A Statistical Analysis of Optimal Trading Time Frames in Stock Markets

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Abstract - Since the beginning of stock market trading, experts have been trying to build a system that can accurately predict stock prices. This has led to continuous refinement of their analyses over the years. This paper aims to unravel an important aspect of stock trading, that is, periods of volatility within the stock market. We have created an in-depth analysis of various periods in the market, in which the volatility of price movement is the greatest. These periods define an optimum time to take a trade. We have used various statistical measures to achieve this such as Mean, Standard Deviation, and Percentiles. The main analysis performed in this paper will be on Indian stock market indices.

Index Terms - Statistics, Standard Deviation, Stock Markets, Mean, Percentile, Data Analysis, Prediction, Derivatives Trading

I. INTRODUCTION

The stock market has long served as a nexus of economic activity and investment, offering the promise of wealth creation, capital allocation, and risk mitigation. The allure of financial markets has drawn participants from every corner of the world, ranging from individual retail investors to institutional behemoths, each seeking to navigate the intricate and often unpredictable terrain of stock market trading. In the trading world, the stakes are high and the consequences of even the smallest decisions can have far-reaching implications.

Stock market trading has witnessed a profound transformation over the years. From the iconic training floors of the past to the contemporary electronic exchanges and the burgeoning world of cryptocurrencies, the means of trading and investing have evolved dramatically.

As the world of stock markets evolves, so do the strategies for investing and trading in the market. This leads to continuous refinement and improvement of trading strategies employed by experts and even retail traders. This paper serves to further that improvement and provide deeper knowledge and understanding of the working of markets. The analyses in the paper are not meant to serve as a sure-shot way to make money or trade in the market, but as a way to improve trading strategies which will enable investors to be able to make smarter trading decisions.

Derivatives - The landscape of modern financial markets is enriched by a sophisticated and intricate realm of financial instruments known as derivatives. Derivatives trading, a subset of financial markets, has experienced explosive growth and transformation over the past decade, evolving into a vital component of global financial systems. These instruments, which include options, futures, and a wide array of structured products, enable market participants to hedge against risk, speculate on price movement, and optimize portfolio performance. The pervasive nature of derivatives makes it crucial to comprehend the inner workings, strategies, risks, and evolving dynamics that define this complex market.

Derivatives trading has grown into a vast and diverse market. Today it encompasses a wide array of instruments, from standardized futures contracts to complex structured products tailored to the needs of institutions and sophisticated investors. Understanding the historical context, development, and classification of derivatives is essential to grasp the foundational principles upon which these instruments operate.

This paper will serve as an analysis used for derivatives trading in the stock market. The analyses used in this paper and the inferences gained from our analyses can be used to modify and refine trading strategies that investors use when trading in derivatives.

BankNifty Stock Index - The BankNifty stock index is among two of the largest stock indices of India. It tracks the performance of banking sector stocks including public sector banks, private sector banks, and non-banking financial companies in India, and holds a unique and crucial place within the country's financial landscape. As the backbone of the Indian economy, the banking sector is inextricably linked to broader economic health, making the BankNifty index an essential barometer of economic well-being and financial stability.

Along with being a measure of financial strength, the BankNifty stock index is highly volatile and dynamic. This is especially opportunistic for derivatives trading as the smallest of movements in indices lead to large movements in the derivatives of the same index.

We will be using the past 3 years' data of the BankNifty stock index for performing our analyses. The methods used in our analysis are not exclusive to the data we will be using here.

II. LITERATURE SURVEY

There have been a multitude of research papers which discuss the volatility of stock markets and use machine learning models to make accurate predictions about future moves in the market.

- **P.K Mishra(2012)** in his paper, 'Derivatives Trading and Stock Market Volatility: An Empirical Analysis', gave a deep explanation on derivatives trading in the stock market and the volatility associated with it. He has used the GARCH model to study the impact of derivatives on volatility in the Indian market.

- 'Stock Market Volatility and Return Analysis: A Systematic Literature Review' by **Roni Bhowmik, Shouyang Wang (2020)** is another research paper which studies stock market volatility and uses the GARCH family model for forecasting stock returns.

There are a plethora of research papers which use machine learning techniques for stock market price prediction such as:

- **Mehar Vijh, Deeksha Chandola, Vinay Anand Tikkiwal, Arun Kumar (2020)** used Random Forest Regression and Artificial Neural Networks to predict next day closing price of various companies in their paper, 'Stock Closing Price Prediction using Machine Learning Technique'.

