PREDICTING VOLUME-WEIGHTED AVERAGE PRICE BEHAVIOUR USING GARCH MODEL

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1 Abstract

In this competitive era of financial expertise predicting stock behavior has become significant because it facilitates data-driven decisions that help traders design their investment strategy which impacts their portfolios. This research aims to use a statistical model to analyze Volume-weighted average prices and make predictions. By examining data and interrelated financial variables the project aims to provide forecasts that reveal trends and risks involved in investment decisions. Utilizing GARCH model will help the understanding of the future ahead of us which gives insights in decision-making. This study not only contributes to the field of analytics but also has practical applications that contribute to investment strategies, risk management, and policy development. The GARCH model is a statistical framework widely used for analyzing and forecasting volatility in time-series data.

2 Introduction

The Stock market is a place that experiences constant fluctuations with numerous changes happening at a time that determines the future of a particular company. The markets by design are made by complicated and interconnected forces that are influenced by economic policies and geopolitical events that affect a trader's sentiment. Understanding the behavior of a stock is not only a fundamental aspect of financial management but also able to predict the future which determines a trader's future course of action. This quest of predicting stock market benchmarks has attracted countless traders and analysts who have been doing intense research for many years. This search for precise and comprehensive tools that help us in forecasting has increased exponentially over the years where data-driven decisions are required. This is the challenge we are trying to solve with this project, we aim to unravel the reliability of the GARCH model in predicting volume weighted average price which can possibly unravel the complexities in the stock market movements.

Buying a stock has become one of the frequent ways for an insightful investor in the current year, be it the Mutual fund or securities or buying a stock directly. The volatile nature of the stock market offers a platform to generate high returns whether it is a short-term or a long term investment. The underlying statement is that traders in the current time need a sophisticated tool that makes predictions faster with small data provided and which can be relied upon to take calculated risks.

There is as much a downside as there is an upside, which means the 1 price can rise or drop at any point given. At times geopolitical events that concern one country can determine the events happening in the stock market of another country. For instance, the Russia-Ukraine war has affected the stock market in India for a week at least. Another instance is the Taliban takeover of Afghanistan. One might argue that there can be better chances in the long-term investment whereas the fact is that there is an equal amount of risk involved in the long-term investment as it is in the short-term investment.

In this project, we concentrate on the benchmark VWAP(Volume-weighted average price), it is a combined indicator for representing average price of a security based on price and volume. It helps the traders in determining the entry and exit points of a particular stock. VWAP is widely used by traders and analysts to make informed decisions because it provides better and more accurate representation of a company's true average price over a stipulated time. VWAP can also be used to determine if a company is undervalued or overvalued when we compare it with the current price. The direction of VWAP indicates the trends in the market, mastering the interpretation of VWAP can be very useful in enhancing trading strategies.

In today's world traders face one common problem on a daily basis, which is to what to do with the money they have. The traders and other participants actively look to make informed decisions rather than depending on sheer luck or chance. The ability to predict stock behavior is not just something nice to have it is also something that helps everyone to make smart choices, know the risks involved, and achieve financial goals.

3 Literature survey

Setiawan et al [1] investigated stock market responses to the COVID-19 outbreak in Indonesia and Hungary, comparing them to the global financial crisis. Utilizing GARCH (1,1) models, the study analyzes market volatility before and during the crises. The research aims to provide insights for traders and policymakers, contributing to financial literacy and sustainable development goals. The study fills a gap in understanding market behavior during unprecedented events, offering valuable recommendations for both emerging and developed economies. The research found that Indonesian and Hungarian stock markets experienced high volatility and negative abnormal returns, Boosting financial literacy is key for traders to navigate uncertainties and enhance inclusion.

Dellaportas and Pourahmadi[2] focused on introducing a new class of multivariate models for asset returns that address the challenges posed by instantaneous dependence among several assets. By utilizing the Cholesky

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decomposition of the covariance matrix, the study presents a framework where univariate GARCH models are employed for individual asset variances, along with parsimonious models for time-varying unit lower triangular matrices. The findings demonstrate forecast consistency when new assets are added to the portfolio, highlighting the robustness of the proposed models. Empirical results from exchange rate data indicate that the choice of stock orders in a portfolio has minimal impact on forecasting performance. Further research is suggested to develop efficient algorithms for optimal stock ordering in Cholesky-GARCH models, emphasizing their practicality and effectiveness in financial applications.

