Vanguard Project

WISER+Womanium 2025

Team: Superposition Squad

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Vanguard's 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+ Vanguard 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 $\Sigma(price_i \times x_i)$
- Yield Maximization: maximize $\Sigma(spread_i \times x_i)$
- Risk-Adjusted: maximize $\Sigma(return_i/risk_i \times x_i)$

Quantum Algorithm Pipeline:
1. QUBO → 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+ Vanguard bonds → 8-16 quantum-optimized assets
- Robust Error Handling: Fallback mechanisms for production reliability
- Multiple Trading Strategies: Portfolio managers' actual objectives

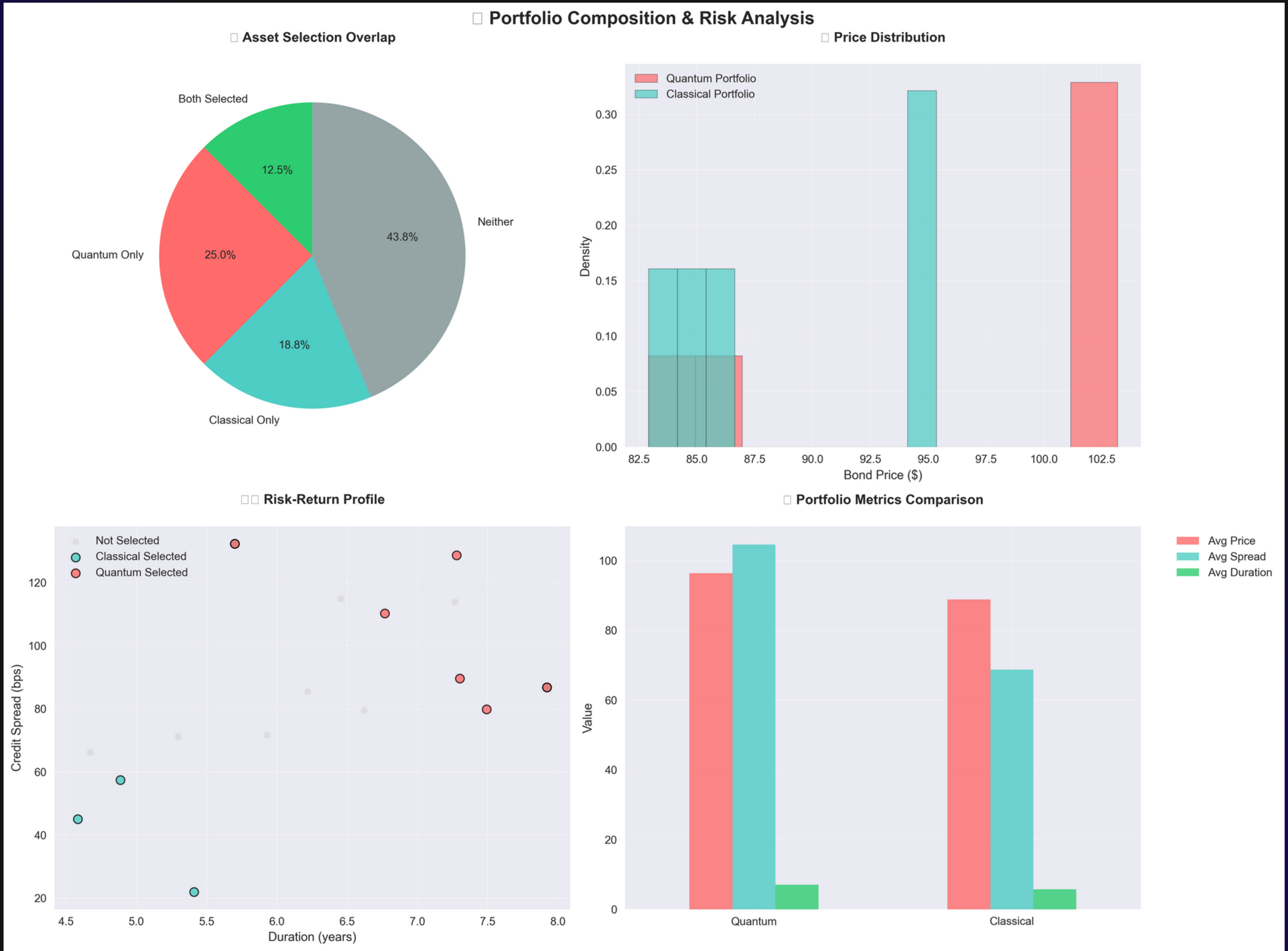
Real-World Implementation : Processing Vanguard Bond Data

