STOCK MARKET ANALYSIS AND THEIR EFFECTS USING DEEP LEARNING MODELS

Project Report

DS8013–DEEP LEARNING

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1 – Introduction

Description of problem:

Stock market has received widespread attention from investors. It has always been a hot spot for investors and investment companies to grasp the change regularity of the stock market and predict its trend. The percentage of investment has increased rapidly over the last century. The performance of stock market not only affects individual investors but also individual businesses who have stakes in big companies and trade in these big companies stocks on day to day basis. The rise and fall of stock prices of big companies impact the businesses of the partners who have invested in their stocks. For small businesses, the trend forecast of the stock market is directly related to the acquisition of profits that helps them in expanding their business. Therefore, the research on the intrinsic value and prediction of the stock market is of great significance which allows the businesses to explore prospects to grow.

The main purpose of this project is to predict the trend of stocks of companies such **as Amazon, Facebook, Apple** and relate their effect on their supply chain partners **CISCO, Accels, Analog Device Inc (ADI)** respectively who not only do business with them but also invest in these big companies. Also, assess the impact on the stocks of these supply chain partners by observing stock movements of these partners as well. The aim is to observe rise and fall of the stocks of big companies and supply chain partners and correlate the effects.

During the last years, deep learning has also entered the stock market realm, particularly through its specific technique to model long-term data dependencies, the **long short-term memory network (LSTM)**. LSTM based deep neural network model is employed to predict the stock market price movement. The associated deep neural model is compared with machine learning models like linear and polynomial regression. The feasibility of the LSTM model is compared with traditional machine learning models and the accuracy of these models is reported.

Dataset description:
1. **Amazon stock data**: https://finance.yahoo.com/quote/AMZN/history?p=AMZN
2. **Facebook stock data**: https://finance.yahoo.com/quote/FB/
3. **Apple stock data**: https://finance.yahoo.com/quote/AAPL/

- **Supply chain partners:**

1. **CISCO (Amazon supply chain partner):**
   https://finance.yahoo.com/quote/CSCO?p=CSCO
2. **Accles (Facebook supply chain partner)**:
   https://finance.yahoo.com/quote/ACCEL.AS/
3. **Analog Device Inc (Apple supply chain partner)**:
   https://finance.yahoo.com/quote/ADI

The dataset for all the companies is taken from the time period starting from the year 2012 to 2019. For all the companies the train-test split is as follows: train set from period 2012-2017 test set from time period 2017-2019. **The dataset consists of seven columns: Date, Open, High, Low, Close, Adj Close, Volume.**

Date	Open	High	Low	Close	Adj Close	Volume
02/04/2012	21.139999	21.299999	21.049999	21.190001	16.644211	30716500
03/04/2012	21.110001	21.190001	20.629999	20.82	16.415558	64106700
04/04/2012	20.639999	20.77	20.25	20.360001	16.052872	43848100
05/04/2012	20.18	20.370001	20.07	20.219999	15.942488	30611900
09/04/2012	19.969999	20.16	19.870001	19.959999	15.737497	26416300
10/04/2012	19.940001	20.1	19.52	19.549999	15.414227	44896400
11/04/2012	19.68	20.040001	19.620001	20.02	15.784801	40610100
12/04/2012	20.09	20.280001	19.98	20.059999	15.816339	32041300
13/04/2012	20.02	20.040001	19.790001	19.85	15.650765	27901500
16/04/2012	19.92	19.959999	19.57	19.73	15.556145	35250100
17/04/2012	19.809999	20.15	19.75	20.08	15.83211	28770700
18/04/2012	19.950001	20.15	19.879999	20.059999	15.816339	27563400
19/04/2012	20.02	20.309999	19.780001	19.91	15.698068	34583500
20/04/2012	19.93	20.040001	19.84	19.91	15.698068	34257200
23/04/2012	19.77	19.780001	19.58	19.68	15.516728	27406400
24/04/2012	19.76	19.85	19.35	19.42	15.311728	67526600

General View of Stock Market.

The percentage of investment in stock market has increased rapidly over the last century. The performance of stock market affects individual businesses in many different ways. For instance, in the United States there are approximately 5,000 publicly traded stocks that can be divided broadly into 11 global industry classifications (GICS). With daily movements across the board, there can be a multitude of affects.

Now a days many companies around the world are investing in stock market and wants to gain profit. For that purposes they hire a lot of employees who can work on multiple financial reports and takes out the best and important information that is needed. However, for that information employees not only focus on main shareholders of the organization but also considers the minimal part that effects the organization. Their work is to gather a lot of information from many different sources and produces the best report with all of their efforts and experiences.

As a matter of fact, that investing in the stock market carries a lot of risk in many ways. Some of factors that effect the whole market includes economic growth, recession, inflation, interest rates, currency fluctuations etc. These factors are very difficult to analyze and therefore creates a lot of risks for an organization.

Factors that Affect the Stock Market:

One of the most apparent risk in the stock market is the economic risk. A Collapse in share prices has the potential to cause widespread economic disruption. This has happened seven times out of ten, that, whenever the country is struggling with their internal matters the stock market has direct effect. For instance, if we talk about terrorist attacks that happened in 2000 in United States, the economy settled into a sour spell and a combination of factors saw the market indexes lose significant percentages. Whereas this effect took years for US to return back to the original shape. Therefore Stock Market and economic performance both are aligned in a way that if one decreases the other will also have an effect on it.

Two way relation ship figure
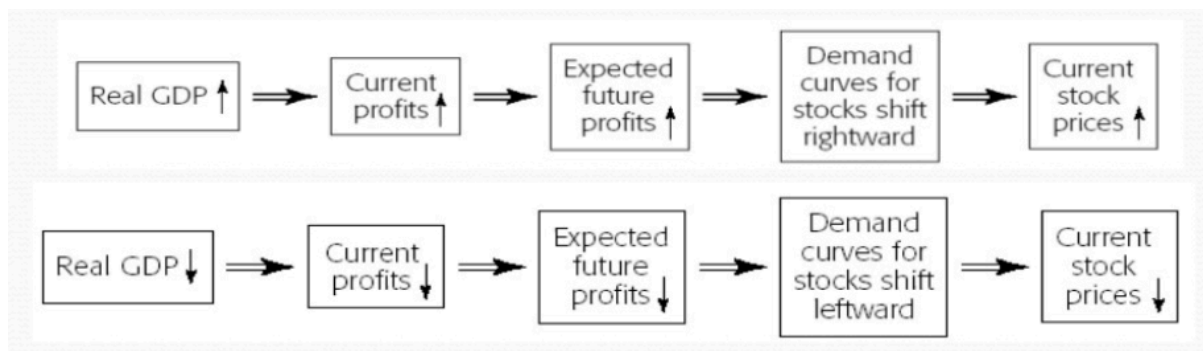
On the other hand, it is rare that some of the economic changes do not really impacts the stock market but this has happened four or five times in a lifetime where share prices fell and did not cause an economic disruption. In other words, share prices alone do not cause economic recessions but if share prices reflect a fundamental weakness in the economy then this may be the harbinger of an economic slowdown.

Another most common factor that impacts stock market are the interest rates. Many countries raises and lower interest rates to rebalance their economy which as a results effect stocks and therefore effects the economy. This is known as monitory policy. In addition, if a company borrows money from banks, international banks, to increase their businesses, higher

interest rates will have an impact in their debt. Less business spending will make hard for an organization to head up along with market and therefore reduces their profits, share prices. it may curtail expansion plans or new ventures, or even induce cutbacks Some small companies survive this kind of situation by reducing their overheads whereas, some big companies leads to bankruptcy.

Chart 2: Interest Rate Expectations (%)
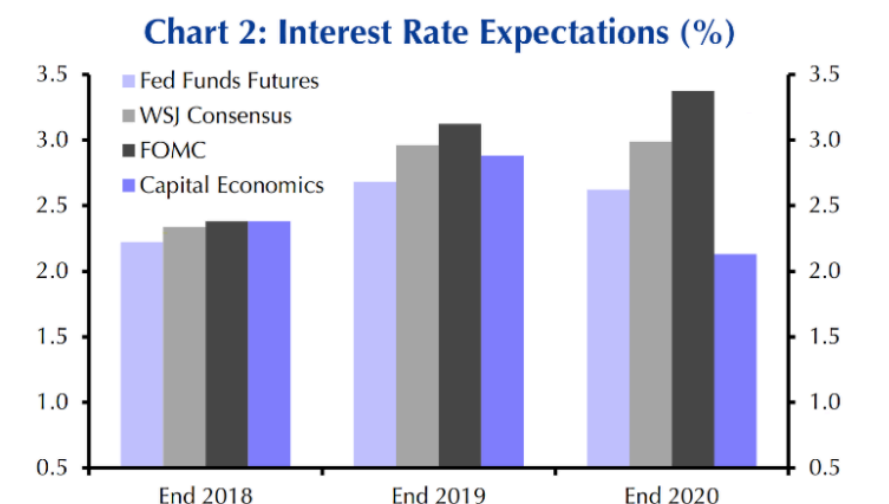
On the other hand, when banks decreases their interest rates, this has the opposite effect of a rate hike. Investors look forward to take loan from banks and expand their businesses. This leads to a greater profit and a robust economy. Many companies can borrow money from banks with lower interest rates and increase their business worldwide. This will increase in their profit and help them grow rapidly, which in turn leads to higher stock prices.

