Indian Stock Markets Data: Analysis of indicators and Market Sentiments

FINAL REPORT

GROUP MEMBERS

- Sagnik Ghosal
- Raman S V
- Arjun Sharma
- Adithyaa V

ABSTRACT

The stock market provides a wealth of structured data that allows investors to assess the performance of individual companies and entire industries relative to the market. Accurately predicting future performance is crucial for both novice and veteran investors to minimize risk and uncertainty. However, the volatility associated with the stock market makes accurate forecasting and predictions challenging. Two schools of thought exist, with one advocating for the use of past data for forecasting and prediction, while the other, the Random Walk Theory, argues that future stock prices cannot be predicted based on past performance.

This project aims to evaluate the effectiveness of some popular stock market indicators, such as CCI, RSI, and MACD, in accurately predicting stock market returns. Additionally, it will compare the effectiveness of investing in an index fund versus purchasing individual stocks by analyzing the returns of a risk-free investment such as treasury bonds or public sector bank Fixed Deposits, compared to the overall stock market. This analysis is relevant not just for stock market traders but even for those interested in dipping into the stock market, particularly from a technical trading perspective.

INTRODUCTION

Stock markets are a readily available source of real-world, structured data. They give us insight into the performance of individual companies as well as entire industries relative to the market. The ability to forecast and accurately predict the future performance of various stocks and indices on the market is paramount for an investor – newcomer and veterans alike, so as to minimize investment risk and uncertainty. Movements in stock markets are influenced by a multitude of factors such as international events, human behavior, etc. The volatility thus associated with stock performance on the market makes it challenging to accurately forecast or predict the direction of the market. There are conflicting ideas pertaining to the predictability of the stock market. One advocates fundamental and technical analysis

to use past data to forecast and predict stock performance, and the Random Walk Theory argues that future stock prices cannot be modeled on the basis of past performance. After studying these different schools of thought and relevant research pertaining to them, we wish to analyze whether there indeed are any particular set of methods that can reliably predict stock market performance reliably.

Project Motivation

One of our project members has been investing and trading in the stock market since 2015. One of the factors they had come across, not just from a trading perspective but even fundamentally to analyze dips to buy on or peaks to sell a certain amount to protect profits, was in the use of indicators such as PE (Price to earnings ratio), CCI (Commodity Channel Index) and RSI (Relative Strength Index). Thus, one of the prime motivations behind this project is to statistically evaluate the validity of some of these more common stock market indicators in accurately predicting stock market returns. In addition, we also compare the effectiveness of investing in an index versus investing in individual stocks.

Intended Audience:

1) Stock market traders – to gain statistical backing for their methods or unearthing hitherto undiscovered trading combinations and indicators
2) Fundamental investors – to identify dips to buy further and peaks to sell to preserve profits
3) People who are curious or new stock market – to compare and contrast the returns from a technical perspective and how it compares to investing in a major index or in risk free options such as state backed fixed deposits

Questions

We examine the below questions as part of our analysis -

1. How effective are market indicators in making buying and selling decisions for stocks? Specifically, we are focusing on three indicators: CCI, RSI, and MACD. To answer this question, we will conduct three stages of analysis:

   Stage 1: We will examine how strongly the different indicators are correlated with the stock price across multiple stocks, we have selected 90 stocks based on their market capitalization over the past 7 years. We chose these stocks because these are generally considered to be blue chip companies and have more trading activity both in terms of volume and price as compared to other mid or small cap stocks.

   Stage 2: We will compare the performance of using indicators to pick stocks versus investing in an index.

   Stage 3: We will use past indicator data and stock prices to predict future prices and evaluate if there is a strong relationship between the indicators and the stock prices.

2. Is it beneficial to invest in an index fund (we choose the Nifty50 as the Index as it is widely used as a proxy in discussions of the larger Indian market's performance) rather than purchasing

individual stocks? Further, we will also compare these returns with that of a risk-free investment (for this, we have chosen Indian's largest State-owned bank's fixed deposit rate) and compare it to the returns of the overall stock market. The goal is to determine whether investing in an index fund is more profitable and less risky than investing in individual stocks.