Actual Financial Data Processing:

Input Data (data_assets_dump_partial.xlsx):
- 1,543 Vanguard 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 Vanguard 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



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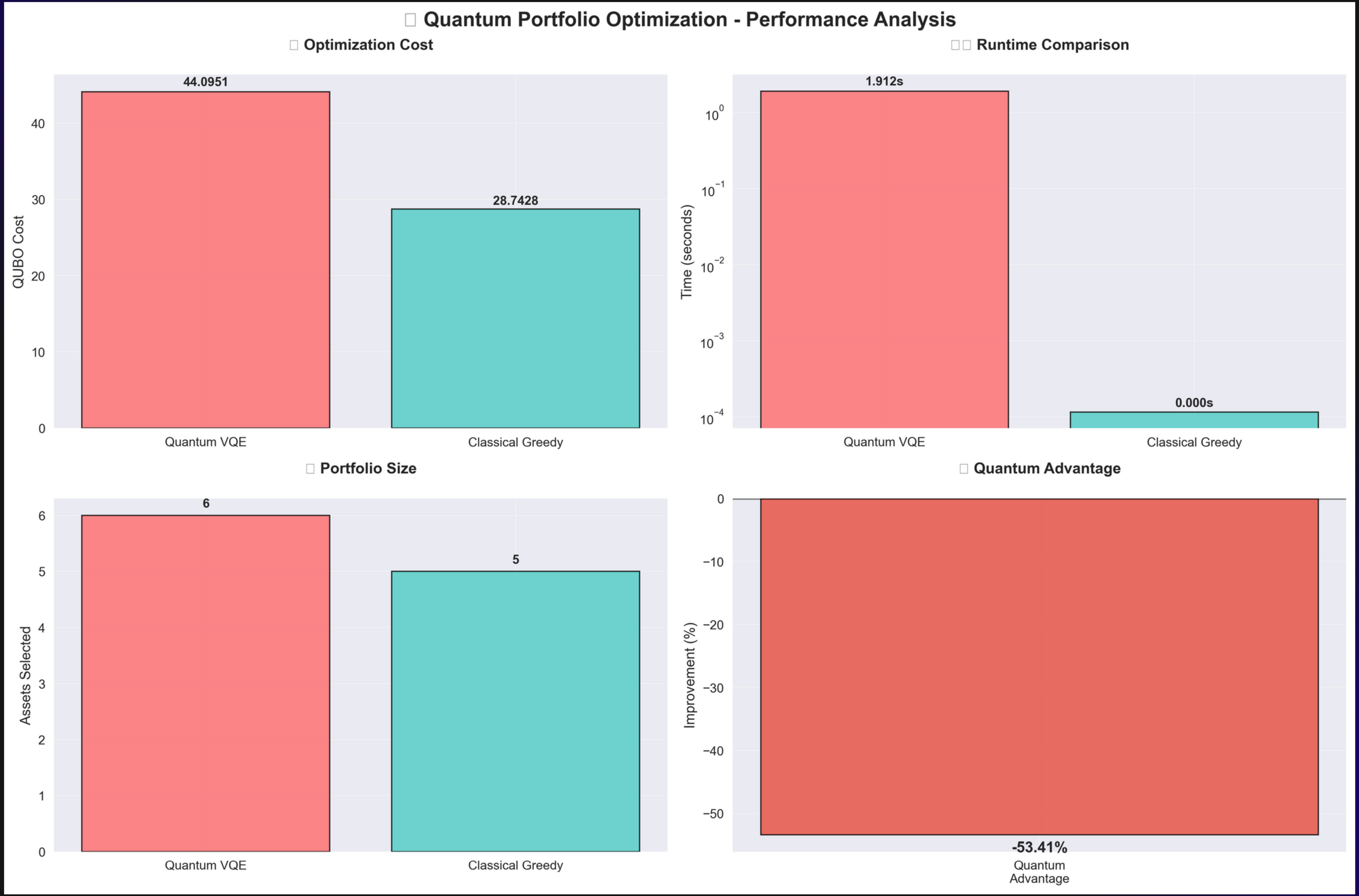

*Note that we used our personal laptops, which is why the graph for quantum advantage shows a negative value.