Third and the most common factor of stock market is the confidence and expectations of the consumers. For instance, if an investor or company observes an organization from a very long term and there is no fluctuations in the stock market of that particular company, then it will be an easy decision for an analysis team to predict the stocks with minimal amount of resources. The more stable the market is, the more confidence it will gain from the investors.

Stock market is not always a best investment when there are certain problems going on in a country such as political issues. This kind of problem plays a vital role in the stock market industry. For instance, the business policies that was made by the previous political parties will remain same forever?

Most of the times, countries presidents are either planning on running for re-elections, or on their second term they are trying to set up another win for their party in the next presidential election. For that purpose, they goes through all potentially damaging legislation that needs to happen in first two years of their term. This sort of the affects comes in many ways such as taxes, regulations, immigrants, market policies, trade agreements or any other important policies that have a negative effect on the economy.

During the presidencies of Barack Obama and Donald Trump, the policies did not remain same as it was before. First two years was the most profitable years in the times of Barack Obama. Where this was not the case when Donald Trump came into being. The problem with investing based on such changes does not guarantee that whatever has happened in the past will give you the same results in the future as well.

Another common factor that affects stocks market is the supply chain management system. For instance, if any two companies buy products from same supplier, then more likely there is a chance that both of them will be affected if the supplier have ups and down in their stocks.

This kind of reaction is known as ripple effect. However, the impact more or less depends on how much linkage there is in between with customer and a supplier. Suppliers are one of the most important stakeholders in an organization structure and therefore has to be carefully analyze while making a decision.

From the other perspective, market competition also plays an important role in business, and therefore impacts the stocks in many ways such as annual sales, products feedback etc. It is not easy task for an analyst to read a financial report of an organization and completely rely on the whatever is written there in the form of words. This often leads a reader to a different path where he trust and make decisions in the favor of an organization. The reader must analyze the financial report with given statistical data from different sources and produces the best conclusion's based on what actually happened in the period of time.
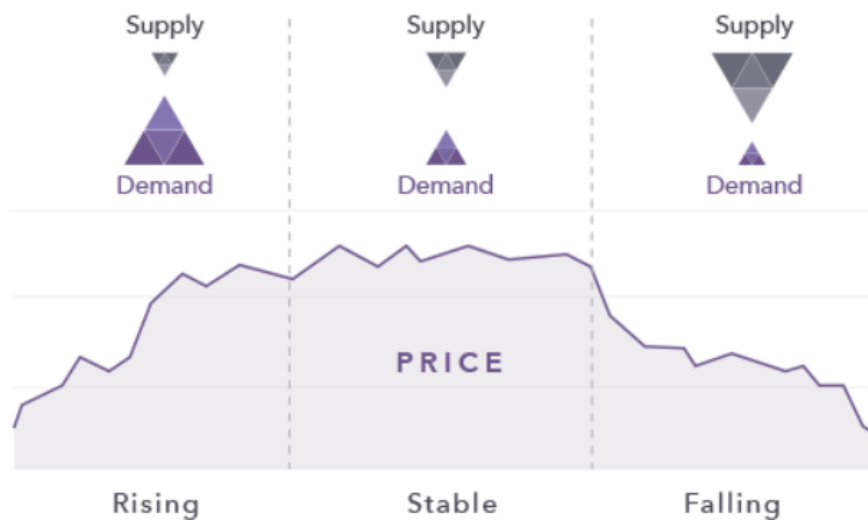
Similarly, if more buyers move into market, as a result the demand grows, and share prices of the sellers grow up especially if there is a limited amount of supply. Whereas, if we see that supply and demand both are same and equally distributing to each other, then share prices will be more stabilize. In the other words, demands and supply both are inversely propositionally to each other.

Technical analysis must be considered while predicting the stocks. This means of studying the historical charts to predict the share prices. If analyst can familiarize their self with past patterns and experiences, this can also be very helpful while predicting stocks.

In today's increasingly interconnected economy, the economic fallout from a natural disaster is rarely relegated to the geographic area it hits. In fact, natural disasters that happened miles away have their impact on a large number of radius. This factor varies country to country and does not account all of its impact to one side. For instance, last year Japanese share market falls around 3 percent due to the impact of earth quack. Factories such as Toyota, Nikkei, Honda where closed disrupting supply chains around the country. All the airlines that were connected to japan were cancelled or postponed because of the disaster. There was rise in the shortage of food due to the closure of accessibility. All the roads including borders were closed. This not happened once in japan but many times.

Similarly, in 2005, US stock market had a big break down due to the impact of hurricanes. This has happened many times in the history of US. Hurricane Katrina was the worst natural disaster in the history of United States, with over 167 billion dollar of revenue that was being damaged. On the other hand, in 2019 there were 6 weather and climate disaster that 4happened, and each disaster had a damage of around 1 billion dollar. Because of unpredictable and severe weather patterns, it becomes even difficult for the government to take a precautional measures. It becomes very hard to maintain for those people who owns small business such as grocery shops, pharmacies, mini super markets. Due to lack of accessibility such as transportation and road closures, push them to close their businesses. As a result, this whole scenario crashes the stocks markets. Weather disasters are not difficult to predict as compared to the earth quack, but it is hard to predict the over all influence that happens after the disaster.

1	Hurricane Katrina (2005)	$167.5 billion
2	Hurricane Harvey (2017)	$130.0 billion
3	Hurricane Maria (2017)	$93.6 billion
4	Hurricane Sandy (2012)	$73.5 billion
5	Hurricane Irma (2017)	$52.0 billion
6	Hurricane Andrew (1992)	$50.0 billion
7	Drought/Heatwave (1988)	$44.2 billion
8	Midwest Flooding (1993)	$37.7 billion
9	Hurricane Ike (2008)	$36.3 billion
10	Drought/Heatwave (2012)	$33.9 billion

Tsunami is also one of common natural disaster. This disaster is common in most countries that comes under Asian region such as, Japan, Indonesia, Korea etc. Investors who wish to invest in Asian countries consider this factor as their first. According to the tradefutures.com, companies in Japan such as Nissan, Honda were having issues in their production due to the affect of tsunami. Employers are scared of going out side due to harsh conditions. Many small business close their showrooms due to lack of budget.

In the Stock Market industry, the Stock Analyst not always follow the same path to predict the future trend. Instead, he observes some of the key patterns that helps him to predict the best from future. It is not always an easy task for Stock Analyst to see and predict in the stock market world.

2 – Literature Review

Paper 1: The Impact of Stock Market Performance upon Economic Growth

Figure 1. Classification of Stock Markets

Source: Handay (1997).
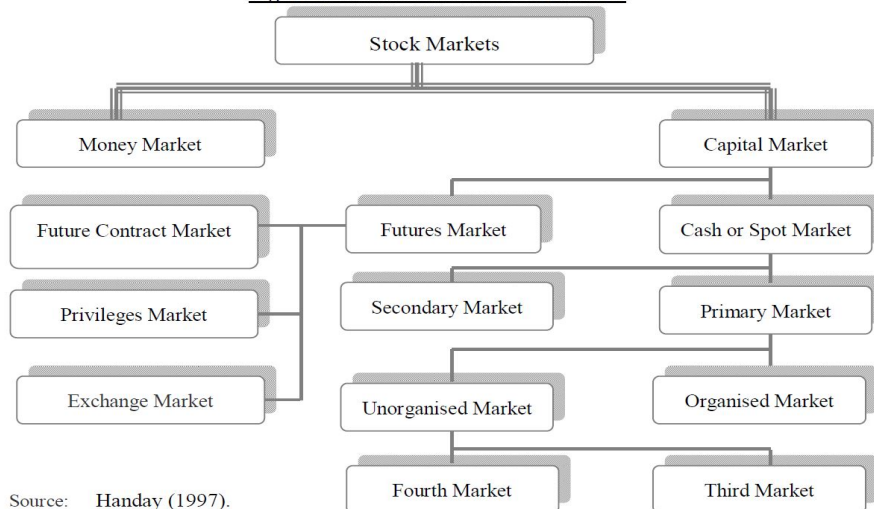
"The stock markets are a complex of institutions and mechanisms through which funds for
purposes longer than one year are pooled and made available to business, government, and
individuals and through which instruments already outstanding are transferred. The stock
markets are well organized and are local, regional, national, and world-wide in scope."

Financial markets are classified as bank-based or market-based systems. A stock market is considered as marketplace, where stocks and shares are the traded commodities. It is central to the creation and development of a strong and competitive economy. It is a key to structural transformations in any economy. From traditional, rigid, insecure bank-based economy to a more flexible, secure economy that is immune to shocks, fluctuations and lack of investors' confidence. Stock markets exist where government and industries can raise long-term capital and investors can purchase and sell securities. Therefor in order to understand what stock market is and how the investment in stock market influences investors' confidence in buying and selling of stocks and shares, there are certain terms that one needs to be well acquainted with.

1. **<u>Money market:</u>**

Refers to the markets where short-term investment securities of less than one year are traded. It provides an opportunity for borrowers to obtain short-term loans. It also provides an opportunity for investors to obtain a high level of security by investing their money in financial assets with high liquidity, as the commercial banks play a critical role in this market's activity. Money market security has three basic characteristics:

- It has usually sold in large denominations
- It has low default risk
- It matures in within one year

2. **<u>Capital market:</u>**

Refers to markets for financial instruments of long-term investment tools with maturities of one year or more and where equity instruments are traded. Securities such as stock and long-term bonds, are often held by financial intermediaries, insurance companies and pension funds, which have little uncertainty about the amount of funds which they will have available to deal with in the future. This has further components like:

2.1. Cash or Spot Market

The one which involves immediate dealing between buyers and sellers and is divided into primary and secondary market.