Chao Yao et al[3] investigated on the impact of the GARCH effect on the prediction of air pollution. The study emphasizes the importance of considering the GARCH effect in air pollution prediction models to enhance accuracy and efficiency. By integrating the GARCH effect into the prediction model, the study aims to provide valuable insights for regulators and practitioners
in the field of air pollution prediction. The findings of the study indicate that integrating the GARCH effect into the GA-SVM model for predicting PM2.5 concentrations leads to improved prediction performance compared to traditional SVM and GA-SVM models. The research demonstrates that considering the GARCH effect significantly enhances the accuracy of air pollution prediction. The study suggests that adopting an SVM-based approach
model for PM2.5 prediction, along with integrating the GARCH model, can yield more accurate results.

Esrin et al [4](2023) revealed that that the LSTM-augmented GARCH MIDAS-LSTM model outperformed traditional GARCH-MIDAS models in forecasting stock market volatility during the COVID-19 economic reopening period in Turkey. Geopolitical risks were identified as a key factor influencing volatility, with industrial production and economic expectations playing contrasting
roles. The LSTM-augmented models showed a significant decrease in forecast error criteria, ranging from 39% to 95%, depending on the economic indicator used.

Alam et al[5] (2024) said that the evolving landscape of cryptocurrencies is intricately linked to traditional monetary policy, with the proposed Structural Break GARCH-MIDAS model effectively capturing the impact of monetary decisions on cryptocurrency volatility. The analysis highlights the diverse nature of cryptocurrencies and their susceptibility to macroeconomic variables,
emphasizing the need for careful monitoring and analysis in light of their growing significance in the global financial landscape.

Tim Bollerslev[6](2023) studied the evolution of GARCH model. Bollerslev's personal account traces the model's creation during his Ph.D. studies, its empirical success in capturing volatility clustering in financial markets, and

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its subsequent widespread adoption in various fields beyond finance. The narrative also addresses the skepticism faced by the GARCH model in the late 1990s, countered by a 1998 paper by Bollerslev and Torben Andersen that demonstrated the model's efficacy in forecasting volatility when using more accurate ex-post measurements of latent daily integrated volatilities.

Bahareh Amirshahi and Salim Lahmiri[7] (2023) studied on forecasting cryptocurrency volatility using GARCH-type models reveal that out of the initial 30 cryptocurrencies analyzed, 27 were deemed predictable by the models, with three cryptocurrencies behaving like white noise series. The research employed GARCH(p, q), EGARCH(p, q), and APGARCH(p, q) models, considering different distributions for residuals and selecting the mean model based on the Akaike Info Criterion (AIC) and Log likelihood function. The study found that the hybrid models, particularly those combining
deep learning models like LSTM with GARCH forecasts, demonstrated superior forecasting accuracy compared to standalone GARCH models, showcasing the potential of integrating neural networks with traditional time series models for improved volatility predictions in the cryptocurrency market.

Kuziboev et al[8](2023) revealed the successful application of ARCH/GARCH models in analyzing the volatility of CO2 emissions in Uzbekistan. The research demonstrates the effectiveness of these models in capturing the heteroscedasticity and volatility clustering present in the CO2 emissions data, providing valuable insights into the dynamics and patterns of emissions fluctuations over time. Additionally, the study highlights the importance of utilizing GARCH-type models for forecasting and managing the volatility of CO2 emissions, emphasizing their significance in environmental risk assessment and policy-making related to carbon emissions in Uzbekistan.

4 Research Gaps

- Model Comparison and Evaluation: Since we deal with volatility which ranges between -1 and 1 the performance evaluation metrics like RMSE, MAPE and MAE give minute values making it tough to assess the model performance. So, we evaluate GARCH based on the predicted direction and actual direction of the stock volatility.

