Stock Price Prediction

using ARIMA and XGBoost Model

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I. Introduction

This report presents the findings of stock price prediction project, which aimed to develop models for forecasting stock prices based on historical data. Five stocks have been used: Apple (AAPL), Google (GOOGL), Morgan Stanley (MS), JP Morgan(JPM), and Goldman Sachs (GS).

II. Methodology

The approach involves the following steps:

1. Data Collection and Preparation
2. Exploratory Data Analysis (EDA)
3. Feature Engineering
4. Model Development (ARIMA and Gradient Boosting)
5. Model Evaluation

III. Data Collection and Preparation

Data of 5 Stocks - Apple, Google, Morgan Stanley, JP Morgan and Goldman Sachs was collected from Yahoo Finance using `yfinance library`

Augmented Dickey–Fuller test Results:

Metric	AAPL	GOOGL	MS	JPM	GS
ADF Statistic	0.2600	0.1529	−0.8182	−0.8664	−1.1432
p-value	0.9754	0.9695	0.8137	0.7988	0.6976
1% Critical Value	−3.4330	−3.4330	−3.4330	−3.4330	−3.4330
5% Critical Value	−2.8627	−2.8627	−2.8627	−2.8627	−2.8627
10% Critical Value	−2.5674	−2.5674	−2.5674	−2.5674	−2.5674

IV. Model Development

ARIMA Model:

I used `auto_arima function` of the `pmdarima` to find the optimal p,q,d values instead of ACF and PACF Plots.

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Performing stepwise search to minimize aic
 ARIMA(2,1,2)(0,0,0)[0] intercept   : AIC=5298.559, Time=1.21 sec
 ARIMA(0,1,0)(0,0,0)[0] intercept   : AIC=5300.881, Time=0.23 sec
 ARIMA(1,1,0)(0,0,0)[0] intercept   : AIC=5299.351, Time=0.17 sec
 ARIMA(0,1,1)(0,0,0)[0] intercept   : AIC=5299.632, Time=0.35 sec
 ARIMA(0,1,0)(0,0,0)[0]             : AIC=5301.885, Time=0.09 sec
 ARIMA(1,1,2)(0,0,0)[0] intercept   : AIC=5297.974, Time=1.07 sec
 ARIMA(0,1,2)(0,0,0)[0] intercept   : AIC=5297.632, Time=0.44 sec
 ARIMA(0,1,3)(0,0,0)[0] intercept   : AIC=5294.344, Time=0.62 sec
 ARIMA(1,1,3)(0,0,0)[0] intercept   : AIC=5294.000, Time=2.06 sec
 ARIMA(2,1,3)(0,0,0)[0] intercept   : AIC=5272.445, Time=9.55 sec
 ARIMA(3,1,3)(0,0,0)[0] intercept   : AIC=5272.005, Time=9.56 sec
 ARIMA(3,1,2)(0,0,0)[0] intercept   : AIC=5271.683, Time=5.50 sec
 ARIMA(3,1,1)(0,0,0)[0] intercept   : AIC=5294.429, Time=1.75 sec
 ARIMA(2,1,1)(0,0,0)[0] intercept   : AIC=5301.005, Time=2.53 sec
 ARIMA(3,1,2)(0,0,0)[0]             : AIC=5273.014, Time=11.12 sec

Best model:  ARIMA(3,1,2)(0,0,0)[0] intercept
Total fit time: 46.272 seconds
                               SARIMAX Results
==========================================================================================
Dep. Variable:                           y   No. Observations:                 1996
Model:                 SARIMAX(3, 1, 2)   Log Likelihood               -2628.842
Date:                  Sat, 03 Aug 2024   AIC                           5271.683
Time:                          07:32:46   BIC                           5310.872
Sample:                      01-31-2014   HQIC                          5286.074
                           - 01-03-2022
Covariance Type:                     opg
==========================================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
intercept      0.0477      0.027      1.734      0.083      -0.006       0.102
ar.L1          0.5766      0.014     42.405      0.000       0.550       0.603
ar.L2         -0.9181      0.012    -74.331      0.000      -0.942      -0.894
ar.L3         -0.0772      0.012     -6.398      0.000      -0.101      -0.054
ma.L1         -0.6246      0.009    -71.570      0.000      -0.642      -0.607
ma.L2          0.9731      0.009    103.374      0.000       0.955       0.992
sigma2         0.8169      0.014     59.225      0.000       0.790       0.844
==========================================================================================
Ljung-Box (L1) (Q):                   0.02   Jarque-Bera (JB):              2377.44
Prob(Q):                              0.89   Prob(JB):                         0.00
Heteroskedasticity (H):               5.82   Skew:                            -0.04
Prob(H) (two-sided):                  0.00   Kurtosis:                         8.35
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XGBoost Model:

I used `Bayesian optimization` instead of GridSearch and RandomSearch for Hyperparameter Tuning for the following reasons.

