Multiverse Computing: Optimizing Financial Portfolios with Quantum Computing

CASE STORY

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Seeking Maximum Reward at Lowest Risk

Every investment entails some measure of risk—the fundamental question is whether the reward justifies the gamble. Accordingly, managing a diverse portfolio of financial assets entails a challenging balancing act in order to achieve the maximum reward with the lowest possible risk. This can be a feat of staggering complexity. For example, the number of possible configurations for a portfolio of eight assets in which transactions are performed every month for four years is far greater than the number of atoms in the known universe.

> ***"I've seen a real transition in published papers from 'toy', model-type problems, to real commercial products...I think we're really reaching that breaking point where quantum computing is becoming something the industry can derive value from."***
>
> Sam Mugel
> CTO, Multiverse Computing

This portfolio optimization problem has proven intractable to classical computing approaches, but Multiverse Computing has now achieved a remarkable breakthrough on this front. Multiverse is a leader in developing quantum computing-based solutions for the financial sector. Using the D-Wave hybrid solver service, which combines the strengths of classical and quantum computing, the company was able to develop an algorithmic approach that rapidly generates portfolios that can be optimized against a variety of constraints.

They recently demonstrated the power of this approach in a pair of collaborations with two major European banks, BBVA and Bankia. "These results are exciting because they really show a commercially valuable application of quantum computing today," says Multiverse CTO Sam Mugel.

Multiverse <> BBVA Study

Problem
Maximize the portfolio's return for a given risk.

Solution
Solutions are given by Modern Portfolio Theory

$$H_0 = \sum_t -\mu_t^T \omega_t + \frac{\gamma}{2}\omega_t^T \Sigma_t \omega_t + \lambda(\Delta\omega_t)^2.$$

Constraints

1. Diversification constraint.
2. Invest all available resources.

A Speedy Solution for Predicting Profitability

The challenge of optimization goes beyond simply achieving net gains in the value of the assets a portfolio contains. For example, one must also take into consideration the dynamic transaction costs associated with each purchase or sale of assets in order to identify the most profitable trajectory for portfolio management over time.

In their collaboration with BBVA, Multiverse set out to demonstrate that they could identify management strategies that yield the highest Sharpe ratio—a metric reflecting the rate of return at a given level of risk. This entailed using an algorithmic solver to find the optimal solution to a cost function equation that describes the risk, return, and transaction costs associated with a given portfolio.

The Multiverse team worked with real daily financial data from 52 different assets over the course of eight years. They then assembled multiple datasets that varied in terms of the number of assets in the portfolio and the number of transactions performed over the course of the simulated investment period, ranging from extra-small (XS) to extra-extra-large (XXL).

Multiverse's collaboration with BBVA represents a landmark in that it used real financial data.

These were then analyzed with a half-dozen different solvers, ranging from an exhaustive 'brute-force' algorithm to the hybrid solver service, which makes use of the D-Wave quantum processor.

The XXL dataset was a daunting challenge, comprising 10 ^ 382 possible portfolios, but the hybrid quantum-classical approach made short work of it. Within just 171 seconds, D-Wave's system identified a portfolio with a Sharpe ratio of 12.16; for comparison, Mugel notes that a ratio of eight is typically considered to be "a virtually risk-free investment." Meanwhile, most of the other algorithms were choked up by smaller datasets—indeed, the Multiverse team estimated that the exhaustive solver would require longer than the age of the universe to process the moderately large 'L' dataset.

Seeking Maximum Reward at Lowest Risk

Other groups have explored the feasibility of using quantum-based approaches to solve the portfolio optimization, but Multiverse's collaboration with BBVA represents a landmark in that it used real financial data. "This is what I'd like to call our first commercially valuable application of quantum computing to capital markets," says Mugel.

The company subsequently built on this success in their collaboration with Bankia, in which they introduced an additional constraint to their optimization workflow. Short- and long-term capital gains are taxed at different rates, and many financial institutions apply a minimum holding period for assets in an investor's portfolio to reduce the tax burden. This introduces another complex parameter that must be taken into consideration during the asset management process.

Once again, Multiverse worked with real financial data, managing a portfolio of seven assets with daily transactions over the course of a full year, with a minimum holding period of seven days.

Mugel notes that their dataset created a staggering 10 ^ 1,300 possible trajectories that the portfolio could follow over the course of their analysis. To wrangle this down to a more manageable scale, the team applied a 'post-selection' procedure that identified and discarded any trajectories that fail to meet the minimum holding requirement at any given point in time. This efficiently collapsed the problem to a scale that was suitable for rapid analysis with the hybrid solver service.