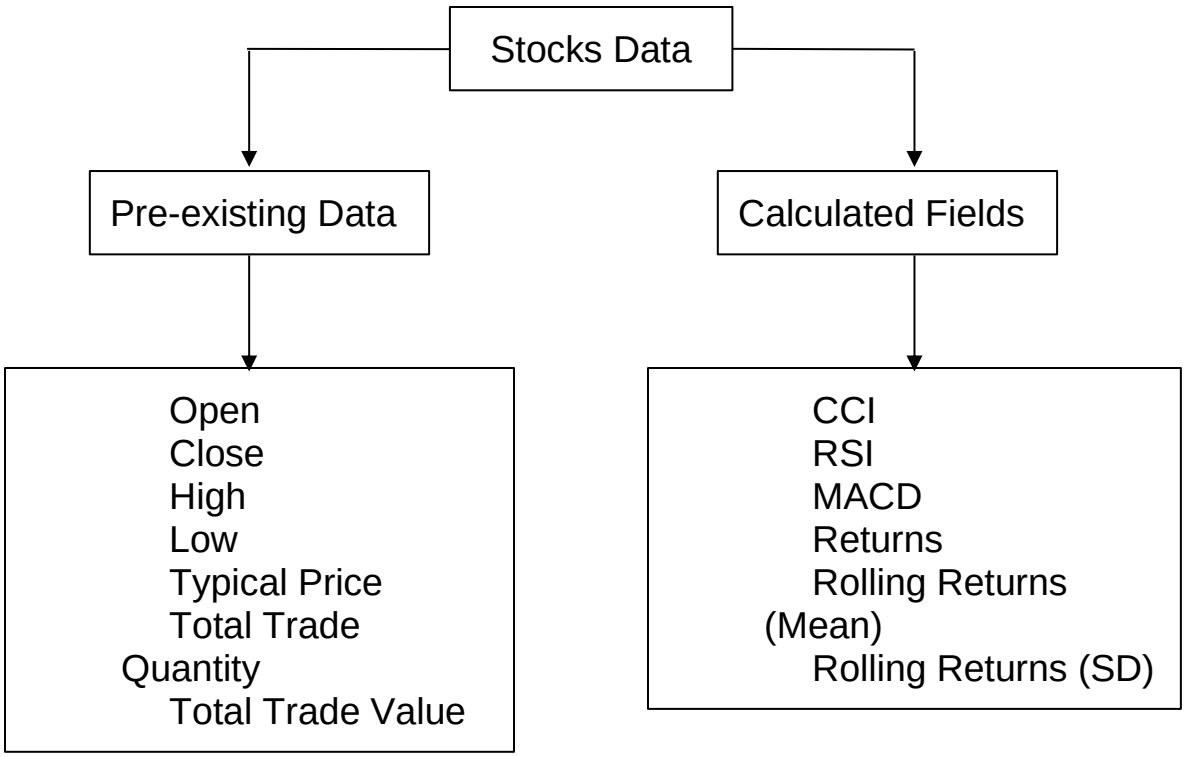
DATA

Data Description

The data used for this study is a collection of daily reports from the Indian Stock Exchange – National Stock Exchange. The data is collected for the time period ranging from January 1, 2016, to December 30, 2022. The data is collected via the official site of the NSE from their archives of daily reports. In particular, we are using the Bhavcopy report to get the stock details of all the constituents on a closing basis for each day. This data consists of daily summaries of the stocks' price movements. There are 3 datatypes per file for the relevant fields – Text (stock name), decimal (stock prices and volumes), and date (timestamp for these values). Each file consists of the following columns:

1. **Symbol**: An entity's identification as it is registered on the NSE
2. **Open**: The first recorded stock/index price for an entity on a given day
3. **High**: The highest recorded stock/index price for an entity on a given day
4. **Low**: The lowest recorded stock/index price for an entity on a given day
5. **Close**: The 30-minute moving average stock/index price during the last 30 minutes of trading for an entity on a given day
6. **Last**: The last recorded stock/index price for an entity on a given day
7. **PrevClose**: The last recorded stock/index price for an entity for the preceding day of a given day
8. **TOTTRDQTY**: The total traded quantity of a particular stock on a given day
9. **TOTTRDVAL**: The total traded value of a particular stock on a given day
10. **Timestamp**: The date for which the above data has been observed

Further, we have manually downloaded the details for the NIFTY 50 index and structured it similar to the above. Nifty50 is an aggregate index of India's top 50 companies by market capitalization that are listed on the National Stock Exchange (NSE). As mentioned above, in discourses around Indian stock market performance, Nifty is used as a proxy for the whole market. The other famous Indian index is the Sensex (sensitive index) that is an aggregate of 30 stocks but is reported by the other major Indian exchange – the Bombay Stock Exchange (BSE). We did not consider this index as BSE is not as easily accessible as the NSE and also the broader 50 stock index of the Nifty is a better indicator of the overall Indian market.



Data Source

The National Stock Exchange is one of the largest stock exchanges in the world. It was established in 1992, with a vision to facilitate transparency in the Indian equity markets on the back of a few infamous scandals involving the Bombay Stock Exchange. The NSE was also intended to be digital as opposed to the older and traditional BSE. Instead of trading memberships being confined to a group of brokers, NSE ensured that anyone who was qualified, experienced, and met the minimum financial requirements was allowed to trade.

Data Collection Methods

The National Stock Exchange maintains daily and monthly archives of stock price movements. The data is from NSE's archives of daily reports. Our method of the collection here is to scrape the data from the archive page for the time period mentioned above. This is achieved through a script written in Python that would automate this process of data collection. For the Nifty50 data, we used this link to download the data for our date range – investing.com's Nifty50 Data.

DESCRIPTION OF THE INDICATORS

For the analysis, we have selected the following three indicators:

CCI (Commodity Channel Index): CCI is a technical analysis indicator that measures a security's deviation from its statistical average. It is often used in the financial markets to identify overbought or oversold conditions, trend reversals, and potential buy or sell signals. CCI above +100 is considered overbought and below -100 is considered oversold.
Mathematically, CCI is represented by:

$$CCI = \frac{TP - 20 - period\ SMA\ of\ TP}{0.015\ x\ Mean\ Deviation}$$

$$TP = \frac{High + Low + Close}{3}$$

Where, Mean Deviation = Mean of the absolute difference between each period's TP and 20-period Simple Moving Average of TP. CCI helps to identify potential overbought or oversold conditions in an asset price.

RSI (Relative Strength Index): RSI is a technical analysis indicator that measures the magnitude of recent price changes to evaluate overbought or oversold conditions in an asset. It compares the average gains to average losses over a specified period and generates a value between 0 and 100. RSI is often used to identify potential trend reversals and to generate buy or sell signals. RSI > 70 typically indicates overbought conditions, while < 30 indicates oversold conditions.
Mathematically, RSI is represented by:

$$RSI = 100 - \frac{100}{1 + RS}$$

$$RS = \frac{Average\ Gain}{Average\ Loss}$$

RSI helps measure the strength of a stock's price action to identify overbought or oversold conditions.

MACD (Moving Average Convergence Divergence (MACD)*:* MACD is a trend-following momentum indicator that shows the relationship between two moving averages of a security's price. A nine-day EMA of the MACD called the "signal line," is plotted on top of the MACD line, which can act as a trigger for buy and sell signals. The MACD histogram represents the difference between MACD and its signal line. When the MACD is above its signal line, it indicates a bullish trend, and when it is below, it indicates a bearish trend.
Mathematically, RSI is represented by:

MACD Line = 12-period EMA - 26-period EMA
Signal Line = 9-period EMA of MACD Line
Histogram = MACD Line - Signal Line

MACD helps Identify trends and potential trend reversals in stock prices, using two moving averages and a histogram.

