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Impact of Covid-19 on Stock Market Behavior: A Volatility Analysis of Tata Motors

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ABSTRACT

The COVID-19 pandemic brought massive uncertainty to financial markets around the world, and Tata Motors was no exception. This study looks at how the pandemic affected the behavior of Tata Motors' stock, focusing on how its price volatility changed before and during the crisis. By applying volatility analysis tools, the research shows that the stock became much more volatile during key periods of the pandemic. Major events such as nationwide lockdowns, supply chain disruptions, and government policy changes caused noticeable swings in investor confidence and stock prices. These results highlight how external shocks can shake even large, well-established companies. The study offers valuable insights for investors and policymakers on how companies and markets react during global crises, and what to keep in mind to manage risk more effectively in the future.

Keywords: Stock Market Volatility, COVID-19 Impact, Tata Motors

Introduction

Economic systems and financial markets around the world have been significantly impacted by the COVID-19 pandemic, which began in late 2019 and quickly developed into a global health emergency by early 2020(Clemente-Suárez et al., 2021; Kolahchi et al., 2021). Since the pandemic affected practically every aspect of daily life, governments were forced to impose harsh lockdowns, impose travel restrictions, and reallocate resources in order to stop the virus's spread. Despite being crucial from a public health standpoint, these actions caused a great deal of economic uncertainty and had a negative effect on business operations, particularly in industries that rely significantly on customer confidence, mobility, and logistics(Hohenstein, 2022). Due to their intrinsic sensitivity to these uncertainties, the financial markets experienced hitherto unheard-of levels of volatility. The high degree of instability was reflected in the fast sell-offs and erratic recoveries that investors caused due to fear, speculation, and quickly shifting policy environments.

In the Indian context, the benchmark indexes fell precipitously in March 2020, and the Bombay Stock Exchange (BSE) and the National Stock Exchange (NSE) also had notable falls during the early stages of the pandemic(Nohani, 2024). One of the industry's most negatively affected was the automobile sector, which accounts for a significant portion of India's GDP and jobs(Gupta et al., 2022; Jha et al., 2023). With a diverse portfolio that includes electric vehicles, commercial vehicles, passenger cars, and international operations thanks to its acquisition of Jaguar Land Rover (JLR), Tata Motors stands out as a significant player in this sector. An excellent example of how firm-specific factors mix with global crises to influence investor behavior and stock price volatility is provided by Tata Motors' stock market performance during and after the pandemic.

One important indicator of risk and investor sentiment is stock market volatility, which is the amount of change in trading prices over time. Volatility sometimes spikes during crises like the COVID-19 epidemic as investors react to fresh news, shifting projections, and changes in governmental regulations(Ahmed & Sarkodie, 2021). Conventional financial theories frequently presume that market participants act rationally, but in practice, crises highlight the emotional and psychological aspects of investor decision-making(Gärling et al., 2009). Consequently, examining volatility at these times offers crucial information about how the market behaves under pressure and the boundaries of market efficiency. This study evaluates and interprets the variations in Tata Motors' stock prices during the various stages of the pandemic using volatility modeling methods like GARCH (Generalized Autoregressive Conditional Heteroskedasticity).

This study is significant in several ways. In the first place, it adds to the increasing amount of empirical research that aims to comprehend how the COVID-19 pandemic has affected financial markets, especially in developing nations like India. Fewer studies have concentrated on the behavior of individual companies at the micro level, despite the fact that many have looked at sectoral indexes and more general market patterns. A more detailed understanding of how corporate performance, industry reputation, worldwide exposure, and crisis management tactics influence market views can be gained through a firm-level analysis. Given its extensive global activities and robust domestic presence, Tata Motors presents a special case for volatility research during a pandemic.

Second, a variety of stakeholders are anticipated to find value in the research's conclusions. A better grasp of risk behavior and asset price fluctuations during tumultuous times might be advantageous for investors and portfolio managers. Lessons on investor confidence and market resilience can be applied by policymakers throughout economic recovery(Challoumis - Κωνσταντίνος Χαλλουμής, 2024). Researchers might expand on this study to examine comparable effects in other industries or businesses, and corporate decision-makers can evaluate how market views change in reaction to crisis-related actions.

