Get set for quantum leap in banking

Michael Brooks explains how quantum computing could revolutionise some banking operations by making super-fast work of processing complex data sets

You have probably heard of quantum theory, the strange science of the atomic world. But you may not have heard that this theory of the microscopic could have an impact on the macro world – and on the world of finance in particular.

Banks have long been at the forefront of adopting new technology. Barclays, for example, was one of the first businesses in the UK to install mainframe computers. Now, many banking and finance institutions are paying attention to the revolutionary potential of quantum computing. In a world where computing resources can make or break a business, the potential of a quantum advantage is too great to ignore.

Why quantum computing would be a revolution

The advantage comes because, in the quantum world, it is possible for atoms to be put into 'superpositions' of two or more different configurations at once. This makes it almost as if they had multiple existences. They can also become 'entangled', which means that physically separated atoms can still affect one another's behaviour, even if there is no physical connection and no signal passing between them.

These odd phenomena open up a world of opportunity. Because quantum things behave so differently, the mathematical laws that describe them are also fundamentally different. This allows the atoms (and other quantum objects) to encode calculations that are impossible in the everyday 'classical' world. So, instead of calculating using just one and zero, quantum computers can exploit the multiple states of atoms to do exponentially more. This results in a new kind of computing that makes quick work of what have long been time- and resource-hungry algorithms.

"It's completely different to classical computing," says Stefan Woerner, Quantum Applications Research and Software Lead at IBM. "It finds shortcuts."

Not, he adds, for all tasks. But there are a growing number of interesting finance problems where quantum computing has the potential to offer a significant speed-up. "Finance is an important vertical for quantum computing," says Joe Fitzsimons, founder of Horizon Quantum Computing, a quantum algorithms developer based in Singapore. "It's a place where you can turn computational advantage into financial gains in a very short time."

That means there are many incentives to be an early adopter. Those who have begun to look into it are cautiously enthusiastic about their experience of quantum computing so far.

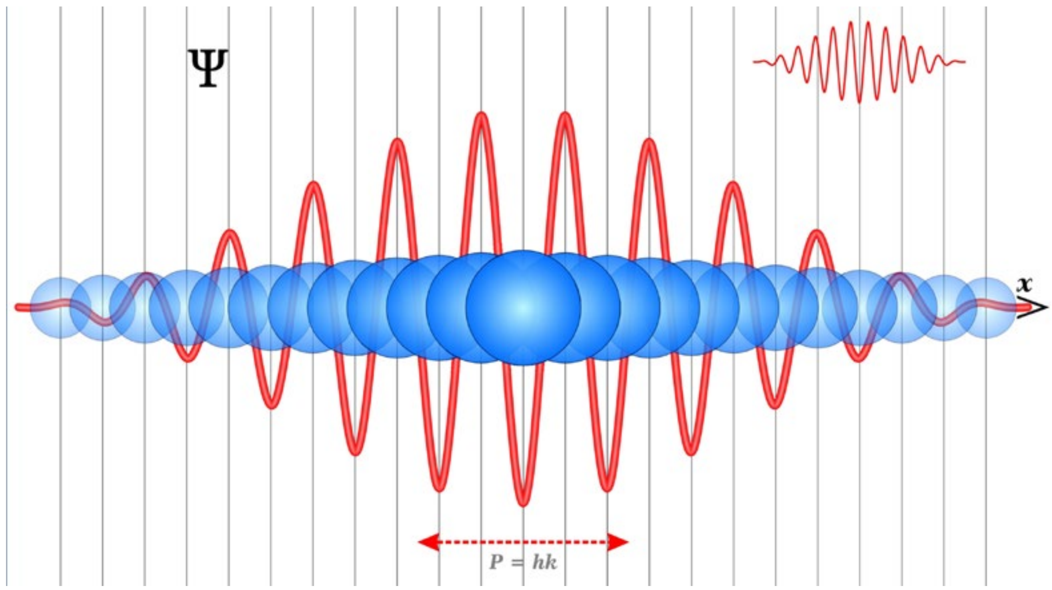
"We started looking at quantum computing about two and a half years ago because it was being talked about as a potential way of achieving better optimisations," says Lee Braine, Director of Research and Engineering in Barclays' chief technology office. He has been impressed by what the bank has learned, but is also aware that people have to be properly informed in order to keep things grounded.

"With something that seems too good to be true, you need to explore it properly to work out where it offers genuine value and what the timelines look like," he says. "There's certainly potential for quantum computing to be revolutionary in certain areas."

> *Finance is a place where you can turn computational advantage into financial gains in a very short time*

In March this year, for example, Deutsche Börse published the results of a trial of quantum computing's advantages in risk modelling. Forecasting the knock-on effects of external influences, such as new regulations or significant economic shifts, is difficult and time-consuming, but the Börse found that a quantum algorithm could trim a standard ten-year process down to around 30 minutes of quantum computing time – albeit in a toy problem.