STATISTICAL ANALYSIS

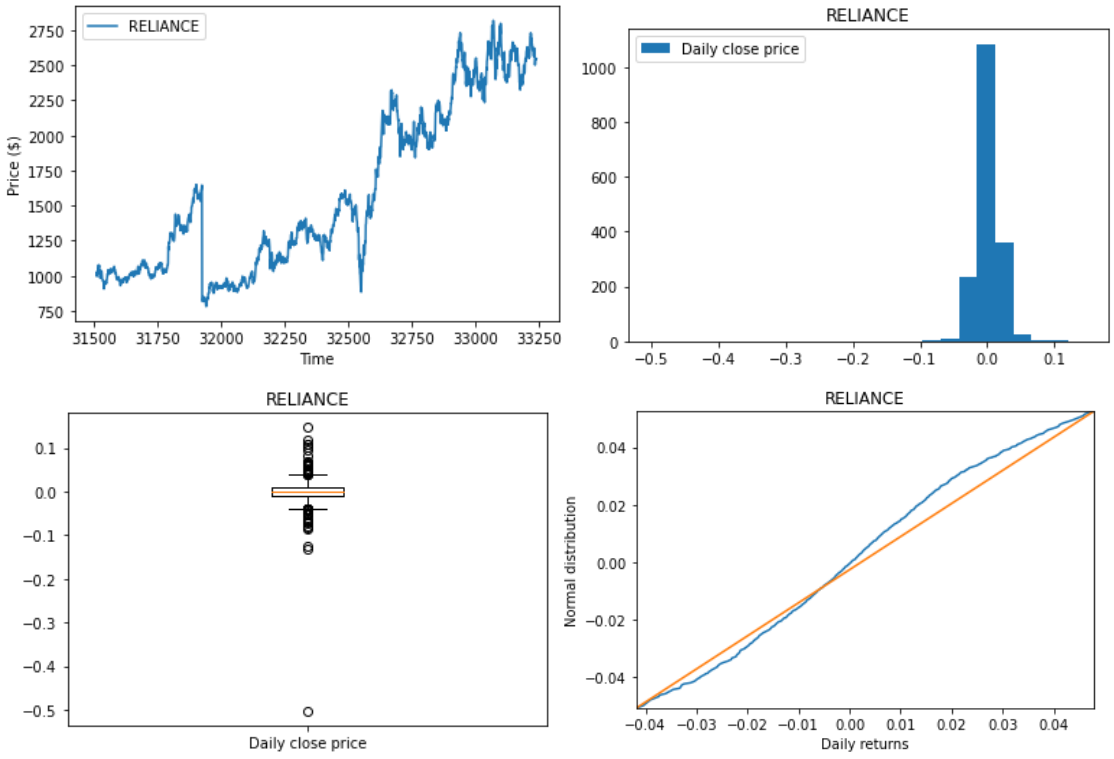
Question 1: Can we trust popular market indicators to guide our buying and selling decisions for stocks?

Assumptions:

1. The returns are normally distributed
2. The stock and index price and returns at any point in time are independent.

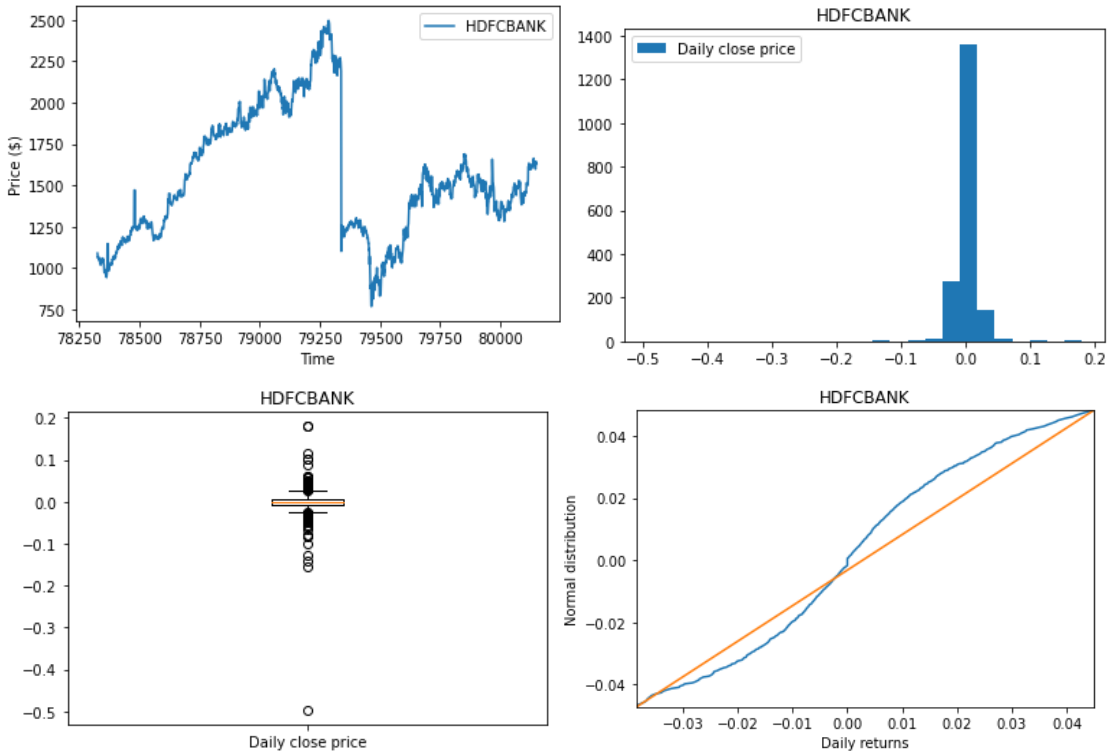
Exploratory Data Analysis:
Prior to analysis of the data in the context of this question, we briefly explore data from 5 stocks on the NSE, namely **RELIANCE, HDFCBANK, MARUTI, INFY**, and **LT**. We choose these stocks in particular as they are top 50 stocks but also represent various industry sectors which are Energy, Banking, Automobiles, IT consulting and Construction respectively.
For these 5 stocks, we evaluate the assumptions mentioned above.

