Research Prospects

1. Quantum vs Classical Risk Assessment

Core question: Can quantum amplitude estimation (QAE) or quantum Monte Carlo estimate portfolio tail risk (VaR / CVaR) faster or more accurately than classical simulation?

Possible studies

- Benchmark QAE against classical Monte Carlo for VaR and CVaR on multi-asset portfolios.
- Measure empirical error vs. sample size → show

  $$(O(1/N))$$

  vs

  $$(O(1/\sqrt{N}))$$

  scaling.
- Hybrid workflow: classical scenario generator + QAE evaluation.

Data / experiments

- Historical equity indices or ETF baskets (S&P 500, NIFTY 50).
- Compare classical 10 –10 samples to quantum-simulated QAE on 8–12 qubits (Qiskit Aer).

Publishable in

- *Quantum Information Processing (Springer)*
- *Frontiers in Physics – Quantum Engineering*
- *Journal of Risk and Financial Management* (for finance-leaning audiences)

2. Quantum-Enhanced Portfolio Optimization

Core question: Does Quantum Mean–Variance (QMV) or QAOA for CVaR achieve better solution quality or runtime for constrained portfolios?

Possible studies

- Encode Markowitz and CVaR optimization as QUBO problems; solve via D-Wave annealer or QAOA.
- Evaluate scalability with number of assets N = 10–50.
- Compare Sharpe ratio, drawdown, and solution sparsity against classical solvers (quadratic programming, DRO).

Data / experiments

- Daily returns of S&P sector ETFs or cryptocurrency baskets.
- Simulated quantum runs + classical baseline (IBM Qiskit Runtime).

Publishable in

- *IEEE Transactions on Quantum Engineering*
- *Journal of Computational Finance*
- *Quantum Machine Intelligence (Springer)*

3. Regime-Adaptive Quantum Trading

Core question: Can a quantum regime detector (QBM or qPCA) improve trading strategy selection and risk-adjusted return?

Possible studies

- Build hybrid pipeline: regime detector (QBM / qPCA) → strategy selector (momentum / mean-reversion / pairs) → QMV optimizer.
- Compare performance to fixed-strategy baselines using Sharpe, Sortino, and maximum drawdown.
- Study regime transition probabilities and stability.

Data / experiments

- Multi-decade equity index and volatility indices (VIX, MOVE).
- Rolling-window training + backtest.

Publishable in

- *Quantitative Finance*
- *Physica A – Statistical Mechanics and its Applications*
- *Quantum Machine Learning (Springer)*

4. Quantum Generative Models for Scenario Simulation

Core question: Can QGAN / QBM generate realistic market return distributions beyond Gaussian/t models?

Possible studies

- Train QGAN on daily returns; compare generated distributions (skewness, kurtosis, tail behavior) to real data.
- Use generated scenarios to stress-test classical optimizers.
- Evaluate sample diversity vs. model capacity.

Data / experiments

- Equity + crypto returns (diverse non-Gaussian behaviors).
- Use Qiskit Machine Learning or Pennylane QGAN.

Publishable in

- *Entropy (MDPI)*
- *npj Quantum Information* (for algorithmic focus)
- *Journal of Computational Science*

5. Quantum Reinforcement Learning in Trading

Core question: Does quantum policy search (QRL) improve learning speed or stability for trading agents?

Possible studies

- Implement classical DQN / PPO vs Quantum Variational RL.
- Compare convergence rate and reward volatility under identical environments.
- Test on discrete trading actions (buy, sell, hold) with transaction costs.

Data / experiments

- High-frequency or daily price data; environment via OpenAI Gym / FinRL.

Publishable in

- *IEEE Access (Quantum Computing special issues)*
- *Frontiers in Artificial Intelligence – AI in Finance*

6. Comparative Framework Paper

Core question: How do quantum and classical methods interact across the entire hedge-fund pipeline?

Possible studies

- Integrate modules from above (risk, optimization, regime detection, trading).
- Quantify computational complexity, scalability, and potential speed-ups.
- Provide taxonomy + performance dashboard.

Publishable in

- *ACM Computing Surveys (if broad)*
- *Quantum Reports*
- *Springer Handbook of Computational Finance* (as a chapter)

Suggested Research Progression

Phase	Focus	Output
1	Implement & benchmark QAE vs classical VaR	Short paper / poster
2	QMV & QAOA portfolio optimization	Journal article
3	Market regime detector (QBM/qPCA) + trading integration	Second journal paper
4	Full hybrid quantum-classical hedge fund simulation	Major publication / thesis

Possible Contributions to Emphasize

- **Speedups** – empirical runtime scaling for QAE/QAOA compared to Monte Carlo or quadratic programming.
- **Performance uplift** – higher Sharpe ratio or lower CVaR under identical risk budgets.
- **Hybrid design patterns** – how classical and quantum solvers interact (data flow, parameter hand-off).
- **Methodological reproducibility** – open-source datasets and Qiskit/Pennylane notebooks.
