MAJOR INVESTMENTS HAVE NOT MATERIALIZED IN 2022 AMID ECONOMIC UNCERTAINTY AND THE BOOM OF INVESTMENTS IN 2021

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In 2022 the frenzy of investments into quantum hardware vendors slowed down, which TBR believes was due in part to a localized saturation of investments in 2021 as well as venture capitalists' shift in focus toward quantum software, from vendors pursuing use-case applications to quantum algorithm development platforms to post-quantum cybersecurity. With the spinoff of SandboxAQ from Google, the company raised an undisclosed nine-figure venture capital round from a number of large investors such as Section 32, T. Rowe Price and Breyer Capital. Aside from SandboxAQ, investments into quantum computing have been more modest, such as the $60 million Series A funding round for Terra Quantum and its Quantum-as-a-Service platform and the $33 million Series B funding round for Classiq, a quantum software platform company.

SCIENTIFIC ADVANCEMENTS

Scale: IBM and Rigetti Computing both had notable advancements in the scalability of quantum computers during the quarter. IBM was able to produce and release its 127-qubit, Eagle quantum processing unit (QPU), which is the largest QPU on the market. Rigetti released a beta version of an 80-qubit system, created by linking two 40-qubit QPUs together in a modular design. If fidelity and speed do not suffer with this new system, it could pave the way for significant scalability in qubit count. Ion-trap systems are less adept in this area, with IonQ systems maxing out at 32 qubits and Quantinuum systems at 20 qubits.

Quality: Quantinuum has the highest-quality systems from the perspective of quantum volume (QV) as it achieved 4096 QV on its H1-2 System Model, meaning the quantum computer was able to run a circuit with a width (qubit count) and depth (gate count) of 12. This is by far the highest QV achieved by a quantum computing (QC) vendor whose results have been publicized and verified. For reference, the next highest QV achieved was IBM's Falcon r10 processor, which reached a quantum volume of 512 (width and depth of 9) in May.

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Speed: In terms of speed, the third critical dimension of QC performance, IBM had the most important announcement with a proposed new quantum computing performance metric, Circuit Layer Operations Per Second. Previously, there was no standardized way to compare QC speed, despite its importance to overall system performance.

QUANTUM COMPETITORS STILL ALLY TO ACCELERATE ECOSYSTEM DEVELOPMENT WHILE ATYPICAL CUSTOMERS BEGIN EVALUATING QUANTUM'S POTENTIAL

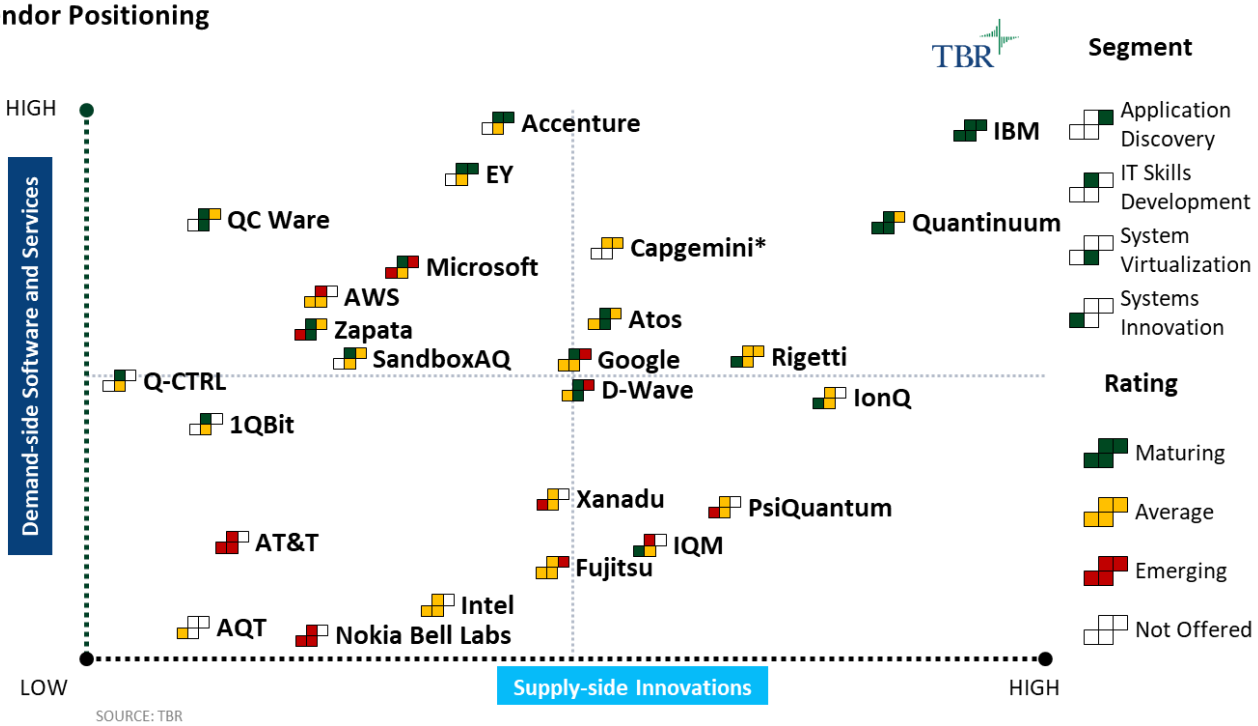
Vendors, academic institutions, governments and large enterprises forge various alliances for scientific discovery, skills development, algorithm development, and use-case exploration. Quantum-native skills are in short supply, leading to the creation of alliances with academic institutions. The industry is recognizing that despite the high-stakes competition, collaboration is key for the technology to reach the quantum advantage, an outcome beneficial to all. Examples of this can be seen with Quantinuum joining the IBM Quantum Ecosystem in February to grow the overarching ecosystem, despite the two hardware vendors being rivals. Other examples of this are with vendors such as Rigetti, IonQ and Xanadu partnering with hyperscalers, which are developing quantum hardware in parallel.

