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The quantum state of affairs

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The eco-system of companies and start-ups developing quantum technologies is booming, but the disparity between private and public funding may become an issue in the absence of commercial uses.

Quantum technology keeps hitting the headlines, in both specialized and mainstream media[1]. The wide-reaching exposition of quantum computing developments in particular has been raising eyebrows, including among researchers in the field[2,3], but it is a natural consequence of the booming interest from investors, and the large market size that the quantum sector is predicted to reach in a few years.

According to the latest McKinsey Quantum Technology Monitor[4], the field could grow to a US$106 billion market size by 2040, with the highest potential commercial value distributed among financial, pharmaceutical and automotive applications. Of the three main subfields that quantum technology encompasses – quantum computing, quantum sensing and quantum communications – quantum computing is expected to hold the largest share, with an upper estimate of around $90 billion.

This may sound surprising, as quantum sensing and quantum communications are arguably more mature technologies and already offer commercially available devices, such as nitrogen–vacancy centres, magnetometers or quantum key distribution devices. But the predicted use cases of quantum computers in more lucrative sectors such as financial services have bumped the evaluation of quantum computing. Nonetheless, the burgeoning interest in the field has often been accompanied by promises that sound speculative at best, like the hope for quantum computers to be 'silver bullets' against climate change[5].

Alongside tech giants like Alphabet, AWS and IBM founding quantum research divisions, we have witnessed in the last decade or so the emergence of a large number of quantum computing start-ups and university spin-outs. Unlike the big players, which can redirect part of their revenue towards more long-term prospects, start-ups rely entirely on external investments to fund their enterprise. And on that front, they have been doing quite well.

Last year marked a record level of investment in quantum start-ups, sitting at $2.35 billion. That figure is the result of a modest (1%) increase with respect to 2021, but it is still more than four times the money raised in 2020. Of those $2.35 billion, the majority went into quantum computing companies, confirming the growing market interest in that area. The flow of investments eventually culminated in the public listing of some quantum companies, such as Rigetti, IonQ and D-wave, on major stock exchanges. But their performance so far has not looked promising.

As of April 2023, Rigetti's stock is at $0.48 per share – a more than 95% drop from initial value. Earlier this year, they have also announced a 28% reduction in overall staff to trim costs and preserve capital. D-wave and IonQ have also experienced severe drops in stock price, and although one can certainly expect fluctuations in cutting edge technology markets, the difficulty in generating revenue is causing some hesitancy from investors. But it is hard to earn money when the immediate benefits of the product you sell are unclear.

The lack of commercial practical uses is the main problem that most quantum computing companies will have to deal with in the near future. Most companies are operating in a pure R&D mode at the moment, and despite some intriguing near-term applications in areas like materials science and quantum chemistry, the currently available devices are still prototypes. Regardless of the specific approach used (superconducting qubits, trapped ions, photonic chips), it is still a long way to the millions of qubits needed to solve meaningful problems.

Building a fault-tolerant quantum computer of that size might take years at best – more likely decades. Are venture capitalists, banks and angel investors willing to stay in the game for the long run? One might expect that governments and public funding agencies would be more naturally predisposed to this kind of long-term investment.

And in fact, they are. The UK has recently announced an updated national investment plan that will pour £2.5 billion in the quantum technology industry over the next ten years[6]. Some EU countries and the US have committed to similar spending, and China has taken a leap in the race by pledging to invest $15 billion of public funds. These are solid numbers for the prospect of developing potentially disruptive technologies, but the vast majority of the inflow still comes from the private sector, which makes up around 80% of the total investments.

The job market has flourished in recent years, and a career outside of academia is now well within reach of physics graduates specializing in quantum computing and information. Working in the private sector has obvious perks from a researcher's perspective, for example, higher salaries and permanent contracts. But should private investors become impatient and start rechannelling capital in the next up-and-coming technology, it is unclear if public funding would be enough to sustain an inflated landscape of quantum companies and start-ups.

Concerns related to the sustainability of the quantum technology start-up business model might be unfounded, and the current slumps experienced by major players may be just a blip. But there is not only money on the line. Attracting funding can encourage a tendency to oversell results and ideas, as well as describe long-term potential applications as closer than they are. If things do not turn out as hoped, the reputation and credibility of physicists as a whole could suffer.

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