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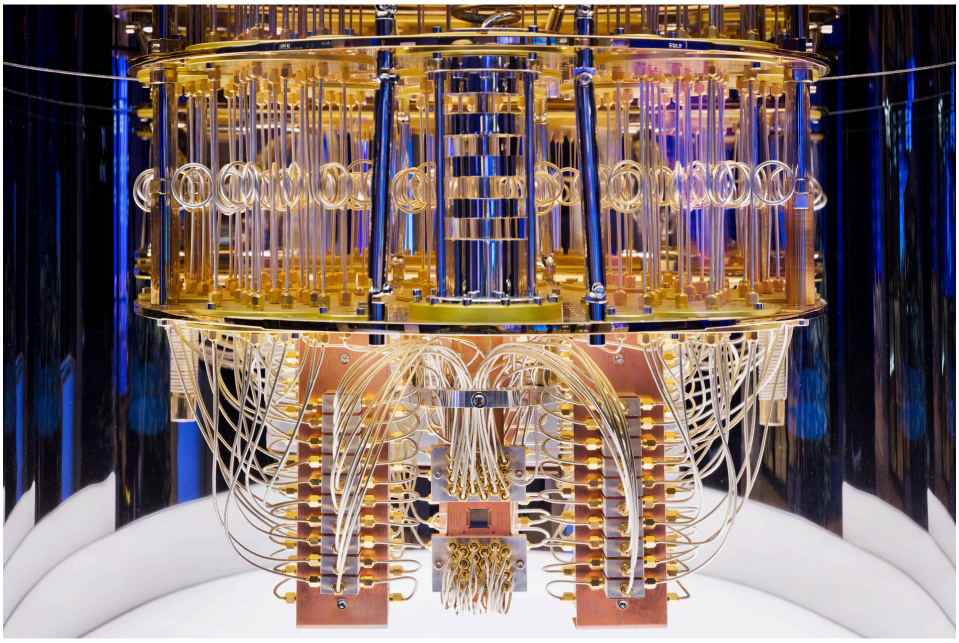
WILL QUANTUM SUPPLY CHAINS FALL VICTIM TO GEOPOLITICS?

Quantum technologies are attracting the attention of investors and policymakers even before they exit the lab. As these technologies mature, it is unclear how and to what extent their supply chains will be shaped by the geopolitical dynamics affecting other critical and emerging technologies. Much will depend on a country's specific ambitions, and the potential applications around which different quantum technology subfields — such as quantum computing — converge, note ***MANOJ HARJANI*** *and* ***SHANTANU SHARMA****.*



How will the geopolitical future influence the supply chains for quantum technologies like the IBM Quantum System One? *Credit: IBM.*

According to a conservative estimate by McKinsey, quantum technologies — technologies that are engineered using the principles of quantum mechanics — have attracted US$31 billion in announced funding since 2001, and US$1.9 billion in the second half of 2021 alone.

These numbers are not surprising given the potential applications of quantum technology, which range from secure communications to drug discovery and climate change modelling. Crucially, many quantum technologies are dual-use and could have significant implications for national security. For instance, a sufficiently capable quantum computer could render current data encryption methods vulnerable, even though fears of such a "quantum apocalypse" have yet to materialise.

Nevertheless, concerns over dual-use applications of quantum technologies are motivating countries to limit their proliferation. In November 2021, the United States added eight Chinese quantum technology companies to the Department of Commerce's Entity List. American companies are now unable to supply these listed entities — which are believed to be supporting the Chinese military's modernisation — without prior approval. China has also introduced similar restrictions, with its Export Control Law enacted in 2020 to restrict companies from exporting quantum technology, particularly for cryptography applications, where China's national efforts have been particularly focused.

Such regulatory actions prompt the question of whether quantum technology supply chains will be shaped by the types of geopolitical dynamics affecting semiconductor chips, which in recent times have become a centrepiece of the technological rivalry between China and the United States.

Understanding Quantum Supply Chains

The existing supply chains for quantum devices are globalised and have high barriers to entry. This is because these devices need advanced enabling technology such as lasers, as well as exotic raw materials and exceptionally skilled engineers that only a few research teams and manufacturers currently possess. As a result, quantum supply chains are by necessity concentrated and capital-intensive.

Applications of the various quantum technology subfields — communications, computing, and sensing — also vary in maturity. This further complicates supply chains as nascent subfields such as quantum computing need to grapple with competing technology paradigms that have yet to be consolidated.

Competing Paradigms and Supply Chain Complexity

There are currently two prominent technology paradigm candidates in quantum computing: superconducting quantum computing and trapped ion quantum computing, which use distinct raw materials and rely on different enabling technologies.

Superconducting quantum computers require dielectric resonators (manufactured only by Germany and Japan), Helium-3 (produced primarily in North America and Russia), and dilution refrigerators (commercially manufactured only by Finland, the Netherlands, and the United Kingdom).

Trapped ion quantum computers, on the other hand, require rare earth ionised materials like isotopically-pure Ytterbium (produced primarily by China and within certain types of nuclear reactors), and 200mm sapphire wafers (produced only by Japan and Russia).

Only a handful of quantum computers exist globally at present. This is due to highly specialised use cases and contrasting technology paradigms imposing different demands for raw materials, components, and engineering capabilities. This situation contrasts with quantum sensors, which have been commercially deployed in areas such as environmental and infrastructure monitoring.

Will Geopolitics Stifle Quantum Supply Chains?

Given the limited supplier base, companies face trade-offs when designing quantum devices. An example would be between the use of less than ideally precise but readily available equipment and raw materials, and developing or using optimal equipment but relying on fewer or unique suppliers. Countries where the few companies involved in the quantum supply chain are located may therefore have an upper hand currently, but the fact that quantum technology is still nascent and evolving means that supply chains have not yet crystallised.

Furthermore, despite significant foreign dependency in current quantum supply chains, geopolitical dynamics are not necessarily the primary factors shaping business and research design decisions. Recent disruptions — such as to the supply of Helium-3 due to Russia's invasion of Ukraine, which have caused delays for some quantum projects — have more to do with pre-existing structural issues across global markets, rather than with countries vying for supremacy over quantum technology.

While export controls signal the potential influence of geopolitics, they are only one part of a larger regulatory umbrella yet to cast its shadow over quantum supply chains. However, given the already fraught global landscape, we can expect geopolitics to have a greater influence as intellectual property regimes and standards for quantum technology are developed. In addition, as the United Kingdom's post-Brexit experience has shown, geopolitical dynamics will also have a significant impact on the movement of talent and its ability to collaborate across borders.

What Can Singapore Do?

As Singapore establishes itself as a key player in commercialising quantum technology by building on research efforts, it will have to take account of potential supply chain challenges. One way forward is to replicate efforts already underway elsewhere in mapping existing quantum supply chains with a view to identifying vulnerabilities, particularly with future needs in mind.

To minimise any potential disruption to research and development and commercialisation efforts, Singapore should plan for the emerging quantum intellectual property regime, particularly given the dual-use nature of quantum technologies. As in other sectors where it is looking to compete globally, Singapore would need to focus its efforts on attracting and developing talent since competition for the small global pool will be stiff.

Singapore can further secure and stabilise its quantum supply chains and talent pool by formalising more strategic cooperation agreements, and alliances with like-minded countries. These can act as buffers on top of existing cross-border collaborations that the private sector and research institutions are already engaged in.

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