RELIANCE:



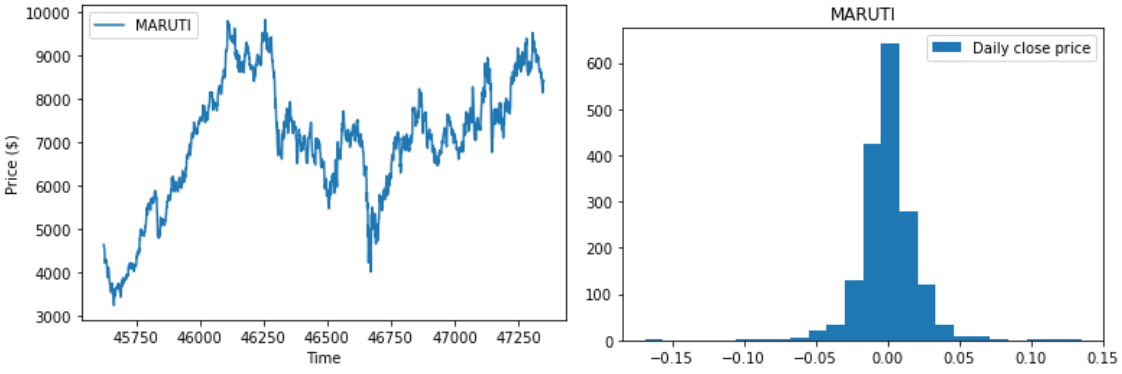
(1, 1): Time series plot of the stock price of RELIANCE,
(1,2): Distribution of the Daily Close Price of RELIANCE,
(2,1): The Box Plot of the Daily Closing Price of RELIANCE,
(2,2): The Q-Q plot for assessment of Normality for RELIANCE.

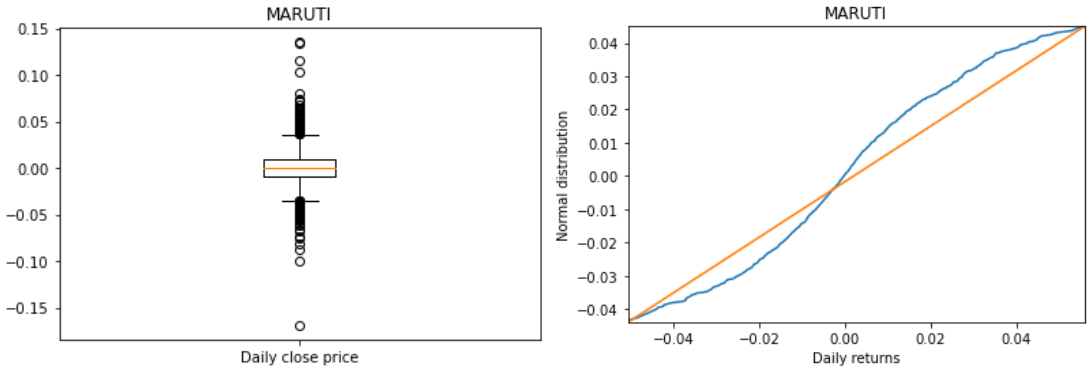
HDFCBANK:



*(1, 1): Time series plot of the stock price of **HDFCBANK**,*
*(1,2): Distribution of the Daily Close Price of **HDFCBANK**,*
*(2,1): The Box Plot of the Daily Closing Price of **HDFCBANK**,*
*(2,2): The Q-Q plot for assessment of Normality for **HDFCBANK**,*

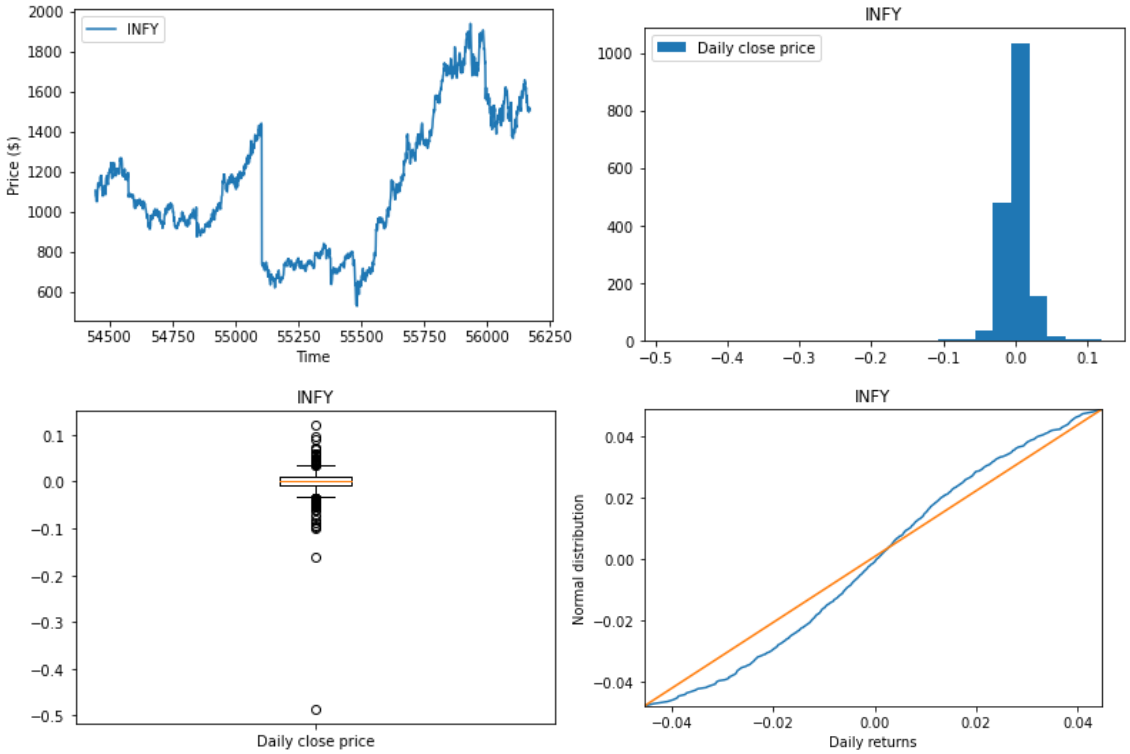
MARUTI:





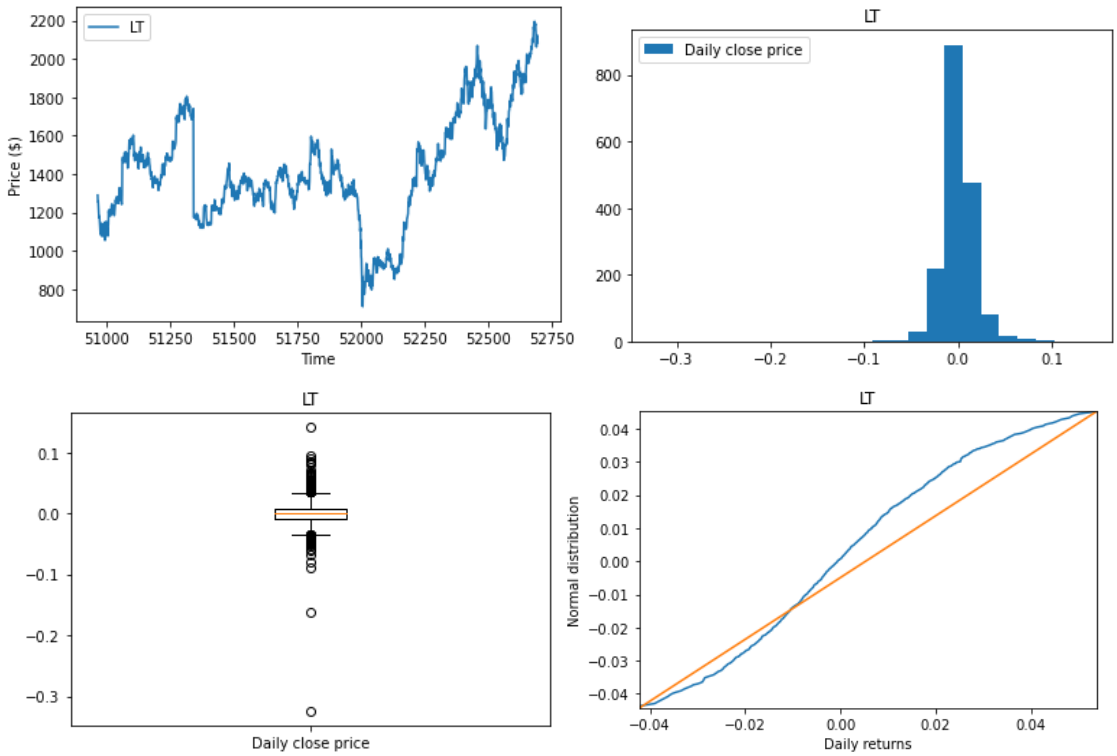
*(1, 1): Time series plot of the stock price of **MARUTI**,*
*(1,2): Distribution of the Daily Close Price of **MARUTI**,*
*(2,1): The Box Plot of the Daily Closing Price of **MARUTI**,*
*(2,2): The Q-Q plot for assessment of Normality for **MARUTI**,*

INFY:



*(1, 1): Time series plot of the stock price of **INFY**,*
*(1,2): Distribution of the Daily Close Price of **INFY**,*
*(2,1): The Box Plot of the Daily Closing Price of **INFY***
*(2,2): The Q-Q plot for assessment of Normality for **INFY**.*

LT:



*(1, 1): Time series plot of the stock price of **LT**,*
*(1,2): Distribution of the Daily Close Price of **LT**,*
*(2,1): The Box Plot of the Daily Closing Price of **LT***
*(2,2): The Q-Q plot for assessment of Normality for **LT**.*

For these five stocks, we observed that they have a high variance in that they have fat tails on each side of the mean which is as expected as stock markets swing wildly and our date range includes multiple black swan events such as –

1) Surgical strike – 29th September, 2016
2) Demonetization – 8th November, 2016
3) Covid19 initial lockdowns – entirety of March 2020

In addition, the Q-Q plot does not align with a normal distribution. We test the assumption of normality through the skewtest and kurtosistest functions from the Scipy library in Python.

Hypothesis for Skewtest:

H_0: There is no difference in the skew of the stock distribution and that of the standard normal distribution

H_A: There is a difference in the skew of the stock distribution and that of the standard normal distribution.

Hypothesis for Kurtosistest:

H_0: There is no difference in the kurtosis of the stock distribution and that of the standard normal distribution

H_A: There is a difference in the kurtosis of the stock distribution and that of the standard normal distribution.

STOCK	Mean	STDev	Skew	Kurtosis	Skewtest		Kurtosistest		Result
					Statistic	p-value	Statistic	p-value	
RELIANCE	0.000818	0.022193	-6.49828	156.2202	-38.7264	0.0	27.628231	5.1e-168	Reject Both Nulls
HDFC BANK	0.000466	0.020482	-7.48107	200.4971	-41.804255	0.0	28.944642	3.27766	Reject Both Nulls
MARUTI	0.000526	0.01911	0.124468	9.28178880	2.1133411	0.034571	17.303236	4.44e-67	Reject Both Nulls
INFY	0.000433	0.02083	-7.59083	174.8167	-40.8883	0.0	27.88705	3.8e-171	Reject Both Nulls
LT	0.000471	0.019229	-2.51970	53.00766	-25.759634	2.5e-146	24.608900	1.0e-133	Reject Both Nulls

The table above depicts the summary statistics of the top 5 stocks.

The table above shows us through the skewtest and the kurtosistest that neither the skew, nor the kurtosis can be neglected. Hence, we cannot assume that the distribution of returns is normal.

Autocorrelation:

We plot the autocorrelation of returns for the top 5 stocks. The autocorrelation gives us the strength of the relationship of a stock price returns with past values of the same.

The autocorrelation function **(**ACF**)** at lag *k*, for $k \geq 0$, of the time series is defined by

