A Heuristic Entrepreneurial Perspective on Quantum Annealing in Combinatorial Portfolio Optimization for Transitional New World Era

Author: Werner Vermeulen
Supervisor: Professor Joe Byers
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Abstract
This research project addresses a literature gap by investigating **Quantum combinatorial portfolio optimization** within the context of financial engineering and FinTech entrepreneurship. The central research question examines whether a Quantum FinTech entrepreneur can outperform a classical financial engineer in solving portfolio optimization problems using the D-Wave Quantum Annealer 2000Q. The study employs **Quantum Finance**, linking Quantum Mechanics to Quantum Computing, specifically utilizing the D-Wave Annealer and its Ocean Software Development Kit alongside Python programming. The paper reflects on the diminishing Moore's Law in classical computing and highlights the transition to a new Quantum era.

Introduction
The study presents a heuristic learning experience derived from a Master's program in Financial Engineering, applying Quantum Finance to solve two NP-complete combinatorial portfolio optimization problems. The research acknowledges classical finance frameworks, particularly the contributions of **Harry Markowitz** and the **mean-variance** portfolio optimization model, while innovating upon them through Quantum Computing techniques.

Structure
The paper is organized into sections:
1. Introduction
2. Background and Context
3. Problem Statement
4. Literature Review
5. Methodology
6. Results
7. Conclusions
8. Recommendations and Future Research

Background and Context
The concept of **Quantum Economics** was introduced by Dr. Asghar Qadir in 1978, and this paper explores the implications of Quantum Computing on classical financial models by examining the limitations of classical physics in solving complex optimization problems.

Problem Statement

The research highlights the critical importance of finding an optimal portfolio amidst increasing data and diminishing computational performance. It investigates existing methods' inadequacies and the potential of Quantum Computing to overcome these challenges.

Research Objectives
- Identify Quantum portfolio optimization strategies in North America.
- Apply these strategies to evaluate their effectiveness in achieving optimal risk-return combinations.
- Compare and contrast these approaches against traditional benchmarks.

Research Questions
The study delves into the application of Quantum Machine Learning through the D-Wave 2000Q, covering various aspects of Quantum Mathematics, Statistics, and Cognition, and introduces methodologies for back-testing portfolio optimization strategies.

Literature Review
The literature review distinguishes between classical and Quantum portfolio optimization, addressing biases present in classical finance, such as overfitting. The review reveals that Quantum portfolio optimization is still an emerging field and that Quantum Computing could provide solutions to problems too complex for classical systems.

Key Themes
- **Classical vs Quantum Portfolio Optimization:** The review identifies inherent limitations in classical methodologies prompting the exploration of Quantum approaches.
- **Quantum Portfolio Optimization:** It discusses the potential of Quantum Annealers to solve complex optimization problems more efficiently than classical supercomputers.

Methodology
The research adopts a mixed-methods approach, emphasizing both qualitative and quantitative analyses. It involves:
- Experiments with the D-Wave Ocean SDK.
- A longitudinal study of data from the London Stock Exchange.
- A comparative analysis of D-Wave results against classical brute-force methods.

Results
The findings confirm that Quantum annealing can indeed solve portfolio optimization problems more rapidly and reliably than classical methods. The study showcases the ability of the D-Wave 2000Q to outperform benchmarks for selected stocks, demonstrating significant advantages in trading performance through Quantum techniques.

Sample Optimization Results
- **Quantum Annealer (QA):** High-return but also high-risk portfolios.
- **Simulated Quantum Annealer (SQA):** Lower return with minimum risk.
- **Hybrid Approaches:** Similar performance to SQA, indicating a balanced risk-return profile.

Conclusions

The research concludes that the D-Wave Quantum Annealer 2000Q provides a viable entrepreneurial opportunity in the realm of Quantum Finance. It emphasizes the importance of Quantum cognition in decision-making processes, advocating for a shift from an "I-mode" (self-interest) to a "We-mode" (collective interest) approach in financial decision-making.

Recommendations and Future Research
- Further analyses with the next-generation QPU, **Zephyr topology**.
- Development of entrepreneurial business cases focusing on educational gaps in Quantum technologies.
- Exploration of Quantum Game Theory's implications for financial markets.

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This summary encapsulates the essential elements of Werner Vermeulen's research, showcasing the innovative integration of Quantum Computing in financial optimization and its implications for the future of FinTech entrepreneurship.