- Feature Selection and Model Performance: Several studies have stated the importance of feature selection in improving the predictive capabilities of Machine learning models. However, there is a need to study those specific features that can be relevant for most predictive tasks. Because after all, it is characteristic of the stock market to be

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volatile and show abnormalities in the data. There is a need to capture and understand these abnormalities.

- Data for training: While taking training data many researchers have taken historical data for more than 5 years and some have considered it for more than 20 years which may take time for the Machine learning algorithms to read and capture the patterns. Moreover especially in stock market data, and historical data for more than 8 previous quarters the predictions may be misleading in a few cases. That is because there will be a change in dividend to price ratio over time which affects the volume of the shares purchased, these metrics are not reflected in the price of the stock.

- Long-term Predictive Modeling: Many researchers have focused on Long-term predictive modeling rather than short to medium predictions for stock market benchmarks. By the nature of the stock market we never know what will happen soon, so predicting for a longer period is risking the accuracy of the prediction. Moreover, most traders look at a picture of 2 to 3 months to determine their entry and exit at a stock.

- Dynamic Model Adaption: Existing predictive models often assume stationary data distributions and have fixed the model parameters over time. However, the financial systems are inherently dynamic and subject to changes, and external shocks. There is a need for research on adaptive predictive modeling techniques that can adjust the model parameters dynamically and structures in response to market conditions.

- Expectations from the results: Predicting the right value at one particular time should not be the goal of a predictive model. When it comes to the prediction of stock market benchmarks the model should be able to deliver the direction of the stock.

5 Proposed system

This system aims to utilize GARCH for the time series analysis to forecast and explain stock market benchmark VWAP's behavior. The mission is to offer valuable insights to traders into dynamic market trends and empower them with clear actionable information. The wishes to encompass comprehensive
data processing using the NNAR with transparent data visualization. In the present day understanding the market is the ultimate goal, this system

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aims to shed light on intricate market patterns and aid data-driven decision making.

5.1 Data Collection and Preprocessing

The foundation of the system begins with the collection of historical data for selected stock market benchmarks. These benchmarks may include indices, opening and closing prices, and other financial indicators. In this case, the benchmark is Volume-weighted Average Price (VWAP). It is calculated by the summation of the rupees traded for every transaction (price multiplied by the number of shares traded at an instance) and then divided by the total shares traded for the day. It is a good indicator because it incorporates both the price of the stock and the volume traded into consideration by providing a comprehensive view of the market activity.

$$Price \times VolumeofPrice$$

$$VWAP =$$

$$TotalVolume$$

5.2 Generalized Autoregressive Conditional Heteroskedasticity (GARCH) Model Implementation

At the core of the system lies the implementation of Generalized Autoregressive Conditional Heteroskedasticity (GARCH) models. GARCH models are instrumental in modeling volatility clustering and time-varying volatility within financial time series data.

1. Model Specification: Defining the model order (e.g., GARCH(1,1)) and selecting error term distributions lay the foundation for capturing volatility patterns.
2. Parameter Estimation: Estimating parameters like autoregressive and moving average terms is crucial for accurate volatility modeling, often done through maximum likelihood estimation.
3. Volatility Forecasting: GARCH models are adept at forecasting future volatility levels based on historical data, aiding risk management and decision-making.
4. Model Evaluation: Evaluating model fit through tests like residual analysis ensures reliability in capturing volatility patterns, crucial for risk management applications like Value at Risk (VaR) calculations.