Third, the epidemic has brought attention to how crucial readiness and flexible tactics are when the world is upended(Wardman, 2022). This research is in line with larger initiatives to develop financial resilience and crisis prediction models. The report examines the wider ramifications for the automotive industry by using Tata Motors as a case study, particularly in light of changing demand trends, supply chain reorganizations, and the increased focus on sustainability and digitization.

Lastly, given the ongoing pandemic's consequences and new global threats including geopolitical unrest, climate change, and economic downturns, this study is both urgent and essential. Academic and practical interest in comprehending how stock markets react to such crises, especially with regard to volatility and investor behavior, will continue to be crucial. Therefore, by offering a targeted, data-driven investigation of the effect of COVID-19 on the volatility of Tata Motors' stock price, the current study seeks to close a sizable gap and eventually contribute to better financial strategies and crisis-response frameworks going forward.

Research Objective:

- To analyze the impact of the COVID-19 pandemic on the volatility of Tata Motors' stock prices.
- To compare stock market behavior of Tata Motors before, during, and after the COVID-19 period using statistical tools.
- To assess investor sentiment and market reaction through volatility patterns observed in different phases of the pandemic.

Research Question:

- How did the COVID-19 pandemic affect the volatility of Tata Motors' stock prices?
- Is there a significant difference in stock price movements of Tata Motors across the pre-COVID, during-COVID, and post-COVID periods?
- Can we identify distinct patterns in stock market behavior attributed to the pandemic?

Hypotheses:

- **Null Hypothesis (H_0):**

  There is no significant difference in the stock price volatility of Tata Motors before, during, and after the COVID-19 pandemic.

- **Alternative Hypothesis (H_1):**

  There is a significant difference in the stock price volatility of Tata Motors before, during, and after the COVID-19 pandemic.

Methodology:

Daily stock prices of Tata Motors obtained from the National Stock Exchange (NSE) website and Yahoo Finance for the period January 2019 to December 2022, covering:

- Pre-COVID period (Jan 2019–Dec 2019)
- COVID impact period (Jan 2020–Dec 2020)
- Post-COVID recovery period (Jan 2021–Dec 2022)

In order to investigate the effect of the COVID-19 pandemic on the volatility of Tata Motors' stock prices, this study uses a quantitative research methodology. From January 2019 to December 2022, secondary data was gathered from reputable sources including Yahoo Finance and the National Stock Exchange (NSE). The pre-COVID period (January 2019–December 2019), the COVID impact period (January 2020–December 2020), and the post-COVID recovery period (January 2021–December 2022) comprise the three separate phases of the study. These periods were chosen in order to document shifts in stock performance and investor behavior prior to, during, and following the pandemic.

Descriptive statistics, such as mean, standard deviation, and variance, which are important measures of volatility, were calculated from the data using Microsoft Excel. Stock price trends across the three periods were visualized using graphical forms such line charts. To evaluate differences in stock price behavior, a comparison analysis was performed, and volatility was analyzed to find any notable swings linked to the epidemic. This methodical

methodology provides insights into the dynamics of the stock market in general during times of crisis and makes it possible to clearly comprehend how COVID-19 affected Tata Motors' market behavior.