2.2.1. Primary Market

Also referred to as **"*issue market*"**, issues security stocks, bonds, shares outstanding, and is in businesses that can issue securities. Vital to capitalist economies, from the owners of these sources to those who utilize them to finance productive activities, since they serve to channel funds from savers to borrowers.

2.2.2. Secondary Market:

Market where the sale of previously issued securities occurs. This involves investors who plan to sell long-term bonds before they reach maturity and also sell their holdings of stock by brokers and intermediaries. Indeed, brokers specialize in secondary markets where they have developed a superior knowledge of the factors that influence risk, costs and returns relating to financial instruments exchanged in these markets.

2.4 *Organized Market*

The organized market has a building which is a site for buying and selling securities (including stocks, bonds, options, and futures) and trading with a specific procedure for instruments of securities to be recorded in accordance with the rules and regulations to ensure that they result in competitive trading.

2.5 *Unorganized Market*

Also known as the **Over The Counter (OTC)** market is unorganized in the sense that it has unlisted stock that get traded. This market trading operates by using a nationwide network

of phone lines and computer links where the price is determined by financial paper negotiations.

2.6 *Third Market*

This involves the trading of listed securities in the OTC market. This market is unregulated and consists of brokerage firms which are not members of the organization, even though they have the right to deal in securities registered in those markets. Furthermore, these brokerages are willing to buy and sell securities at a greater or lesser amount.

2.7 *Fourth Market*

Refers to direct trade between institutions without the use of an exchange. This market is intended for major institutions and rich individuals who deal with them in buying and selling securities in large orders, as a strategy to reduce commission paid to brokers and in a strong network of telephones and computers, so that the conclusion of transactions in the market can happen quickly and at a lower cost.

2.8 *Futures Markets*

In this, forward contracts involve no upfront payment and cash only changes hands at the expiry of a contract, which is negotiated between two parties and is not significant. A future contract is traded in the market and involves a down payment known as the initial margin. This is a deposit to ensure both parties to the contract do not default, which usually earns a competitive interest rate without cost.

The Role and Function of a Stock Market:

Stock markets and economic functions may no longer be distinct to many human beings but, in fact, they represent a relationship between the disparate sectors in social society between savers and producers as the saving sector needs to invest their savings in more beneficial and ambitious projects. Additionally, the productive sectors always require financial sources to aid them to proceed and perform more in functional economy, in which overall stock market performance and functions of basic economy transfer funds from people who have collected surplus to those who have a paucity of funds.

Figure 2. Flows of Funds through the Financial System
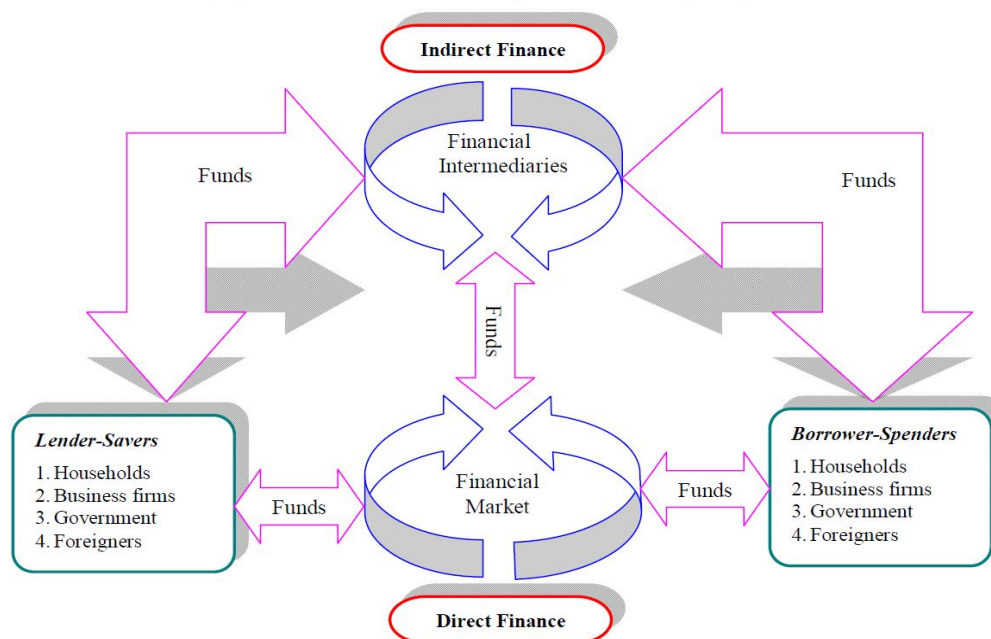
Source: Mishkin and Eakins (2003).

Factors Considered for daily analysis of stock market:

Following have been considered for analysis in this project:

- **The Open and Close price** represent the starting and final price at which the stock is traded on a day.
- **High, Low and Last** represent the maximum, minimum, and last price of the share for the day.
- **Total Trade Quantity or trade volume** is the number of shares bought or sold in the day.

Why stock market is of prominence today:

In recent years attracting and consolidating savings and other forms of capital has become critical for the development and growth of both the public and private sector. This has increased the stock market's role in commerce, information technology, communication and management. This highlights the importance and impact of stock market in development of economy. There are numerous factors which have helped financial markets to gain prominence, like increasing the private sector's influence in various economic activities, cutting edge technological advancements and the ease of access to financial information. There have been advancements in communication and emergence of new and effective financial tools besides new legislation that guarantees freedom of trade and movement of capital. This indicates the significance of stock market in providing opportunities for growth. Last few years have witnessed an increase in the importance of developing and establishing stock markets across the world. Active features like stock market size in terms of market capitalization ratio, opening and closing price, volumes of stocks traded effect real per capita GDP. At the same time, market volatility has significant effect on real per capita GDP growth.

Paper 2: Predicting the Direction of Stock Market Index Movement Using an Optimized Artificial Neural Network Model

The stock market index refers to the movement of the price index or fluctuation in the stock market index in future. Predicting the direction of the index heavily influences a financial trader's decision to buy or sell an instrument. Accurately forecasting the trend of stock index help investors to acquire opportunities for gaining profit in the stock exchange. Hence, accurate forecasting of the stock price index can be extremely advantageous for investors. The main contribution and objective of this study is the ability to predict the direction of the next day stock price index using deep learning model. This is done for the Japanese stock market by using an optimized Artificial Neural Network (ANN) model.

Previous studies have applied various models in forecasting the direction of the stock market index movement. Machine learning models have been used to forecast stock market movement using algorithms like Support Vector Machines (SVM) and it was concluded that the model was good at predicting the direction. But since the daily volume of traded stocks is large, deep neural architecture of Artificial Neural Network (ANN) was subsequently used to predict the future trend of stock market. Hence, ANN has become popular method and it has proven to outperform conventional machine learning methods like SVM. The most popular neural network algorithm for financial forecasting is the Back Propagation (BP) algorithm.

This study predicted the direction of the daily Nikkei 225 index for Tokyo stock exchange using trained ANN model. ANN model using gradient descent technique of the BP algorithm achieved considerable accuracy in prediction, although this has some limitations. Limitations became apparent when ANNs are applied to complex nonlinear problems where there are complex features. The BP algorithm has two significant drawbacks, i.e., slowness in convergence and an inability to escape local minima. Taking these limitations into account, search techniques such as Generic Algorithm (GA), were proposed to overcome the local convergence problem. In this study, GA technique was applied to optimize the weights and biases of the ANN model, and then predict the direction of the daily closing price movement of the stock market index.

Paper 3: A Machine Learning Model for Stock Market Prediction

Stock price prediction has been an overgoing challenge not only for the economists but also for machine learning scientists. Different approaches have been applied to model either long-term or short-term behavior, considering the daily stock market trend. This study predicts stock market movement to determine the future value of a company stock or other financial instrument traded by the company.

The paper proposed Machine learning model to predict stock market value. The proposed algorithm integrates two strategies for effective prediction: **Particle swarm optimization (PSO) and least square support vector machine (LS-SVM)**. The PSO algorithm is employed to optimize LS-SVM to predict the daily stock prices. The model studies

historical data and technical indicators for effective future prediction. PSO selects best parameters combination for LS-SVM to avoid over-fitting and local minima problems and improve overall prediction accuracy of the model. The results so obtained showed that the model has better prediction accuracy and validates the potential of PSO algorithm in optimizing LS-SVM.

The proposed model, which is LS-SVM optimized with PSO performed better in comparison to ANN and LS-SVM doing the prediction taken individually. LS-SVM-PSO overcome the overfitting problem seen in ANN and solved the problem of hyperparameter tuning seen in LS-SVM.