- **Kamalakannan J, Indrani Sengupta, Snehaa Chaudhary (2018)** in their paper, 'Stock Market Prediction Using Time Series Analysis' used the ARIMA algorithm to build their model to predict stock prices. They also focused on the MACD indicator.

The uniqueness of our research stems from the fact that this paper focuses on the statistical analysis of the market rather than trying to create a final model. The base of all successful research is meaningful data and through our research, we aim to bring to light meaningful data about the stock market which can be used for future innovations.

III. STATISTICAL ANALYSES

In our analysis, we will be using several statistical measures to do a thorough analysis of our data. By using multiple statistical measures, we can gain a more complete view and deduce unbiased inferences.

1. **Mean -** In statistics, the mean is a fundamental measure of central tendency used to summarize a set of numerical data points. It is a numerical value that represents the central value of the dataset. The mean is calculated by summing up all the data points in the set and dividing it by the total number of data points.

   The mathematical formula of the mean is:

$$Mean(\underline{x}) = \frac{Sum\ of\ all\ data\ points}{Total\ number\ of\ data\ points} = \frac{\Sigma x}{n}$$

2. **Standard Deviation -** Standard deviation is a statistical measure that quantifies the amount of variability or dispersion in a dataset. It provides insight on how individual data points deviate from the mean of a dataset. A higher standard deviation implies data points are more widely spread, while a lower standard deviation suggests that data points are closer to the mean.

   The mathematical formula for standard deviation is:

$$Standard\ Deviation(\sigma) = \sqrt{\frac{\Sigma(x_i - \underline{x})}{n}}$$

3. **Percentile -** Percentiles are a statistical concept used to divide a dataset into 100 equal parts, with each part representing a specific percentage of the data. They are used to describe the relative position of a particular data point within a dataset in terms of its rank compared to other data points. This concept is especially useful when dealing with large datasets.

   To calculate a percentile, the data is first arranged in ascending order. Then, the desired percentage is used to find the position in the ordered dataset. For example, the 50th percentile represents the point at which 50 percent of the data falls below and 50 percent falls above.

IV. METHODOLOGY

The goal of our analysis is to identify points of time within the market that are an optimum time to enter a trade. To identify such points, firstly we will be dividing the trading day into 5 different time frames of 75 minutes each. We are going to only focus on the Indian stock market whose regular trading hours are between 9:15 AM Indian Standard Time (IST) to 3:30 PM IST. Based on this we have the following time frames:

1. 9:15 AM - 10:30 AM
2. 10:30 AM - 11:45 AM
3. 11:45 AM - 1 PM
4. 1 PM - 2:15 PM
5. 2:15 PM - 3:30 PM

Within these time frames, our aim is to find the beginning and end of the largest movement of the market within that frame during the trading day.
For our analysis, we are going to be taking the past 3 years' data of the BankNifty stock index. To download our data we will be using the API from the Zerodha platform.

- Zerodha is one of the largest online brokerage and trading platforms in India. It provides a wide range of financial services, including trading and investment in equities, commodities, currencies, mutual funds, and bonds. They also provide abundant historical data related to the stock market which can be accessed through their paid API.

Firstly, we will be downloading the per-minute data from the API for the past 3 years for each trading day. We will be using the Open, High, Low, and Close points for each minute. This data will be especially important in identifying the largest moves.

The next step is to combine the data points into the time frames that we've decided. Each trading day will be divided into 5 time frames. Each time frame will be an aggregation of 75 per-minute data points.

- We can calculate the Open price of our time frame by considering the Open price of the first-minute record within the given time period.
- We can calculate the High price during that time frame by considering the maximum value of the High price of all the one-minute records within the given time period.
- We can calculate the Low price during that time frame by considering the minimum value of the Low price of all the one-minute records within the given time period.

- We can calculate the Close price of our time frame by considering the Close price of the last-minute record within the given time period.

Once we have created our new dataset, we are going to be taking the largest move within each time frame. The largest move will be the difference between the High and Low prices for the given time frame. Our aim is not to measure the largest move but to note the start and end time of the move.
For this, we will take the time stamps of the High and Low prices from our per-minute dataset. Whichever timestamp is earlier can be considered as the beginning of the move and the later timestamp is the end of the move. We will calculate this for all time periods, each trading day, for the past 3 years of BankNifty data.