EY contacted 1,516 U.K. executives, of whom 501 were qualified to complete its survey on quantum computing. Sixty-five percent of the 501 respondents stated their organizations had high interest in quantum. In terms of when quantum would play a significant role in their industries, 18% believed it would arrive in 2022, 27% estimated between 2023 to 2025, and 33% believed it would occur between 2026 and 2030. The remaining 4% felt it would occur after 2035.

Savvy enterprises recognize the potential advantage quantum will bring to their businesses. For example, the virtual Commercialising Quantum symposium held by The Economist included participants from diverse industries such as media and advertising, who viewed speedier insights on human emotion as vital to ongoing advertising efforts to know the customer and anticipate buyer sentiment. The fact that advertisers are evaluating quantum for search algorithm use cases suggests to TBR a second tranche of quantum interest is developing alongside the traditional use cases commonly discussed for optimization, logistics, finance, security and materials science.

INCREMENTAL ADVANCEMENTS CONTINUE DUE TO SCIENTIFIC DISCOVERIES AND ENHANCED ADVISORY SERVICES PORTFOLIOS SERVING EMERGING BUSINESS INTEREST

Vendor Positioning



SOURCE: TBR

*Capgemini shifted right due to IBM alliance

MULTIPLE NATIONS VIE TO ESTABLISH QUANTUM EXPERTISE FOR ECONOMIC VIBRANCY AND NATIONAL SECURITY

The U.S. maintains a technological advantage and government interest

U.S. government efforts primarily revolve around establishing National Institute of Standards and Technology industry standards in addition to various agency investments around defense and national security. More broadly, the private sector has multiple startups and leading established vendors vying to create de facto standard commercial quantum systems. The National Quantum Initiative Advisory Committee, which consists of 22 experts, will meet semiannually to review the program's impact and progress in facilitating U.S. leadership in quantum technology. Several pieces of proposed legislation (notably H.R. 4521) are aimed at vetting the export of niche intellectual property to other nations, particularly China, and seemed designed to protect the nascent quantum ecosystem.

Europe invests independently and collectively through the European Union

France, Germany, the U.K. and the Netherlands are listed in the top 10 nations investing in quantum. England has invested the most, in the $1.3 billion range, while the Netherlands announced a 10-year investment commitment to QuTech, a quantum technology institute developing building blocks for scalable quantum computing. The EU takes an industry champion approach, backing startups such as IQM, whose 5 qubit superconducting machine lags offerings from non-European firms such as IBM. The concept of industry champions has held currency in the EU for decades, with very mixed results in past applications.

China's efforts dwarf those of in region competitors, Japan and South Korea

China is the APAC nation receiving the most attention for its quantum investments coupled with speculation about the national security implications of those investments to the rest of world. Japan has invested $270 million over a 10-year period and is taking a leadership position in the development of quantum information science career tracks. South Korea has stated it will invest $40 million over the next five years to develop core quantum technologies for the purpose of establishing an in-country research ecosystem.