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The Year of Quantum: From concept to reality in 2025

Our fourth annual *Quantum Technology Monitor* report shows that surging investment and faster-than-expected innovation could propel the quantum market to $100 billion in a decade.

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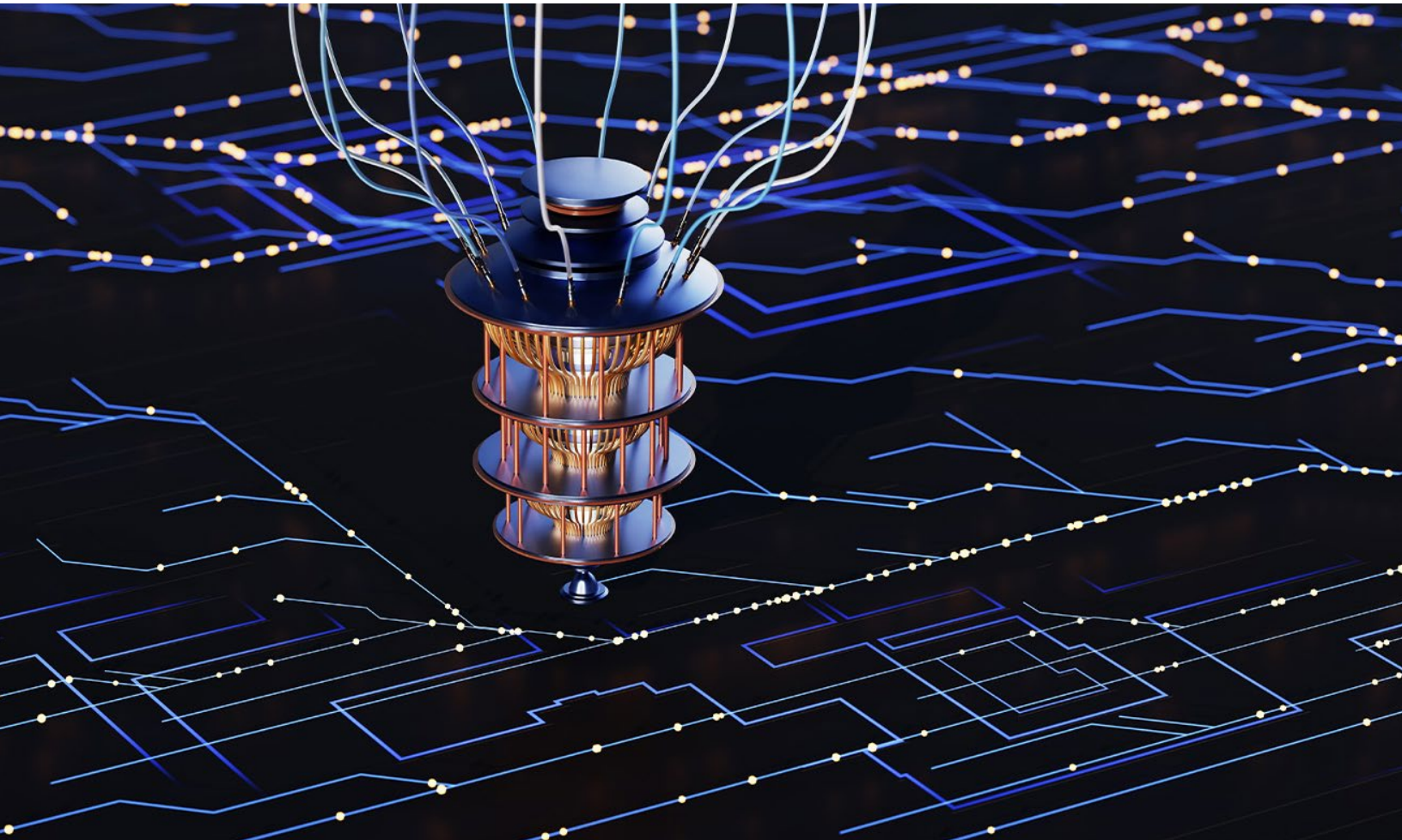


When it comes to quantum technology (QT), investment is surging and breakthroughs are multiplying. The United Nations has designated 2025 the International Year of Quantum Science and Technology, celebrating 100 years since the initial development of quantum mechanics. Our research confirms that QT is gaining widespread traction worldwide. McKinsey's fourth annual *Quantum Technology Monitor* covers last year's breakthroughs, investment trends, and emerging opportunities in this fast-evolving landscape.

In 2024, the QT industry saw a shift from growing quantum bits (qubits) to stabilizing qubits—and that marks a turning point. It signals to mission-critical industries that QT could soon become a safe and reliable component of their technology infrastructure. To that end, this year's report provides a special deep dive into the fast-growing market of quantum communication, which could unlock the security needed for widespread QT uptake.

