Portfolio Optimization

Using quantum computing

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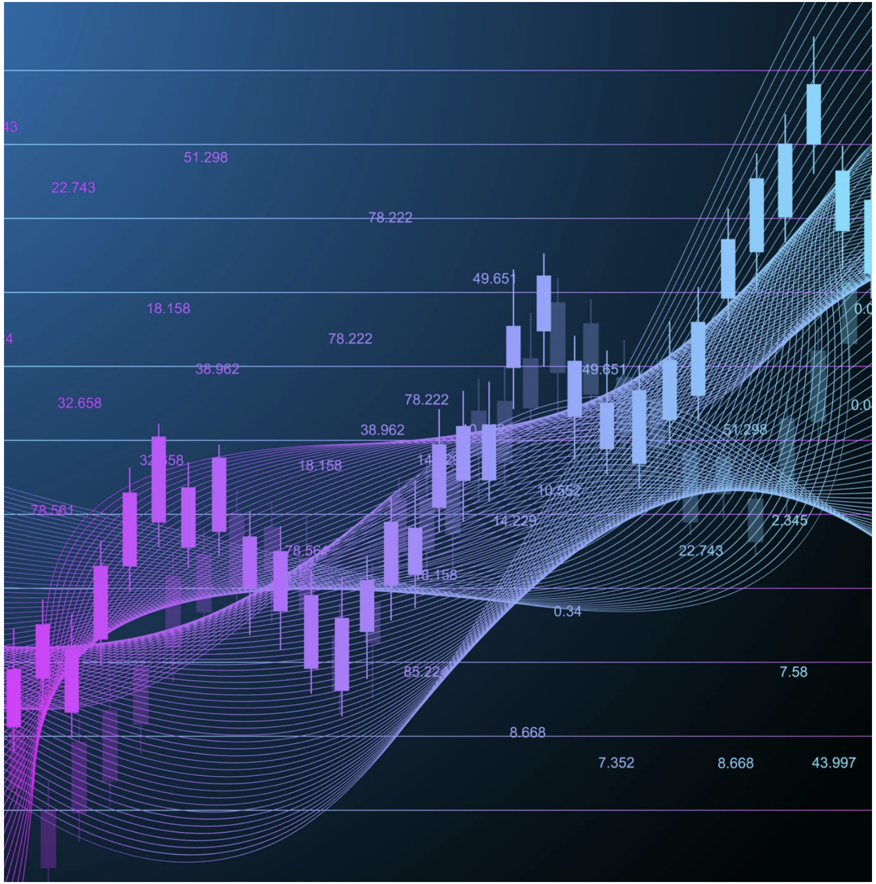
Understanding the problem

What’s portfolio optimization?

Finding the best distribution of assets to maximize or minimize a desired metric

Examples:

- Maximizing the return while limiting the risk
- Minimizing the risk while maintaining a minimum return



Classical Approaches

- Linear Programming
- Quadratic Programming
- Genetic Algorithms

In general, heuristic methods

Why take a hybrid approach?

- Limited quantum resources
- Suboptimal results in classical methods
- Long runtimes in classical methods
- Using the best of both worlds

Current Quantum Solutions

- VQE
- QAOA
- Quantum Annealing 👈

Hybrid Solvers

	BQM	DQM	CQM
Maximum number of variables	20 000 dense 1 000 000 sparse	3 000	5 000
Variable types	Binary	Binary Discrete	Binary Integer
Maximum number of biases	2 billion	3 billion	750 million
Maximum number of constraints	--	--	100 000
Naturally supported constraints	--	1-Hot	Equality Inequality
Solution	Single best solution found	Best solution + intermediary solutions	Best solution + intermediary solutions

Source: D-Wave

Modeling the problem

Things to consider

- The expected return
- Cost of the portfolio
- The interactions between stocks

The expected return

Our linear terms and objective function

$$Obj = \sum_{i=1}^{n} r_i p_i x_i$$

r_i is the expected monthly return

p_i is the price per share

x_i how many shares to buy

The cost of the portfolio

First constraint

$$C \leq B$$

C is the total cost

B is the maximum budget

The cost of the portfolio

First constraint

$$C \leq B$$

$$\sum_{i=1}^{n} p_i x_i \leq B$$

p_i is the price per share

x_i how many shares to buy

The interactions between stocks (Risk)

Second constraint

$$R \leq M$$

R is the risk

M is the maximum risk

The interactions between stocks (Risk)

Second constraint

$$R \leq M$$

$$\sum_{i=1}^{n} \sum_{j=1}^{n} \sigma_{ij} p_i x_i p_j x_j \leq M$$

σ_{ij} is the covariance between stocks

p_i is the price per share

x_i how many shares to buy

Demo