Others are finding similar speed-ups for a variety of financial and banking applications. BBVA has partnered with Fujitsu's quantum computing arm and found in a proof-of-concept demonstration that quantum tools significantly reduced the resources needed to process complex data sets, such as those involved with optimising investment portfolios. "We can start using this advantage now," says Carlos Kuchkovsky, Chief Technology and R&D Officer New Digital Business at BBVA.



Optimisation appears to be a particular strength for quantum computing. Wherever classical computing struggles to find solutions to questions asked of complicated data sets – and there are many complicated data sets in finance – quantum computing's acceleration could potentially cut through the problem.

Another area of interest is risk calculations. These tend to be run overnight but Fitzsimons can see a day coming when they are run much more frequently because of the speed at which quantum algorithms can operate. "If you can do them on an hour-by-hour basis, then you can be more agile because you have better visibility of your current position," he says.

Machine learning accelerated

But the most impactful application of the quantum advantage might come through quantum versions of the machine-learning algorithms that occupy an ever-growing slice of the decision-making space in finance.

The sheer volume of relevant data available to financial firms can overwhelm even large teams of human decision-makers, but, with minimal training, machine-learning algorithms can process that data to uncover optimal trades, advice for investors and to detect fraud, among other applications.

Here, too, there appears to be a quantum advantage coming over the horizon. As with optimisation, the advantage lies in the ability quickly and efficiently to scrape relevant facts from large, unstructured databases. Kuchkovsky thinks it's clear that this will improve a bank's ability to detect problematic activity. "In fraud, it will have a great impact," he says.

Still a leap too far

For all the interest, it's unlikely that any bank or stock exchange will have its own quantum computer in the foreseeable future. Although several companies and university research groups are working on the hardware, they are still a long way from harnessing the revolutionary capabilities of quantum technology. No one even agrees on the best way to build a quantum computer. IBM, Intel and Google are pursuing materials called superconductors as their technology of choice, but others think 'trapped ions', photons (the quantum particles of light) or traditional silicon are a better bet.

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Not that it matters to the banks. "We are agnostic about the hardware," Kuchkovsky says. "As a bank, we are not building hardware: we just need to create algorithms and understand what are the advantages we can create."

Nonetheless, the kinds of practical advantage available will ultimately depend on the capabilities of the machine. Quantum computers use quantum bits ('qubits', pronounced 'kew-bits') to process information. Not only are lots of them required to do useful things, they also need to be stable – quite a challenge when dealing with hardware that can lose its data at the slightest vibration, temperature fluctuation or interaction with other objects. Many of the vaunted applications of quantum computing will require a few hundred, if not a few thousand, extremely well-isolated qubits, but at the moment even the biggest quantum computers tend to operate with no more than a few dozen. These are not available for installation in your basement: most are held in centralised laboratories, accessed via the cloud.

These hardware issues mean that there are some applications that will have to wait. Perhaps the most ominous application of quantum computers is in breaking public key encryption algorithms. Something called Shor's algorithm makes child's play of breaking apart today's most secure cryptographic protocols because, with enough quantum computing muscle, it can work out prime factors. But to make a real impact will require thousands of qubits at the very least. Given where we are with the hardware, the concern over immediate implementations of Shor's algorithm – and undermining current cryptography – has been put on hold for now. That said, it always pays to be cautious, and mathematicians are already working to develop 'quantum-resistant cryptography' that even a quantum computer can't break.

Big regulatory issues

A more immediate issue is the need for regulatory understanding and approval, and that is nowhere near ready. "Regulators have started looking at these things, but it will be an interesting process," Woerner says.

There are questions of insurance for the hardware provider, guarantees of hardware performance, and checks and balances to ensure that decisions based on quantum algorithms don't become 'black box' issues where no one can check for insider trading or instabilities that might endanger markets and products.

Those developments will come, Braine suggests. "We're finding that governments and regulators are keen to find out more about this space and explore it," he says.

Barclays and others are very willing to help – indeed, they are all sharing information even with competitors. "We're in a pre-competitive phase," Woerner says. "Everyone can profit more by being open about these results."

That is, perhaps, an indication that the finance world's quantum revolution is still a way off yet. Certainly, no one in the industry is keen to talk about precisely when quantum computing will really take off. "It's an interesting question, and one that is very difficult to answer," says Escolástico Sánchez, Executive Director at BBVA.

At the moment, Braine says, Barclays is purely in an experimentation and research mode. "We've been in that mode since summer 2017, and it may well be another three or more years before a 'go live' – and even that would be very restricted," he says. It may well be, he adds, that a five- to ten-year timeframe is more realistic. "It really depends on the speed at which hardware improves." ■

***Michael Brooks** is a freelance writer and broadcaster who holds a PhD in quantum physics. He is the author of many books, including* The Quantum Astrologer's Handbook *and the bestselling* 13 Things That Don't Make Sense