- Efficiency: Bayesian optimization explores the hyperparameter space more efficiently than GridSearchCV.
- Complex Search Spaces: Bayesian optimization handles complex relationships between hyperparameters better.
- Early Stopping: Bayesian optimization can terminate the search early if performance plateaus.

Model Parameters:

1. ARIMA (Auto-Regressive Integrated Moving Average)
   `ARIMA(3,1,2)(0,0,0)[0] intercept`
2. XGBoost
   `'n_estimators': 325, 'learning_rate': 0.0455081099701603, 'max_depth': 5, 'min_child_weight': 14, 'subsample': 0.9939195480488889, 'colsample_bytree': 0.9742302863939567`

V. Key Findings

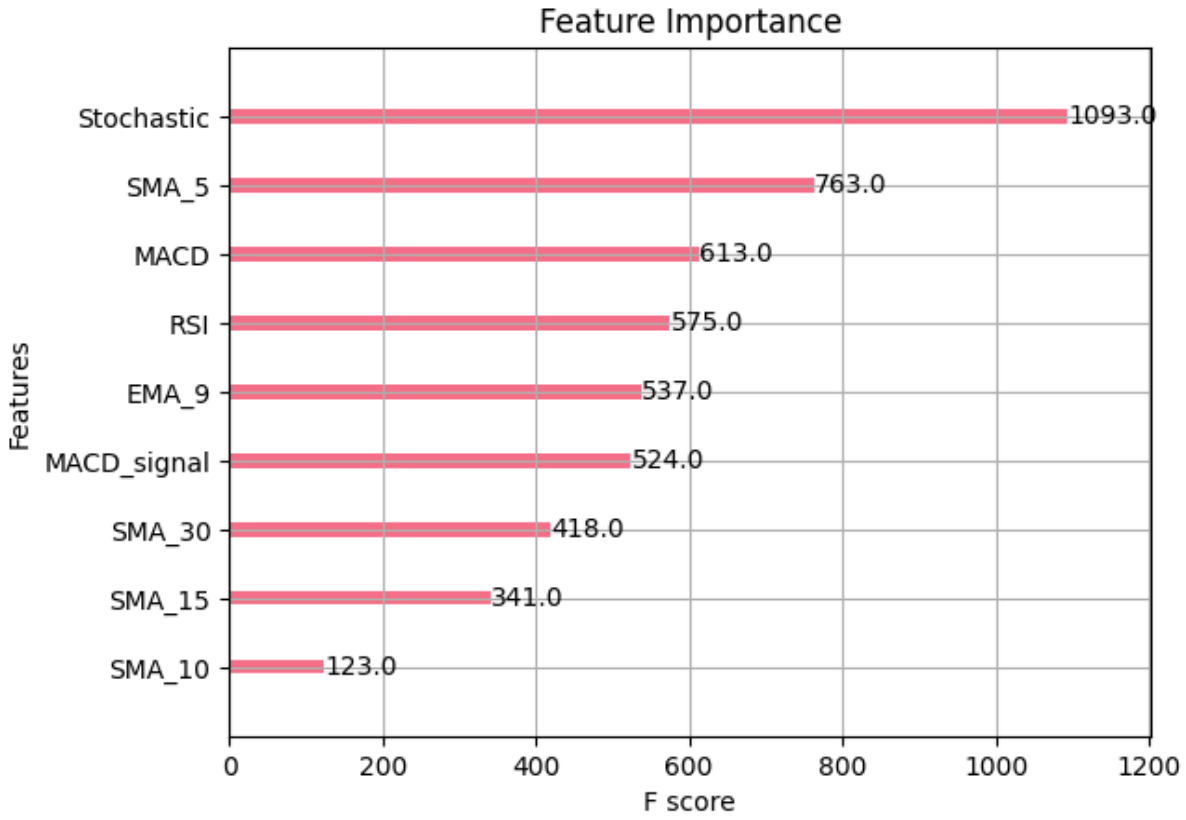
Data Analysis

- The stock prices of all five companies showed an overall upward trend over the analyzed period.
- We observed varying levels of volatility across the stocks, with some periods of high volatility coinciding with major market events.
- The distribution of daily returns for most stocks appeared to be approximately normal but with fat tails, indicating the presence of extreme price movements.