Our new research shows that the three core pillars of QT—quantum computing, quantum communication, and quantum sensing—could together generate up to $97 billion in revenue worldwide by 2035. Quantum computing will capture the bulk of that revenue, growing from $4 billion in revenue in 2024 to as much as $72 billion in 2035 (see sidebar "What is quantum technology?"). While QT will affect many industries, the chemicals, life sciences, finance, and mobility industries will see the most growth.

We conducted extensive analysis to project the 2035 global market sizes for each of the three pillars of QT. We found that by 2035, quantum computing could be worth $28 billion to $72 billion, quantum communication could be worth $11 billion to $15 billion, and quantum sensing could be worth $7 billion to $10 billion—for a total of as much as $97 billion. This growth shows no signs of slowing. We predict that by 2040, the total QT market could reach $198 billion. We present our market size estimates as a range because of the large variance in potential technological progress, adoption rates, and scaling opportunities for QT in the decade to come (see sidebar "About the report").

What is quantum technology?

Quantum technology encompasses three subfields:

- Quantum computing is a new computing paradigm that capitalizes on the laws of quantum mechanics to provide significant performance improvement for certain applications, and to enable new territories of computing beyond existing classical computing.
- Quantum communication is the secure transfer of quantum information across distances and could ensure security of communication even in the face of unlimited quantum computing power.
- Quantum sensing includes a new generation of sensors, based on quantum systems, that provide measurements of various quantities (for example, electromagnetic fields, gravity, or time) and that are orders of magnitude more sensitive than classical sensors.

Gaining momentum in investments

More funding for start-ups

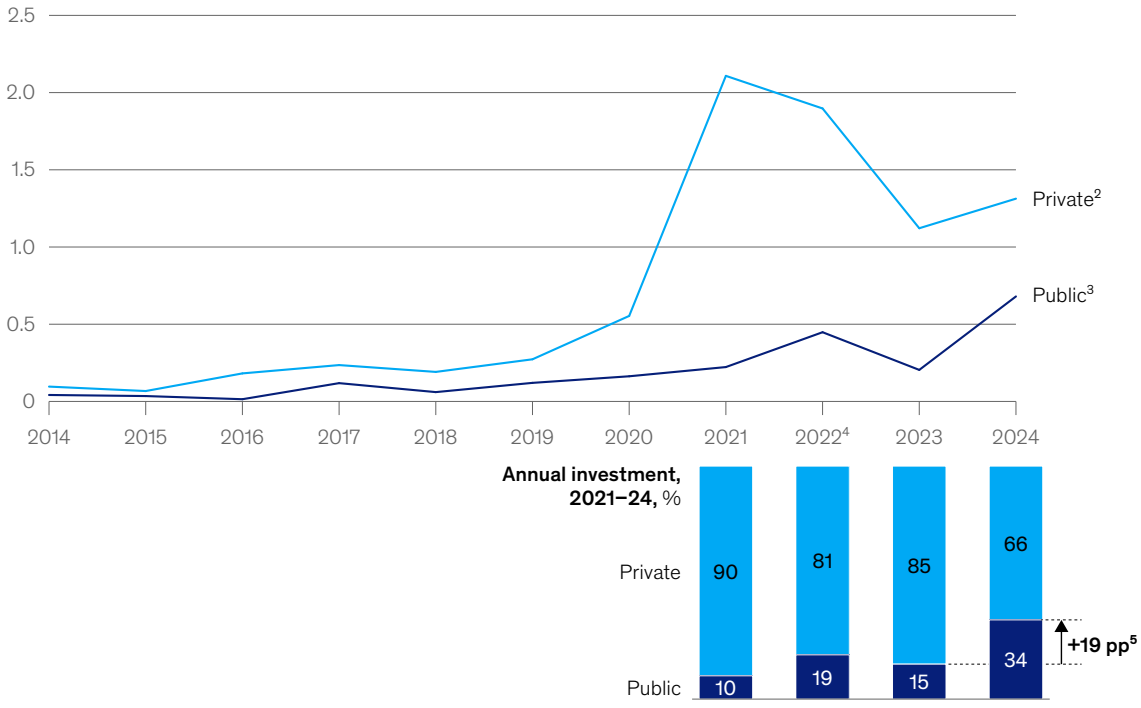
Private and public investors are increasingly confident that QT start-ups will generate measurable value. In 2024 they poured nearly $2.0 billion into QT start-ups worldwide, a 50 percent increase compared to $1.3 billion in 2023. Private sector funding from venture capital and private equity firms accounted for two-thirds of that total, or about $1.3 billion, a decline of 19 percentage points compared with 2023. Public funding took up the reins, increasing 19 percentage points relative to 2023 to account for 34 percent of 2024 funding, or $680 million (Exhibit 1). This shows increased urgency from governments to invest in QT's potential.

