Hiding Behind The Contagion

COSC2669, Case Studies in Data Science

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A detailed analysis to understand and answer the true reasons behind the fall in stock prices of various companies during the pandemic.

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1 INTRODUCTION

When the World Health Organisation declared COVID-19 as a global pandemic in March 2020, countries braced themselves for *economic shockwaves*, and reluctantly locked down to contain the spread. Consequently, some of the biggest economies of the world shrank by as much as 20% during the same period. Companies big and small, from far and wide, reported crippling sales and bad business, their stocks plummeting to unprecedented levels. While this was expected as aforementioned, some perpetually loss-making companies, however, were pointing at the situation to hide their bad decisions and mistakes from the past, and escape investor scrutiny.

This report attempts to develop a *data driven* approach to help investors steer clear of such manipulative narratives presented by companies. The analysis has been demonstrated with a dataset of stock prices of the companies trading at the National Stock Exchange of India, and in addition to the analysis, an LSTM model has been developed to help investors predict future prices during these uncertain times.

2 PROBLEM STATEMENT

2.1 MOTIVATION - THE CASE OF HERTZ

When the hundred year old, American car rental company, *Hertz*, filed for bankruptcy in May, 2020, it cited the pandemic for declining sales, and bad business. Even a cursory analysis of its stock prices and global revenues, however, revealed a contradicting narrative.

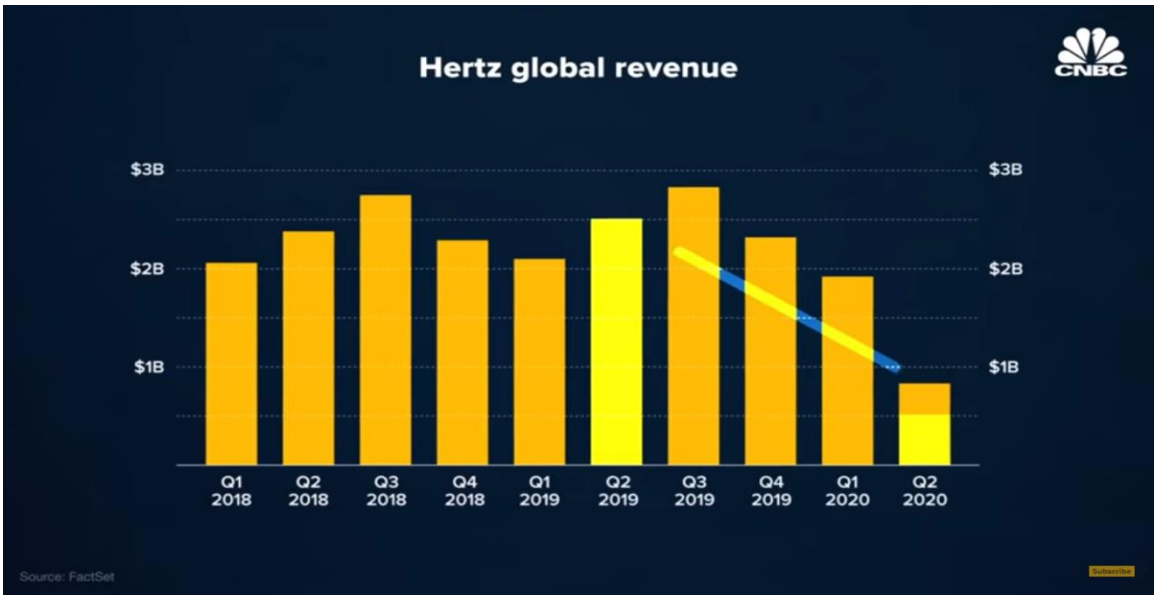

Figure 1 : Global revenues of Hertz (courtesy of CNBC's YouTube Channel)

As seen above, Hertz had been witnessing global revenues declining by 67% at least since the second quarter of 2019, seven months ahead of the onset of the pandemic. Hence, it can be inferred that the pandemic dealt a deathblow to a company that was already debilitated by other reasons. A later analysis detailed a range of reasons, dating back to as early as 2012, like the decision to shift company headquarters to Florida, and ineptitude at reinventing itself as the true causes of bankruptcy.

2.2 PROBLEM STATEMENT DEFINITION

Will this pandemic become the scapegoat of companies that were already reeling under losses? If yes, how can investors/stakeholders discern the truth from deliberate attempts to keep them in the dark?

As mentioned earlier, stock prices of companies took a great hit the first time a lockdown was announced around the March of 2020.

This report aims at answering two questions -

- Is ***the slump***, witnessed in the stock prices of almost every company around March, 2020, only a product of the lockdown?
- And are there are signs of irrecoverability much akin to the case of Hertz discussed above?

3 METHODOLOGY

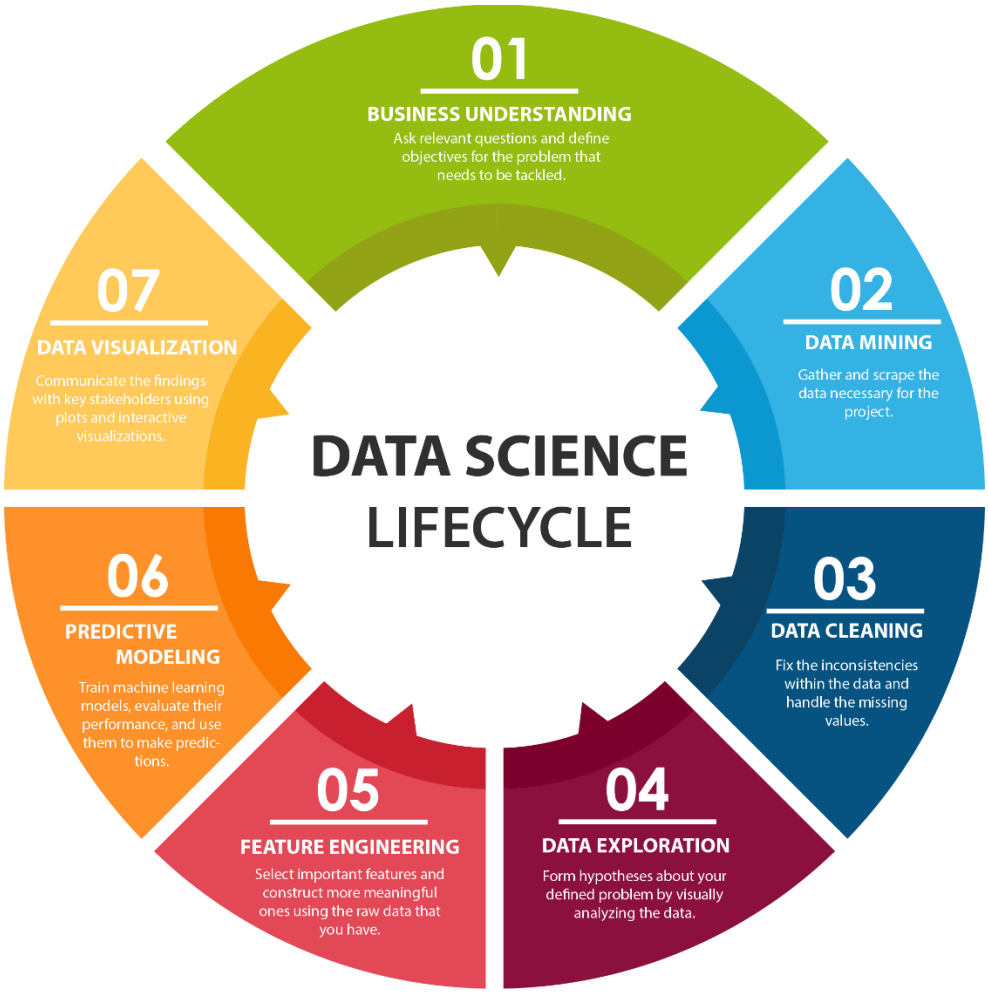

Figure 2 : Data Science Life Cycle

3.1 DATA COLLECTION

The dataset used for understanding & uncovering the truth behind the oscillations of stock prices of various companies during pandemic was pulled from this Kaggle repository: Nifty-50 Stock Market Data. The data repository provides the stock prices and numerous other components related to trading of the last 20 years. The dataset consists of 15 features with 226,804 instances.

3.1.1 CHOICE OF VARIABLES AND METRICS

The primary feature on which the analysis is conducted is VWAP: Volume Weighted Average Price which gives overall average price a security has traded throughout the day based on both volume and price. [1] VWAP trends have been visualised for the current and previous fiscal years and unusual points of rise and fall have been marked and investigated. Percent change in VWAP prices between successive Mondays, have been visualised, and points that lie more than two standard deviations below the mean, and on the defined period, have been carefully investigated to unmask the truth. In the modelling and prediction, we are predicting the close price of the stock.

