Research Proposal

Quantum Oscillation Modeling of Stock Prices

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Submitted in Partial Completion of Senior Research Requirement

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Submitted: September 25, 2024

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1 Introduction:

My proposed work is to use quantum oscillations to model stock prices. In general, oscillations can help investors and businesses predict changes in price through short term and long term modeling. Similar to the up and down changes in the stock market, oscillations can measure up and down patterns in stock prices based on previous data of the stock and the prices of other related securities. Additionally, oscillations can help with measuring changes in volatility to better measure notable changes in stock prices.

1.1 Intellectual Merit

Using quantum oscillations instead of classical oscillations has become more popular over the past decade as developments in quantum mechanics have shown multiple benefits to classical oscillations. Modeling for the stock market is only one of the uses of quantum oscillations and other popular uses include applications to materials science and light measurements. In terms of modeling for the stock market, quantum oscillations can provide multiple benefits. First, quantum oscillations have energy levels that discrete, given by spin up and spin down, which is unlike classical oscillations where energy varies continuously. Quantum oscillations also always have a minimum energy level. Due to its energy levels, quantum oscillation can help with more accurate modeling. Moreover, quantum oscillations are described by wave functions which can give probability distributions to measure for a particular position. The added variability in quantum oscillations due to the uncertainty principle also tells more about volatility. Simply put, quantum oscillations have the potential to better measure stock prices.

1.2 Broader Impacts

On top of adding to current understanding of quantum mechanics and oscillations, modeling the stock market using quantum oscillations can be very useful for companies and businesses at large for their investments. One example of how they would help with better investing include more accurate financial analysis that can better predict market interactions and changes. This could lead to more effective use of financial tools and better risk management whether through short or long term investments, or by helping with portfolio optimization. Quantum oscillations for stock markets can also lead to interdisciplinary applications such as combining physics with data and economics, which can provide experts and students with a comprehensive understanding of market dynamics and advanced modeling techniques.

2 Specific Project Goals and Measurements:

1. **Understand Classical and Quantum Oscillations and Make Classical Model of Oscillations**
   My initial goal is to learn how classical oscillations work and how to use classical computing to model quantum processes. To do this, I need to first understand more in depth the mechanics behind wave functions and energy levels and how they relate to classic examples of oscillations such as springs or simple harmonic motion. Learning about the continuous energy levels and minimum energy levels of these classical examples will allow me to better understand quantum oscillations later in my project. After learning how classical and quantum oscillations work, I will start learning how to use classical computing for quantum applications, but first make a classical model. During this process, I will need to find out what kind of coding I need to do and what software or extensions are necessary. I will need to collect data from online for whatever stock prices I am trying to forecast. I will know if my model works if it produces a function that reasonably follows the trend of the stock price during whatever period of its growth I am modeling.

2. **Use Quantum Computing to Make Quantum Model and Possibly Introduce New Insight**
   My second goal is to recreate existing quantum oscillation models of the stock market. First I will need to learn how to use remote quantum computers. After doing that, I will start to examine what oscillation models to recreate. Out of the research articles I have looked at, I plan to examine which quantum models are possible to recreate and then to recreate one or some of the oscillation models. This is the main step of my second goal because I want to make sure I can use quantum computing for quantum oscillations before trying to include something different from what I have seen in the articles. i will continue to use data I collected during goal 1 for modeling. If I have time after already recreating some existing quantum oscillation models, I can try to add something new.

3 Potential Pitfalls and Alternative Strategies:

1. Recreating Oscillation Models, Classical or Quantum

    Potential Challenge: One challenge is knowing what software and coding language I would use to recreate an oscillation model. I don't how advanced coding skills I need or how difficult it is to recreate a classical or quantum model using classical code.

    Solution: Starting early, while researching and learning how oscillations work, I will also research different types of coding and software for creating oscillation models, as well as what equations and data are necessary.

    Potential Challenge: Another challenge is actually recreating a quantum oscillation model. I don't know how quantum computing works or if the remote quantum computing given to us by the IBM is capable of computing data and sending it back in a reasonable time frame.

    Solution: To overcome this challenge, I should start learning about quantum computing and working with the quantum computer as early as possible. This means I should finish the classical component of my project without delay.

2. Creating Algorithms and Collecting Data for Stocks

    Potential Challenge: One challenge is the complexity of the financial market and all the different variables that can go into determining the value of a stock. Because of this, it will be difficult for me to accurately access what data I need. I also might not have access to some downloading data for certain variables or stock prices.

    Solution: I will began researching early on what datasets I can obtain stock prices and other stock variables from, so that I will know which resources I can use for stocks and data for which variables is necessary.

    Potential Challenge: Since there are so many variables, another challenge is to make an effective algorithm that accounts for all of those variables that may effect stock price, whilst also making sure that I don't neglect the quantum aspect of the algorithm I use.

    Solution: Similar to the solution of the first challenge, I would need to do comprehensive research on what variables are necessary. I would also look into multiple different algorithms as I research and interpret.

4 Proposed Timeline:

4.1 Experimental Timeline

Mid-October: Benchmark 1: Complete Most Learning and Research

Task: Learn how classical and quantum oscillations work and complete most of the researching for what articles' quantum models I will recreate.

Objective: Make sure I know the important components of classical and quantum oscillations.

Goal: Ensure that I have sufficient knowledge to eventually create a working oscillation model and that my project has approval from my research teacher.

Mid-December: Benchmark 2: Code Classical Oscillation Model using Classical Computing

Task: Learn how to use classical computing to create a model for a classical oscillation model of stock prices.