Significant private and public entities investing in QT start-ups in 2024 include SoftBank's partnership with Quantinuum and Aramco's investment in Pasqal. Japan's National Institute of Advanced Industrial Science and Technology's collaboration with QuEra and IonQ and Qatar Investment Authority's partnership with Alice & Bob are other examples of major investments in this space.

Exhibit 1

Public investment in quantum technology start-ups increased 19 percentage points from 2023 to 2024.

Quantum technology (QT) investments by funding type, 2014–24,[1] $ billion



[1]Based on investment data recorded in PitchBook; actual investment likely higher (excluding investments with missing details on investment types); data availability on start-up investment in China is limited. [2]Including investments from venture capital funds, hedge funds, corporations, angel investors, and accelerators. [3]Including investments from governments, sovereign wealth funds, and universities. [4]Excluding other uncategorized funding data. [5]Percentage points.
Source: PitchBook

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About the report

McKinsey initiated its annual quantum technology report in 2021 to track the rapidly evolving quantum technology landscape. We analyze three principal areas of the field: quantum computing, quantum communication, and quantum sensing. The analysis is based on input from various sources, including publicly available data, expert interviews, and proprietary McKinsey analyses. The conclusions and estimations have been cross-checked across market databases and validated through investor reports, press releases, and expert input. Because not all deal values are publicly disclosed and databases are updated continuously, our research does not provide a definitive or exhaustive list of start-ups, funding activities, investment splits, or patents and publications.

Two late-stage start-ups, PsiQuantum and Quantinuum, received half of total investment in 2024, underscoring investors' confidence that mature, established start-ups will continue to grow. Our research indicates this is already happening; quantum computing companies alone generated $650 million to $750 million in revenue in 2024 and are expected to surpass $1 billion in 2025. This revenue surge comes from continuous growth in the deployment of quantum hardware across private industry and the defense sector.

When it comes to early-stage companies, most new start-ups launched in 2024 are developing equipment and components or application software. Overall, we anticipate a value shift with QT start-ups moving from hardware toward software in the next five to ten years.

Increasingly, these new start-ups are being created in innovation "clusters" that group together start-up accelerators, academic institutions, research centers, and investors. Quantum start-ups are actively partnering with regional and national authorities to create these clusters, which often include the construction of greenfield QT manufacturing and computing facilities. There are several emerging hubs in Asia, especially in Abu Dhabi, Tel Aviv, and Tokyo, and growing clusters in the United States—in Illinois and Maryland, for example.

A surge in public funding

Global governments' $680 million worth of investments in QT start-ups in 2024 was only part of their commitment to the sector. Overall, governments announced $1.8 billion in funding for all types of QT endeavors in 2024. For example, the Australian government announced a $620 million financial package for PsiQuantum to build the world's first utility-scale, fault-tolerant quantum computer in Brisbane.[1] Meanwhile, the State of Illinois announced a $500 million investment in the development of a quantum park.[2] Asian investments also rose in 2024, led by Singapore's approximately $222 million investment in QT research and talent.[3] Five of the 19 new QT start-ups founded in 2024 are based in Asia, underscoring the region's emerging dominance in the field.