Market Sentiment Indicator

Table 1 Market Sentiment Indicator: Pre-COVID 19 Period

Pre- COVID 19 Period				
Date	**Open**	**Close**	**Market Sentiment Indicator (C-O)**	**Interpretation**
01-01-2018	430.95	404.15	-26.8	Bearish Month (Sellers dominated)
01-02-2018	407.9	431.85	23.95	Bullish Month (Buyers dominated)
01-03-2018	430.95	399.5	-31.45	Bearish Month (Sellers dominated)
01-04-2018	399.9	369.9	-30	Bearish Month (Sellers dominated)
01-05-2018	369.75	326.85	-42.9	Bearish Month (Sellers dominated)
01-06-2018	335	340.4	5.4	Bullish Month (Buyers dominated)
01-07-2018	340.4	282.5	-57.9	Bearish Month (Sellers dominated)
01-08-2018	284.5	269.3	-15.2	Bearish Month (Sellers dominated)
01-09-2018	276	264.1	-11.9	Bearish Month (Sellers dominated)
01-10-2018	250	267.5	17.5	Bullish Month (Buyers dominated)
01-11-2018	271.4	223.7	-47.7	Bearish Month (Sellers dominated)
01-12-2018	225	179.1	-45.9	Bearish Month (Sellers dominated)
01-01-2019	182	171.95	-10.05	Bearish Month (Sellers dominated)
01-02-2019	173.25	172.7	-0.55	Bearish Month (Sellers dominated)
01-03-2019	173.5	181.2	7.7	Bullish Month (Buyers dominated)
01-04-2019	182	177.45	-4.55	Bearish Month (Sellers dominated)
01-05-2019	178.65	174.25	-4.4	Bearish Month (Sellers dominated)
01-06-2019	176.35	214.3	37.95	Bullish Month (Buyers dominated)
01-07-2019	214.3	172.6	-41.7	Bearish Month (Sellers dominated)
01-08-2019	170.5	162.55	-7.95	Bearish Month (Sellers dominated)
01-09-2019	163.7	135.6	-28.1	Bearish Month (Sellers dominated)
01-10-2019	135.5	116.7	-18.8	Bearish Month (Sellers dominated)
01-11-2019	116.7	117.45	0.75	Bullish Month (Buyers dominated)
01-12-2019	118	177.7	59.7	Bullish Month (Buyers dominated)

According to data on the sentiment of the Tata Motors stock market from 2018 to 2019 (Table 1), over 75% of the months were pessimistic, indicating a period of waning investor confidence. The market sentiment indicator indicated a favorable difference between the opening and closing prices, and purchasers controlled the market for just six months during the bullish trend. At +59.7, December 2019 had the strongest positive market sentiment, indicating a period of recovery for the stock and strong investor confidence. However, the most notable negative sentiment was recorded in July 2018 at -57.9, indicating a large sell-off and a decline in market confidence. This time frame suggests that the stock was under a lot of strain in 2018, with a particularly severe decline noted in the middle of the year. Despite this, 2019 saw a modest rebound, especially in the latter part of the year, when the positive sentiment in December suggested that investor confidence had increased. Prior to the pandemic's impact on international markets, the pre-COVID-19 period was primarily marked by a pessimistic market with a few indications of recovery towards the end of 2019.

Table 2. Market Sentiment Indicator: COVID 19 Period

COVID 19 Period				
Date	**Open**	**Close**	**Market Sentiment Indicator (C-O)**	**Interpretation**
01-01-2020	175.2	161.5	-13.7	Bearish Month (Sellers dominated)
01-02-2020	160.95	185.15	24.2	Bullish Month (Buyers dominated)
01-03-2020	185.15	176.6	-8.55	Bearish Month (Sellers dominated)
01-04-2020	175.4	128.95	-46.45	Bearish Month (Sellers dominated)
01-05-2020	160.95	185.15	24.2	Bullish Month (Buyers dominated)
01-06-2020	185.15	176.6	-8.55	Bearish Month (Sellers dominated)
01-07-2020	175.4	128.95	-46.45	Bearish Month (Sellers dominated)
01-08-2020	133	71.05	-61.95	Bearish Month (Sellers dominated)
01-09-2020	70.5	93.25	22.75	Bullish Month (Buyers dominated)
01-10-2020	93.25	87	-6.25	Bearish Month (Sellers dominated)
01-11-2020	88.9	98.25	9.35	Bullish Month (Buyers dominated)
01-12-2020	99	104.65	5.65	Bullish Month (Buyers dominated)
01-01-2021	103	143.2	40.2	Bullish Month (Buyers dominated)
01-02-2021	143.4	133.3	-10.1	Bearish Month (Sellers dominated)
01-03-2021	135.9	132.65	-3.25	Bearish Month (Sellers dominated)
01-04-2021	133.65	180.35	46.7	Bullish Month (Buyers dominated)
01-05-2021	182.35	183.85	1.5	Bullish Month (Buyers dominated)
01-06-2021	184.95	262.7	77.75	Bullish Month (Buyers dominated)
01-07-2021	269.75	322.95	53.2	Bullish Month (Buyers dominated)
01-08-2021	330	301.8	-28.2	Bearish Month (Sellers dominated)
01-09-2021	306.75	293.85	-12.9	Bearish Month (Sellers dominated)
01-10-2021	289.3	318.75	29.45	Bullish Month (Buyers dominated)
01-11-2021	319.2	339.6	20.4	Bullish Month (Buyers dominated)
01-12-2021	341.5	293.95	-47.55	Bearish Month (Sellers dominated)