S.No.	Variable	Metrics
1	Symbol	Unique series of letters assigned to a security for trading purposes [2]
2	Previous Close	Refers to the prior day's final price of a security when the market officially closes for the day. [3]
3	Open	The open is the starting period of trading on a securities exchange or organized over-the-counter market. [4]
4	High	The highest price at which a stock traded during the course of the trading day. [5]
5	Low	Lowest price at which a stock traded during the course of the trading day. [6]
6	Last	The final quoted trading price for a particular stock, or stock-market index, during the most recent day of trading. [7]
7	Close	The close is a reference to the end of a trading session in the financial markets when the markets close for the day. [8]
8	VWAP	The volume weighted average price (VWAP) is a trading benchmark used by traders that gives the average price a security has traded at throughout the day, based on both volume and price. [1]
9	Volume	Trading volume is a measure of how much of a given financial asset has traded in a period of time. [9]
10	Turnover	Share turnover is a measure of stock liquidity calculated by dividing the total number of shares traded over a period by the average number of shares outstanding for the period. [10]
11	Deliverable Volume	The quantity of shares which actually move from one set of people (who had those shares in their demat account before today and are selling today) to another set of people (who have purchased those shares and will get those shares by T+2 days in their demat account).

3.2 DATA WRANGLING

The Nifty-50 Stock Market Data is a time series data originating from 1 January 2000. The original data is too huge for our analysis purposes, so we have reduced the dataset to the time period around the pandemic. As we are exploring the days and the stock value on particular day, the index of the dataset has been set to 'datetime'. It was observed that all the stocks in this dataset were of the Equity Series and this constant feature was dropped. No missing values were found in the dataset which indicates that it there was no need for data imputation and dropping. Inconsistencies and sanity checks were performed on the dataset.

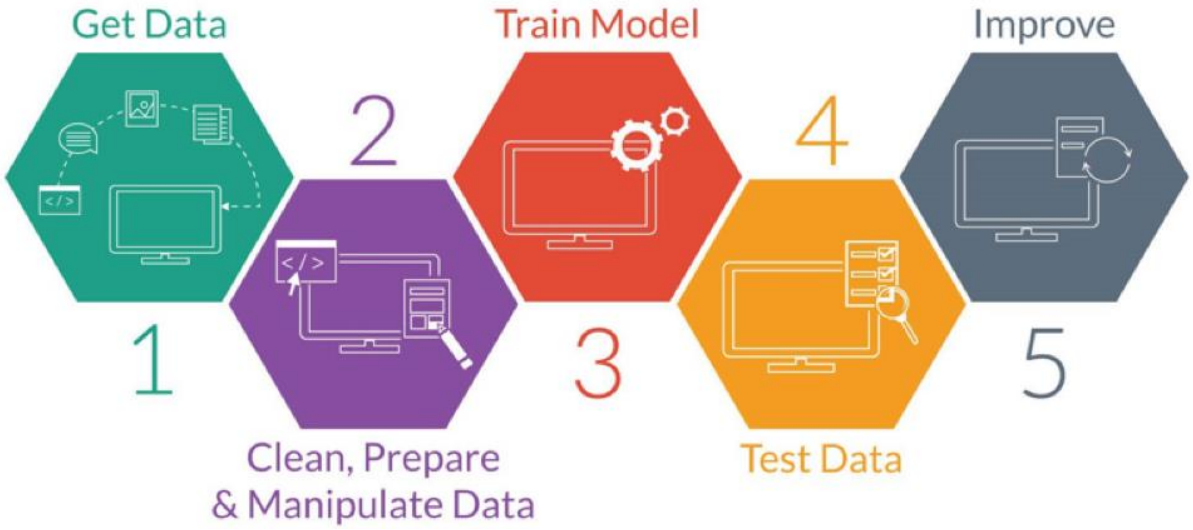

Figure 3 : Methodology

3.3 ANALYSIS

The *analysis* primarily deals with answering the questions aforementioned in section 2.2. The wrath of the pandemic on the stock prices of companies seem inevitable. Hence, to be acquitted of malpractices, the stock prices of companies must exhibit a period of stable recovery post a defined period on the timeline. It is also necessary that companies display a period of stability in prices before the pandemic set in.

- Volume Weighted Average Price gives the average prices a security has traded at on any day, based on both volume and price, and has been primarily considered for the analysis.
- Fundamental to the analysis is the definition of a period during the pandemic for which the claims of the companies have to be validated against its past. With India locking down around the mid of March, a brief period around it has been identified.
- Trends in VWAP have been visualised for the current and previous fiscal years and unusual points of rise and fall have been marked, and investigated.
- Percent change in VWAP prices between successive Mondays, has been visualised, and points that lie more than two standard deviations below the mean, and on the defined period, have been carefully investigated to unmask the truth.
- Periods of stability and recovery are expected prior to and beyond the defined period.

4 SECTOR-WISE ANALYSIS

As an application of the methodology defined in the preceding subsection, a sector-wise analysis has been performed on the selected dataset.

4.1 BANKING & FINANCE

4.1.1 INDUSIND BANK

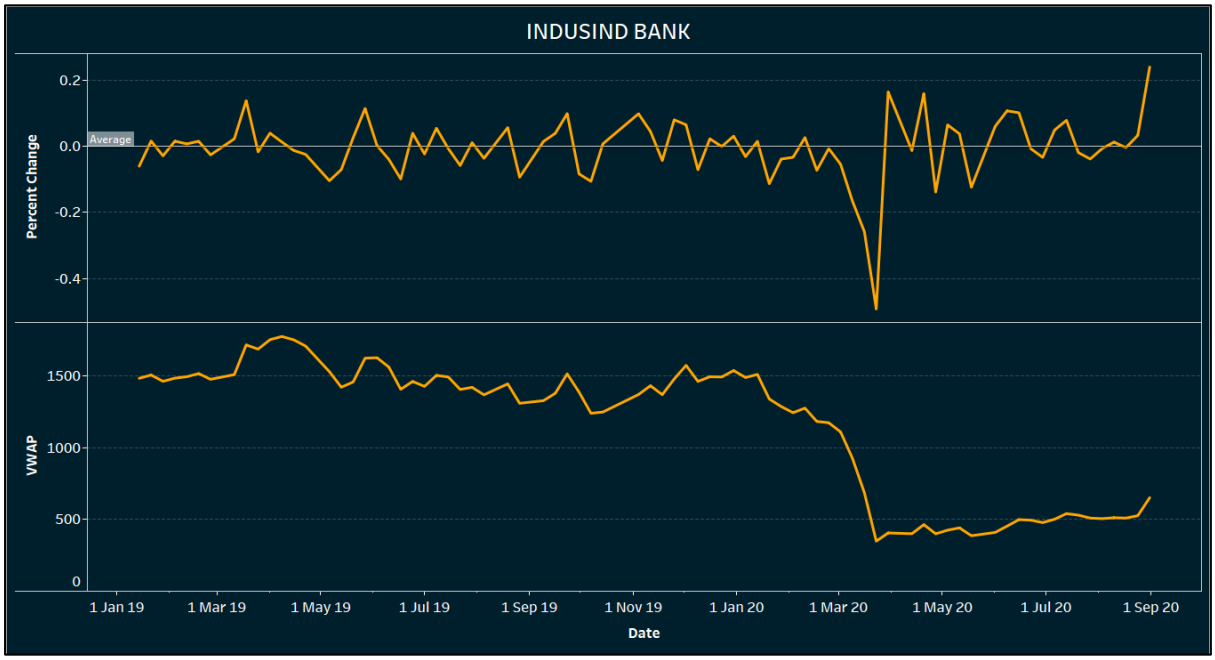

Figure 4 : Trends in %change in VWAP and trends in VWAP of IndusInd Bank

In Banking & Finance sector stock performance of nine companies in Nifty50 is analysed. The graph above shows the VWAP trends of IndusInd Bank, which exposes an expected slump in share prices around mid-March. Similarly, the plot of percent change in successive VWAP prices show the sharpest drop by almost 40% during the pandemic days, seems to be a lot severe as compared to the price of stock before pandemic i.e. March. The slump can hence be attributed to bank's smaller size and higher risk exposure accelerated by the pandemic.

The financial results of IndusInd Bank stated that in Q2 2019 i.e. from July – September, there was 52.22 per cent year-on-year rise in consolidated net profit and the price of stock was stable during that period. Similarly, in Q3 2019 i.e. October – December, there was 33 per cent rise on a yearly basis profit of bank and the stock price was stable in that period. For Q4 i.e. January to March, there was 16.18 per cent year-on-year (YoY) fall in profit and the stock price is decreased significantly in March.

