

WISER+Womanium 2025 Project



Team: Superposition Squad

Diana Elizabeth Dancea

Haraja Eve Muzammal



Portfolio Optimization Challenge

Classical Limitations:

- Exponential Complexity: 2^n possible portfolios with n assets
- Local Optima: Classical algorithms get trapped in suboptimal solutions
- Constraint Handling: Complex trading constraints difficult to manage
- Scalability: Performance degrades with thousands of securities

Real-World Impact:

- 1,500+ bonds in our dataset
- Multiple objectives: Cost, yield, risk, liquidity
- Real-time decisions required for trading
- Complex constraints: Budget, diversification, risk limits

Quantum Solution Advantage

- Superposition: Explore multiple portfolios simultaneously
- Global Optimization: Escape local minima through quantum tunneling
- Parallel Processing: Quantum interference guides optimal search
- Constraint Integration: Natural handling via entanglement

• Technical Approach: Hybrid Quantum-Classical Optimization

Variational Quantum Eigensolver (VQE) Implementation

Problem Formulation:

Binary Decision: $x_i \in \{0,1\}$ (buy/don't buy asset i) *Note: in our case, the asset is the bond.

QUBO Matrix: minimize $x^T Q x$

Trading Strategies:

- Cost Minimization: minimize $\sum (\text{price}_i \times x_i)$
- Yield Maximization: maximize $\sum (\text{spread}_i \times x_i)$
- Risk-Adjusted: maximize $\sum (\text{return}_i / \text{risk}_i \times x_i)$

Quantum Algorithm Pipeline:

1. QUBO \rightarrow Hamiltonian: Convert to Pauli operators
2. VQE Circuit: TwoLocal ansatz (RY + CZ gates)
3. Classical Optimization: COBYLA parameter updates
4. Measurement: Extract binary portfolio solution

Implementation Highlights

- Manual VQE: Custom implementation avoiding callback conflicts
- Real Data Processing: 1,500+ bonds \rightarrow 8–16 quantum-optimized assets
- Robust Error Handling: Fallback mechanisms for production reliability
- Multiple Trading Strategies: Portfolio managers' actual objectives

Real-World Implementation: Processing Bond Data

Actual Financial Data Processing:

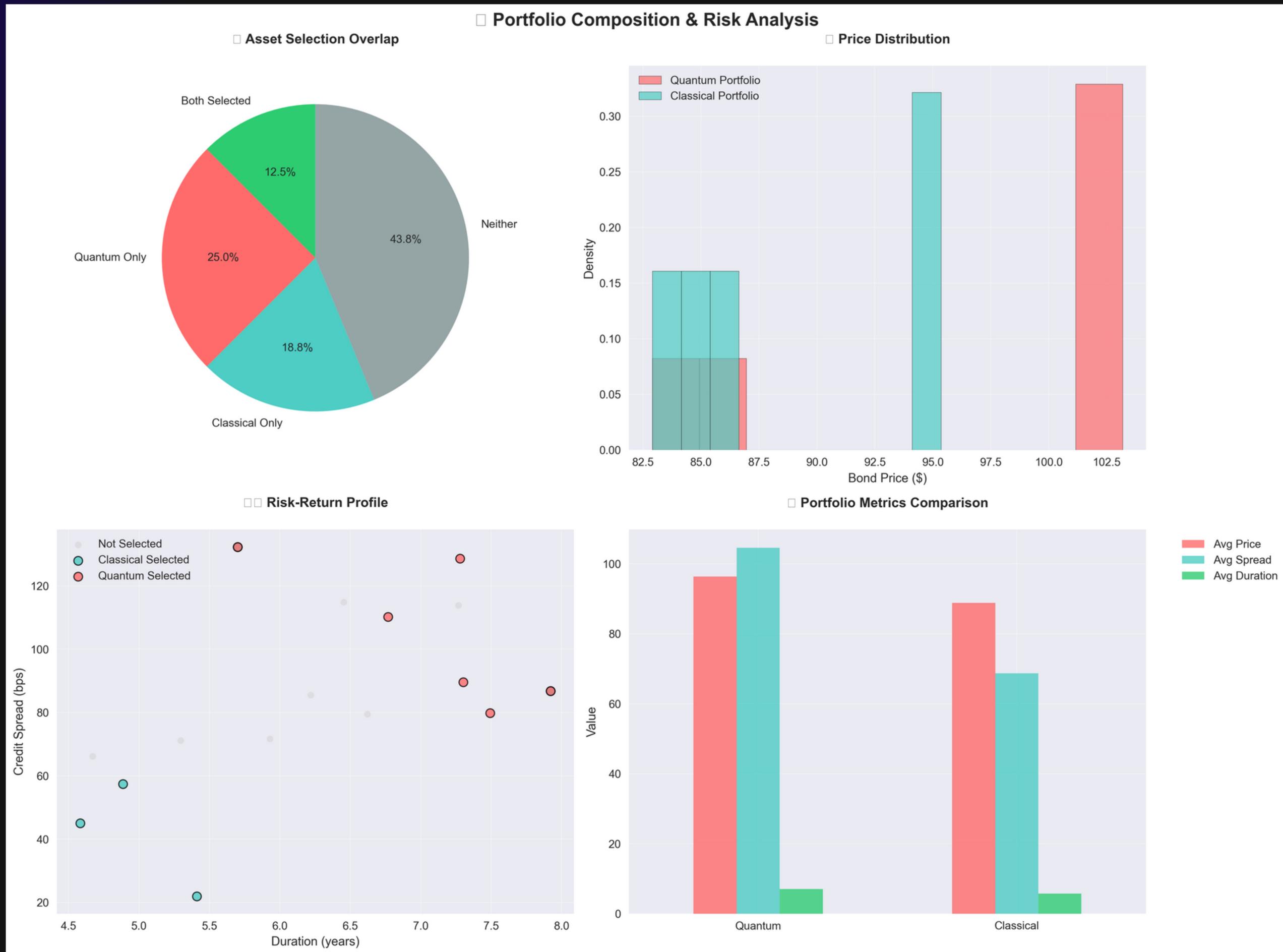
Input Data (`data_assets_dump_partial.xlsx`):