Significant market volatility is evident in the statistics regarding the sentiment of the Tata Motors stock market throughout the COVID-19 period, which ran from January 2020 to December 2021 (Table 2). There was a continuous conflict between bullish and bearish months during this time due to the worldwide pandemic. Because of the uncertainties and disruptions brought on by COVID-19, the market mood indicator, which measures the gap between opening and closing prices, changed a lot. The stock market was initially quite pessimistic in early 2020, with significant drops in the first quarter. For instance, there was a period of severe sell-off in January 2020, when mood was negative at -13.7, and then there was a major decline in April 2020, when sentiment hit -46.45. Nonetheless, there were small intervals of recovery, like February and May 2020, when the sentiment score was 24.2 each, indicating that investors were somewhat optimistic despite the crisis.

With notable declines, particularly in August 2020 when the sentiment hit -61.95, the pessimistic trend persisted until mid-2020. By the end of 2020, the stock had shown some resilience in spite of the ongoing uncertainties, with many months showing a return to bullishness, such as November and December, when the sentiment indicators were 5.65 and 9.35, respectively. 2021 got off to a great start, especially in the first quarter. Positive investor sentiment and the start of market confidence following COVID-19 were reflected in the bullish sentiment that peaked in June 2021 at 77.75 after reaching 40.2 in January. Although the market saw gloomy months in August and September of 2021, the trend persisted with a bullish month in July (53.2).

With December closing at -47.55, indicating a bearish year-end, the market sentiment began to exhibit signs of instability once more by the end of 2021. With a combination of negative months and brief periods of bullish recovery, the COVID-19 period was characterized by extraordinary volatility overall, presenting Tata Motors with both chances and challenges during the pandemic.

Table 3 Market Sentiment Indicator: Post-COVID 19 Period

Post-COVID 19 Period				
Date	**Open**	**Close**	**Market Sentiment Indicator (C-O)**	**Interpretation**
01-01-2022	299.15	287.3	-11.85	Bearish Month (Sellers dominated)
01-02-2022	289	333.35	44.35	Bullish Month (Buyers dominated)
01-03-2022	332.65	483.7	151.05	Bullish Month (Buyers dominated)
01-04-2022	486.45	458.6	-27.85	Bearish Month (Sellers dominated)
01-05-2022	467.85	482.4	14.55	Bullish Month (Buyers dominated)
01-06-2022	493.5	517.75	24.25	Bullish Month (Buyers dominated)
01-07-2022	508	454.05	-53.95	Bearish Month (Sellers dominated)
01-08-2022	454.05	433.75	-20.3	Bearish Month (Sellers dominated)
01-09-2022	434	437.6	3.6	Bullish Month (Buyers dominated)
01-10-2022	437.95	443.55	5.6	Bullish Month (Buyers dominated)
01-11-2022	414.9	439.4	24.5	Bullish Month (Buyers dominated)
01-12-2022	443	387.95	-55.05	Bearish Month (Sellers dominated)
01-01-2023	392.5	452.1	59.6	Bullish Month (Buyers dominated)
01-02-2023	456.8	420.7	-36.1	Bearish Month (Sellers dominated)
01-03-2023	421.5	420.8	-0.7	Bearish Month (Sellers dominated)
01-04-2023	423	484.95	61.95	Bullish Month (Buyers dominated)
01-05-2023	484.95	526.3	41.35	Bullish Month (Buyers dominated)
01-06-2023	527.5	595.55	68.05	Bullish Month (Buyers dominated)
01-07-2023	600	644.3	44.3	Bullish Month (Buyers dominated)
01-08-2023	645	601	-44	Bearish Month (Sellers dominated)
01-09-2023	604.2	630.2	26	Bullish Month (Buyers dominated)
01-10-2023	630.2	628.65	-1.55	Bearish Month (Sellers dominated)
01-11-2023	630	706.4	76.4	Bullish Month (Buyers dominated)
01-12-2023	708	779.95	71.95	Bullish Month (Buyers dominated)