Now that we have our timestamps, we can perform our statistical analysis. For each time frame, the lower timestamp is considered the beginning of the move and the later the end. We will take the simple average of all the beginning and end points for each time period. This will be our mean.
Next, we use the standard deviation formula to calculate the standard deviation for the beginning and end of each time frame.
Finally, we calculate the percentile distribution of our data. This will allow for a more in-depth understanding of the beginning and end of our moves.

We are going to be performing all these operations on an Excel datasheet and tabulate the results in the same.

V. RESULTS

The results from our analysis give us a fair idea about when the market will be taking a polar move. The beginning and end of the price movement are crucial in taking a successful trade. From the analysis of price movements over the past 3 years we get the following results:

	9:15 AM - 10:30 AM		10:30 AM - 11:45 AM		11:45 AM - 1 PM		1 PM - 2:15 PM		2:15 PM - 3:30 PM	
	Begin	End	Begin	End	Begin	End	Begin	End	Begin	End
Mean	4.933	44.456	11.116	52.966	13.589	54.859	14.391	55.792	11.253	51.755
Standard Deviation	9.322	21.076	12.982	16.781	14.473	15.789	14.373	15.88	12.036	17.341

Fig 1. Mean and Standard deviation

- We find the mean of the beginning of the largest moves in our first time frame is around 4.933 minutes and the mean of the end of the largest moves in the first time frame is 44.456 minutes. This implies that the average move in this time frame starts at around 9:20 AM and the move ends at around 9:59:27 AM. The standard deviation for both the beginning and the end of the moves in the first time frame is 9.322 minutes and 21.076 minutes respectively.

- Similarly, for the second time frame of 10:30 AM - 11:45 AM, the average largest move begins at 10:30 + 11.116 minutes, which is around 10:41:07 AM and the move ends at approximately 10:30 + 52.966 minutes, which is 11:22:58 AM. The standard deviation for this period is 12.982 minutes and 16.781 minutes for the beginning and end respectively.

- For the third time frame of 11:45 AM - 1 PM, the average largest move began at 11:58:34 AM and ended at 12:39:52 PM. The standard deviation for this period is 14.473 minutes and 15.789 minutes for the beginning and end respectively.

- For the fourth time frame of 1 PM - 2:15 PM, the average largest move began at 1:14:23 PM and ended at 1:55:48 PM. The standard deviation for this period is 14.373 minutes and 15.88 minutes for the beginning and end respectively.

- Finally, for the fifth time frame of 2:15 PM - 3:30 PM, the average largest move began at 2:26:15 PM and ended at 3:06:45 PM. The standard deviation for this period is 12.036 minutes and 17.341 minutes for the beginning and end respectively

	9:15 AM - 10:30 AM		10:30 AM - 11:45 AM		11:45 AM - 1 PM		1 PM - 2:15 PM		2:15 PM - 3:30 PM	
	Begin	End	Begin	End	Begin	End	Begin	End	Begin	End
Percentile										
25%	0	27	0	42	0	45	3	42	0	39
50%	0	48	6	59	9	60	12	60	6	54
75%	6	63	18	68	21	69	24	67	18	65
80%	9	66	21	69	27	69	27	69	21	69
90%	18	72	30	72	36	72	36	72	30	72
95%	27	75	36	75	42	75	42	75	36	75
100%	60	75	63	75	63	75	66	75	51	75

.Fig 2. Percentiles

By examining the percentile distribution of the start and end times of movements, we can get a broader idea of when the movement during a given time frame is likely to start.

For example, we can see that 80% of all the largest moves have started by the 9-minute mark during the first time frame. We can also notice trends such as 80% of all moves usually end by the 66-69 minute mark throughout all the time frames. Percentiles give us a more accurate representation of our historical data.

VI. Conclusion

In the course of this research paper, we have done a comprehensive analysis of periods of price movement within the BankNifty stock index of the Indian stock market. The analyses used in the paper can also be implemented for other instruments in the stock market including other indices, stocks, currencies, etc.

The analyses in this paper can be further refined and combined with other analyses and models to create more complete and successful trading strategies. The world of trading is rough and unforgiving; punishing even the smallest of mistakes heavily. We must proceed with caution when making decisions based on our analyses. With the ever-evolving world of the stock market, the strategies and models used to study the market will evolve too.

This analysis happens to only study periods of movement in the market. However, there is still the question of which direction the movement will be and to what extent the move will occur. Future work can be done using the research and methods of analysis discussed in this paper.

VII. References

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