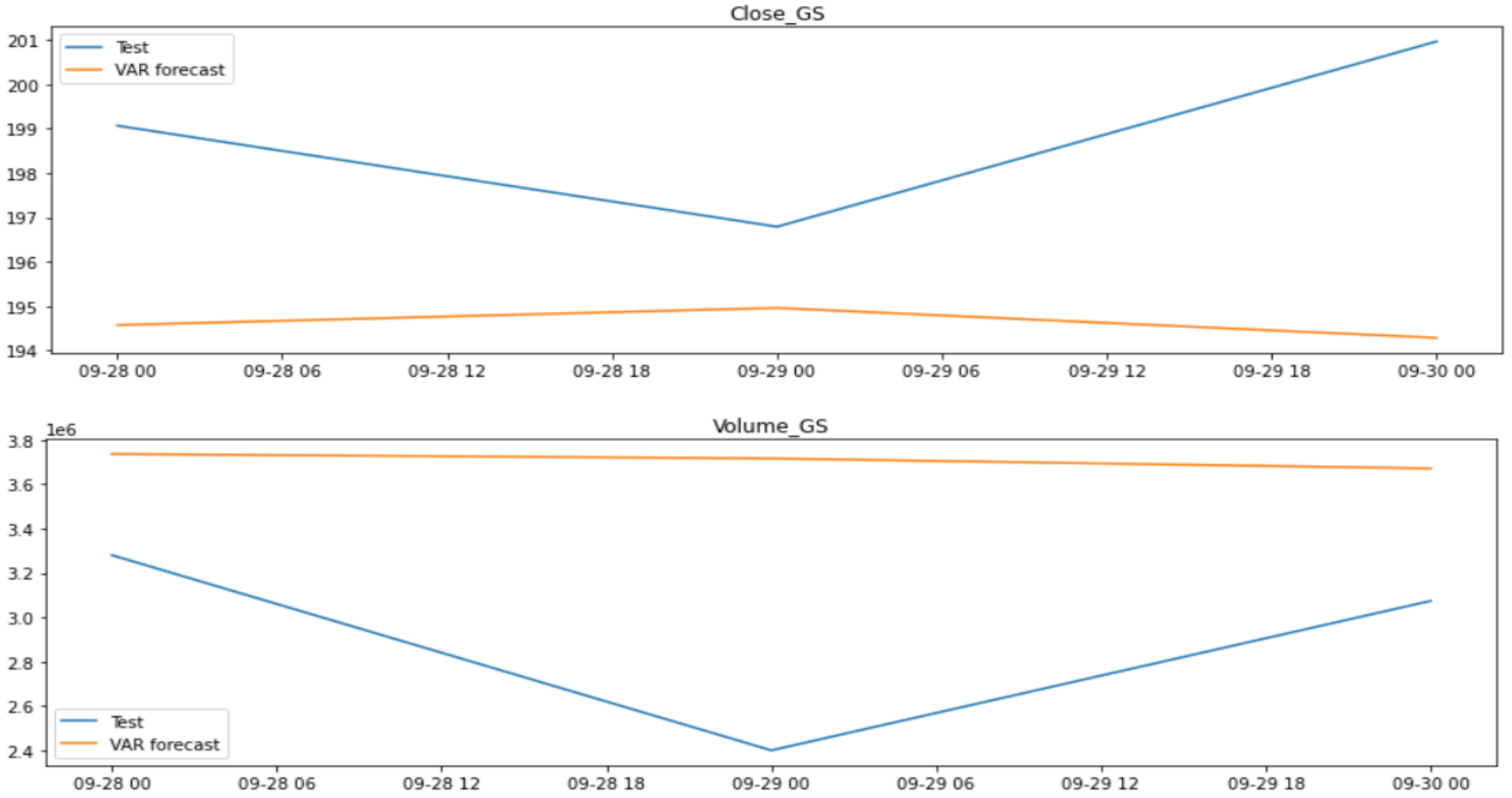
Model Building & Forecasting

Goldman Sachs Close Price and Volume Prediction – Train, Test and Forecast



Model Building & Forecasting

Goldman Sachs Close Price and Volume Prediction – Test and Forecast



Comparison & Findings

- Selected the test/validated set for 3 days for prediction/forecasting.
- Alaska Air Group has close prediction with the test dataset as observed from the visuals/plots.
- Alaska Air Group has the least RMSE and MAPE values when compared with the other selected stocks.
- Google stock has the highest RMSE among all the selected stocks.
- Apple has highest MAPE value among all the stocks.

	Column	RMSE	MAPE
0	Close_AAPL	4.62	3.82
0	Close_ALK	0.60	1.34
0	Close_GOOG	32.78	2.19
0	Close_GS	4.77	2.17

Conclusion

- Portfolio creation for our Investor – Ms. Alexandra Koslishnyick.
- The investor wishes to invest in stocks which shows promise but also are stable.
- All the stock files are merged/concatenated to a single dataset.
- Datasets with NULL values and Inappropriate datatype ‘Date’ column were correctly handled.
- No Outliers present in the dataset.
- Calculation of different metrics – Returns, Risk/Volatility, Correlation Analysis.
- Visualization/Comparison of various Stock/Normalized Stock Prices with Market Index S&P500.
- Calculation of Beta values of stock with Market Index using Linear Regression.
- Stocks Selected are – **Google, Apple, Goldman Sachs and Alaska Air Group.**
- CAPM Model for calculation of Expected Returns, Portfolio Beta and overall Portfolio Returns.
- Portfolio Beta is **1.1524** and Portfolio Returns is **14.1%.**
- CAPM Validation using Sharpe Ratio and Portfolio Risk.
- Sharpe Ratio is **0.58** and Portfolio Risk is **22.91%.**
- Model Building using VAR method and evaluation using RMSE & MAPE values.
- Alaska Air Group has the least RMSE and MAPE values compared with other stocks selected.
- Google has highest RMSE value and Apple has highest MAPE value.