$$r_k = \frac{s_k}{s_0}$$

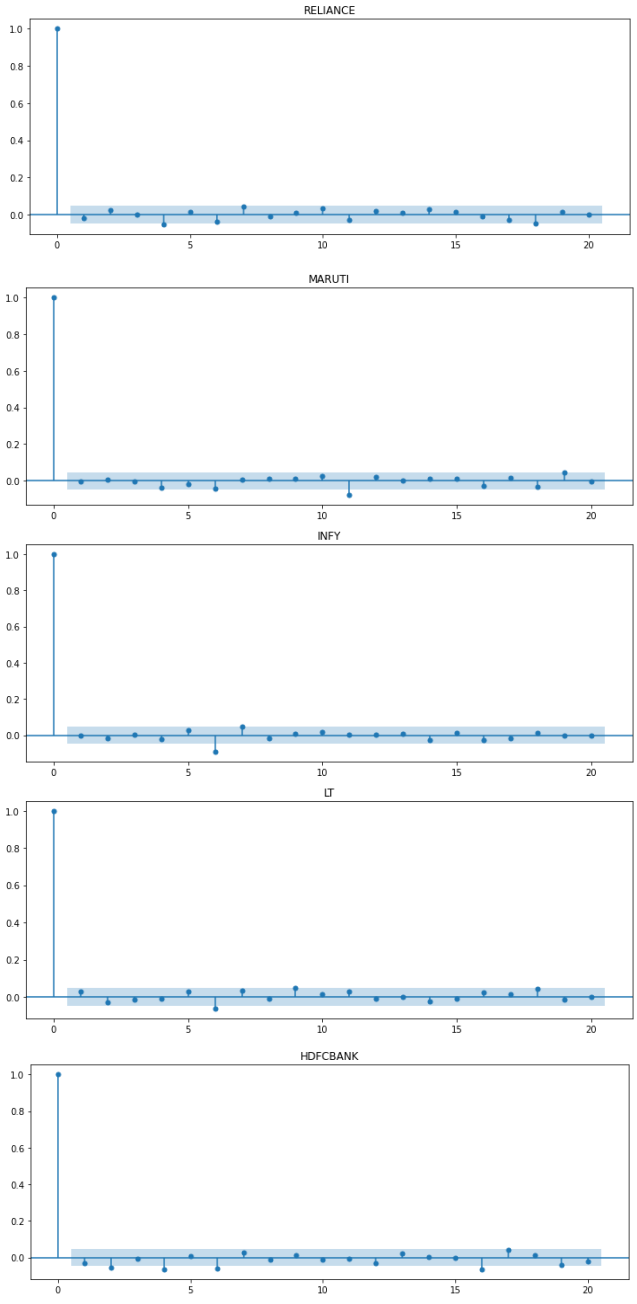
Where s_k is the autocovariance function at lag k, for $k \geq 0$, of the time series is defined by

$$s_k = \frac{1}{n}\sum_{i=1}^{n-k}(y_i - \bar{y})(y_{i+k} - \bar{y}) = \frac{1}{n}\sum_{i=k+1}^{n}(y_i - \bar{y})(y_{i-k} - \bar{y})$$

Where y_i and $\bar{y}$ are the instances of the time series and the mean of the time series, respectively, mathematically the mean of the time series is expressed as:

$$\bar{y} = \frac{1}{n}\sum_{i=1}^{n} y_i$$

The figures below denote the autocorrelation for the top 5 stocks:



The Autocorrelation for all 5 stocks.

It's clear from this plot that there's no high autocorrelation among all lags for all the stocks. There are some lags between 5 and 10 that show some correlation, but it's quite small compared to 1. We uphold our assumption that the observations for each stock are independent over time.

Stage 1: Correlation Analysis

In this stage, we examine how strongly the different indicators are correlated with the stock price across multiple stocks.

We only consider stocks that satisfy conditions:

1. CCI(34) of at least 100 (indicating a 'buy' signal) at any point of time.
2. RSI of at most 40 at any point of time.

The above 2 thresholds are subjective and can be tweaked as per a trader's beliefs or margins. But generally, an RSI value of under 30 implies an oversold stock and above 70 implies an overbought stock. CCI being above 100 implies the stock is moving up in average price and this coinciding with an oversold stock implies we notice a trend before the majority of trades flow in. Stocks that do not satisfy the conditions above are not considered for the analysis.

To test if there is a strong linear relationship between the "returns", "CCI", "RSI", and "MACD", we use a correlation analysis. Correlation analysis measures the strength and direction of the relationship between two or more variables. We calculate the correlation coefficient between each pair of variables, and then determine if the coefficients are statistically significant. We use the Pearson correlation coefficient, which measures the linear relationship between two continuous variables.

We formulate our Hypothesis for correlation as follows:

H_0: There is no correlation between the indicator(s) and the returns.

H_A: There exists a correlation between the indicator(s) and the returns.

We use a **two-tailed t-test** to test the statistical significance of the correlation coefficients between the "returns" and the technical indicators (CCI, RSI, and MACD). We used a two-tailed test because we wanted to determine whether there was a significant difference between the correlation coefficient and zero, regardless of the direction of the correlation.

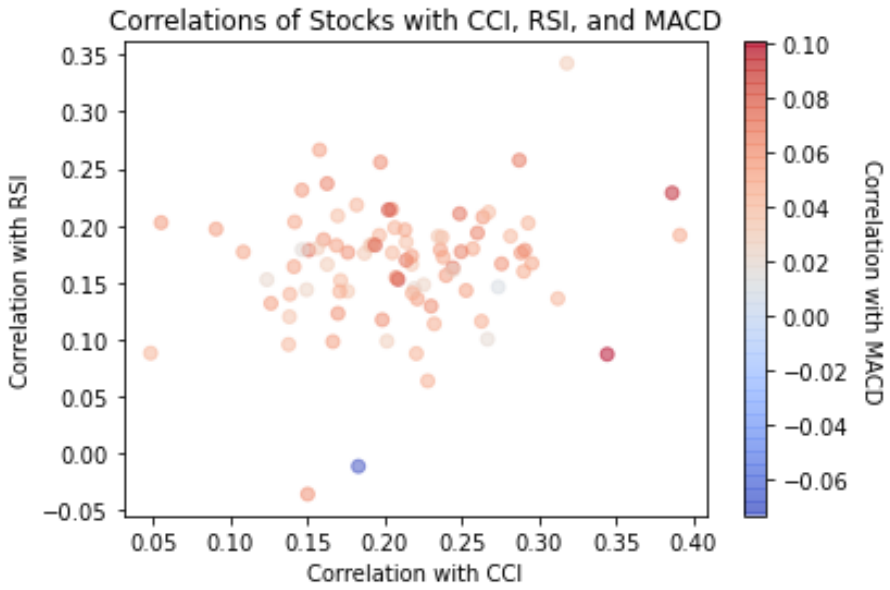
Testing Conditions:

- Test Performed: two-tailed t-test
- Significance Level: $\alpha = 0.05$
- The test is repeated for all individual stocks

Interpretation: If the p-value of the t-test is less than 0.05, we reject the null hypothesis and infer that there is significant correlation between the variables. If the p-value is greater than 0.05, we fail to reject the null hypothesis and conclude that there is no significant correlation.