Feature Engineering

- **Exponential Moving Average (EMA)** - 9 days: Calculates the EMA over a 9-day period to capture short-term trends.
- **Simple Moving Averages (SMA)**: Computes SMAs for various window sizes (5, 10, 15, and 30 days) to analyze price trends over different periods.
- **Relative Strength Index (RSI)**: Measures the speed and change of price movements over a 14-day period, indicating overbought or oversold conditions.
- **Moving Average Convergence Divergence (MACD)**: Computes the difference between the 12-day and 26-day EMAs to assess the strength and direction of a trend.
- **MACD Signal Line**: Calculates the 9-day EMA of the MACD to identify potential buy or sell signals.
- **Stochastic Oscillator**: Measures momentum by comparing the closing price to its price range over a specific period. The `Technical Analysis Library (ta)` was used to calculate Stochastic Oscillator.

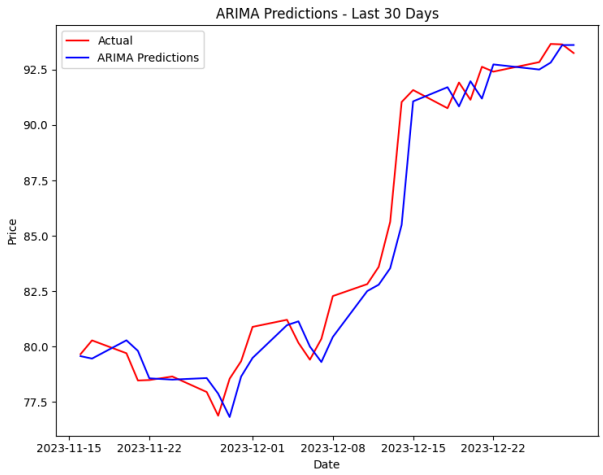
Feature Importance Graph

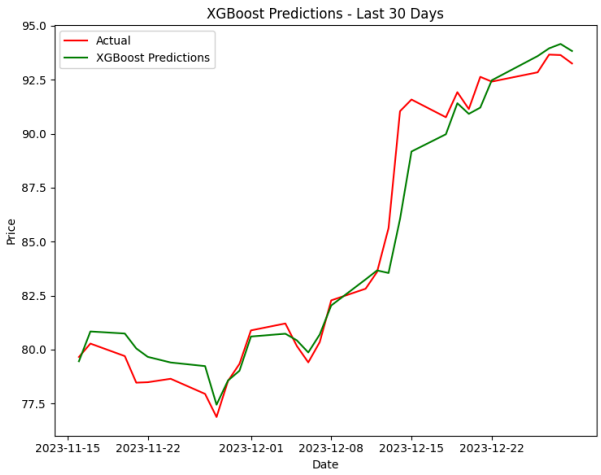


Model Performance

Metric	ARIMA Model	XGBoost Model
Mean Squared Error (**MSE**)	2.589	1.662
Root Mean Squared Error (**RMSE**)	1.609	1.289
Mean Absolute Error (**MAE**)	1.211	0.981
Mean Absolute Percentage Error (**MAPE**)	1.401	1.140

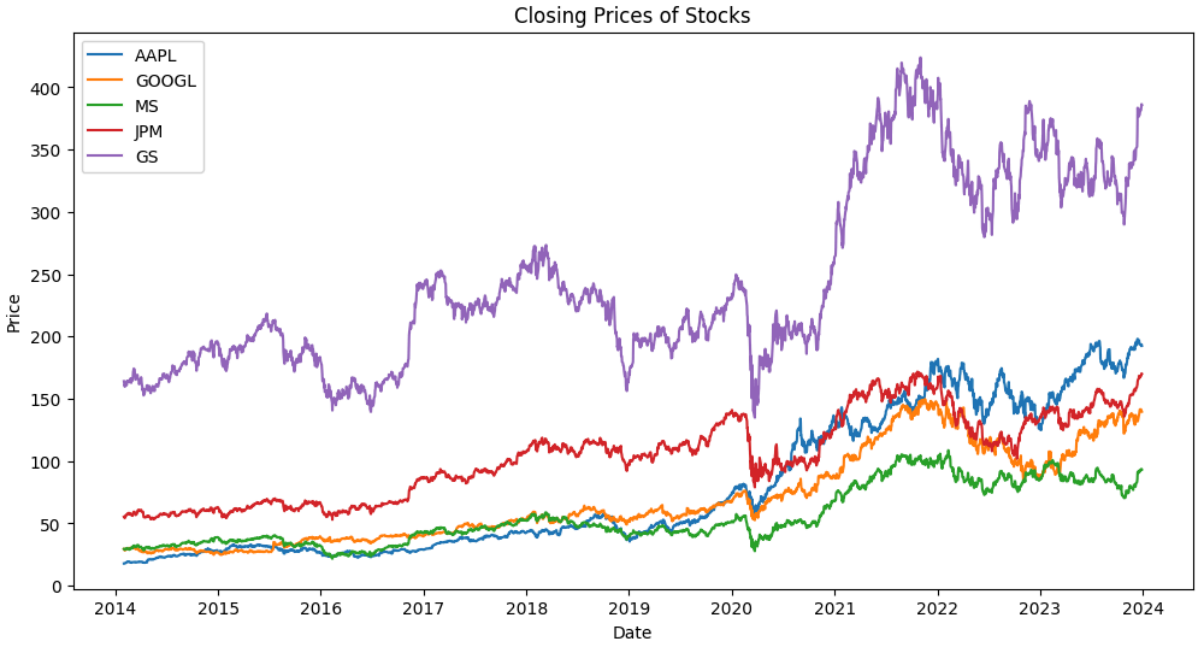
The Evaluation Metrics and the Graph show that the **XGBoost Model is better** in Accuracy and Reliability than the ARIMA Model.