5.3 GARCH model in detail

The GARCH model represents the conditional variance σ^2_t of a time series as a function of past squared residuals and past conditional variances. It can

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be expressed as

$$\sigma^2{}_t = \omega + {}^p{}_{i=1}\, \alpha_i \varepsilon^2{}_{t-i} + {}^q{}_{j=1}\, \beta_j \sigma^2 t - j$$

where

- ω is the constant term representing the long-term average volatility.
- $\alpha_i$and β_j are parameters representing the impact of past squared residuals and past conditional variances, respectively.
- p and q are the orders of the autoregressive and moving average components, respectively.
- $\varepsilon^2{}_t - i$represents the squared residuals at lag i
- $\sigma^2{}_t - j$ represents the conditional variance at lag j

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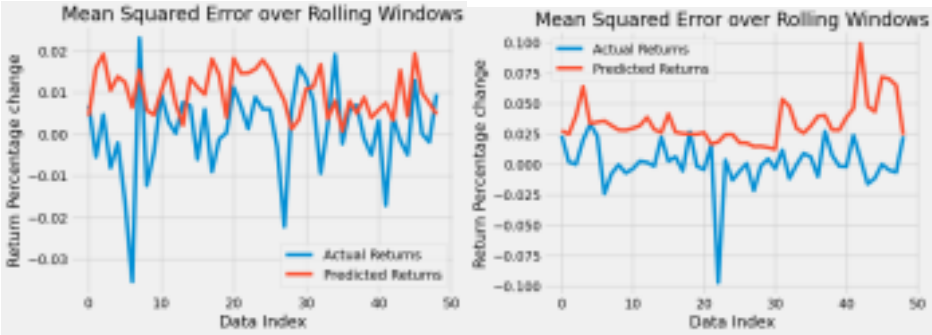
6 Results

We have taken one fiscal year's(1st April 2022 to 31st March 2023) data for each stock to train the models, i.e. data from the previous four quarters. The models were individually tuned to give better predictions and tested the results with the upcoming quarter(1st April 2023 to June 30th 2023).

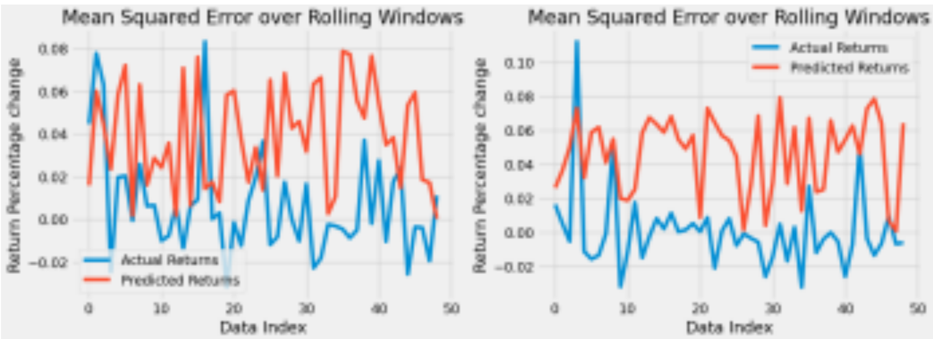
We have conducted experiments on 20 companies across 5 sectors by at least considering 4 companies per sector.