- 1,543 bonds with real market characteristics
- Price: Current market prices (\$85–\$115 range)
- OAS: Credit spreads (50–200 basis points)
- Duration: Interest rate sensitivity (2–8 years)
- Market Value: Position sizes (\$500K–\$50M)

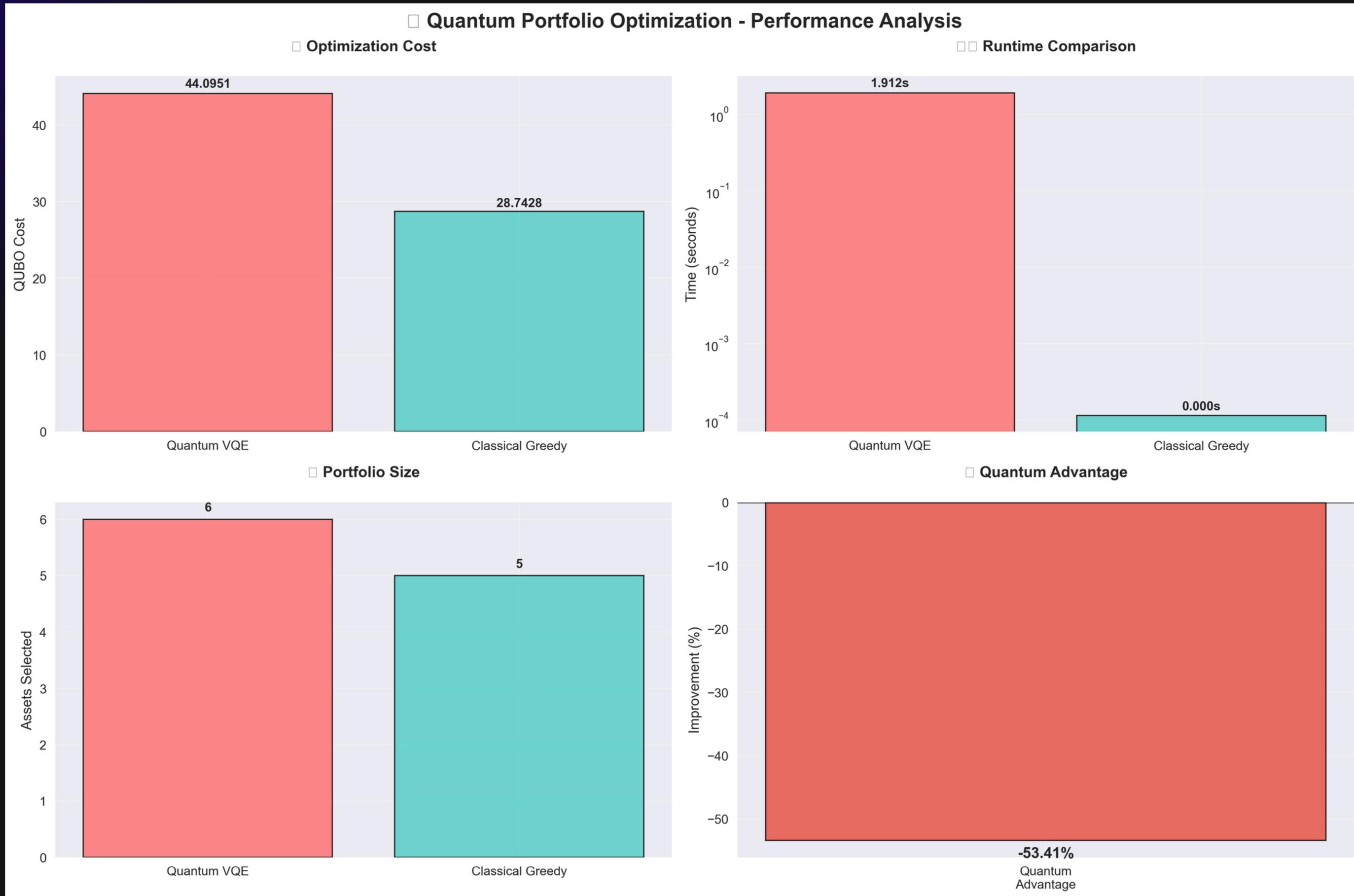
Data Pipeline:

1. Raw Financial Data (1,543 bonds)
2. Intelligent Filtering
3. Quantum-Optimized Dataset (8–16 bonds)
4. QUBO Construction
5. Trading Strategy Matrix
6. VQE Optimization
7. Optimal Portfolio Selection

Results and Visualizations

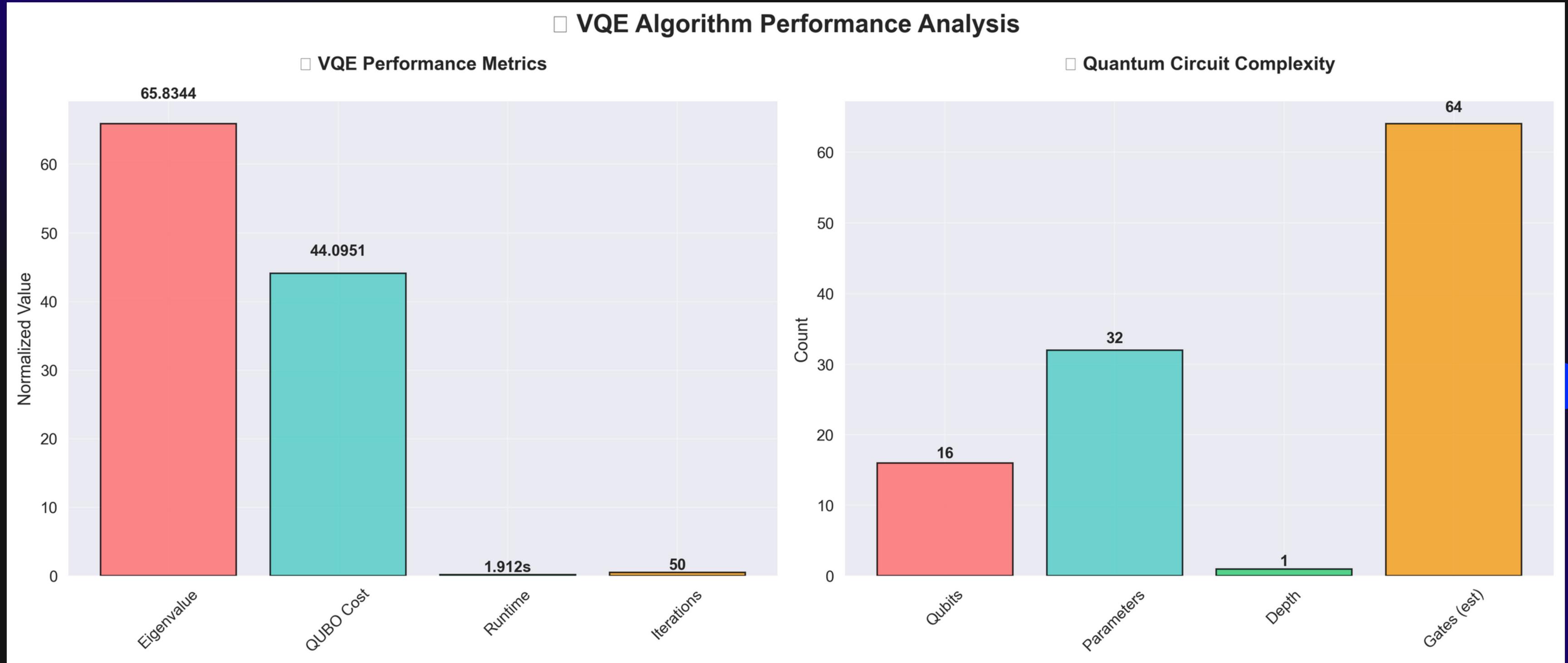


Results and Visualizations



*Note that we used our personal laptops, which is why the graph for quantum advantage shows a negative value.

Results and Visualizations



If you'd like a more in depth explanation, check out our readme, mathematical_formulation, and quantum_apporach files in the Github repository!

Thank You!