Paper 4: Deep architectures for long-term stock price prediction with a heuristic-based strategy for trading simulations

There are several factors that determine the sale and purchase of a stock. Predicting the closing price of stock is one such factor that effects the sale and purchase of a stock in a day or over a period. During the last years, deep learning models have entered the stock market realms, particularly through its specific technique to model long term dependencies. Building upon this notion, this paper puts forward the idea to estimate the closing price of 25 companies of Bucharest stock market. Also, CNN model with 1D convolution layer is employed to produce the estimate of closing price of stock. LSTM and 1D CCN are then compared to see which model give better estimate of closing price for 25 companies.
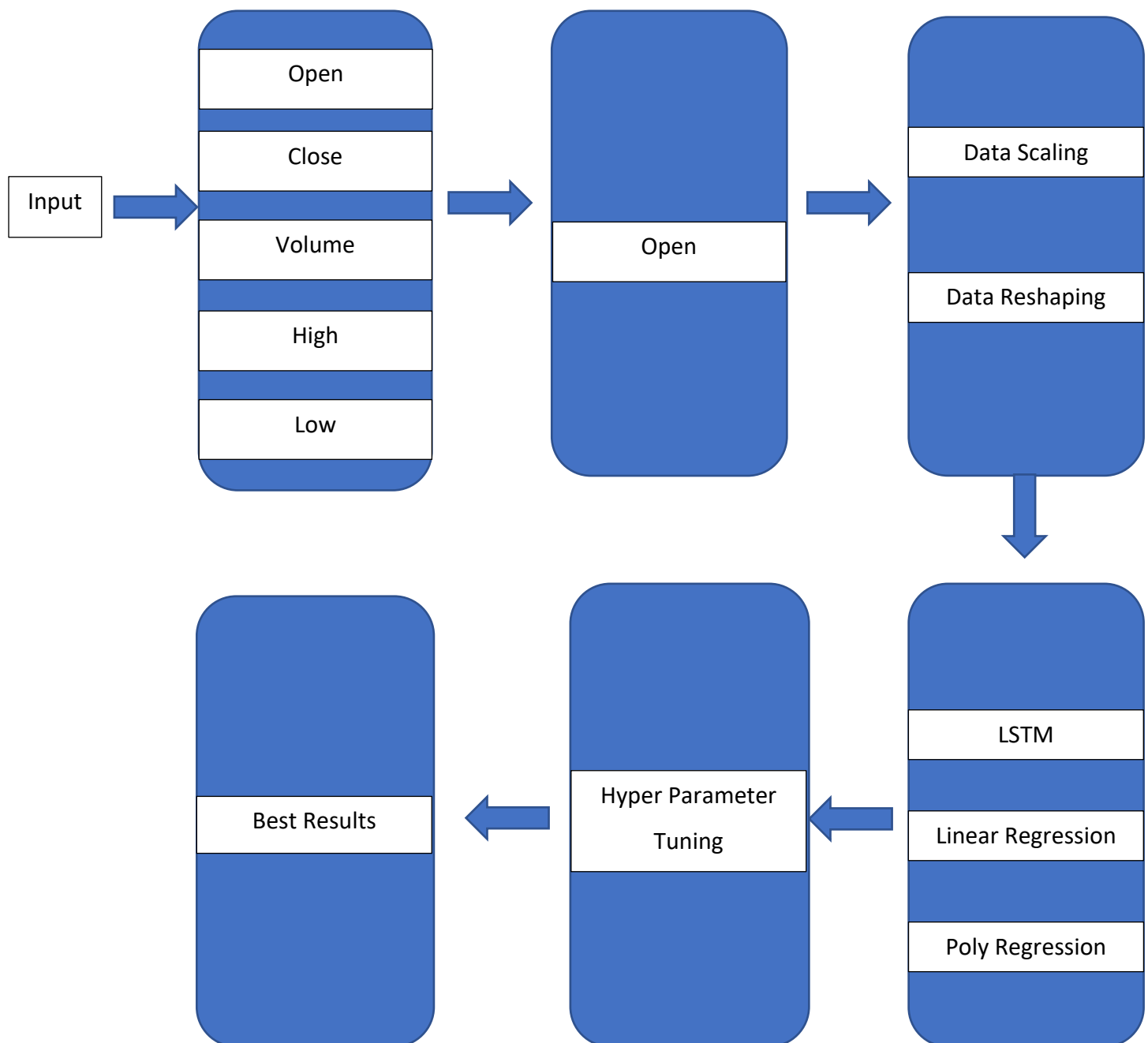
The focus of the author was to parametrize the Buy and Sell rules and determine the optimal value for future. The first choice for learning the stock price series data is LSTM. LSTM is a recurrent neural network that can study long term dependencies in data. The design of the LSTM model for this study consisted of subsequent layers, each followed by a Dropout layer and final dense layer. Dropout is a regularization method where input and recurrent connections to LSTM units are probabilistically excluded from activation and weight updates while training a network. This has the effect of reducing overfitting and improving model performance.

Also, trading simulation environment was created to practically assess the performance of the model in identifying the future trends. Optimal trading rules for the simulation were created using the Hill Climbing heuristics to determine BUY and SELL value of stock and based on these simulated values assess the model behavior.

LSTM and 1D CNN both were used to determine the trend, but it was found that although, 1D CNN took less execution time as compared to LSTM, the mean squared error (MSE) for LSTM was less as compared to 1D CNN. Also, LSTM was better at estimating the long-term gain based on closing price of the stock.

3 – Methodology

Architecture:

Input	→	Open / Close / Volume / High / Low	→	Open	→	Data Scaling / Data Reshaping

Best Results	←	Hyper Parameter Tuning	←	LSTM / Linear Regression / Poly Regression

Technologies Used:

	Data pre-process	**Results**	**Implementation**	**Data Visualize**
Libraries	Sklearn, Numpy	Sklearn, Numpy	Tensor Flow, Keras, Scipy	Plotly, Matplotlib

Since the data that has been used in this project is non-linear and changes with respect to time. For this purpose, the most suitable algorithm that can be used for this task is the LSTM (Long Short-Term Memory network).
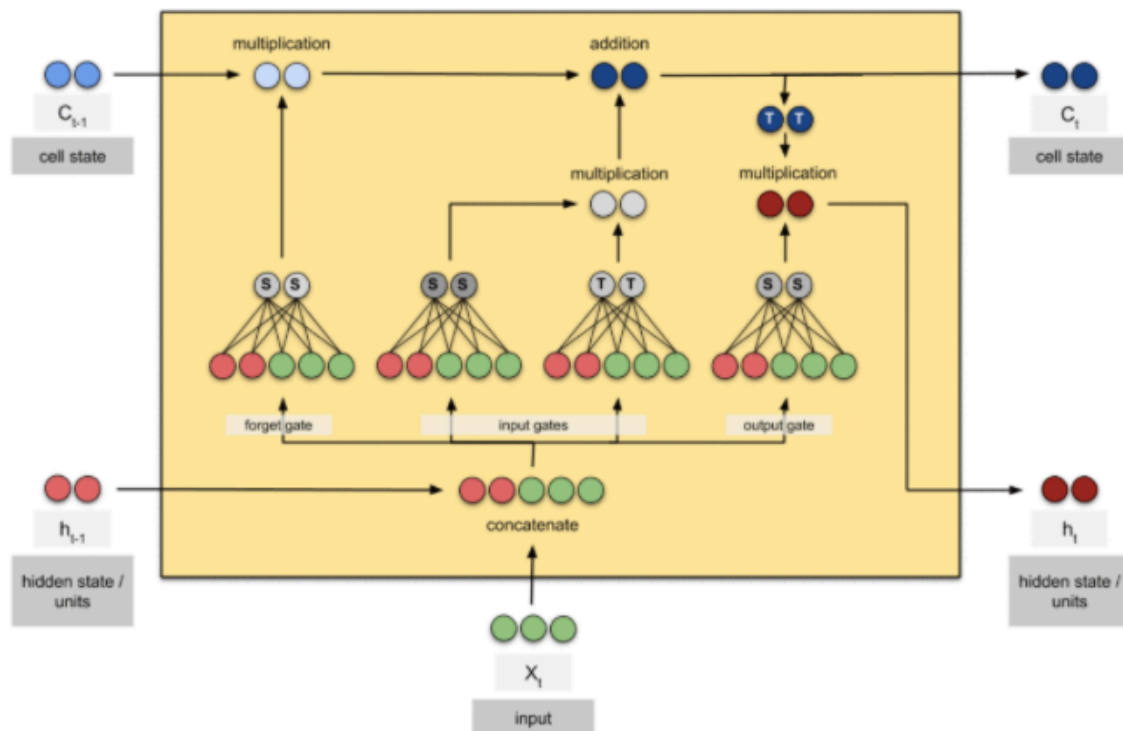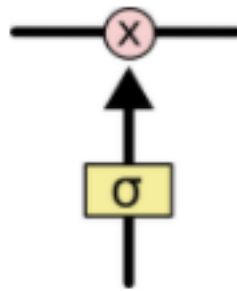
LSTM:


Long Short Term Memory with its gates

Long Short Term Memory (LSTM): It is a special kind of RNN, which is capable of learning long-term dependencies. It was invented by the Hochreiter & Schmidhuber in (1997). It was further researched by many people and got popularized in the following work. The best use of LSTM, is mainly on large variety problems. One of biggest role of LSTM is that, it keeps the past knowledge and uses that knowledge to predict the future trend. This kind of learning in LSTM, avoids long-term dependency problem.

The LSTM does have the ability to remove or add information to the cell state, carefully regulated by structures called gates. Gates are a way to optionally let information through. Gates are linked with the sigmoid layer which gives the probability between 0 and 1. These probabilities decides which information should go through and which information should be avoided. On the scale from 0 to 1, 0 means to avoid the information and 1 means to let everything through.