With both bullish and negative periods, the post-COVID-19 period for Tata Motors' shares demonstrates shifting market sentiment (Table 3). A drop in market optimism was indicated by the stock's bearish sentiment of -11.85 starting in January 2022. Nonetheless, the attitude improved in February 2022, hitting a noteworthy 44.35, and kept rising, to an astounding 151.05 in March. Although the stock had another decline in April 2022, with a negative sentiment of -27.85, this period showed substantial buyer domination.

Positive feelings in May and June of 2022 were 14.55 and 24.25, respectively, indicating recovery. However, in July and August, there was increased volatility, with pessimistic feelings of -53.95 and -20.3, following this optimism. With positive numbers of 3.6 and 5.6 in September and October of 2022, respectively, market sentiment resumed its upward trajectory. After a severe decrease in December 2022 with a negative sentiment of -55.05., November 2022 witnessed additional optimism with a sentiment of 24.5.

The stock began 2023 with a bullish sentiment of 59.6 in January, indicating optimism in the market. Nonetheless, there were minor drops in February and March, with negative mood readings of -36.1 and -0.7. With a sentiment of 61.95 in April, the stock resumed its upward trajectory, and it maintained this pace in May and June, hitting 41.35 and 68.05, respectively. With a sentiment of 44.3 in July 2023, the optimistic trend persisted until August, when

a tiny decline to -44 indicated the start of another bearish phase. Nevertheless, with numbers of 26 and -1.55 in September and October of 2023, respectively, the stock recovered its positive feeling, and it ended the year well in November and December of the same year with sentiments of 76.4 and 71.95.

The stock had both positive and bearish months prior to the COVID-19 pandemic, which reflected market swings and cautious optimism. Though there was a slight recovery in early 2021 as a result of vaccine hopes, the stock had major declines during the COVID-19 period, especially starting in March 2020 and fueled by widespread uncertainty and sharply unfavorable sentiment. As economies reopened and investor optimism restored, the post-COVID period saw a considerable comeback, with stronger and more stable bullish months. Despite occasional oscillations, the general mood was upbeat and demonstrated faith in both the expansion of Tata Motors and the global economic recovery.

Monthly Return

Table 4 Monthly return during Pre-COVID, COVID and Post-COVID Period

Post- COVID 19 Period		**COVID 19 Period**		**Pre- COVID 19 Period**	
Date	**Monthly Return**	**Date**	**Monthly Return**	**Date**	**Monthly Return**
01-12-2023	Null	01-12-2021	-13.40%	01-12-2019	51.30%
01-11-2023	-9.43%	01-11-2021	6.50%	01-11-2019	0.60%
01-10-2023	-11.05%	01-10-2021	8.50%	01-10-2019	-14.00%
01-09-2023	0.26%	01-09-2021	-2.60%	01-09-2019	-18.30%
01-08-2023	-4.59%	01-08-2021	-6.50%	01-08-2019	19.90%
01-07-2023	6.91%	01-07-2021	22.90%	01-07-2019	-6.20%
01-06-2023	-7.56%	01-06-2021	42.90%	01-06-2019	22.80%
01-05-2023	-9.93%	01-05-2021	1.90%	01-05-2019	-18.70%
01-04-2023	-7.56%	01-04-2021	36.00%	01-04-2019	1.80%
01-03-2023	-7.62%	01-03-2021	-0.50%	01-03-2019	2.10%
01-02-2023	-0.02%	01-02-2021	-6.90%	01-02-2019	-5.20%
01-01-2023	7.49%	01-01-2021	36.80%	01-01-2019	-0.40%
01-12-2022	−11.7%	01-12-2020	-4.00%	01-12-2018	4.10%
01-11-2022	13.26%	01-11-2020	12.90%	01-11-2018	-10.40%
01-10-2022	0.94%	01-10-2020	-6.70%	01-10-2018	1.30%
01-09-2022	-1.34%	01-09-2020	7.10%	01-09-2018	-1.20%
01-08-2022	-0.85%	01-08-2020	-23.90%	01-08-2018	-4.50%
01-07-2022	4.44%	01-07-2020	-12.50%	01-07-2018	-20.50%
01-06-2022	13.24%	01-06-2020	37.00%	01-06-2018	4.10%
01-05-2022	-6.82%	01-05-2020	4.90%	01-05-2018	-11.60%
01-04-2022	-4.91%	01-04-2020	-30.40%	01-04-2018	11.30%
01-03-2022	45.10%	01-03-2020	-9.50%	01-03-2018	7.40%
01-02-2022	-30.53%	01-02-2020	10.80%	01-02-2018	6.90%
01-01-2022	Null	01-01-2020	Null	01-01-2018	Null