After analysing all the factors, it was observed that the performance and stock price of bank before pandemic i.e. from January 2019 – February 2020 was stable, but suddenly in March the stock price of bank decreased significantly which leads to the possibility that the IndusInd bank is affected by pandemic.

4.1.2 ICICI BANK

A very similar narrative can be fit on the trends observed of one of India's leading lenders ICICI Bank. At a negative 29%, the pandemic slump seems to be a lot severe than the prices before pandemic. The depression is preceded by stability, and recovery is imperceptible prima facie, but is not negligible. After comparing the performance of stock prices with financial results it was observed that in Q2 2019 i.e. (July to September) bank posted 27% fall in net profit but the stock prices during that period were constant. Similarly, in Q3 2019 i.e. (October to December) the bank posted 2.75% fall in net profit, but it was observed that stock prices were increasing during this period. In Q4 2019-20 i.e. (January to March) bank posted 26% rise in net profit and it was observed that stock prices were increasing till February 2020 but suddenly in March 2020 stock price decreased significantly by 30% and this was the period when lockdown started in India. From all the analysis it can be concluded that stock price of ICICI bank was affected by COVID-19 pandemic.

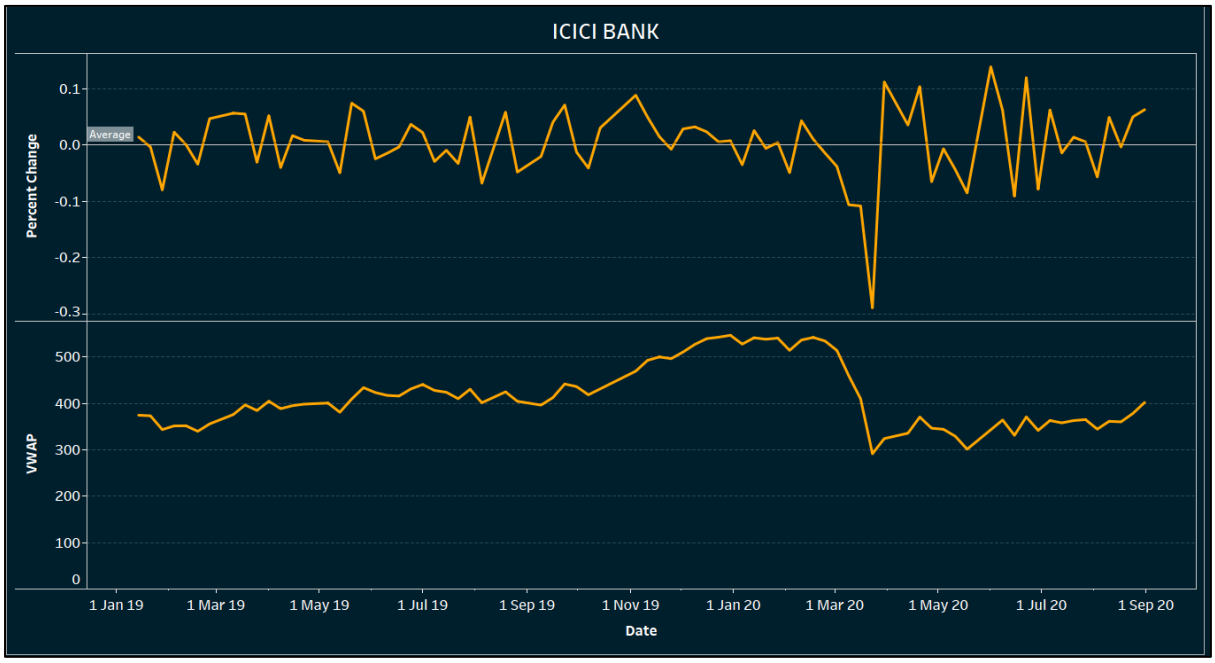

Figure 5 : Trends in %change in VWAP and trends in VWAP of ICICI Bank

Table 1

Company	Percent Decrease
IndusInd Bank	40%
Axis Bank	36%
Bajaj Finance	33%
Bajaj FinServ	32%
ICICI Bank	29%
HDFC Bank	22%
Kotak Bank	20%
SBI Bank	17%
HDFC	16%

Similar pattern was observed for all the other companies in Banking & Finance domain. After analysing all the companies in Banking & Finance sector it was observed that stock price of almost all the companies in this sector were severely affected by pandemic. From all the companies in this sector, IndusInd Bank was most affected with almost 40% decrease in stock price and HDFC was least affected with almost 16% decrease in stock price.

4.2 PHARMACEUTICAL

4.2.1 CIPLA

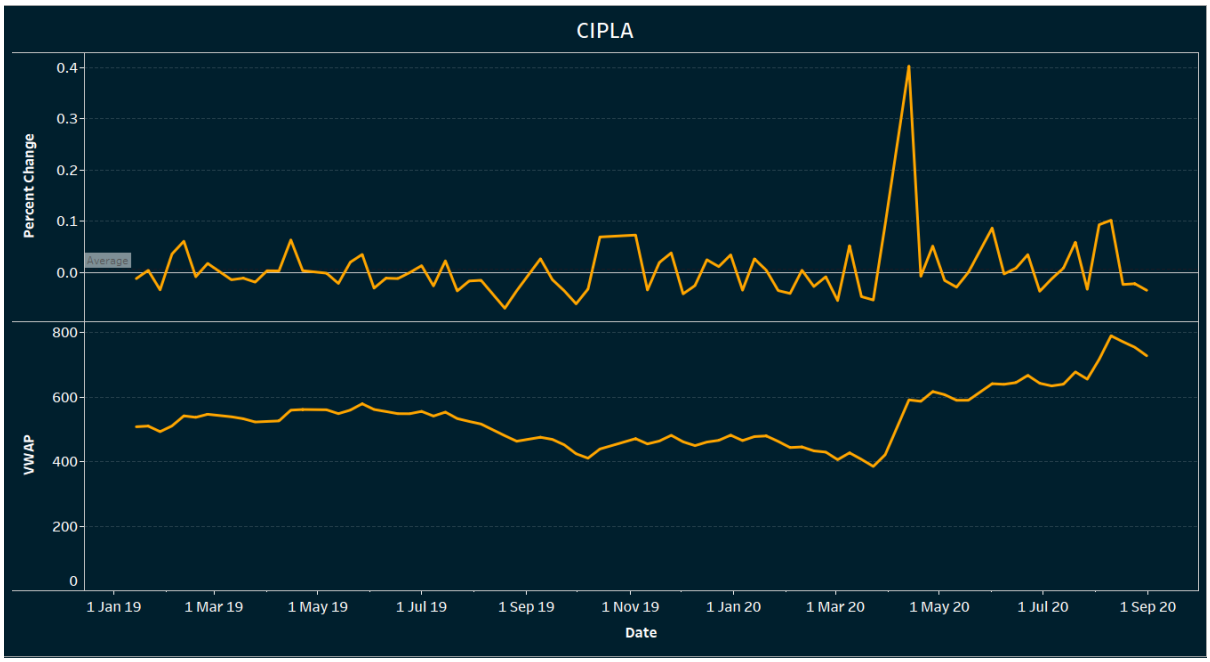

Figure 6 : Trends in %change in VWAP and trends in VWAP of Cipla

In Pharma sector stock performance of two companies in Nifty50 is analysed. The graph above shows that slump observed previously goes unnoticed as a small dent on the canvas of one of India's leading medicine maker, Cipla Pharmacies. Comparatively, even the sharpest percent change in VWAP prices is less than 10%.

The financial results of Cipla stated that in Q2 2019 i.e. from July – September, there was 25 per cent year-on-year rise in consolidated net profit and the price of stock was stable during that period. Similarly, in Q3 2019 i.e. October – December, there was 13 per cent rise on a yearly basis profit of company and the stock price was stable in that period. For Q4 i.e. January to March, there was 17 per cent year-on-year (YoY) fall in profit and the stock price is decreased significantly in March.

After analysing all the factors, it was observed that the performance and stock price of CIPLA before pandemic i.e. from January 2019 – February 2020 was stable, but suddenly in March the stock price of CIPLA initially decreased by small amount and then significantly increased because of the medicine demand which lead to improve in the profits.

4.2.2 SUNPHARMA

Following Cipla closely on the heels, Sun Pharma recorded a dent of just 15% that was later nullified by a whopping 40% recovery. There hence seems to be no space for accusations of manipulative narratives.

