IQM

DATEV

The Future of Portfolio Optimization is in Quantum

Technical Whitepaper

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Summary

As financial markets have grown increasingly complex, selecting and optimizing portfolios from a vast array of assets has become more challenging. Quantum computing offers potential by tackling complex optimization tasks and solving high-dimensional financial problems with speed. A recent collaboration between IQM and DATEV demonstrated this potential by using a 20-qubit quantum computer for portfolio optimization. DATEV presented an industry-relevant case, while IQM provided a quantum computing approach, revealing the potential of the technology. Early adopters of this technology will be best positioned to capitalize on its transformative power.

The financial markets are fundamental to the global economy, providing liquidity and facilitating open global commerce.

Every day, billions of dollars flow through exchanges, with commodities, bonds, and shares of companies being traded based on their expected yield and performance. Financial markets provide an essential service by helping companies raise capital, allowing people to preserve and grow their wealth, and serving as a global measure of economic health. For society, financial markets offer a mechanism for valuing and exchanging ideas, innovations, and risk, impacting virtually every aspect of economic life.

The diverse world of asset classes

In the financial markets, a wide range of asset classes exist, each offering unique characteristics and risk profiles. Stocks represent ownership in companies, bonds are debt instruments that provide fixed returns, and commodities like oil and gold fluctuate with supply and demand. Investors choose these assets based on their potential to provide returns above inflation or act as hedges against environmental or economic risks.

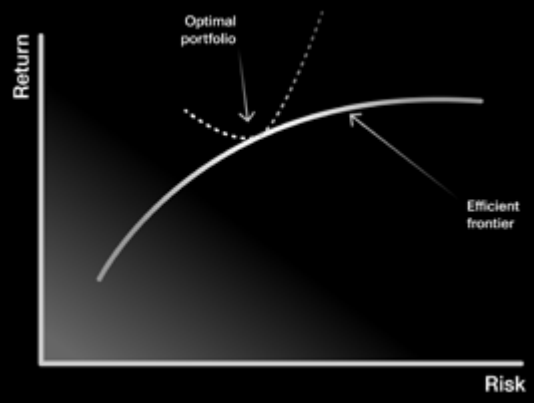
But what is the ultimate goal for an investor? Mainly to beat inflation and protect against financial volatility. The market continuously assigns values to these assets, measuring their risk and potential reward. As we delve deeper into the financial markets, the complexity of selecting the right assets and optimizing their performance grows exponentially.

The challenge of portfolio selection

One of the most challenging aspects of investing is selecting the right combination of assets that maximize returns, minimize risk, and stay in the budgetary framework. The seemingly straightforward problem of portfolio selection quickly becomes a complex mathematical puzzle, especially as the number of available assets increases. Each financial instrument has a historical performance, a set of risk factors, and a tendency to fluctuate in response to various market forces.

The challenge of DATEV was a portfolio optimization task focused on their own product offerings.

They sought to identify and select the most promising or profitable products from their portfolio. The goal was to optimize their product selection by using the Markowitz principal of maximizing returns and minimizing risk at the same time, using IQM's unique quantum computing systems to handle the complexity and scale of the problem.



The closest to the Efficient Frontier have the potential to produce the greast return with the lowest degree of risk

The **Markowitz model** is a well-known approach, which helps investors reduce risk by selecting a diversified portfolio of assets that do not move in tandem. The goal is to find the optimal mix of assets that provides the highest possible return for a given level of risk. However, even with models like Markowitz, the problem grows increasingly difficult when applied to a large number of assets.

Portfolio optimization

The process of selecting the right assets while accounting for returns, risk, and budget constraints, is an **NP-hard problem**. In other words, the time required to solve the problem grows exponentially as the number of assets increases, making it practically unsolvable on classical computers for large portfolios. To better understand the complexity, let's consider the challenge of selecting 5 assets out of 10. This involves 252 possible combinations. Now, if we expand this to selecting 25 assets out of 50, the number of possible combinations explodes to over 126410606437752. This is far beyond what classical computers can handle efficiently.

Enter quantum computing

This is where quantum computing comes in.

Quantum computers operate on fundamentally different principles than classical computers, leveraging quantum bits (qubits) to perform calculations using constructive interference effects to increase the probability of measuring good solutions. In portfolio optimization, quantum computers have the potential to explore all possible configurations of assets simultaneously, making them ideally suited for tackling high-dimensional problems that are impossible to solve on classical systems.

For example, a quantum computer can make a superposition of all 1125899906842620 possible portfolio configurations when selecting from 50 assets. Quantum algorithms can then be designed to incorporate risk factors, budgetary constraints, and historical performance data to find an optimal or near-optimal portfolio configuration.

DATEV

“As we want to stay ahead with the latest technological approaches, we partnered with IQM to streamline our offering, using quantum computers. Their improved algorithms and unique hardware, show that quantum technology holds great potential for us.”

– **Martin Braun,**
Research Engineer, DATEV

Outcome and learnings

In our collaboration with DATEV, we developed a specific quantum algorithm tailored to the company's product portfolio optimization challenge. By using the data of DATEV and applying advanced transpilation techniques, we were able to execute the algorithm on our quantum hardware, leveraging a quantum processing unit (QPU) with 20 qubits.

The results of the project were highly promising. Our quantum solution **showed state-of-the-art performance**, thanks to the following key factors:

1.

Algorithmic improvements:

The custom algorithm developed for DATEV was optimized for this specific problem, providing a significant improvement.

2.

Superior hardware:

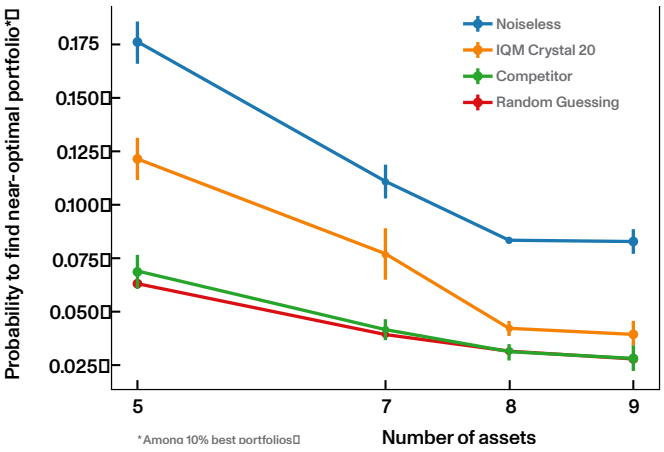
IQM's unique QPU topology offered a more suitable environment for the computation, enabling better performance.

3.

Lower noise levels:

IQM's system had relatively lower noise compared to typical quantum systems, which helped achieve more accurate results.

Additionally, we gained valuable experience in running highly dense circuits, where all qubits needed to interact with each other. This challenge provided critical insights into algorithmic behavior under such conditions, marking significant progress in the practical application of quantum computing to real-world industry problems.



The results on IQM quantum computers, which are closer to the perfect case in comparison to the results on competitor machines.

The need for speed in a dynamic market

In financial markets, speed is everything. Historical asset values fluctuate rapidly, and investors need to make decisions in real-time. As market conditions evolve, the need to re-optimize portfolios becomes a dynamic and ongoing process. This is another area where quantum computing offers significant advantages. **Quantum algorithms** can provide **fast**, approximate **solutions** to complex portfolio **optimization** problems, enabling investors to **adapt to changing market conditions** more effectively.

The dynamic nature of financial markets means that decisions must be made quickly to capitalize on fleeting opportunities. Quantum computing, with its ability to calculate optimal solutions rapidly, will entirely change the way financial institutions approach portfolio management.

DATEV

“We learned that our full-stack solution approach clearly showed state-of-the-art performance . Everyone in the team was impressed by our results.”

– **Dr. Elisabeth Wybo,**
Team Leader Optimization, IQM Quantum Computers

The future of finance

As the financial world continues to evolve, quantum computing is emerging as a powerful tool for portfolio selection and optimization. The complexity of portfolio management, particularly when dealing with large datasets and high-dimensional problems, makes quantum computing a natural fit for the industry. We strongly believe that the financial institutions that thrive in the future will be those most adept at leveraging innovative technologies, such as quantum computing. They will be better positioned to navigate the challenges of an increasingly complex and interconnected global market.

In a world where success often hinges on timely and accurate decision-making, quantum computing offers a glimpse into a future where the most intricate financial problems can be solved with unprecedented speed and precision.

About DATEV

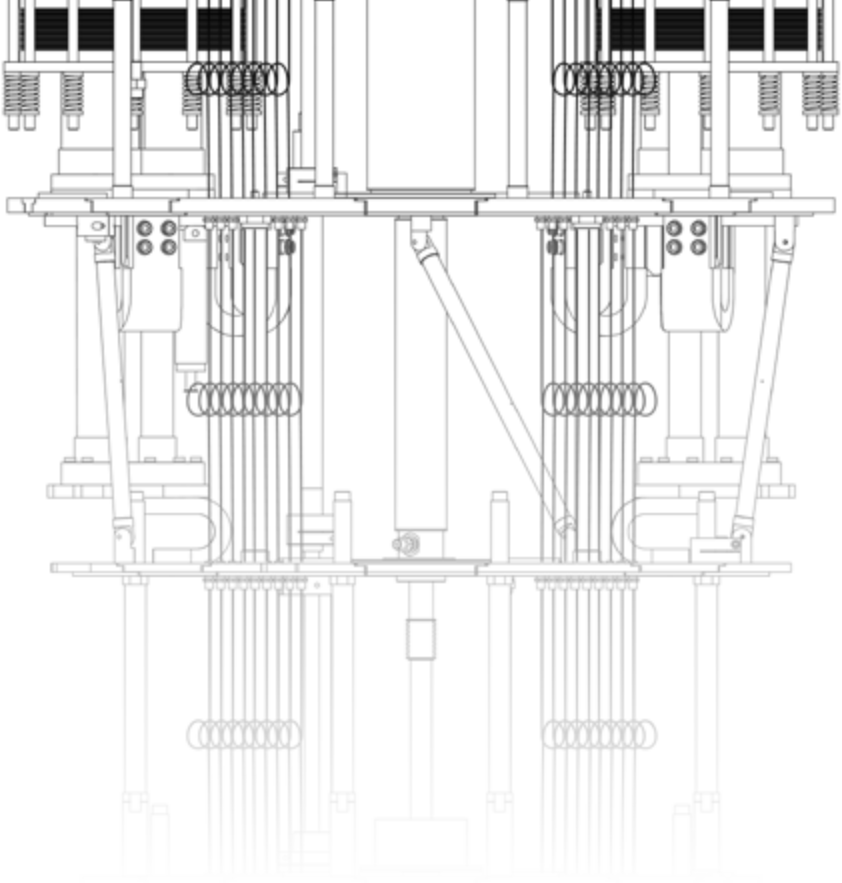
Organization

DATEV eG is a data processing cooperative with more than 620,000 customers. Founded in 1966, it now employs a staff of about 8,800, working at its headquarters in Nuremberg and 22 branch offices throughout Germany. Its legal structure as a cooperative guarantees continuity, meaning no investor can buy DATEV.

DATEV portfolio

DATEV offers software for accounting, human resources, business consulting, tax calculation, and office and business organisation. Some figures to illustrate this: More than two million German companies use DATEV software for their financial accounting. DATEV's printing and dispatch centre in Nuremberg processes around two million business assessments every month. More than fourteen million pay slips are processed each month using DATEV software.

www.datev.com



About IQM

We build and deliver quantum computers for the world

At IQM, we are pioneers in quantum computing, founded in 2018 with a vision to create impactful quantum solutions for the well-being of humankind, now and for the future. Our international team provides both on-premises full-stack quantum computers and a cloud platform to access its computers anywhere in the world. We focus on sustainable practices and collaborate with research institutions, universities, data centers and enterprises to advance the capabilities of quantum computers. Our mission is to develop innovative solutions that prioritize human welfare and drive transformation across various industries.

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Contributors

Martin Braun
DATEV

Henrikki Mäkynen
Consultant

Dr. Elisabeth Wybo
IQM Quantum Computers

Technical Whitepapaer