The different dynamics of the financial markets are highlighted by the examination of market returns during the COVID, Post-COVID, and Pre-COVID periods. Significant volatility was observed throughout the post-COVID-19 period (2022–2023), as evidenced by the large fluctuations in monthly returns. For example, January 2023 had a 7.49% return, whilst December 2022 had a precipitous decline of -11.7%. This suggests a setting that is still attempting to recover from the economic upheavals caused by the pandemic. The market suffered with negative returns for many months, reflecting investor caution and continued concerns in the recovery phase, while there were periods of resurgence, such as the 13.26% return in November 2022.

On the other hand, the COVID-19 period (2020–2021) was marked by high volatility, including both sharp drops and swift recoveries. For instance, the early panic at the start of the pandemic was reflected in the sharp loss of -30.4% in April 2020. But there were also notable market recoveries, as the 42.9% return in June 2021. The sharp swings during this time frame highlight the pandemic's acute psychological and economic repercussions, as investors react to quickly shifting conditions and governmental actions. Uncertainty characterized this time as markets responded to different stimulus plans, the effects of lockdowns, and the vaccination race.

Prior to the pandemic, during the Pre-COVID era (2018–2019), the market exhibited less sharp swings and more steadiness. The returns were comparatively stable, with a few slight decreases interspersed with moderately good returns, such as 4.1% in June 2018 and 19.9% in August 2019. With fewer outside shocks influencing investor mood, this time frame reflects a more normal market environment. The market seemed more stable than the turbulent times that followed the start of COVID-19 because it was primarily driven by regular economic cycles, company expansion, and predictable policy initiatives.

Volatility and Risk Analysis

To understand the volatility and risk, the study also calculated the standard deviation, skewness and Kurtosis which indicates the Volatility Measurement, Symmetry of Return Distribution and Tail Risk Measurement respectively.

Table 5 Volatility Measurement, Symmetry of Return Distribution and Tail Risk Measurement

Post-COVID Period (Monthly Return)	**COVID Period (Monthly Return)**	**Pre-COVID Period (Monthly Return)**
Mean: -1.01%	Mean: 4.217%	Mean: 0.98%
Median: -2.97%	Median: 4.90%	Median: 0.60%
Standard Deviation: 13.71%	Standard Deviation: 17.13%	Standard Deviation: 15.36%
Skewness: 1.32	Skewness: 0.86	Skewness: 1.36
Kurtosis: 3.98	Kurtosis: 2.94	Kurtosis: 2.76

The negative mean of -1.01% and median of -2.97% for the Post-COVID period show that returns were generally somewhat negative and skewed toward lower returns. When compared to the pre-COVID era, the standard deviation of 13.71% indicates a comparatively high degree of volatility, indicating more erratic market swings. The distribution's rightward tail can be attributed to a combination of exceptional positive returns and lower-than-average returns, as indicated by the positive skewness of 1.32. A leptokurtic distribution, which suggests the presence of extreme values (heavy tails) and outliers in the returns, is indicated by a kurtosis of 3.98 that is more than 3. This implies that although the majority of returns were slightly negative, there were sporadic, higher return spikes, indicating a high degree of risk and market uncertainty following the epidemic.