The financial results of SunPharma stated that in Q2 2019 i.e. from July – September, there was 16.10 per cent year-on-year rise in consolidated net profit and the price of stock was stable during that period. Similarly, in Q3 2019 i.e. October – December, there was 26.44 per cent rise on a yearly basis profit of company and the stock price was stable in that period. For Q4 i.e. January to March, there was 52.63 per cent year-on-year (YoY) fall in profit and the stock price is decreased significantly in March.

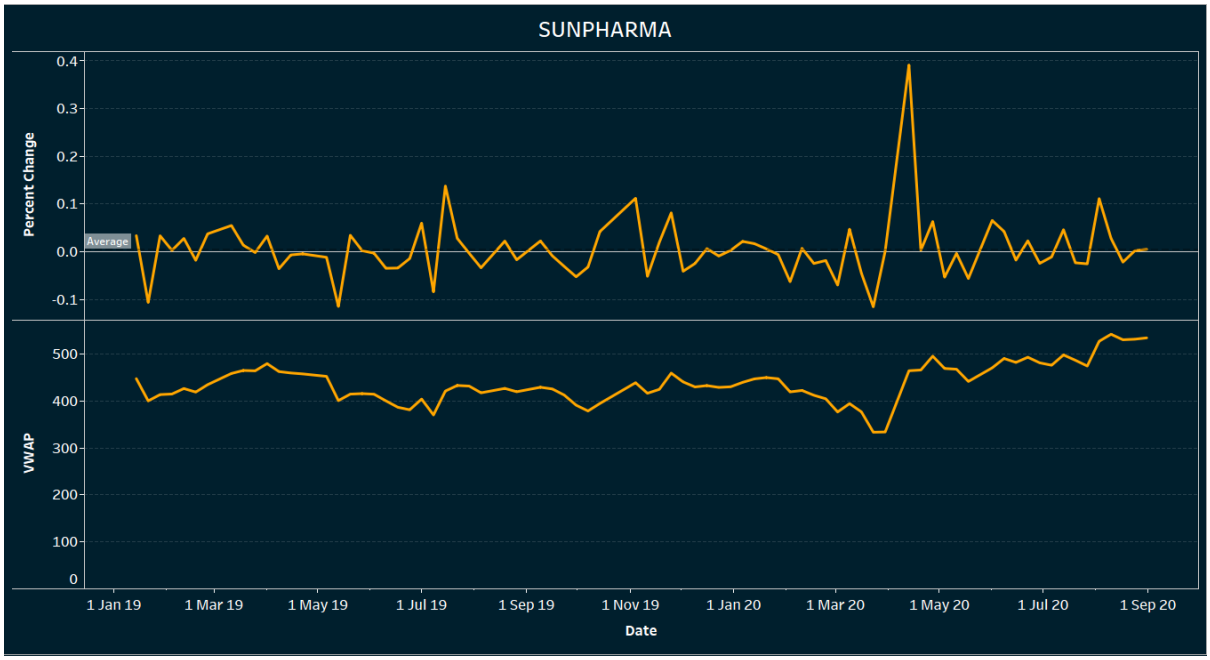

Figure 7 : Trends in %change in VWAP and trends in VWAP of SunPharma

After analysing all the factors, it was observed that the performance and stock price of Sun Pharma before pandemic i.e. from January 2019 – February 2020 was stable, but suddenly in March the stock price of SunPharma initially decreased by small amount and then significantly increased because of the medicine demand which lead to improve in the profits.

4.3 INFORMATION TECHNOLOGY

4.3.1 TCS

As India's tallest outsourcing company, the analysis of VWAP trends on TCS sheds light on the overall performance of similar companies in the sector and the problems faced during the pandemic.

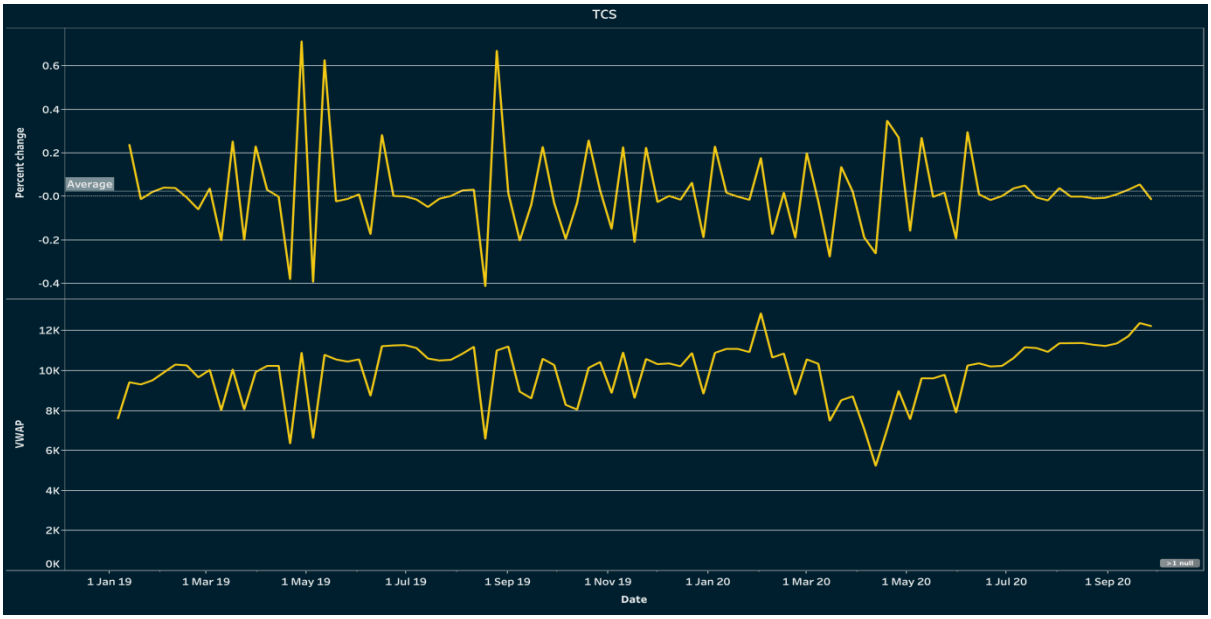

Figure 8 : Trends in %change in VWAP and trends in VWAP of TCS

Unlike other sectors that showed a drastic drop in prices around the pandemic period, the VWAP trends of TCS shows a drop that cascades until it hit rock bottom around the mid of April. The drop however seems to have started around February, a month prior to the declaration of lockdown. At its worst, the company had lost almost 50% of its share price, from a 12k around mid February to just less than 6k around mid April. Nevertheless, the company seemed to have quickly regained the loss thanks to a stable recovery witnessed beyond May. The share prices seemed to be back to pre-Covid levels. This quickness in recovery is reflective of the company's capability to establish work-from-home protocols efficiently for its workers.

This observation made from the VWAP plots above is corroborated by the figures posted by the company during its quarterly press releases. TCS reported Q2 profits growth of 4.9% to INR 8433 crores, and revenue by 3% to INR 40,135 crores.

Hence, TCS seems to be a safe bet for the investors during the pandemic.

4.3.2 TECHMAHINDRA

Being at number 5 of the top 10 outsourcing companies in India, analysis of the stock prices of TechMahindra would help understand the performance of mid-sized players in the sector.

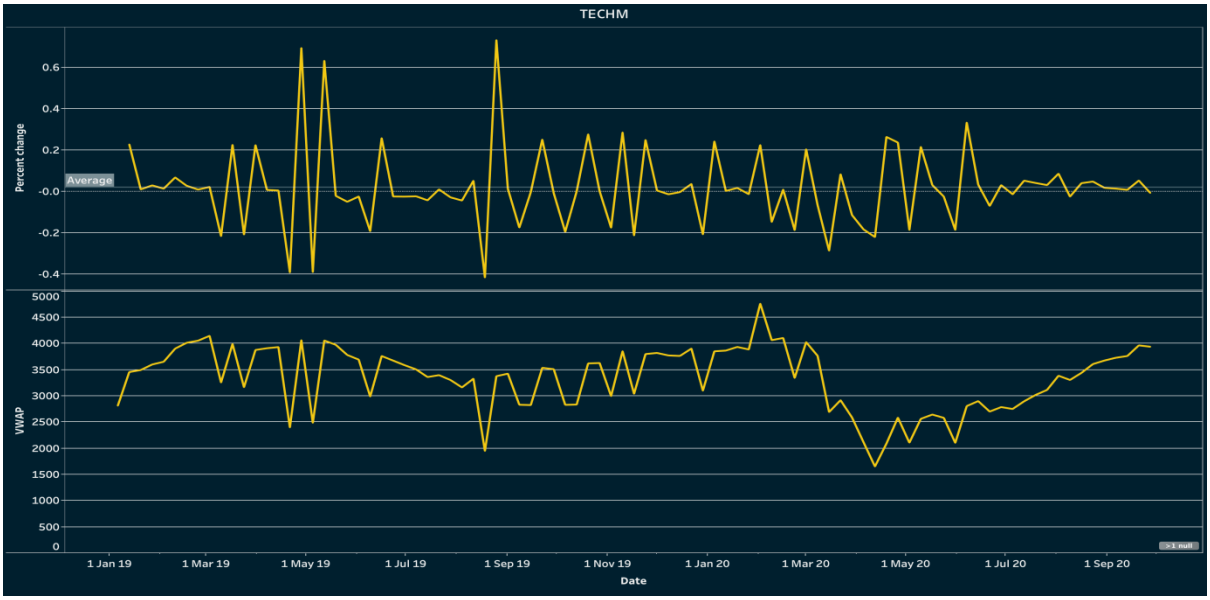

Figure 9 : Trends in %change in VWAP and trends in VWAP of TechMahindra

A cursory analysis of the trends show very similar patterns in the fall and recovery of share prices between TechM and TCS. Yet another cascading fall can be seen here, albeit the strides are longer than that of TCS'. At its worst, TechM had lost almost 44% in its share price from a pre-COVID high of almost INR 4500. And akin to TCS, it displays a strong rallying in the period beyond May. However, unlike TCS, the prices haven't reached the pre-COVID levels at least by the middle of September.