6.1 Performance Evaluation of Models with IT Sector



(a) Results on HCLTECH (b) Results on LATENTVIEW

6.2 Performance Evaluation of Models with Pharma Sector



(a) Results on AARTIDRUGS (b) Results on SHILPAMED

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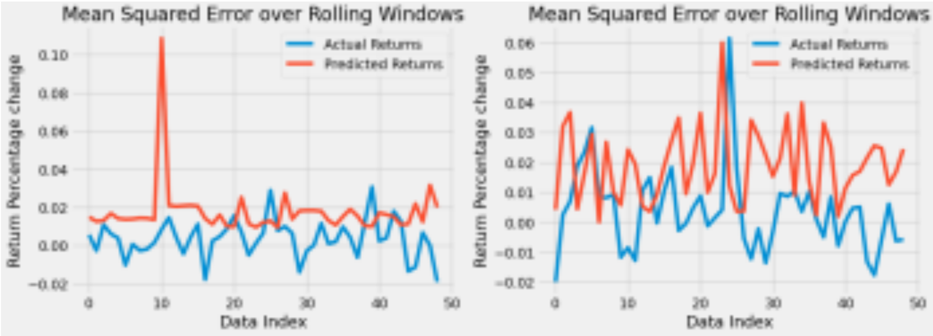
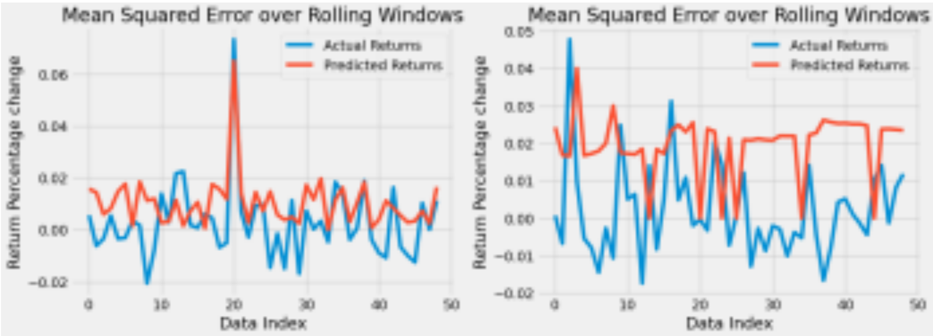
6.3 Performance Evaluation of Models with Automobile sector



(a) Results on HEROMOTOCO (b) Results on EICHERMOT

6.4 Performance Evaluation of Models with FMCG Sector



(a) Results on MARICO (b) Results on VIPIND

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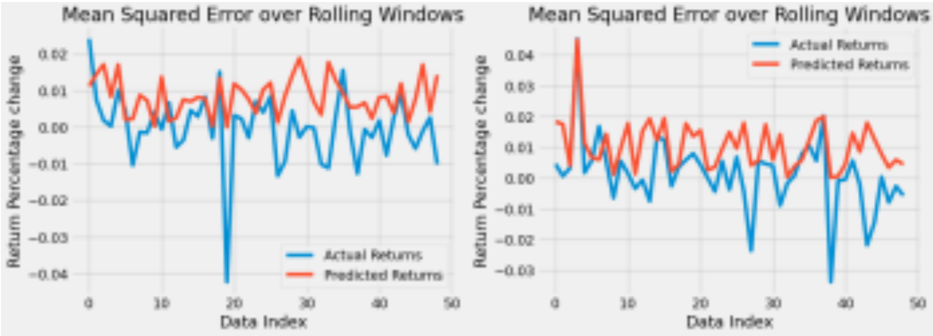
6.5 Performance Evaluation of Models with Banking Sector



(a)

Results on HDFCBANK (b) Results on KOTAKBANK

7 Conclusions

A predictive model should determine the direction of the stock from a particular point to another point between any two given points of the graph that match the observed values.

From the observed results we can confidently say that the GARCH model was successful in predicting the behavior of VWAP and can be said to be a reliable tool that can make predictions that traders can trust by the factor of direction.

A predictive model's ultimate goal should be serving its stakeholders right. Here in our research, we wish to empower traders with data-driven decisions who can determine their entry and exit from a stock to maximize their profit. Usually, most traders look at a picture for a month or two in our results we have given our best to produce reliable predictions for a quarter that is three months which is a huge window. Another aspect is that traders need to make decisions faster, comparatively the GARCH model is a faster model to execute than the other Bootstrapping and Bagging algorithms in machine learning.

The benchmark VWAP is chosen in our project to predict the stock market because this particular benchmark is a combined metric of several factors. Let us say there is an important decision that was taken and has been announced to the market, it is not the price that is affected immediately after the announcement it is the volume. The volume transacted and the price at which the volume was transacted determines the behavior of the

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stock. Since VWAP is a combined metric of volume and price, the predicted fluctuations in VWAP can be mapped to the fluctuations of the observed prices. The financial decision that was taken cannot be fed into the model but we can feed the effect of that decision by considering VWAP. When we take the price of the stock as our variable to predict we can only determine the price volatility but when we consider VWAP we can determine price volatility and also the volume volatility.

Predictions are said to be reliable in the financial sector when an interested trader can use a particular set of predictions to determine when to buy a stock and when to sell it. A model is said to be robust when it generates predictions that can be used to make informed decisions on when to enter and when to exit.

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