Objective: Make sure that I have coded at least one oscillation model that accurately models whatever stock I decided to predict.

Goal: Ensure that I understand how to code oscillations models to prepare me for using quantum computing to create a quantum model.

Mid-March: Benchmark 3: Code Quantum Model using Quantum Computing

Task: Learn how to use the IBM remote quantum computing and create a quantum oscillation model of stock prices.

Objective: Make sure that I have successfully coded one quantum oscillation model for the stock price I am trying to predict.

Goal: Ensure that I understand the use of quantum oscillations and analyze the data of the stock to interpret the results and how effective the quantum model was.

End of May: Final Benchmark: Complete Experiment and Prepare for TJStar

Task: Finalize the quantum model to make sure it is effective and that I have all necessary data of stocks and save necessary graphs, models, and data to present.

Objective: My quantum oscillation model of stock will be clear enough that I can present it at TJStar.

Goal: Provide a clear presentation with graphs, models, data, and equations I used to explain the broader impact of quantum oscillations on modeling finance to underclassmen.

4.2 Research Paper Timeline

Mid-December: First Draft of Introduction and Background

Task: Write the introduction, including what oscillations are and how they model the stock market, as well as the merits of quantum models. Summarize the theoretical basis for the quantum oscillations and the significance of its applications to the stock market.

Goal: Complete a rough draft of the first sections of the paper.

Mid-March: First Draft of Methods, Results, and Discussion

Task: Write the experimental methods section in detail, including what stock data I collected, and how I used classical and quantum computing to model the stock price. Also draft the results section based on the data collected and how accurate the graphs of my oscillation models are. Then, draft the discussion section of the paper to discuss how my analysis can be applied to the real world.

Goal: Ensure the methods are clearly described and the preliminary results are reported accurately. Also have a draft of the discussion section.

End of May: Final Research Paper

Task: Finalize the results, discussion, and conclusion sections, integrating final data and analysis. Refine the introduction and background sections based on feedback. Ensure proper citations and formatting.

Goal: Submit my final research paper, showcasing the experimental process, results, as well as a discussion of the broader implications of oscillation models to finance/economics.

5 Annotated Citations

1. A. Bhatt and R. Gor, Exploring Quantum Harmonic Oscillator as an Indicator to Analyse Stock Price Volatility, International Journal of Mathematics Trends and Technology, (2023).

    - The main focus of this work is to use a quantum harmonic oscillator to predict stock price movements. The specific method used allows for analysis of the mean percentage change in price, which can help determine the range of energy levels that correspond to small price changes. This is useful for my research topic because it shows how I can use energy levels of wave functions to measure slight variability in stock prices. The authors of this paper are researchers affiliated with the Department of Applied Mathematical Science, Actuarial Science, and Analytics at Gujarat University. In this paper, they reached the conclusion that the volatility of a stock could be determined based on what energy levels the mean percentage price change of a stock is between. This paper could aid me in studying energy levels and how they tell more about volatility in stock prices.

2. A. Bhatt and R. Gor, CALIBRATION OF QUANTUM HARMONIC OSCILLATOR AS A STOCK RETURN DISTRIBUTION MODEL ON THE INDEX OF NSEI, International Journal of Engineering Science Technologies (2022).

- This work focuses on a quantum harmonic oscillator which uses a stock return from short-run oscillations to long-run equilibrium. This paper could be useful for my research as it shows how oscillatory movement can predict long term equilibrium prices of stock prices. It does this through creating goodness of fit quantum harmonic oscillators for stock return, showing mostly normal distributions of stock returns, indicating the strength of the oscillator for. The authors of this paper are the same as the paper from before. Through their results, the authors made observations between stock holding periods and stock returns, and concluded that the mean value of a quantum harmonic oscillator is close to the mean value of the stock return.

3. D. Orrell, A Quantum Oscillator Model of Stock Markets, Sage Journals, (2024).

   - The main focus of this work is to develop a quantum model in which the energy level corresponds to an integer number of transactions, to model stock buyer and seller interactions. This relates to my research topic because it shows one aspect of how quantum oscillators can be used to model stock prices. Unlike other oscillation models, the model in this paper is derived by quantizing entropic forces which represent the intentions of buyers and sellers to transact as a function of price. The author of this paper is David John Orrell, a Canadian writer and mathematician who received his doctorate in mathematics from the University of Oxford. In this paper, Orrell reached the conclusion that a quantum approach offers a way to bring energy and entropy into finance, in a manner that is consistent with observed market behavior. This paper could aid me in studying energy and entropy and how they can tell more about stock volatility and buyer seller interactions.

4. T. Gao and Y. Chen, A Quantum Anharmonic Oscillator Model for the Stock Market, Elsevier, (2017).

   - The main purpose of this paper is to use an anharmonic oscillator. This is different from a harmonic oscillator, which is used for stock prices that follow more normal up and down trends. The authors use a quantum model where they introduce mixed state and multiple potential levels to model the leptokurtic distributions (distribution with lots of outlier) of price return. The paper also focuses on how price return is different in a non-liquid market with a bimodal distribution. The authors concluded that an anharmonic quantum model is better than the simple random walk model at describing the probability distributions of price returns.The authors of this paper have conducted multiple research projects on quantum applications to stocks and finance, but it is unclear if they have an affiliation with any company or university. This research is relevant to my research because it can help me analyze how stock price trends may differ when there are atypical conditions in market conditions.