This observations from the above plot are once again supported strongly by the figures released to the press by the company. For the second quarter ending September, the company posted a 4.8% increase in revenues compared to its previous quarter that was marred by the lockdown.

It can hence be concluded that TechMahindra has nothing to manipulate to its investors.

4.4 ENERGY

4.4.1 ONGC

The Indian energy market is still majorly held by the government, and hence manipulation or fear of investor scrutiny is highly unlikely. However, analysis of a state-owned oil and natural gas corporation could reveal trends in the market that could later be used to compare the statements made by private players in the sector.

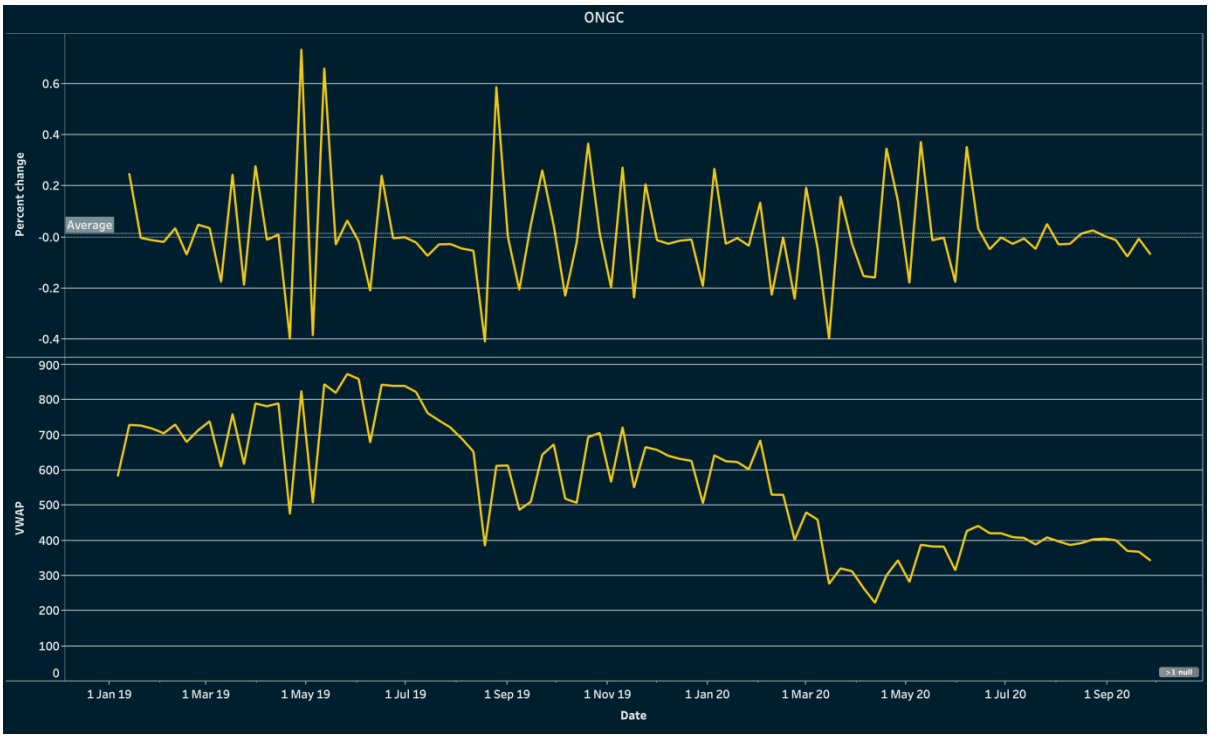

Figure 10 : Trends in %change in VWAP and trends in VWAP of ONGC

Stock prices of the company have started tumbling down even before the country locked down. At its worst in mid-April, the company had lost almost 71% of its price from the pre-COVID period. And very much unlike other sectors explained above, there seems to be a very dull recovery of the sector. Supporting the claims from the plots, the press releases by the end of second quarter of the current fiscal year reports a profit of only INR 6263 crores, which is almost 24.2% lower than the profit reported for the previous quarter.

Energy, unlike other sectors, depends heavily on the global demand for its rally. A weak oil demand coupled with lower energy consumption at an industrial level during the pandemic could have very well contributed to the deep slump and the dull recovery witnessed above.

4.4.2 GAIL

As one of India's well established and reputed organisations, GAIL or Gas Authority of India Limited has been carrying the energy aspirations of the country for almost half a decade now.

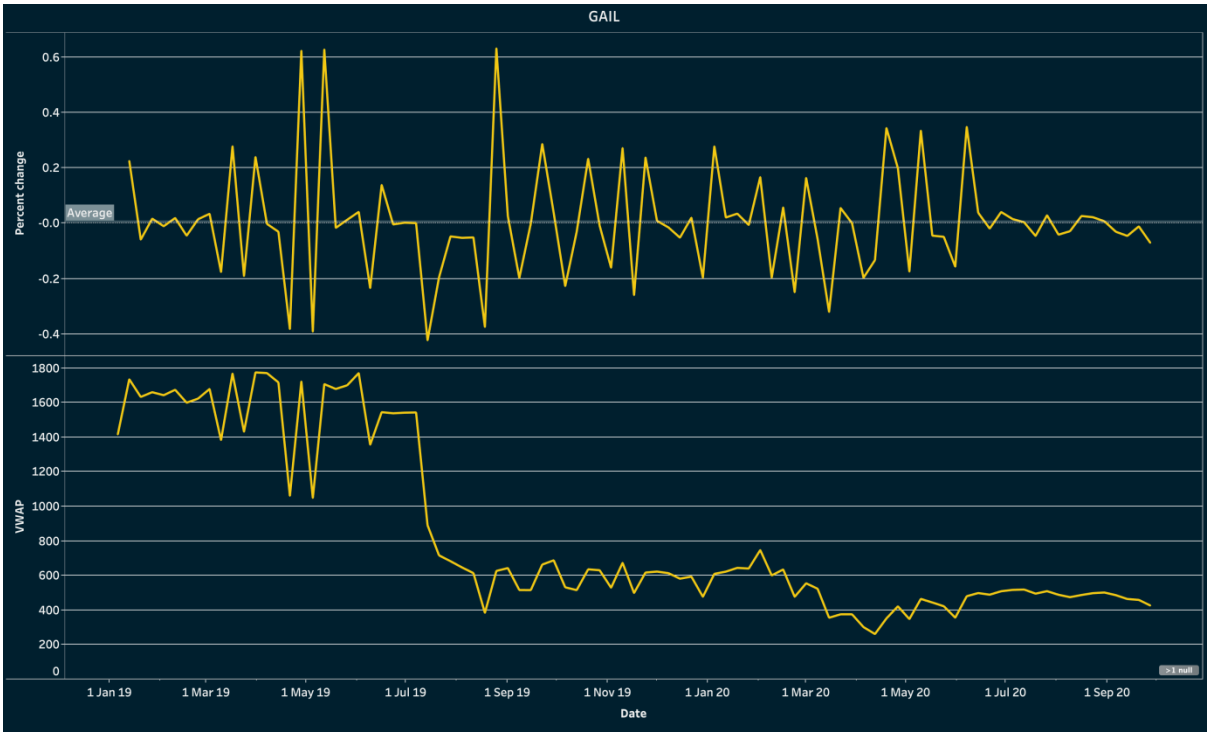

Figure 11 : Trends in %change in VWAP and trends in VWAP of GAIL

A cursory observation of the stock prices of GAIL reveal a pathetic, unrecoverable picture of the company since the pandemic. A deeper look into the plot of %change in VWAP reveal stability in prices at the moment, prices of the stock have fallen by almost 75%, and seem highly unrecoverable. While this may ring the alarm for its investors, a look into the pre-COVID periods reveal times of stability. Hence issues external to COVID can be discarded as reasons for the fall in prices. As discussed earlier under ONGC, the reason for fall could only be attributed to the pandemic, and its associated factors.