**The core behind LSTM is divided into 3 steps.**

Forget Gate: This phase makes the decision that how much knowledge (information) from the past should be kept in the memory. However, this decision is made by probabilities given by the sigmoid layer between 0 and 1. 0 means to forget completely whereas 1 means to keep the information in memory.
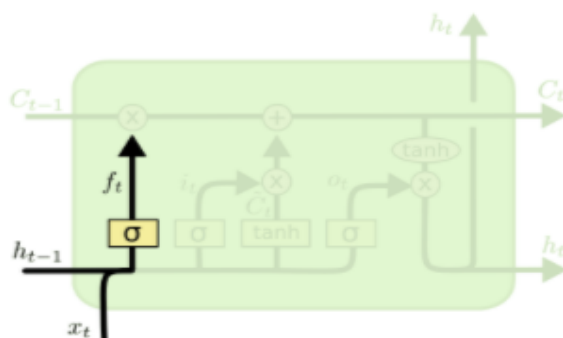

$$f_t = \sigma \left(W_f \cdot [h_{t-1}, x_t] \; + \; b_f \right)$$

Update Gate: This gate is also called as input gate. It Decides how much of this unit is added to the current state. The rest decision is made by the sigmoid layer that gives the probabilities between 0 and 1, where 0 means nothing to keep and 1 means to let that information through.

tanh function gives weightage to the values which are passed deciding their level of importance ranging from-1 to 1.

Input/Update gate

$$i_t = \sigma\left(W_i \cdot [h_{t-1}, x_t] + b_i\right)$$
$$\tilde{C}_t = \tanh(W_C \cdot [h_{t-1}, x_t] + b_C)$$
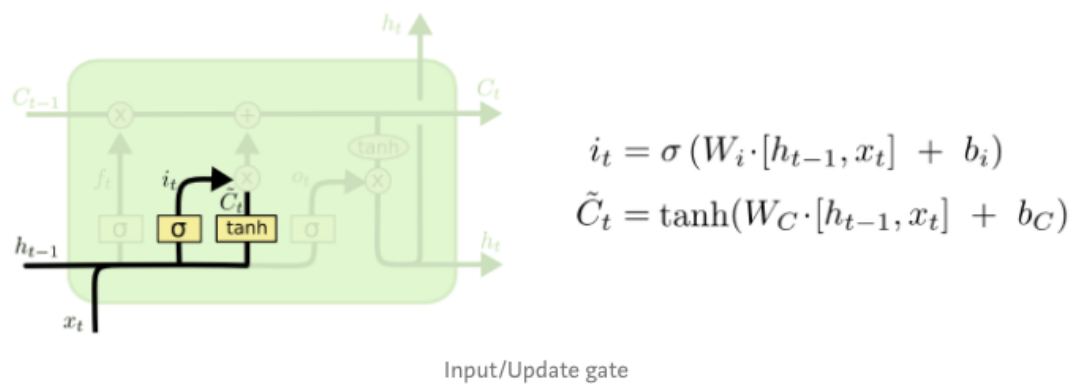
Output Gate: This gate makes the decision which part of the current cell should be considered to the output. This is also connected with sigmoid layer and tanh that gives the results for the output.

Output Gate

$$o_t = \sigma\left(W_o\left[h_{t-1}, x_t\right] + b_o\right)$$
$$h_t = o_t * \tanh\left(C_t\right)$$
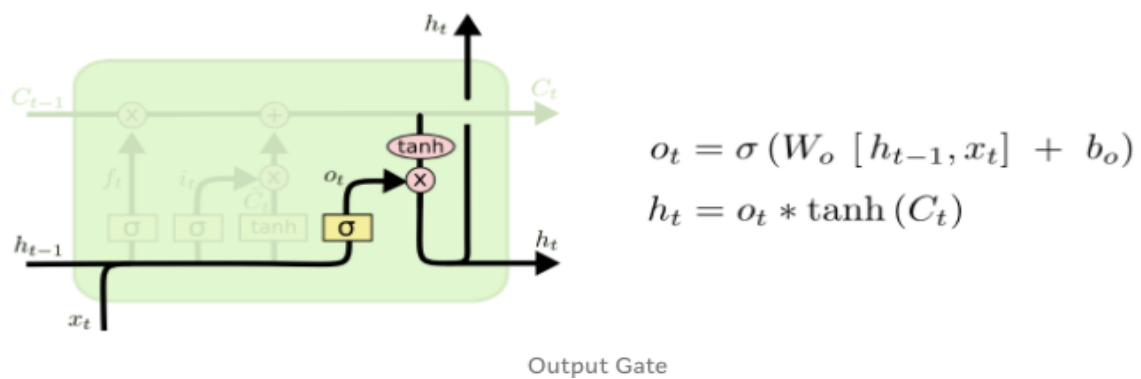
The complete LSTM looks like this:
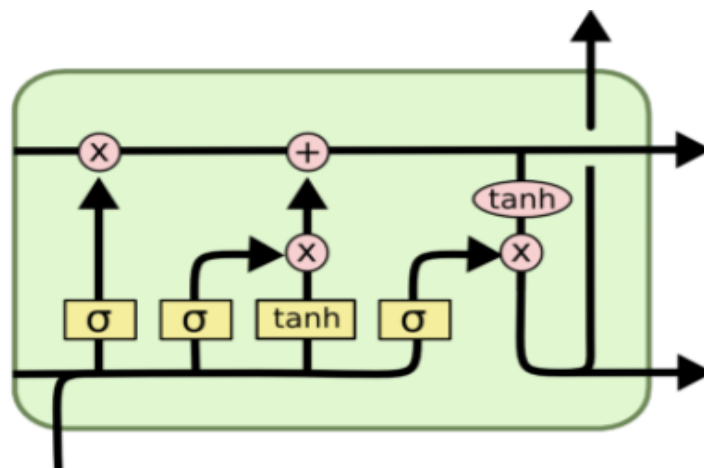
Data Preprocessing:

The LSTM input layer is specified by the "input shape" argument on the first hidden layer of the network. For that purpose, we have to make our data broken down into batches. The input data of LSTM has to be 3 dimensional. Sample, Time Steps, Features.

By using reshaping technique in python we were able to make batches and 3D array, which fits the LSTM Model. Choosing previous steps as 5.

```
x_train = x_train.reshape(x_train.shape[0], x_train.shape[1], 1)
```

```
(1506, 5, 1)
```

```
[[[-0.9679918 ]
  [-0.97311079]
  [-1.05331397]
  [-1.1318102 ]
  [-1.16764568]]

 [[-0.97311079]
  [-1.05331397]
  [-1.1318102 ]
  [-1.16764568]
  [-1.17276467]]

 [[-1.05331397]
  [-1.1318102 ]
  [-1.16764568]
  [-1.17276467]
  [-1.21713237]]
```

The data was also scaled to have a better results. For that purpose, we have used sklearn preprocessing inbuilt function. Scaling down the data was not giving much difference in these datasets. That's why our team has implemented the function but have not used for these dataset files.

```
X_scaled_train = preprocessing.scale(x_train)
X_scaled_test = preprocessing.scale(x_test)
```

Implementation of LSTM model on the dataset:

Company: Amazon

Supply Chain Partner: Cisco

Training Data: 2012 – 2017
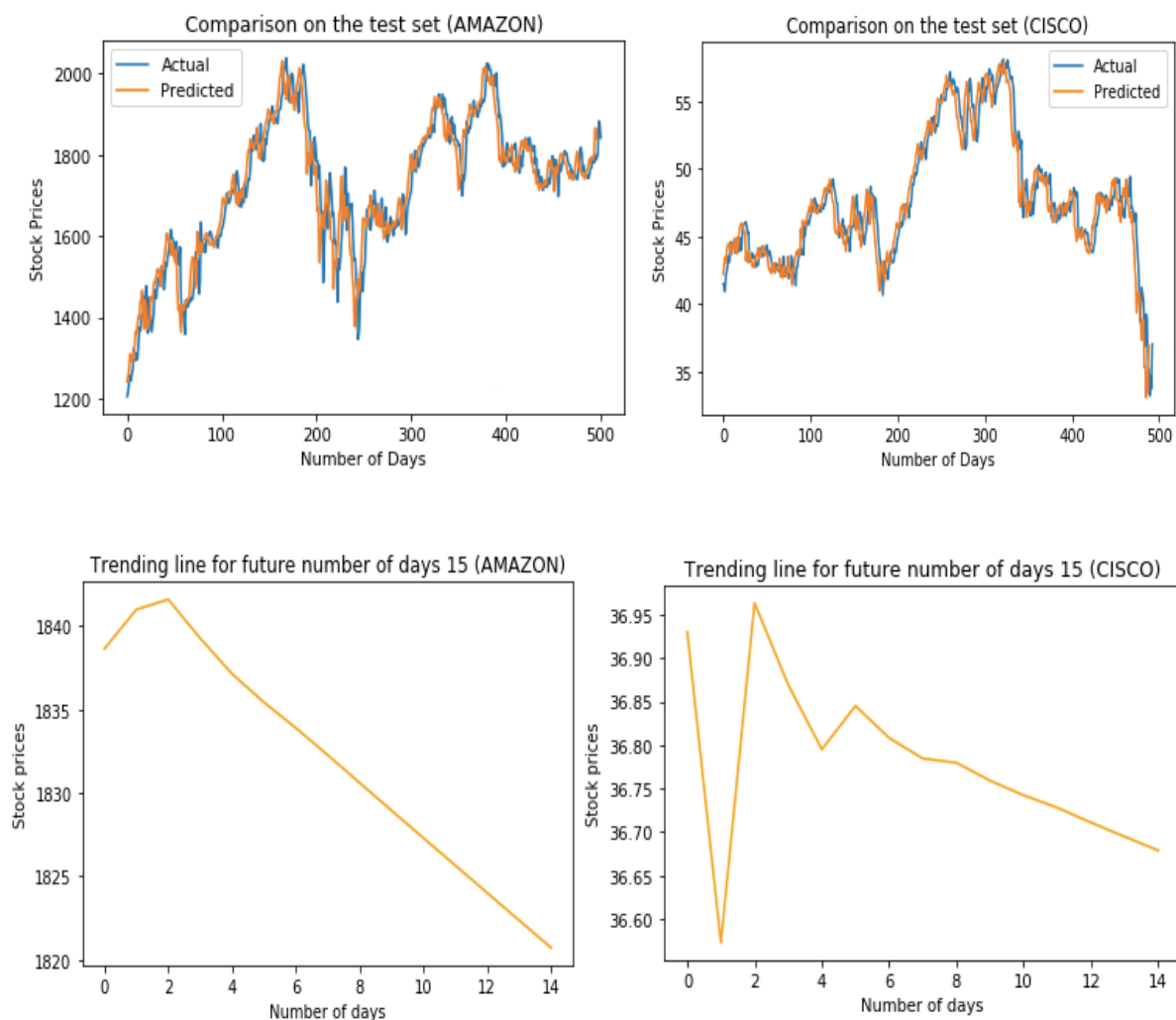
Test Data: 2017 - 2019

Best Results:

Assuming that the external factors for 15 days will remain the same as it was in past. First two graph shows the stocks trend of Amazon and Cisco. The blue line shows the actual data and the orange line shows the prediction that was done by LSTM.