			10^{139} solutions			10^{382} solutions
Method	XS	S	M	L	XL	XXL
VQE	3.59					
Exhaustive	6.31	8.90				
VQE Constrained	6.31	6.04	4.81			
Gekko	5.98	8.90	8.39	15.83	20.76	
D-Wave Hybrid	5.98	8.90	8.39	7.47	9.70	12.16
Tensor Networks	5.98	8.90	9.54	16.36	15.77	15.83

Sharpe ratios computed by the different methods for the different datasets and time periods.

Method	XS	S	M	L	XL	XXL
VQE	278					
Exhaustive	0.005	34				
VQE Constrained	123	412	490			
Gekko	24	27	21	221	261	
D-Wave Hybrid	8	39	19	52	74	171
Tensor Networks	0.838	51	120	26649	82698	116833

Run-times (in seconds) estimated for the different methods for the different datasets.

Only D-Wave's hybrid solver service and Tensor Network's classical systems could deliver solutions to the XXL dataset. However, the D-Wave approach took 171 seconds to solve the problem, while Tensor Networks' system took more than a day to run.

Portfolio Management is just one many possible financial applications for quantum technology.

The results offered a range of portfolio trajectories that delivered robust gains at every level of risk. For example, the D-Wave analysis identified a portfolio with 15% risk that yielded a 60% return on investment, whereas randomly selected portfolios at the same level of risk were entirely scattered along a continuum ranging from a 20% return to a 20% loss. "We were very proud to be able to provide a portfolio that promised such a large return on investment," says Mugel.

Multiverse is continuing to build on this quantum processing-based strategy for portfolio management. But this is also just one of many possible financial applications for this technology, and the company also sees a bright future for quantum computing in areas such as fraud detection and producing early warning for impending market crashes.

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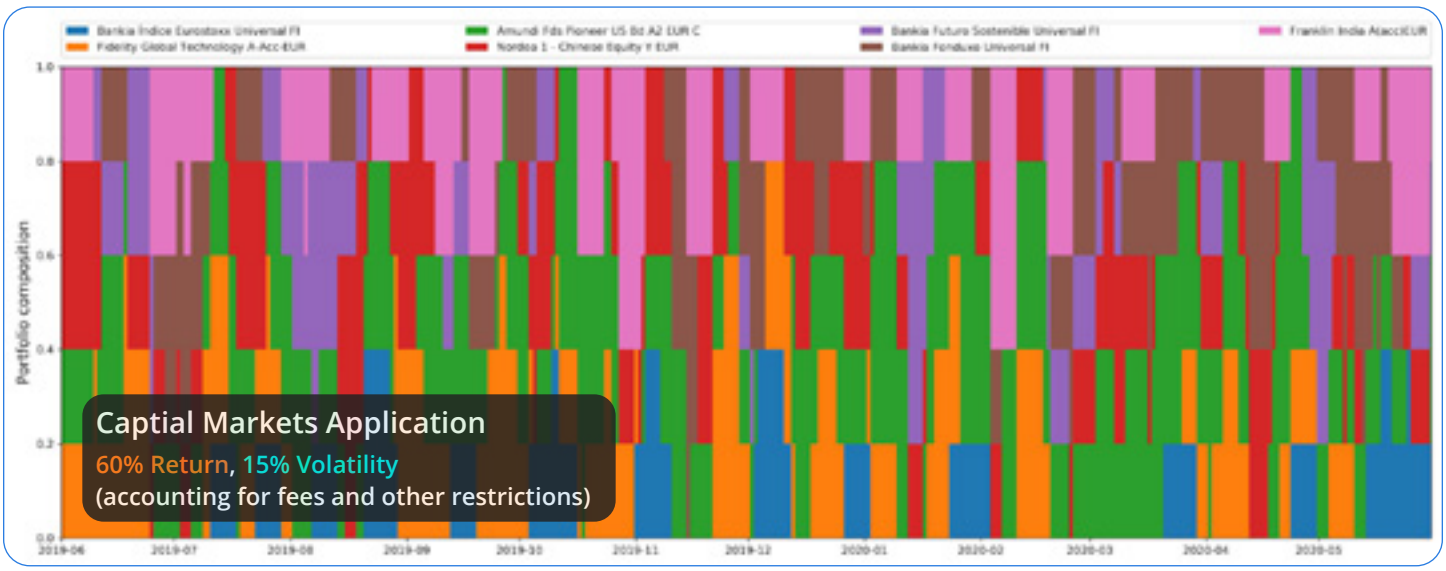
Constraints

1. Diversification constraint.
2. Invest all available resources.
3. Minimum holding period.



D-Wave Launch: The on-board to quantum computing program

If you are ready to get started but not sure how, the D-Wave Launch program has been designed to help enterprises at every step of their quantum journey, from problem discovery through production implementation.

- Identify the problem best suited to quantum
- Get your team trained and start the development process
- Move your application into test and ready for production
- Get your application up and running to deliver benefit to your business

Sign Up Now To Get Started: www.dwavesys.com/d-wave-launch