All arguments mentioned above are corroborated by the recent press releases from the company. Consolidated revenue of the company declined 34 per cent YoY to Rs 12,180.62 crore. The performance of the company was impacted due to nationwide lockdown, GAIL (India) said in a release. However, it added that the same is expected to reach to normal levels during upcoming period in FY 2020-21. Segment wise, revenue from natural gas marketing declined 37.83 per cent YoY to Rs 11,635.38 crore. Likewise, topline from transmission services and city gas slipped 12. Hence, investors need to stay patient as requested by the company and witness the unfolding of the situations as the world gets adjusted to the new normalcy.

4.5 AUTOMOBILE

Automobile industry of any country is almost the backbone of the country as it provides stability in terms of economy and producing jobs in a country. According to ‘Make In India’ [12], the automobile sector contributes 7.1% in India’s GDP. The automobile sector in the NIFTY-50 dataset consists of wide range of companies: Bajaj-auto, Eicher motors, Hero Moto Corp, Mahindra & Mahindra, Maruti and Tata Motors. There are various aspects of an automobile company starting from designing & manufacturing spare parts and full-fledged vehicles; sales and marketing etc. The firms in this dataset are not small-scale firms but they contribute so much in the GDP of India.

So, it can be argued that this sector is crucial in terms of investment and trading. It should be noted that not all companies manufacture their products. However, the parts are assembled at major plants. But how could the assembly be done if there are no parts available? This was the story behind oscillation of stock prices for these firms. The common trail of all these firms is the obstruction of transportation from one country to another. It is a commonly known factor that most of the spare parts are manufactured in China and assembled in the respective countries. But due to the obstruction in transportation, the spare parts were not available for assembling. On top of it, the sudden announcement of lockdown in the country in mid-March meant that the workers who were working in the plants were laid off by the firms for obvious reasons like cost-cutting. VWAP trends of these firms are visualized and analyzed keeping in mind the seasonality and cyclicity. It is interesting to analyze that in the beginning of February, for all these firms, the stocks were on highest level in the whole time period. Afterwards, they all follow downwards trend till April.

4.5.1 TATA MOTORS

The below graph shows the VWAP trends and percent change trends of Tata Motors, which exposes an expected slump in share prices around mid-March. The reason for the huge slump was the decline in the production by 75.29% in comparison to last year which include a total of both passenger and commercial vehicles.

In particular, it was the commercial vehicles production which got decline by 90.21% whereas the passenger vehicles production took a hit by 34.41% which is understandable due to lockdown restrictions imposed.

In Q1 2019, there was a decline of 19% in the stock performance. Similarly, there was a decline in the Q2 by 23.5%. From Q3 2019, the stock started performing better with upwards trend ending by 47% profit. It was Q4 where the stock suffered the most by a huge slump of 62.5%.

After analysing all the factors, it was observed that the performance and stock price before pandemic i.e. from January 2019 – February 2020 was stable, but suddenly in March, the stock price decreased significantly which leads to the possibility that the Tata Motors is affected by pandemic.

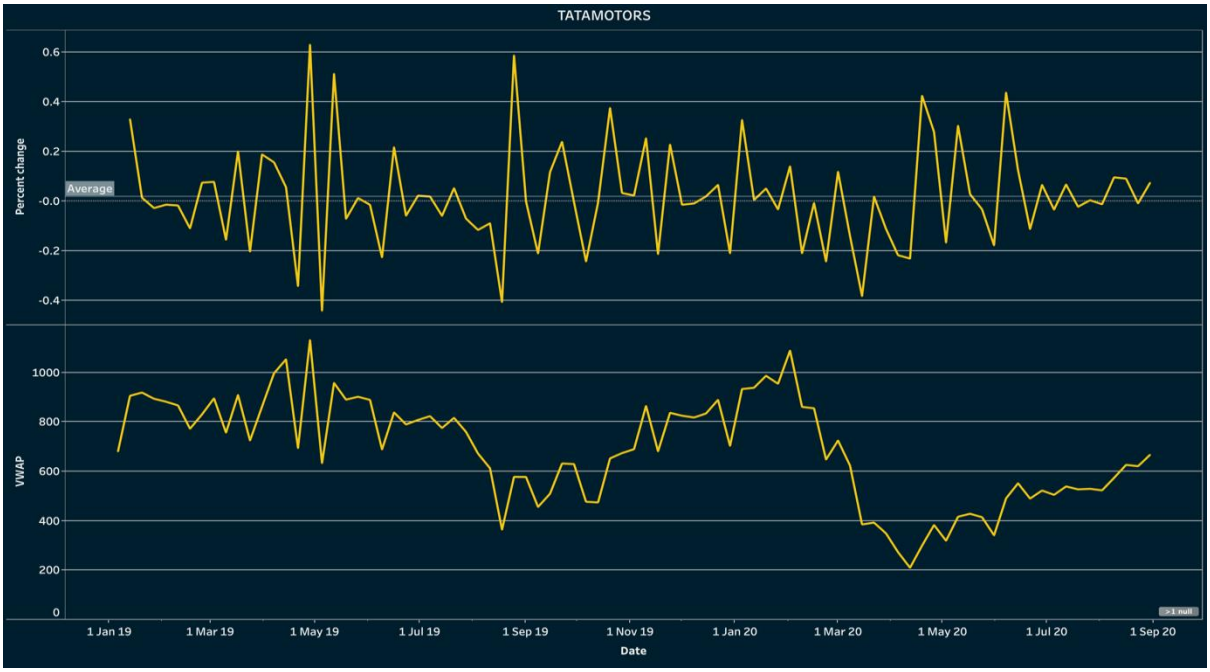

Figure 12 : Trends in %change in VWAP and trends in VWAP of TATA Motors

4.5.1 BAJAJ AUTO

Similarly, the performance of Bajaj-Auto leads one to thinking that there was something which happened during pandemic. By visualizing the VWAP trends and percent change trends in the below graph, the volatile nature of the stock can be attributed to the company's policies. The prices are fluctuating too much which raises questions whether the pandemic has any effect during March 2020.

In Q1 2019, despite too much fluctuations, the quarterly dip was just by 1%. However, there was an increase in performance by 2.5% in Q2 i.e. July-September. From Q3 2019, there was a further increase by 10%. However, it was Q4 where the stock suffered the most by a huge slump of 37%.

After analysing all the factors, it was observed that the performance and stock price before pandemic was volatile but in the end of each quarter, the difference was not too much i.e. from January 2019 – February 2020 was stable, but suddenly in March, the stock price decreased significantly which leads to the possibility that the Bajaj-Auto is affected by pandemic.

Figure 13 : Trends in %change in VWAP and trends in VWAP of BAJAJ AUTO

Table 2

Company	Percent Decrease (in %)
Tata Motors	38.1
Bajaj-Auto	27.5
Maruti	25.1
Mahindra & Mahindra	24.8
Hero Moto Corp	24.5
Eicher motors	20.6

Similar pattern was observed for all the other companies. After analysing all the companies, it was observed that stock price of almost all the companies in this sector were severely affected by

pandemic. From all the companies in this sector, Tata Motors was most affected with almost 40% decrease in stock price and Eicher motors was least affected with almost 20% decrease in stock price.

5 MODELLING

In this section linear regression and LSTM (Long Short Term Memory) models are built to predict the close price of stock market companies. With Linear Regression model as a base model, advanced neural networks LSTM model is built to get more accurate results. The aim was to predict the next day's closing price to help investors to decide a strategy of whether to sell the stock or to buy. Many traders do intra-day trading i.e. they buy the stock in morning at the lowest price and tend to sell it the highest price in a day. So, from the prediction of the next day's closing price, intraday traders can make up a strategy.

5.1 LINEAR REGRESSION

The close price is a numeric attribute and so Linear Regression is used as a base model. Base Linear Regression model without any hyper-parameter tuning reported a Root Mean Squared Error (RMSE) of 80.23 on test data. The figure below shows the results of Linear Regression results.