The graphs on the second line shows the trend line for the future. However, the model is designed in such a way that these days of prediction can be changed. Since, in stock market

there are plenty of external factors that disturbs the trend, it is not a good practice to predict for a long time without consideration of factors of the current situation.
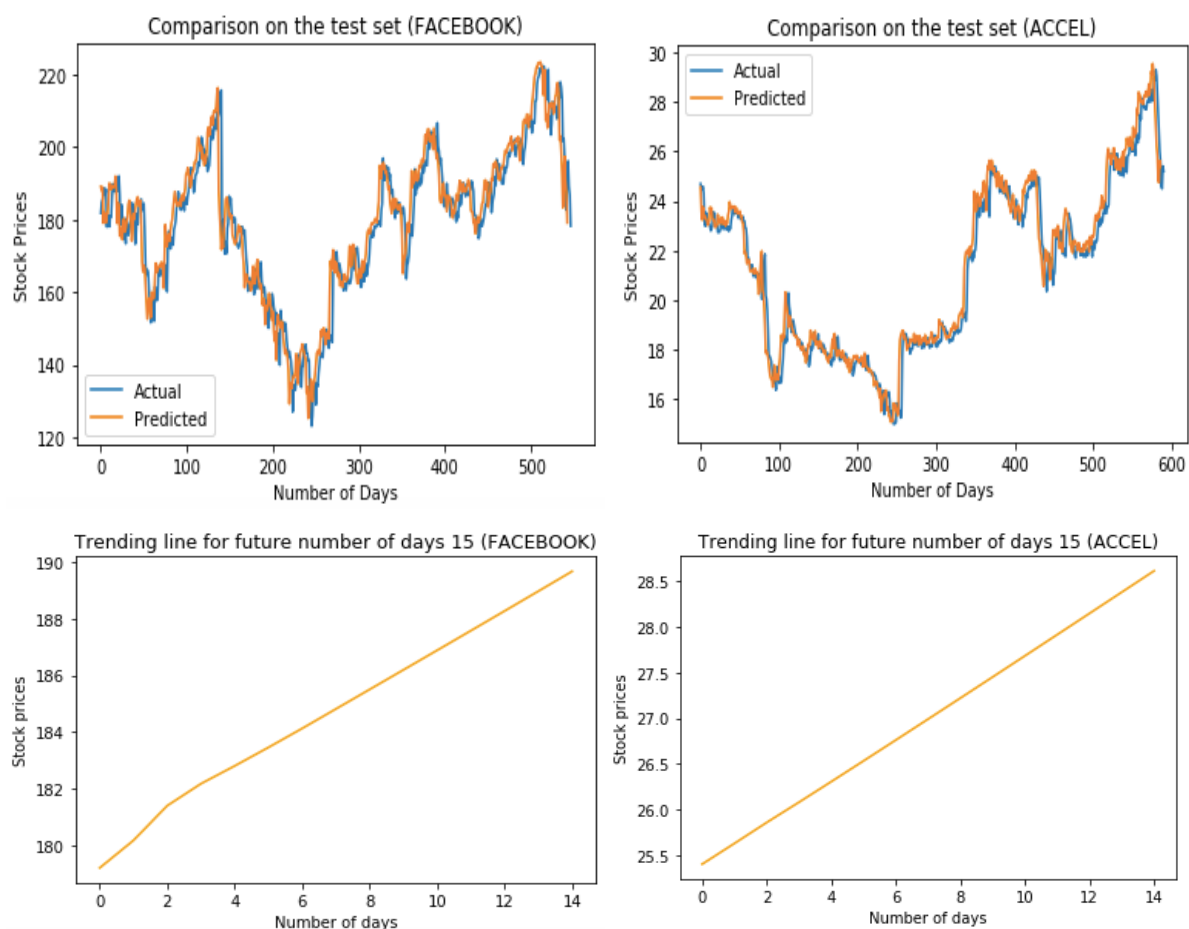
Company: Facebook

Supply Chain Partner: Accel

Training Data: 2012 – 2017

Test Data: 2017 - 2019

Best Results:

Assuming that the external factors for 15 days will remain the same as it was in past. First two graph shows the stocks trend of Amazon and Cisco. The blue line shows the actual data and the orange line shows the prediction that was done by LSTM.

The graphs on the second line shows the trend line for the future. However, the model is designed in such a way that these days of prediction can be changed. Since, in stock market there are plenty of external factors that disturbs the trend, it is not a good practice to predict for a long time without consideration of factors of the current situation.

Company: Apple

Supply Chain Partner: ADI

Training Data: 2012 – 2017

Test Data: 2017 - 2019

Best Results:

Assuming that the external factors for 15 days will remain the same as it was in past. First two graph shows the stocks trend of Amazon and Cisco. The blue line shows the actual data and the orange line shows the prediction that was done by LSTM.

The graphs on the second line shows the trend line for the future. However, the model is designed in such a way that these days of prediction can be changed. Since, in stock market there are plenty of external factors that disturbs the trend, it is not a good practice to predict for a long time without consideration of factors of the current situation.
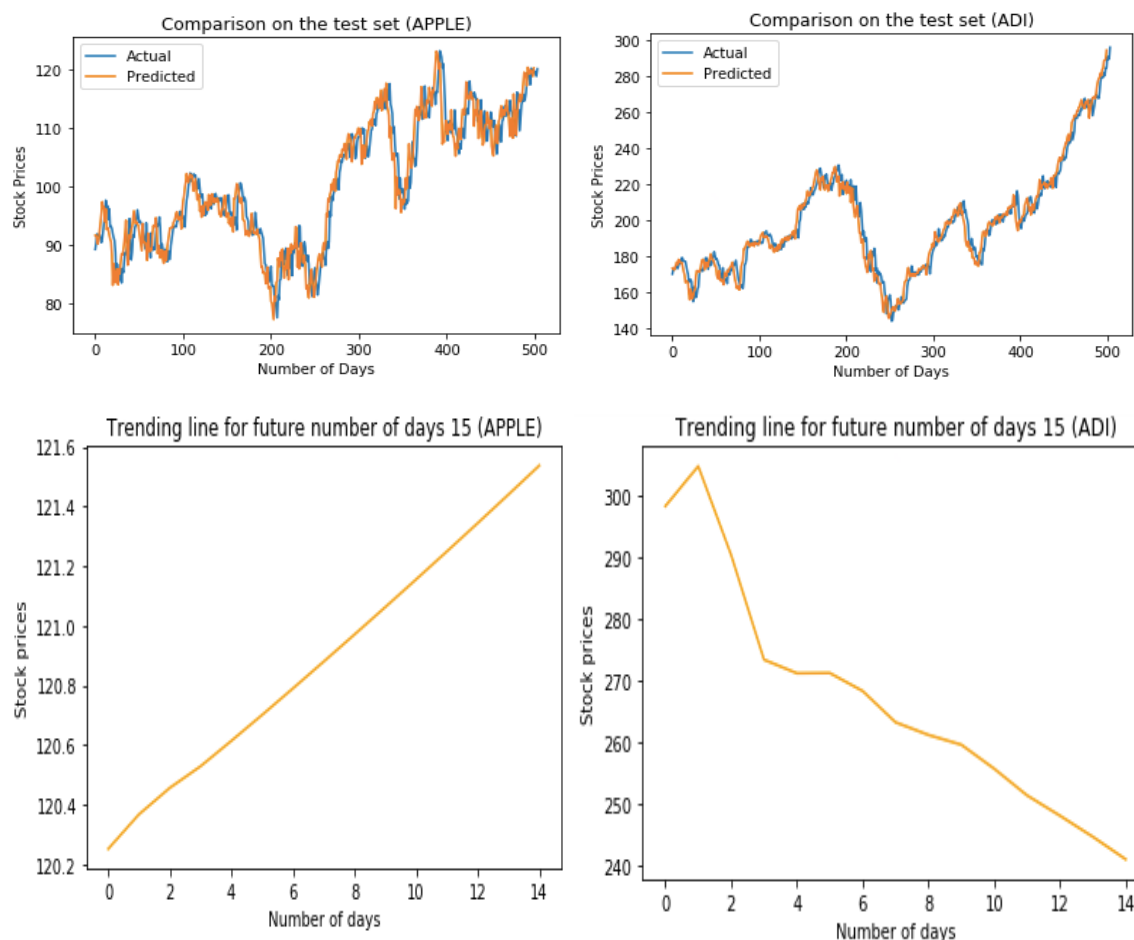
Implementation of machine learning Algorithms:

Note: The implementation of machine learning algorithms are done only on one company data set, to show the implementation.

