



What will be the role of Quantum Computing in the future of finance?

With its promise of incredible power, quantum computing (QC) is a game-changing prospect for financial players. It's a breakthrough that will reduce risk and create bigger profits by analysing market situations faster and in infinitely more detail.

Satya Nadella, Microsoft's Chief Executive Officer, calls QC: ***"One of three emerging technologies that will radically reshape the world, along with artificial intelligence and augmented reality."***

Bob Sutor, Vice President of IBM's quantum computing program, explains: ***"[QC is] a completely different way of computing, a different beast entirely, and the most significant improvement in computation in the last century. It offers the opportunity to rethink so much of what we've achieved."***

Some analysts believe that the quantum tipping point has arrived and that within a decade, quantum computers will make today's fastest supercomputer look like an abacus.

Jeremy O'Brien, Physicist and Professorial Research Fellow at the University of Bristol, agrees: ***"In less than 10 years, quantum computers will begin to outperform everyday computers, leading to breakthroughs in AI. The very fast computing power given by QC has the potential to disrupt traditional businesses."***

When you consider what the financial industry wants and combine it with quantum computing's phenomenal increase in the availability of processing capability for probabilistic algorithms, it's a disruption made in heaven.

How does Quantum Computing actually work?

Optimisation is at the core of many financial problems. In portfolio optimisation, the problem exists in selecting the best assets to invest in to balance the risk with the expected returns. This is known as a NP-Hard problem, meaning it is extremely difficult, if not impossible, for classical computers to solve efficiently. Professors of both physics and mathematics at MIT are working together on Quantum algorithms that could provide the required processing capacity to viably identify optimisation solutions.

Consider that every time a large asset manager rebalances their portfolio, investors lose out as a consequence of transaction costs and slippage. In an environment where most funds struggle to make single digit returns, losing three percent on rebalancing costs is problematic. QCs could create portfolios that are globally optimal over multiple investment horizons, hence significantly reducing the need for rebalances and their associated losses.

Financial derivatives contracts have a payoff that depends on the future price trajectory of a given asset. Brokers must know how to assign a price to the derivatives from the state of the market. The current approach to this problem is via simplified scenarios, such as the Black-Scholes-Merton model and Monte Carlo sampling. Due to the growing number of derivative products, only Monte Carlo simulations are viable but at a huge computational cost and with lengthy execution times. A quantum-accelerated Monte Carlo algorithm has been developed in The Department of Science at Bristol University, which could reasonably tackle this problem and provide a quadratic speedup.

Lee Braine, from the Investment CTO office at Barclays, says that the bank is actively investigating these and other potential uses for quantum computing. He thinks the technology is ***"in a similar place to where blockchain, which many banks are looking to exploit, was 10 years ago."***

JPMorgan Chase's Senior Engineer and Quantum Project Lead, Constantin Gonciulea, is researching a range of financial services areas where quantifiable operational benefit could be derived from a phased transition to quantum enablement.

Areas of interest for JPMorgan include the redefinition of trading strategies, optimisation of portfolio management, asset pricing and risk analysis. ***"Fund managers have to choose from an infinite number of investment***

combinations for their portfolios, based on the level of risk they want to take,” Gonciulea explains. **“Imagine if they had a computer that could detect potential risk – based on their appetite for risk – within seconds of a change taking place in a particular market.”**

The physics behind Quantum Computing

Quantum computers could realise these advances because they tap into the quirky behaviour of sub-atomic particles, which bend our normal understanding of physics. One of these properties, called superposition, involves a particle being in two states at the same time. Unlike the most basic binary elements, or bits, in a classical computer, which represent either ones and zeroes, quantum bits (or qubits) can be a one and a zero at the same time.

By stringing together dozens or even hundreds of these qubits, the number of states they could represent rises exponentially, making it possible to compute millions of possibilities instantly.

A second property quantum computing draws on is entanglement: two quantum bits can influence each other, even when they aren't physically connected. This is something Albert Einstein called “spooky action at a distance”. By harnessing this property, it will be possible to write algorithms that take short-cuts around the usual sequential logic processes in computers, making it possible to rule out incorrect answers and home in on the correct ones far more quickly.

In classical, or binary, computing, each step in a calculation follows logically from the one before it, quantum programming is, according to IBM's Bob Sutor:

“Much more three-dimensional. There are very unusual correlations and linkages between qubits. You can figure out solutions that don't work, and things that could solve the problem are magnified.”

This will also allow the financial industry to

develop previously unimaginable trading strategies and approaches to risk by searching for patterns in past data – things too NP-Hard for even today's most powerful digital computer.

What prevents Quantum Computing from taking over?

The immediate goal is to achieve what experts call “quantum supremacy”. This is reached when a quantum computer can remain in a stable state and achieve computations that today's most powerful supercomputers cannot handle.

However, quantum computers currently require temperatures colder than deep space in order to operate and typically need to be reset after just 100 microseconds of computing or else they are liable to enter into a state of chaos. They also need complete silence to function, which is costly and complicated to achieve. Another barrier is that classical algorithms can't just be re-worked to give a quantum approach. Quantum computation is so different from digital, it's like comparing cricket to Scrabble, both games with players but also chalk and cheese. In algorithm terms it means starting again from scratch.

Top 5 ways Quantum Computing will impact markets

- 1 High Frequency Trading
- 2 Fraud Detection
- 3 Development of complex Quantum algorithms
- 4 Portfolio Optimisation
- 5 Security and Risk Assessment

Where is Quantum Computing currently developing?

The development of quantum computers isn't a race it's a marathon. **“No one is buying one and putting it in the basement yet,”** says IBM's Sutor. But the possibility of what QC has to offer means that the U.S and China are investing billions in quantum hardware and software R&D.

With implications that go beyond computing.

Advances in quantum communications and cryptography could produce theoretically un-hackable networks. Quantum radar and sensing could unmask the location of stealth aircraft and underwater submarines. And quantum navigation could provide

precision geolocation capabilities without reliance on space-based GPS.

Whoever leads in harnessing quantum could gain huge economic and national security advantages, especially as QC has the potential to supercharge AI applications.

China has paid special attention to investing in quantum science as a way of bypassing traditional technological advantages enjoyed by the United States and is believed to be investing \$11 billion to develop a laboratory for researching quantum technology. Set to open in 2020, it will be one of the largest facilities for quantum research.

In December 2018, President Trump signed the National Quantum Initiative Act into law. It provides more than \$1.2 billion in spending to coordinate research and development efforts in quantum computers.

The law came together in a rare moment of bipartisanship. ***“Countries that harness the power of quantum technology will revolutionise computing systems,”*** U.S. Representative Lamar Smith

observed in a speech at the time. He was a co-sponsor of the legislation in the House, where

it passed 348-11. The Senate vote was unanimous.

The European Union has funded a \$1.1 billion quantum research plan. To support research into high performance computing as part of the implementation of the European Cloud initiative.

Speaking at the launch of London Tech Week in June, former British Prime Minister Theresa May announced investment of £1 billion in the development of quantum computing in the U.K. And this year the UK’s Cambridge Quantum Computing, an independent company, unveiled ‘Ironbridge’, the first commercially available quantum cryptographic device.

Clearly, quantum is squarely on the agenda of the major powers and tech companies both big and small. Who could blame them for chasing the chance to unlock such possibility. As Seth Lloyd, Professor of Mechanical Engineering and Physics at the Massachusetts Institute of Technology, states: ***“The history of the universe is, in effect, a huge ongoing quantum computation. The universe is a quantum computer.”***

That’s too much power for financial players to ignore in any strategy for their future.

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