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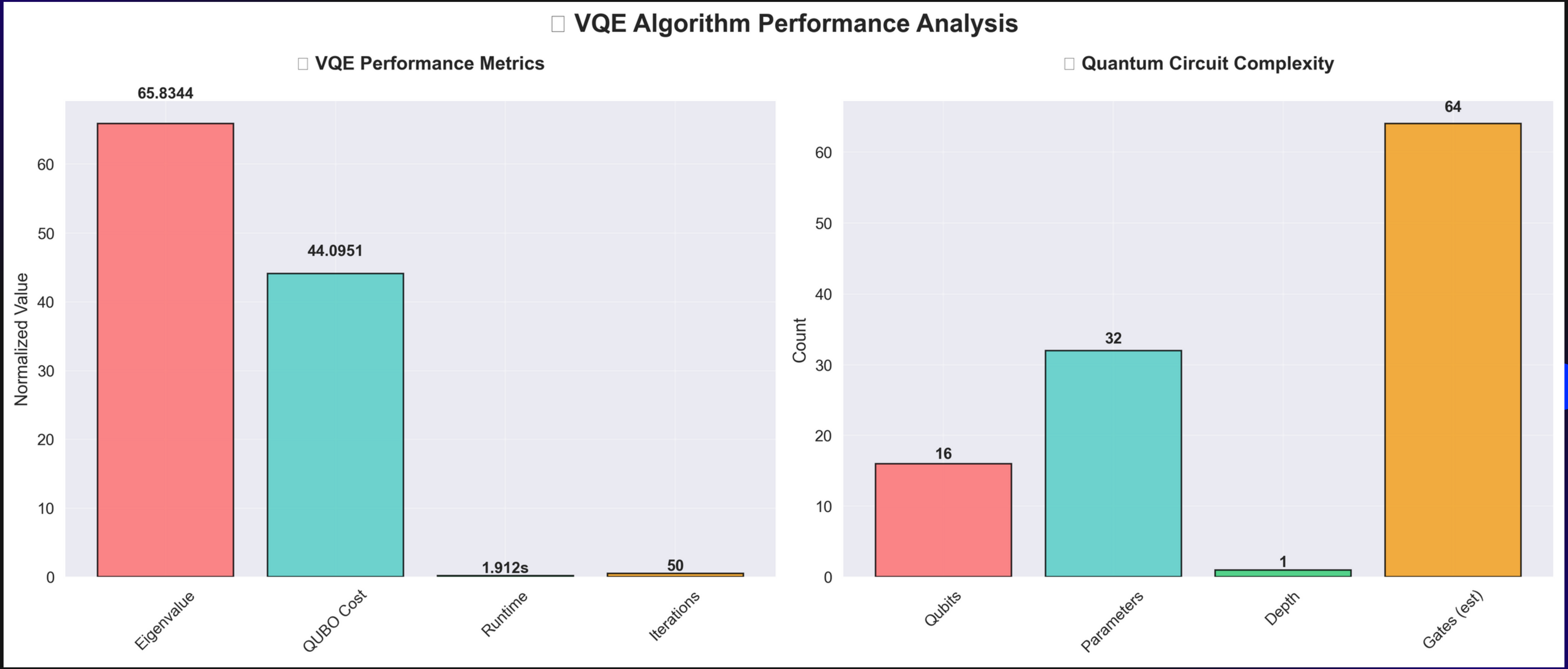

If you'd like a more in depth explanation, check out our readme, mathematical_formulation, and quantum_apporach files in the Github repository!

Thank You!