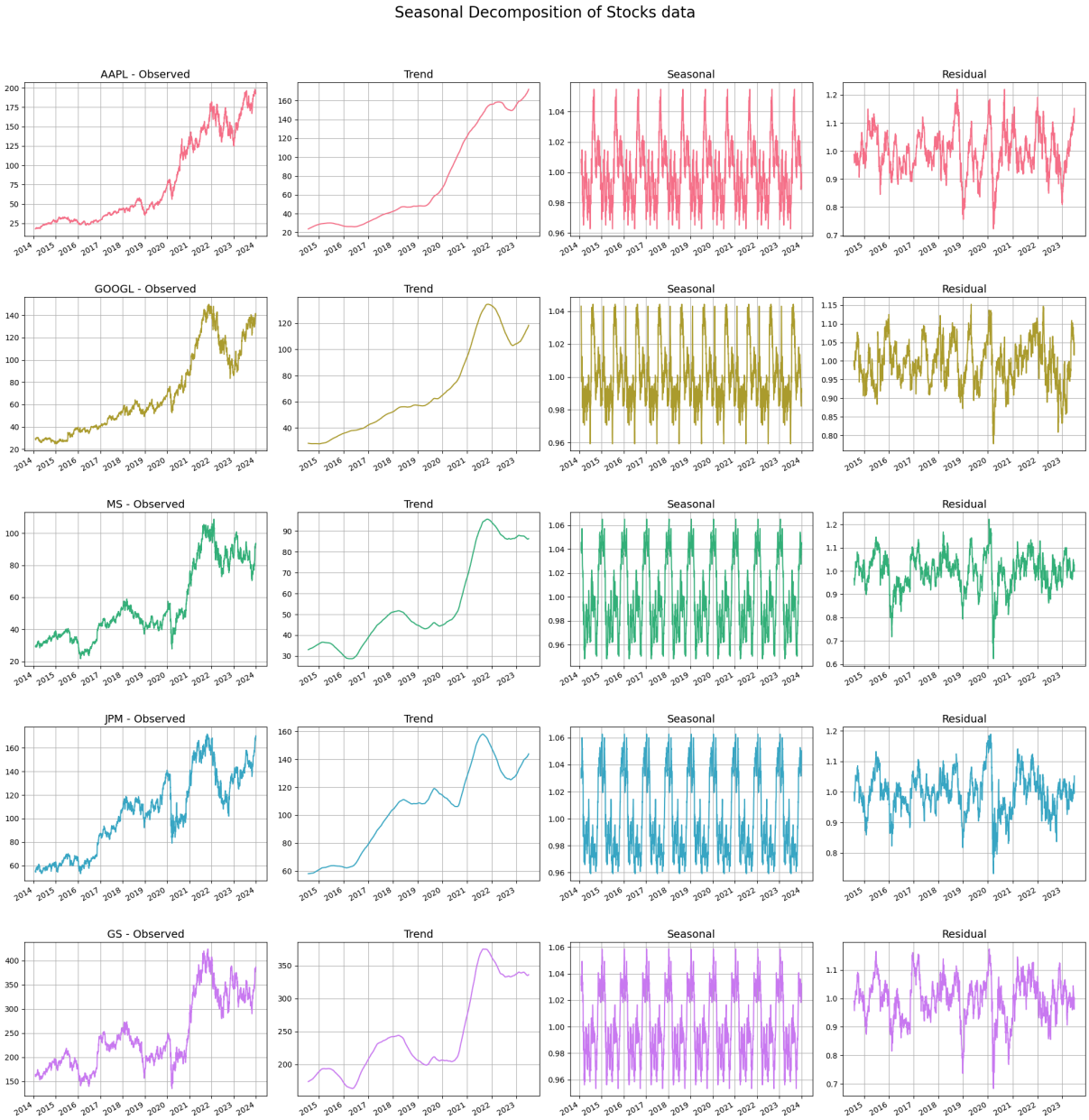


VI. Visualizations

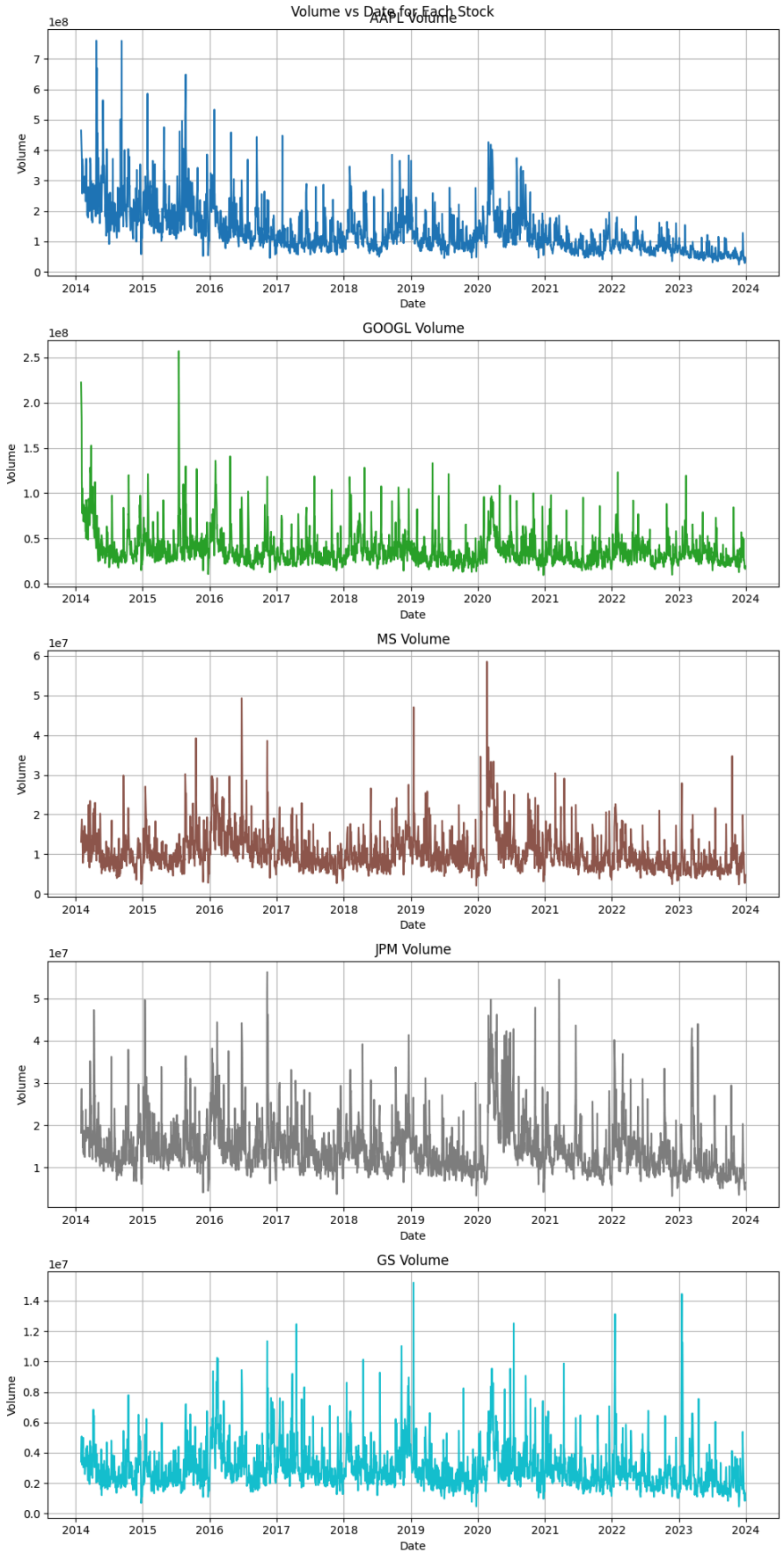
Closing Price vs Date Graph:



Seasonal Decomposition of the Stocks:



Volume vs Date Graph:



Volatility vs Date Graph: