

ENGG*3130 - Final Report

Study of Volatility of the Stock Market Using Agents to Represent Stockholders

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Abstract

The stock market is a complex system that is influenced by a multitude of factors, including global events, economic indicators, and investor sentiment. Understanding and predicting its behavior is crucial for investors and financial institutions. However, studying the stock market is challenging due to its unpredictability and non-linear nature. In addition, real-world experimentation is expensive and time-consuming, and it may not provide sufficient data for analysis. Therefore, there is a need for a code simulation that can simulate the stock market and provide a platform for testing different investment strategies and scenarios in a cost-effective and efficient manner.

CCS Concepts • Theory of computation → Market equilibria

Keywords Complex systems, Stock market, Economy

1. Introduction

The stock market is a complex system that plays a crucial role in the lives of everyone. Investors make decisions based on many factors such as news, markets, social media, and many other factors. Predicting the behavior of the stock market accurately is a difficult task that requires many brilliant minds. Agent-based modeling is a relatively new method used to simulate the interaction between people, things, places, and time. It uses many agents which are assigned certain attributes to simulate a larger model. In this study, we create an agent-based model that mimics stock-

holder behavior and examine the effects of various scenarios, including short squeezes, pumps and dumps, and other elements that can influence the behavior of the stock market. By gathering and examining the results to come to a conclusion about the future tendencies of the stock market based on the model's output results.

2. Problem Statement

'Study of volatility of the stock market with the use of agent-based model by representing stockholders as agents.' It's difficult to comprehend and forecast stock market behavior, and conventional approaches are not always accurate. The ability of agent-based modeling to simulate investor behavior and forecast market highs and lows has shown promise. To create a trustworthy and accurate agent-based model that can predict future patterns in the stock market, more investigation and analysis are required. By providing a data-set large enough for the agent-based model to learn from and perform accurately, the data must be valid. This is necessary to achieve a sense of trust during our testing period and once it has provided us with results that are satisfactory, the model may be able to use data from the current scenario of the stock market.

The stock market is one of the most volatile fields present. It is difficult to state that the stock market can be made to work in one single way unless the investors of the stock market maintain their method of investing. The method of investing will differ depending on the volatility status of the stock market. We can maintain the volatility by finding methods to alter the current behavior of the investors in a manner that would not significantly affect or change the status of the stock market. Real world experimentation is extremely effective and may include possibilities of error. An agent-based model would be a cost effective and less time-consuming approach to obtain a satisfactory analysis. This paper aims to recreate and study the volatility of the stock

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CONF'23 April 23, 2023, Guelph, Ontario, Canada

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ISBN 978-1-2022-2023-n/23/04...\$15.00B

DOI: <http://dx.doi.org/10.1145/123456789.123456789>

market by introducing an agent-based model to replicate the results.

3. Literature review and related work

Over the years, Agent-based models have aided the understanding and possible predictions of several topics. Similarly, a model for our research has helped us understand the subject better and provided us with a much clearer understanding. A stock market model can provide us with insight into the future and allow better predictions for a stable or prosperous market. These agent-based models may be capable of predicting the lows and highs of the stock market based on external news and the behavior of the stockholders. ‘An Agent-Based Computational Model for China’s Stock Market and Stock Index Futures Market’ is a research paper that talks about an agent-based model simulating the behavior of the agents in China’s stock market and the future index’s stock market (Xu et al. 2014). The model is structured in two different layers where one layer is focused on each trader in the system while the other layer is focused on the whole market in its entirety. The research paper compares the results simulated from the model and real-world results (Xu et al. 2014). The results support the paper, and the model provides accurate results under several scenarios (Xu et al. 2014). Different scenarios cause different results in the model. The differences were noted depending on which one suited the Chinese stock market.

Similarly, ‘The Behavior and Impact of Heterogeneous Investors in China’s Stock Index Futures Market: An Agent-Based Model on Cross-Market Trades’ is another paper talking about the impacts of heterogeneous investors in the Chinese stock market (Yang et al. 2022). The authors speak about the different types of investors. A few of the investors can be classified as trend followers, noise traders, people with fundamental research/ideas, and cross-market traders. During the research, the authors came to the conclusion which suggested that those who used fundamental research/ideas while contributing to the stock market in China had a significant impact on the stability of the stock market (Yang et al. 2022). These individuals were the reason behind the stock market becoming stable after any impact from sources such as noise traders and trend followers (Yang et al. 2022). It is important to have the stock market behave stably, otherwise, the country’s market may crash and cause a catastrophic economic issue. Predictions caused by agent-based models would aid the economist, statisticians, and mathematicians in providing information and support to the users. The guidance from the scholars after they have evaluated the information from the agent-based model can suggest information to stabilize and excel the stock market under certain conditions.

The next literature review is ‘Using realistic trading strategies in an agent-based stock market model’. This literature review is quite similar to the previous paper (Llacay and

Peffer 2018). This paper focuses on finding strategies that would aid the idea of realistic strategies in an agent-based models by improving the simulation accuracy. The paper marks the importance of using realistic and current scenarios to compare with the results obtained from the model. The results showed almost an identical result between the two (Llacay and Peffer 2018). This research can conclude that the volatility of the market can be reduced significantly if agent-based models are used as a prediction tool for the stock market (Llacay and Peffer 2018). Agents replicate the behavior of investors and provide a result close to what a human would do in that situation.

4. Description of Approach

In terms of the design approach, our team has broken down the system into many smaller yet important systems. We defined the problem statement and will be studying the volatility of the stock market by creating a Jupyter Notebook to replicate an agent-based model that replicates investors. We have used the first three references to understand the difference between the models and how they have affected the research conducted [1, 2, 3]. The next step was to create an agent-based model on Jupyter Notebook using object-oriented programming concepts in Python. The notebook consists of code with two classes, ‘shareHolder’ and ‘stock’.

The ‘stock’ class represents the stock itself and the ‘shareHolder’ class represents the individuals who hold the stock. While the ‘shareHolder’ class has a specific task to aid users in buying, selling, and updating the status of shares held by a particular user. The ‘stock’ class allows the initialization of the stockholders and updates the prices of the stock in accordance with the data provided. The graphs in the notebook provide aid to the user to understand the changes in prices of the stock and the differences between number of stocks owned against the prices of the stocks. The limitations of this project consist of the number of models used with different parameters. Our team did not test for all scenarios possible.

5. Scope of Project

Objectives:

1. Develop an agent-based model that will replicate the behavior of stockholders. Any pressure, trends or news will affect the decision of the agent.
2. Analyze the impact of short squeeze, Pumps & Dumps, and other situations that may influence the behavior of the stockholders.
3. Identify and examine the effects made of the market volatility and draw an assessment of the impact made on different situations.
4. Accumulate and analyze the results obtained from the model to draw a conclusion.

Tasks that will be completed:

1. Literature review of studies supporting our problem description.
2. Create a Jupyter Labs document to display an agent-based model using Stockholders as agents. The agents could buy, sell, or abstain using pressure from outside.

Exclusions:

1. Natural disasters, environmental factors, political factors, influence from companies and social media cannot affect the data of the agent-based model.
2. Working with a certain restrictive section of data prior to exploring all options of the stock market.
3. Working on specific types of agents. Exploring with all the types of agents is not an ideal option to gain the results needed for our goal.

6. Constraints and Criteria

Constraints:

1. The model will only consider the behavior of stockholders and not any external factors such as natural disasters, environmental factors, political factors, influence from companies and social media.
2. The model will work with a certain restrictive section of data related to the stock market.
3. The model will not focus on specific types of agents, but rather explore all the types of agents to gain the results needed for the goal.
4. The availability of data is restrictive. To test the model, a larger data-set is required for a conclusive result.

Criteria:

1. The agent-based model must accurately replicate the behavior of stockholders in the stock market.
2. The model must consider external pressure, trends, and news that may affect the decision of the agent.
3. The impact of short squeeze, Pumps & Dumps, and other situations that may influence the behavior of the stockholders must be analyzed and examined.
4. The model must identify and examine the effects made on market volatility and draw an assessment of the impact made on different situations.
5. The results obtained from the model must be accumulated and analyzed to draw a conclusion.

7. Design Execution and Simulation

To see how certain parameters affect the behavior of the stock price, certain parameters were changed and then the price was plotted. The first test was how an increased drive to buy or sell affected the stock price. When compared to

the baseline seen in Figure 1, the higher drive to sell programmed into the agents causes an overall decline in stock price as seen in Figure 3. As well, there seems to be less volatility in the price which is likely because the share holders all have similar ideals when compared to the baseline. For increasing the share holder buying drive, the stock price is higher, as seen in Figure 2, than the baseline which is to be expected as the stock is more sought after increasing its worth. The next parameter changed was the number of shares the share holders started off with as seen in Figure 4. Increasing this seemed to slightly decrease volatility although it is hard to distinguish. This indicates that the simulation seems to reach a steady routine even though it looks very chaotic as increasing the starting shares yielded a very similar graph to the baseline. The final parameter changed was the amount of wealth that the share holders started with. Increasing this again seemed to cause very little change, as seen in Figure 5. This was unexpected as more wealth would mean more room for purchasing more shares but this unexpected behavior again leads to the idea that this simulation seems to reach a predictable pattern.

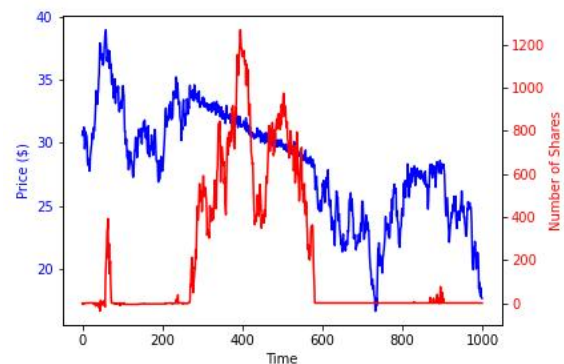


Figure 1. Baseline

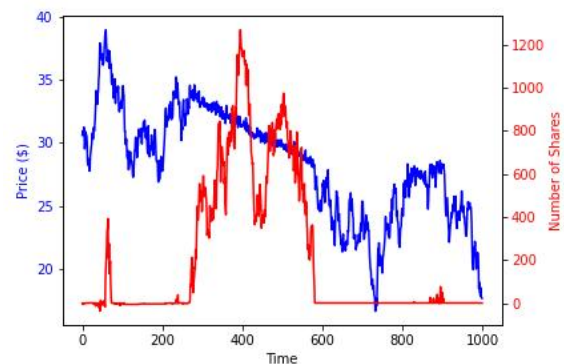


Figure 2. Higher buy probability

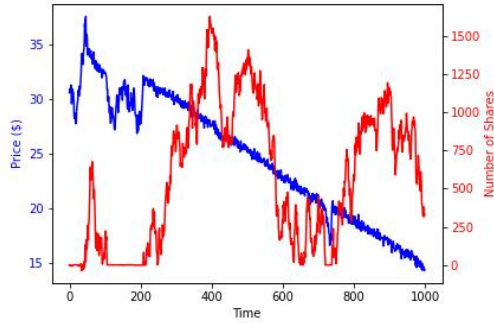


Figure 3. Higher sell probability

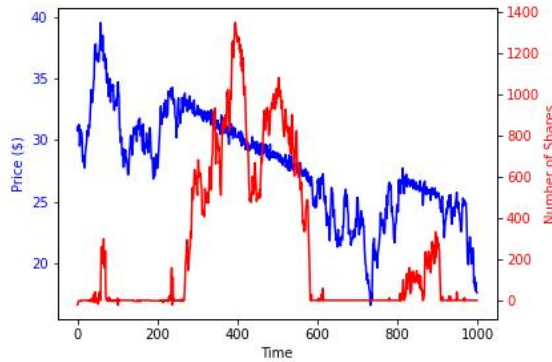


Figure 4. Higher number of shares owned

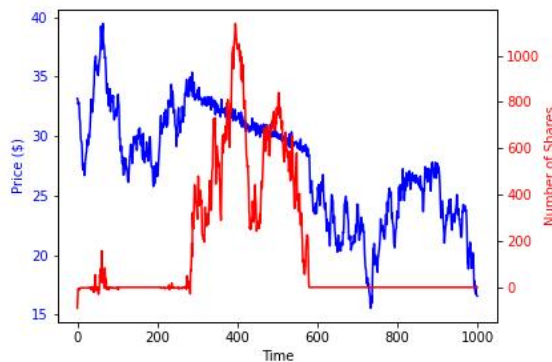


Figure 5. Higher wealth cap

8. Conclusion

In conclusion, the objective of this project was to develop an agent-based model that accurately replicates the behavior of stockholders in the stock market. The project analyzed the impact of external pressure, trends, and news on the decision of the agents and examine the effects made on market volatility. The design approach involved creating a Jupyter Notebook using object-oriented programming concepts in Python, and analyzing the results obtained from the model. The limitations of the project included the number of models used with different parameters, and the availability of data

being restrictive. Overall, this project has the potential to provide valuable insights into the behavior of stockholders in the stock market and their response to external pressure, trends, and news.

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