Despite the significant volatility, the COVID period exhibited a positive mean of 4.217% and a median of 4.90%, indicating that returns were generally positive and the market was generally stronger. The COVID era was especially turbulent, as evidenced by the standard deviation of 17.13%, which is larger than both the Post-COVID and Pre-COVID periods. A somewhat positive skew, shown by a skewness of 0.86, indicates that while there were a few exceptionally favorable months, the distribution stayed more in line with typical. In comparison to the Post-COVID period, the kurtosis of 2.94 is lower, indicating that the return distribution's tails were less severe, with fewer outliers and a decreased risk of extreme events.

The market's mean of 0.98% and median of 0.60% during the pre-COVID era showed very modest but consistent returns. There was some volatility, but not as much as during the COVID or Post-COVID periods, as indicated by the standard deviation of 15.36%. The distribution featured more occurrences of higher-than-average returns, but the tail was heavier on the right, as indicated by the positive skewness of 1.36. Although not as dramatic as during the Post-COVID period, the leptokurtic distribution indicated by the kurtosis of 2.76 indicates that there were more extreme returns than a normal distribution would imply.

A thorough understanding of market behavior, volatility, and risk during each of the three periods Post-COVID, COVID, and Pre-COVID is provided by the examination of these periods. With a notable number of outliers and extreme returns, the post-COVID time has the highest volatility, indicating increased risk. In contrast to the Post-COVID period, the COVID period displayed a more balanced return distribution and fewer extremes, despite its volatility. Returns during the pre-COVID time were comparatively steady and predictable, with less risk and mild volatility.

Augmented Dickey-Fuller (ADF) test

To understand the existence of a trend or the seasonality, ADF test was conducted in all the three period. The test helps to understand the given time periods have a stationary or has a unit root.

Table 6 Augmented Dickey-Fuller statistics

Post-COVID Period	**COVID Period**	**Pre-COVID Period**
ADF Statistic: -2.162	ADF Statistic: -3.748	ADF Statistic: -0.96
p-value: 0.2202	p-value: 0.0035	p-value: 0.768
Critical Values:	Critical Values:	Critical Values:

1%: -4.138	1%: -3.788	1%: -4.068
5%: -3.155	5%: -3.013	5%: -3.127
10%: -2.714	10%: -2.646	10%: -2.702

The p-value is 0.2202 and the ADF test statistic is -2.162 in the post-COVID period, both of which are higher above the significance level of 0.05. This suggests that the time series is non-stationary and shows that we are unable to reject the null hypothesis. The fact that the ADF statistic is higher than the crucial values at 1%, 5%, and 10% further supports the idea that the series is non-stationary due to unit root and structural or trend changes over time. Because of this non-stationarity, the consistency of the post-pandemic market returns may still be affected by lingering uncertainties, volatility, or outside variables.

The p-value is 0.0035 and the ADF test statistic is -3.748 during the COVID era, both of which are significantly below the significance level of 0.05. As a result, we determine that the time series is stationary and reject the null hypothesis. Strong evidence of stationarity is provided by the ADF statistic, which is likewise below the critical values at all significant levels (1%, 5%, and 10%). The market's stagnant behavior during the COVID period may indicate that, following an initial shock, it followed more predictable patterns or corrected itself during the pandemic, most likely as a result of market stabilization measures or government involvement.

The ADF test statistic for the pre-COVID era is -0.96, and the p-value is 0.768, both of which are much greater than 0.05. The time series is non-stationary as a result, and we are unable to reject the null hypothesis. Additionally, the ADF statistic is higher above the essential levels, confirming that long-term trends or variations most certainly had an impact on the results throughout this time. The non-stationary character may be explained by normal market cycles, habits, or pre-pandemic external causes.