We used a two-tailed test because we wanted to determine whether there was a significant difference between the correlation coefficient and zero, regardless of the direction of the correlation. For example, if the correlation coefficient between "returns" and "CCI" was positive, a one-tailed test would only test whether the correlation was significantly greater than zero. A two-tailed test, on the other hand, would also test whether the correlation was significantly less than zero. This is important because even a negative correlation can be significant and informative.

Therefore, by using a two-tailed t-test, we are testing whether the correlation coefficient is significantly different from zero, regardless of the direction of the correlation.



Correlation of the filtered stocks' CCI, RSI, and MACD.

Results:

1. Correlation between CCI and Stock Returns:
   We ran the test for 88 stocks, testing the correlation between CCI and returns. For all 88 of the individual stocks, we reject the null hypothesis that correlation between CCI and returns. The table with the data for all the stocks is present here.
2. Correlation between RSI and Stock Returns:
   We ran the test for 90 stocks, testing the correlation between RSI and returns. For all 90 of the individual stocks, we reject the null hypothesis that correlation between RSI and returns. The table with the data for all the stocks is present here.

Conclusion:

We infer that the correlation between the said indicators with the returns is significant.

Stage 2: Individual Stocks vs Index Returns

Is it more beneficial to invest in an index fund rather than purchasing individual stocks?
Here, we compare market returns from individual stocks with those from the Nifty50 index. We are comparing the 30-day rolling returns of the stock with those of the Nifty50 index.

Assumptions:

1. The returns of the stock(s) and the Index are normally distributed.
2. The returns of the stock(s) and the Index have unequal variances.

We formulate our hypothesis as follows:
H_0: There is no difference between the returns on investing in the Nifty50 index and the returns on investing in individual shares.
H_A: There is a difference between the returns on investing in the Nifty50 index and the returns on investing in individual shares.
We use the **Unequal Variance t-test** (Welch Test), to test for a difference in the stock returns from an individual stock compared to those from an index.

The following calculations are performed:
Sample Mean:

1. $\bar{X}_1$: Mean of stock returns.
2. $\bar{X}_2$: Mean of index returns.

Sample Standard Deviation:

1. s_1^2: Standard deviation of the stock returns.
2. s_2^2: Standard deviation of the index returns.

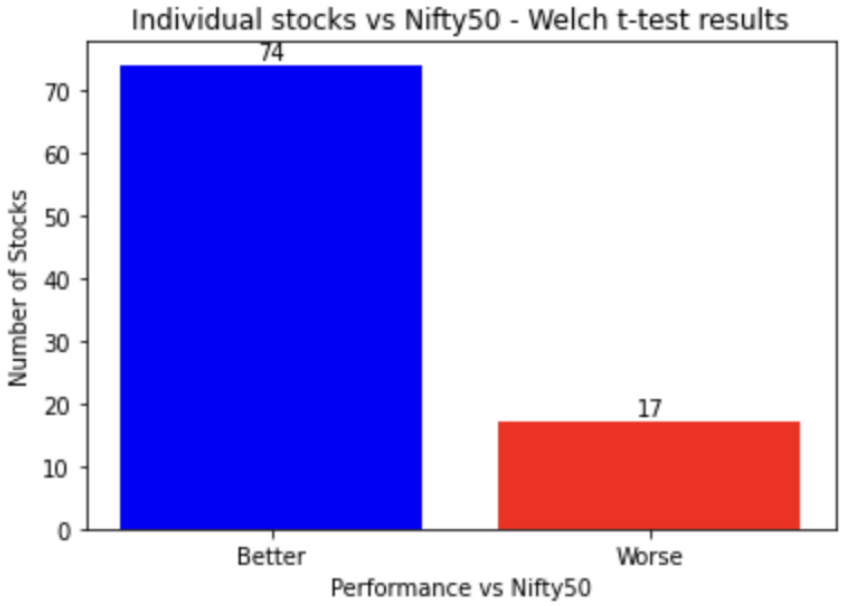
Test Statistic:

$$T = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \quad , T \sim t_v$$

Testing Conditions:

- Test Performed: Welch test (t-test with unequal variance)
- Significance Level: $\alpha = 0.05$
- The test is repeated for all individual stocks vs. Nifty50 index (91 iterations)

Results:
We ran the test for 91 stocks, each compared to the Nifty50 index. For 74 of the individual stocks, we reject the null hypothesis that the individual stock returns are not different from that of the Nifty50 index. The table with the data for all the stocks is present here.



Comparison of individual stocks vs. Nifty50 index

Conclusion:

We infer that for 74 of the 91 stocks there is a difference in the returns as compared to that of investing in the Nifty50 index. But this does not imply that we should individually invest in all of these 74 stocks as opposed to invested in 1 entity which is the Index. What this does imply is that the correlation with the index is not strong for the majority of the stocks so we need not pay attention to news reports that only talk about the Nifty's ups and downs.

Stage 3: Linear Regression

Using past indicator data and stock prices to predict future prices and evaluate if there is a strong relationship between the indicators and the stock prices. In this stage, we perform a multiple linear regression analysis to analyze the relationship between the "Returns" column and the "CCI", "RSI", and "MACD" columns. This will allow us to determine the extent to which changes in the three independent variables (CCI, RSI, and MACD) are associated with changes in the dependent variable (Returns).

The outcome will include the following information for every indicator:

1. Coefficients
2. Standard errors
3. Confidence Intervals for all Indicators
4. F-statistics
5. p-values

We use the p-values to determine whether each predictor is significantly associated with the dependent variable.

Assumptions:

1. The returns are not normally distributed (based on the analysis of the 5 stocks examples in the Exploratory Data Analysis section above)
2. The indicators used by us are independent
3. The stock or index prices and returns at any point in time are independent.

We formulate our Hypothesis for correlation as follows:

H_0: All the coefficients are equal to zero and to each other i.e., $\beta_0 = \beta_1 = \beta_2 = \beta_3 = \ldots \beta_n$

H_A: At least one $\beta_i \neq 0$, where $i \in n = 0, 1, 2, 3\ldots, n$.

The null hypothesis for multiple linear regression analysis for timeseries data states that there is no significant relationship between the independent variables (CCI, RSI, and MACD) and the dependent variable (Returns). In other words, the regression coefficients for all the predictors are zero.

The alternative hypothesis, on the other hand, states that there is a significant relationship between at least one independent variable and the dependent variable. This means that the regression coefficients for one or more predictors are non-zero.