Linear Regression:

Linear regression is a predictive mode technique which is well-known and well understood machine learning algorithm which investigates the relationship between a dependent and independent variable. *Using this relationship between variables, the aim is to find best fit line or the regression equation that can be used to make predictions.* Learning a linear regression model means estimating the values of the coefficients used in the representation with the data that is available. Linear regression performs the task to predict a dependent variable value (y) based on a given independent variable (x). So, this regression technique finds out a linear relationship between x (input) and y(output). Hence, the name is Linear Regression. If we plot the independent variable (x) on the x-axis and dependent variable (y) on the y-axis, linear regression gives us a straight line that best fits the data points. This predictive modeling is primarily concerned with minimizing the error of a model or making the most accurate predictions possible.

Amazon:
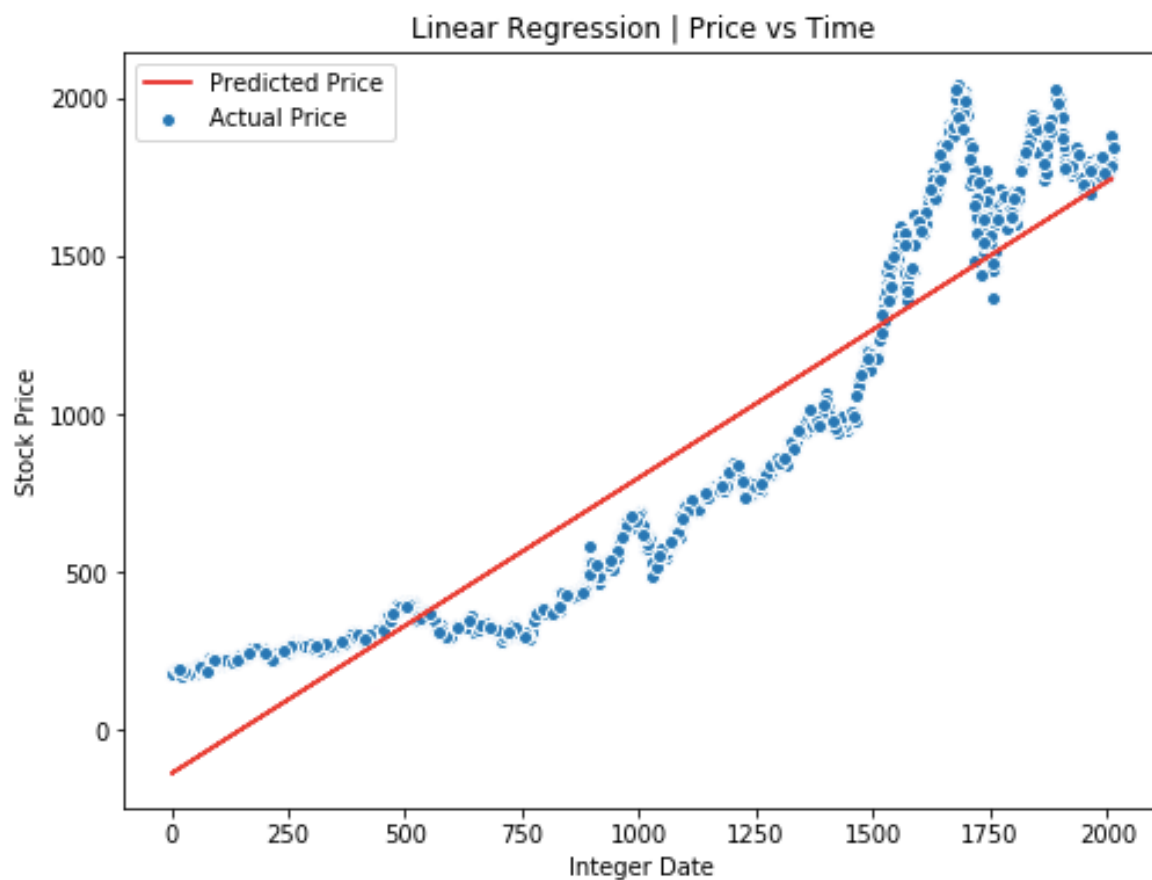
Polynomial Regression:

Polynomial Regression is a form of linear regression in which the relationship between the independent variable x and dependent variable y is modeled as an *nth* degree polynomial. Polynomial regression fits a nonlinear relationship between the value of x and the corresponding conditional variable y. It **fits a polynomial equation on the data with a curvilinear relationship between the target variable y and the independent variables x.**
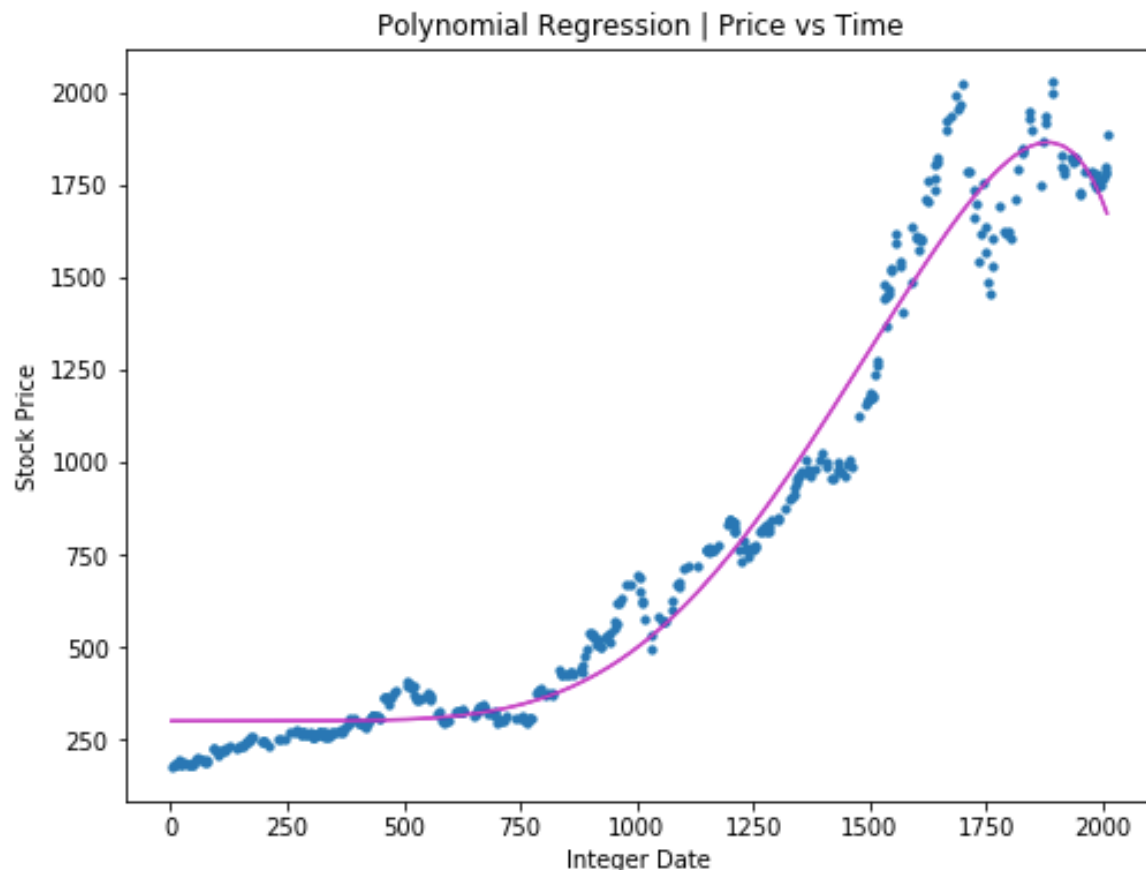
4 – Results

Comparisons and Effects of companies with respect to their supply chain partner:

Facebook & Accel

The graphs are showing the comparison of stock prices of Facebook and ACCEL. It's noteworthy that, the changes in the trend of Facebook are greatly influencing the trend of ACCEL. Furthermore, Facebook's stock price was lower between the timeline of 200 to 300 days. Similarly, ACCEL's stock price went down in a period of 200 to 300 days. Moreover, the similar downfall of stock prices of Facebook and ACCEL is noticeable between the timeframe of 80 to 100 days. Therefore, ACCEL's trend line is lower so as Facebook between the timeline of 400 to 500 days.

Since ACCEL's trend is fluctuated by Facebooks trend its ultimately showing similar trend status. Thus for the next 15 days, the system has predicted trend status for Facebook and ACCEL going up.

Amazon & CISCO

Amazon and CISCO both companies are leading companies in the world. It's noticeable that even if they have collaborated, there are no significant similarities in their trend such as Facebook and ACCEL. Since both are reputable companies their trend are controlled by many other organizational factors rather than collaboration strands. Moreover, ACCEL is not a renowned company it easily gets dominance by its collaborated & eminent company Facebook. Since Amazon and CISCO are not following any pattern in their trend, the system has predicted for the next 15 days a distinct trend status for Amazon and CISCO

Apple & ADI

In the case of Apple and ADI, it's not following any significant pattern in terms of their trend status. Since ADI doesn't have many shares with Apple it's evident that it's not going to follow Apple's pattern of the trend.