There are notable variations in stationarity when the results from the three periods are compared. The increased p-value and ADF statistic that fall short of crucial levels indicate that the series is non-stationary in the post-COVID era. The market may have recovered or stabilized following the early shocks of the pandemic, as evidenced by the stationary time series with a p-value < 0.05 during the COVID era. Like the post-pandemic period, the pre-COVID period also exhibits non-stationarity, indicating that long-term cycles or patterns had an impact on the market prior to the pandemic.

Correlation and Regression Analysis

The ADF test identified that the Post and pre COVID 19 period shows a similar trend while the COVID 19 period was almost stationary, showing no similarity with the Post-COVID and Pre-COVID periods. So it is essential to understand the relationship between these tree time series.

Table 7 Correlation and Regression Analysis

Metric	**COVID vs. Post-COVID**	**Pre-COVID vs. COVID**	**Pre-COVID vs. Post-COVID**
Correlation	-0.08	0.0141	-0.123
Slope (β1)	-0.052	0.0196	-0.1097
Intercept (β0)	0	6.7509	-1.744
R-squared (R^2)	0.007	0	0.0151
p-value	0.707	0.948	0.567

At -0.08, the correlation between the returns from the COVID period and the post-COVID period shows a very weak negative association (Table 6). The model's R-squared value for the regression analysis is 0.007, meaning that the COVID returns can only account for 0.7% of the variation in the post-COVID returns. According to the regression data, the coefficient for the COVID returns is -0.0520, meaning that the post-COVID return falls by roughly 0.052% for every 1% rise in the COVID return. The link may not be statistically significant, though, as indicated by the p-value of 0.707 for this coefficient. Therefore, we may say that in this dataset, the COVID returns have no significant predictive potential for post-COVID returns.

There is very little association between the monthly returns during the COVID-19 period and the pre-COVID-19 period, as seen by the correlation of 0.0141. The regression analysis shows an intercept of 6.7509, which indicates that the COVID-19 returns would be roughly 6.75% when the Pre-COVID-19 returns are zero. The slope, which is 0.0196, indicates that the COVID-19 returns only rise by 0.0196% for every 1% increase in Pre-COVID-19 returns. But according to the Pre-COVID-19 results, the model is unable to account for any of the variance in the COVID-19 returns, as indicated by the R-squared value of 0.000. The slope's p-value of 0.948 indicates that there is no statistically significant association between the two sets of returns, as it is far higher than the conventional significance threshold of 0.05. There appears to be no significant association between the monthly returns during the COVID-19 period and the returns during the Pre-COVID-19 period, as demonstrated by both the regression and correlation analyses.

A weakly negative correlation is indicated by the correlation coefficient, which is roughly -0.123, between monthly returns before and after COVID. The regression analysis's slope is -0.1097, which indicates that post-COVID returns fall by roughly 0.11% for every 1% increase in pre-COVID returns. The intercept, which is -0.0174, indicates that post-COVID returns typically have a tiny negative trend, even in cases when pre-COVID returns are zero. Only over 1.5% of the variance in post-COVID returns can be accounted for by pre-COVID returns, according to the R-squared value of 0.0151. This link is not statistically significant, indicating that pre-COVID returns do not significantly predict post-COVID performance, according to the high p-value (0.567).

Conclusion

The volatility analysis of Tata Motors' stock during the pre-COVID, COVID, and post-COVID periods reveals a significant shift in investor behavior and market performance due to the pandemic. The findings indicate that the COVID-19 outbreak triggered increased uncertainty in the stock market, as reflected in the sharp fluctuations in stock prices and heightened volatility during 2020. However, the gradual recovery observed in the post-COVID period, with relatively stabilized prices and improved investor sentiment, suggests a market adaptation to the crisis over time.

This study highlights the sensitivity of stock markets to global disruptions such as pandemics, emphasizing the importance of risk management and investor awareness. For policymakers and financial analysts, the results underscore the need for robust financial systems capable of absorbing shocks. For investors, understanding such volatility patterns can aid in making informed decisions during uncertain times. Overall, the COVID-19 crisis served as a real-world stress test for financial markets, and Tata Motors' stock behavior exemplifies how companies navigate such challenges and eventually stabilize in the face of global adversities.

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