We use an **F-test** to test the statistical significance of the correlation coefficients between the "returns" and the technical indicators (CCI, RSI, and MACD). We used a two-tailed test because we wanted to determine whether there was a significant difference between the correlation coefficient and zero, regardless of the direction of the correlation.

Testing Conditions:

- Test Performed: F-test
- Significance Level: $\alpha = 0.05$
- The test is repeated for all individual stocks

Results:

We ran the test for 90 stocks, testing for whether the regression coefficients can explain the variance of the predictor. We also wish to see if the correlation coefficients can accurately predict stock price returns.

For all 90 of the individual stocks, we reject the null hypothesis that the correlation coefficients are all zero. The table with the data for all the stocks is present here.

Conclusion:

We conclude that the indicators can predict the stock price returns.

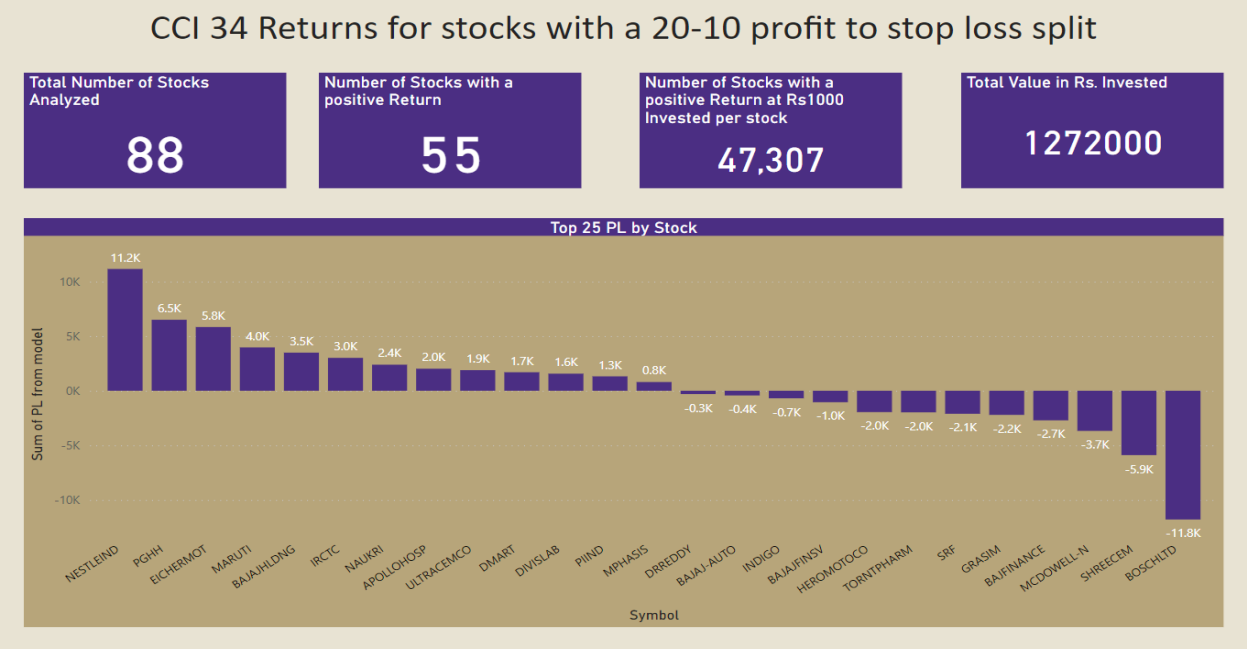
DISCUSSION

Based on the above analysis, we notice that there is a definite relationship between the indicators and the returns. However, we also noticed that the returns are not normally distributed and there is no structure to the data that would imply a trend would hold. As a famous stock market saying goes "Returns represent past performance, are not a guarantee of future performance, and are not indicative of any specific investment.".
Further, whenever the indicators "signaled" a buy, we notice that in majority of the cases we will be able to make a profit as long as we have a set return ratio and stop loss coverage to ensure no one trade incurs a deeper loss. This is displayed in the table below in the last 3 rows. The values in the parenthesis indicate the profit threshold for a trade and the stop loss, (30,7) implies that we exit a trade at either 30% profit or 7% loss. Based on this, for the top 25 stocks, we generate a maximum return for a profit of 50% and stop loss of 15%.

One of the use cases for our project was to provide this as a sort of tool to an investor to tweak and adjust as per their model. And customizing the thresholds as well as deciding the amount to invest in a trade will help maximize profits. What our analysis has shown here is that it is indeed "possible" to generate returns based on these indicators but it is also tougher to predict if this will hold for future data.

Investment Type	Security	Invested Value - as of 01-Jan-2016	Return as of 31-Dec-2022	Annualised Return %	Absolute return %
Risk Free return	SBI Fixed Deposit	10000	16149	7%	61.5%
Index Return	Nifty BEES	10000	24569	13.7%	145.7%
CCI Indicator (20,10)	Top 25 Stocks by Trades	346,000	357,336	NA	3.3%
CCI Indicator (30,7)	Top 25 Stocks by Trades	315,000	325,326	NA	3.3%
CCI Indicator (50,15)	Top 25 Stocks by Trades	151,000	163,286	NA	8.1%

The below figure is a representation of the returns for a 20-10 split for 88 stocks.



Further, as we see from the table above, unless a trader has significant time to enter and exit trades, an investment in the index is indeed a profitable venture over the last 6 years timeframe.
The index returns are calculated based on the NiftyBees symbol data from our dataset.
Further, the risk free returns here is the State Bank of India fixed deposit that had a yearly rate of interest of 7% as of 1-Jan-2016. This is an important factor to note as risk free returns are often used to evaluate mutual fund returns via metrics such as the Sharpe Ratio.

To conclude, we believe that despite our extensive analysis here, this is just a stepping stone in the field of stock market analysis and we would need more than just 1 indicator or a combination of 3 indicators to accurately predict stock market returns. However, we now have the code and blueprint for the process to evaluate indicators either standalone or as a group, and this will help us develop further models that would perform better than the one from our analysis.

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APPENDIX

CODE

The codebase for our analysis is present on our Git here:
https://github.com/svraman1991/Data557Stonks/tree/main/Final%20Codes