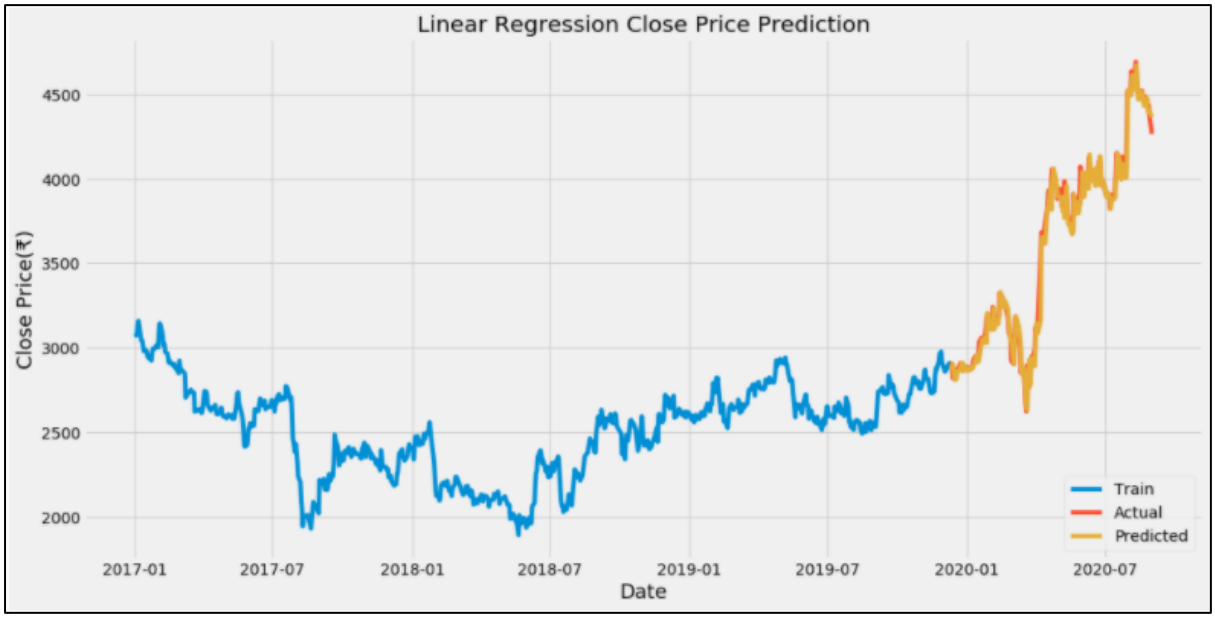

Figure 14 : Linear Regression Close Price Prediction

The above figure displays the results predicted by linear regression model. The blue line represents the training data on which the model is trained. The orange line represents the test data i.e. actual close price and the yellow line represent the close price predicted by linear regression model. It was observed that model is performing quite well with correctly predicting the trend of close price.

5.2 LSTM

LSTM is an effective algorithm to make predictions and processes based on time series data. To process and store historical information, a sequence of data is required. The stock market has tremendously historical data that changes with the trading date, which is time-series data, so when the dataset has a large amount of data, the LSTM model forecasts future stock price over a short-term timeframe with greater precision.

The best way to reduce the rate of error and improve the accuracy of the model is to provide feature scaling and data normalisation. There are distinct types of data in the given data set. Here, I put all the characteristics selected on the same scale. However, none of the traits overpower others. Below

the code, a snapshot is used to scale up the results.

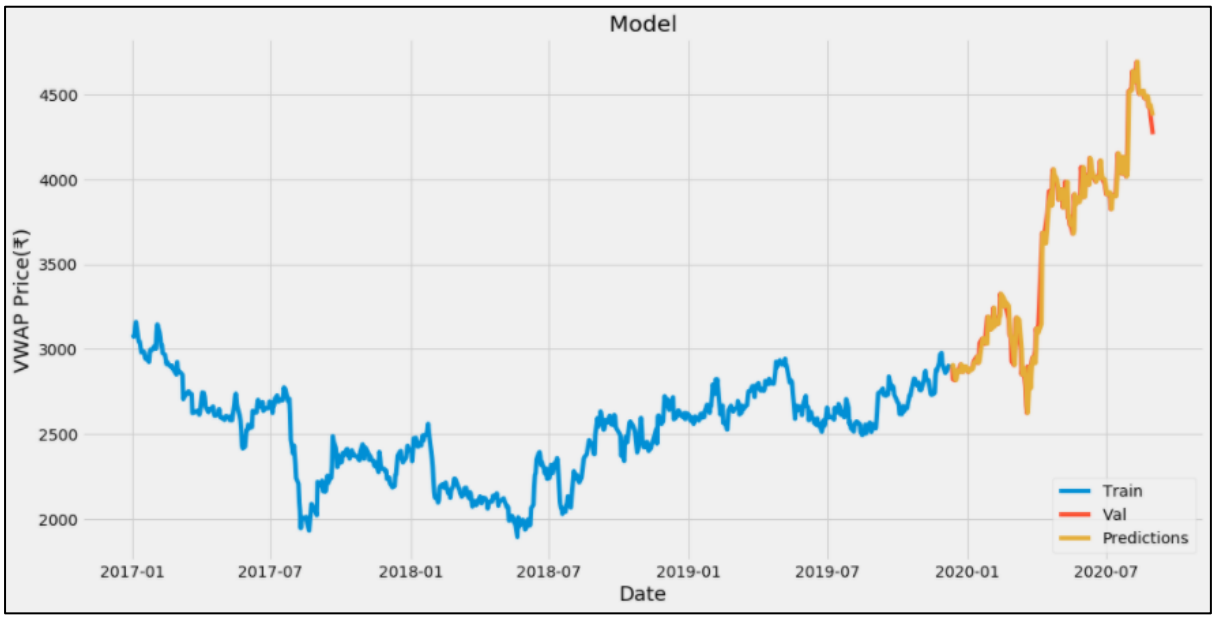

Figure 15 : LSTM Close Price Prediction

Graph shown above gives the result of predicting stock price against the trading day. Here, validation and prediction are much the same. Obtained the error rate of the training model is specified as Root Mean Squared Error (RSME) which is 77%. it evaluates the prediction accuracy.