Experimental results of LSTM

Company	Model	Previous steps	Layers	Hidden Nodes	Activation	Iterations	R2 on Training	R2 on the Test
Amazon	**LSTM**	**5**	**1**	**20**	**Relu**	**100**	**0.996**	**0.892**
Amazon	LSTM	20	1	50	Relu	100	0.978	0.556
Amazon	LSTM	30	1	30	Relu	100	0.986	0.686
Amazon	LSTM	15	1	30	Sigmoid	100	-10.2	-92.10
Cisco	LSTM	15	1	30	Relu	100	0.934	0.495
Cisco	**LSTM**	**5**	**1**	**20**	**Relu**	**100**	**0.985**	**0.915**
Cisco	LSTM	5	1	30	Sigmoid	100	0.974	-3.00
Cisco	LSTM	30	1	50	Relu	100	0.888	0.0888

Company	Model	Previous steps	Layers	Hidden Nodes	Activation	Iterations	R2 on Training	R2 on the Test
Facebook	**LSTM**	**5**	**1**	**20**	**Relu**	**100**	**0.996**	**0.877**
Facebook	LSTM	15	1	70	Relu	100	0.989	0.6924
Facebook	LSTM	30	1	50	Relu	100	0.9739	0.1154
Facebook	LSTM	15	1	30	Tanh	100	0.709	-14.2
Accel	LSTM	15	1	30	Relu	100	0.9457	0.8145
Accel	**LSTM**	**5**	**1**	**20**	**Relu**	**100**	**0.986**	**0.9449**
Accel	LSTM	100	1	50	Relu	100	-3.202	-3.01
Accel	LSTM	10	1	50	Relu	100	0.9643	0.882

Company	Model	Previous steps	Layers	Hidden Nodes	Activation	Iterations	R2 on Training	R2 on the Test
Apple	LSTM	10	1	50	Relu	100	0.9756	0.8153
Apple	**LSTM**	**5**	**1**	**20**	**Relu**	**100**	**0.98834**	**0.9161**
Apple	LSTM	30	1	50	Relu	100	0.90841	0.2355
Apple	LSTM	15	1	30	Tanh	100	0.209	-54.2
Accel	LSTM	5	1	20	Relu	100	0.9457	0.8145
Accel	**LSTM**	**5**	**1**	**20**	**Relu**	**100**	**0.986**	**0.9449**
Accel	LSTM	30	1	50	Relu	100	-10.202	-4.01
Accel	LSTM	10	1	50	Relu	100	0.9143	0.812

Results of Linear Regression

Company	Model	Slope	Intercept	MAE	MSE	RMSE	R2
Amazon	Linear Regression	0.934594	-133.720	15.469	377.121	19.4196	0.3266

Results of Polynomial Regression

Company	Model	degree	R2
Amazon	Polynomial Regression	10	0.9766

Lessons Learned:

Stock Market are unpredictable and often violate in the short term. No matter how much knowledge you have gained about stock market it is always risky when it comes to predict the future in this unstable world. In this project our aim was not only to learn different DL models but also to know and understand the stock market world.

Changes in the market are based on the market behavior and human phycology, which is not even hard to predict but impossible. Each situation plays a different role. It is not 100 percent confirm that whatever the model we have made now will work permanently. Changes happen in the world and that's how they reflect on the dataset.

From the technical perspective, we have learned that machine learning models are not suitable for predicting stocks. This is because they are not efficient in capturing the varying market trend, as market is mostly random and ideal conditions hardly exist. Also, they are not efficient in capturing and understanding the long-term market trends and fluctuations that are used to predict the future of stocks. For example, as seen in Regression models, if the training data is consistent with less fluctuations, the line will fit the data very well, but if the training data has lot of fluctuations, it will fit the data poorly as it is not intelligent enough to learn the trends. Also, if higher order polynomials are used, it is more likely that it will overfit the training data since it tends to learn the training data well but performs poorly on test data. Therefore, it is quite often the case that it is situational of when the right order polynomial best fits the data without overfitting. Also, if the model fits the data poorly, the mean squared error is large in case of Regression models.

Challenges Faced:

- Gathering Data of supply chain partners
- Data Reshaping, For input layer LSTM
- Hyperparameter Tuning
- Prevention of Overfitting in LSTM

5 – Conclusion

There are different theories about the behavior of markets. One of them is the efficient market hypothesis, which states that the stock movements are essentially a random walk, although not 100% random. In a nutshell it means that instead of exact prediction, we try to reliably predict the market.

Practically speaking, **Deep Learning** is a subset of **Machine Learning** *that achieves great power and flexibility by learning to represent the world as nested hierarchy of concepts, with each concept defined in relation to simpler concepts, and more abstract representations computed in terms of less abstract ones. Deep learning does input to target mapping via a deep sequence of simple data transformation. As seen in the implementation of LSTM,* stacking layers makes the model deeper which helps the model to store more complex information and trends. As compared to traditional machine learning models, it can easily process an entire sequence of data and introduces the memory cell, which make the network able to effectively associate

memories and input remote in time. The gates regulate the flow of information into and out of the cell and are responsible for keeping track of the dependencies between the elements in the input sequence. It allows automated feature selection capabilities to select best features which give better insights. And as known popularly, these models can handle large amount of data without worrying about the hardware resources required for execution.
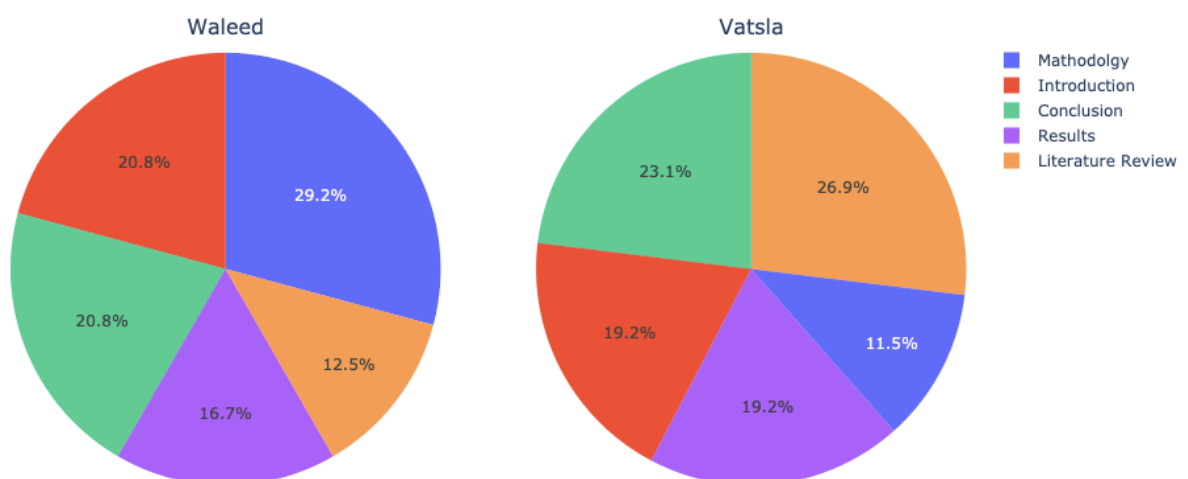
This timeline chart describes how we have used divide and conquer approach to achieve our goal.

Timeline:
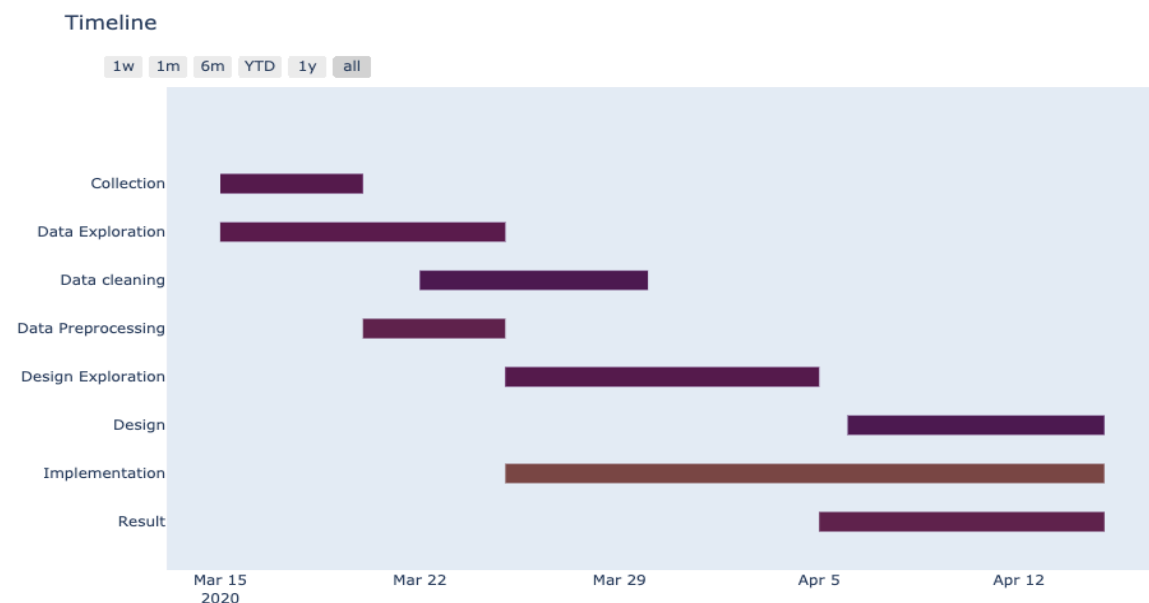
Work done by team members:

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