5.3 PREDICTION USING LSTM

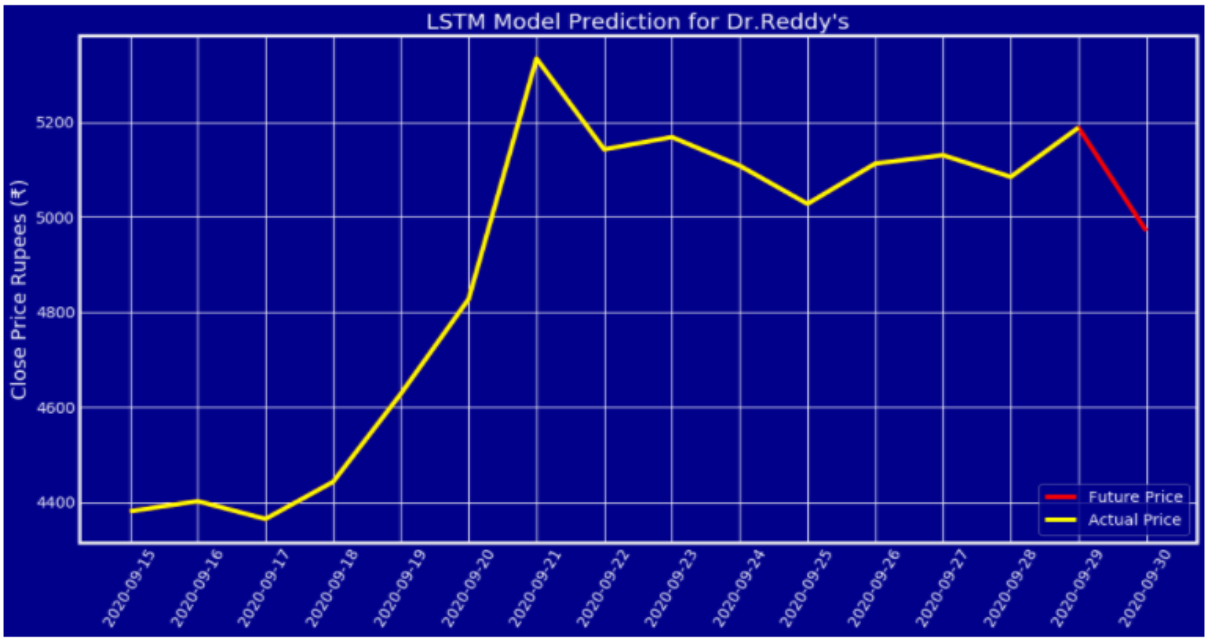

Figure 16 : LSTM Close Price Prediction for Dr Reddy's Laboratories

6 CONCLUSION

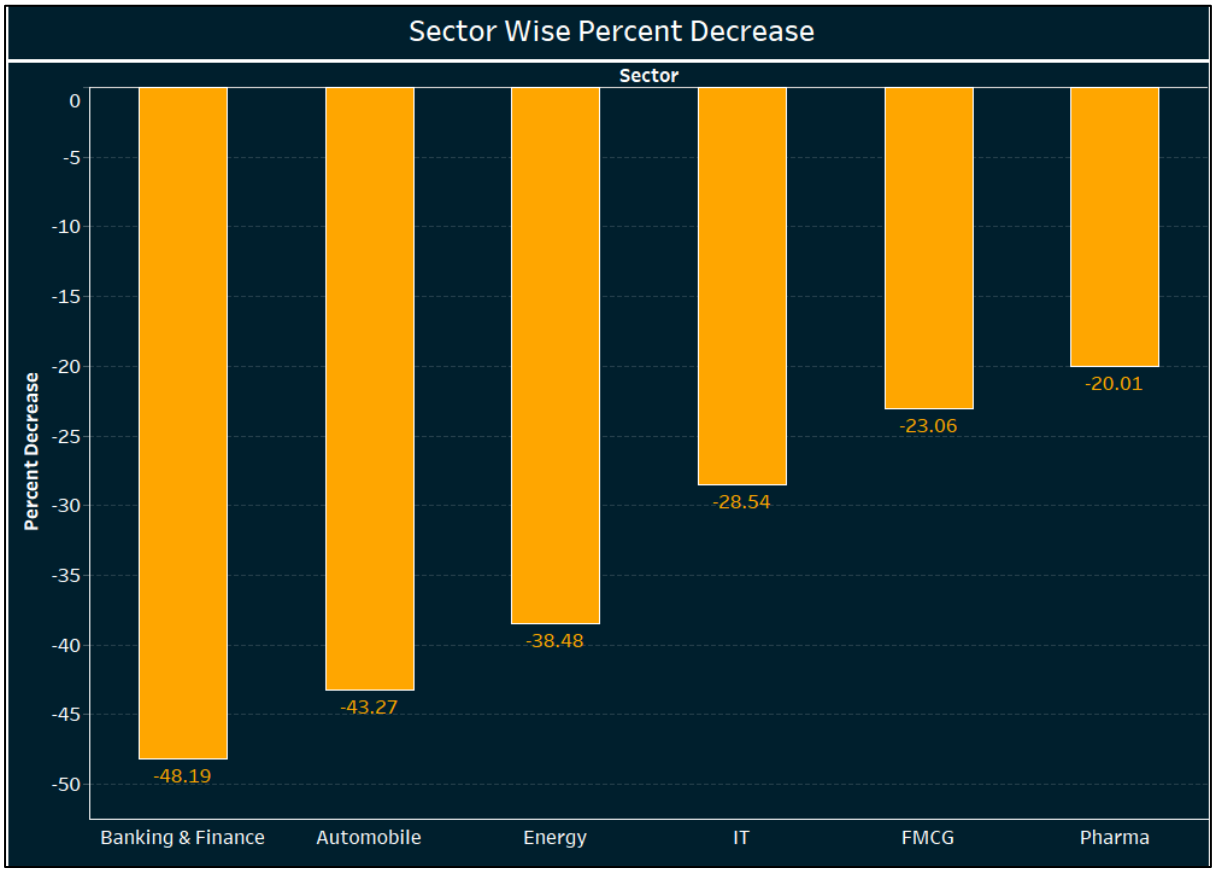

Figure 15 : Sector-wise summary

The graph above displays the Percent decrease in the Index value of each of the six sectors in Nifty50. It can be observed that the most affected sector was Baking & Finance with maximum percent decrease of 48.19% decrease in Nifty Bank during pandemic. The Pharma sector was the least affect by pandemic with least percent decrease of 20.01% decrease in Nifty Pharma. It was observed that sectors which come under essential services were least affected by pandemic. With pharma being the topmost essential service. FMCG was also not much affected by pandemic because even in pandemic all the supermarkets and grocery stores were open since these are the basic day to day requirements. In sectors like IT, work from home option was made available to employees and because of pandemic most of things were moved online and so IT sector was not much affected by pandemic. But in sectors like Automobile, work from home is very rare as all the machinery set up is in industry and so companies were forced to shut the automobile plants in pandemic. Because of lockdown announced in entire country there was huge impact on the economy of India because of which Banking & Finance was the most affected sector.

- All companies listed on the Nifty50 display an overarching theme of a nose dive in prices when the pandemic set in, flanked by periods of stability and recovery, despite different rates of the latter.
- These companies can hence be acquitted of any manipulative narratives to hide historical issues behind the contagion.
- **This methodology can as well be extended to stock prices of companies trading across the many global stock exchanges to ascertain if their narratives are manipulative or not.**

7 PROJECT MANAGEMENT DESCRIPTION

Agile Framework was applied to this WIL project. Daily standup meetings were held to discuss daily progress of project. Each team member updated the progress of His/Her tasks assigned. All the meetings were hosted on Microsoft Teams. The overall progress of project was monitored to keep the track of all the activities as planned in Milestone 1. Trello boards as a Kanban board is used to track the progress and all the activities assigned to each team member. Github is used as a central repository to maintain all the code. Frequent meetings with mentor were organized to get feedback and update the progress of project. The screenshot of Trello is attached below for reference.

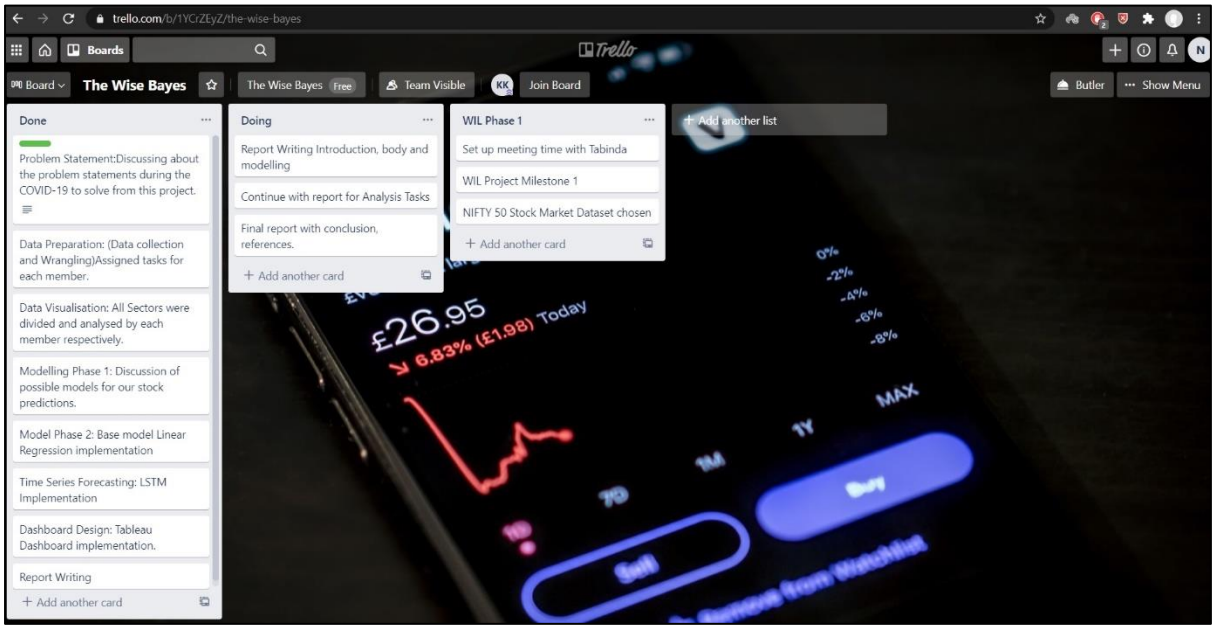

Figure 16 : Trello Board

8 CONTRIBUTIONS/ROLES

Team Member	Contribution/Roles
Sudharsan Seenivasa Raghavan (s3778243)	Sectorial Analysis, Presentation Story Building, Presentation slides preparation, Report Writing, Team meetings
Nihit Sachin Joshi (s3796753)	Sectorial Analysis, Modelling, Graphs creation on Tableau, Presentation slides preparation, Report Writing
Niranjan Patel Mallikarjuna (s3795569)	Sectorial Analysis, Modelling, Presentation slides preparation, Report Writing, Presentation story building
Kashish Kohli (s3794337)	Sectorial Analysis, Presentation slides preparation, Graphs creation on Tableau, Report Writing,
Jeyakaran Karnan (s3773303)	Sectorial Analysis, Presentation slides preparation, Report Writing, Presentation video editing.
Navin Anto Felix Sagayasargunam (s3795996)	Sectorial Analysis, Report Writing

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