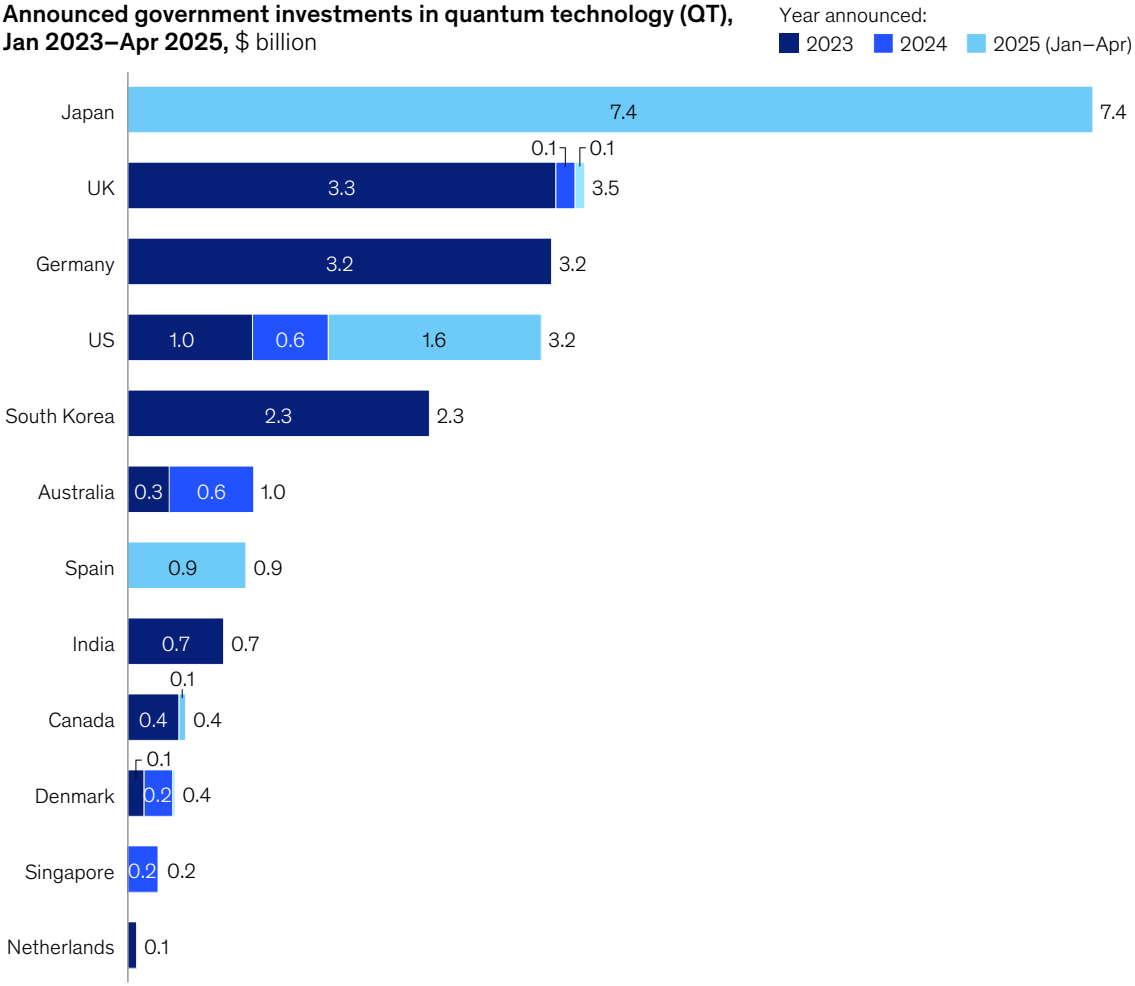
The government-backed QT financing trend shows no signs of slowing. In fact, it accelerated in the first months of 2025 when Japan announced a $7.4 billion bet on the sector and Spain committed to investing $900 million, bringing announcements for public financing to more than $10 billion (Exhibit 2).

[1] "PsiQuantum to build world's first utility-scale, fault-tolerant quantum computer in Australia," PsiQuantum, April 29, 2024.
[2] For more, see the website of the Illinois Quantum & Microelectronics Park.
[3] Matt Swayne, "Singapore invests s$300 million in national quantum strategy," Quantum Insider, May 30, 2024.

Exhibit 2

Announcements of public investments in quantum technology reached $10 billion in early 2025, with Japan accounting for nearly 75 percent.

Announced government investments in quantum technology (QT), Jan 2023–Apr 2025, $ billion



Total (for selected countries) 2023: **~11.4** 2024: **~1.8** 2025: **~10.0**

Note: Figures may not sum, because of rounding. Limited transparency on commercial activity in China; numbers excluding the $136 billion announced investment toward emerging technologies due to unclarity of relevance for QT; the ~$15 billion investment is not shown here because it was announced before 2023. Numbers also excluding $680 million in Swedish investments toward research and innovation, and US–Swedish investment of $40 million toward next-generation networks, AI, quantum technology, and educational science within STEM areas. Also excluding Saudi Arabia's $6.4 billion investment in 2022 toward future tech because no breakdown for quantum technology is present; excluding Qatar's (QIA) and Bpifrance's investment in Alice & Bob in 2025 due to missing breakdown of investment. Japan's investment is not exclusively directed toward quantum technology (includes next-generation chip design as well).
Source: Press search

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Breakthrough innovations

For the first time since McKinsey began monitoring the QT market four years ago, we see a shift from development to deployment. Much of the innovation that emerged in 2024 has made QT safer and more secure. And while the QT start-up ecosystem is fertile ground for potential breakthroughs, leading technology companies drove the bulk of change in 2024. Companies such as Amazon, Google, IBM, and Microsoft continued to progress in quantum innovation, unveiling key breakthroughs that signal a new era for the industry. Notable recent advancements from large companies include the suppression of error rates relative to the number of qubits; the development of multiple high-fidelity qubits; and substantial reductions in the cost of quantum error correction.

Quantum control solutions

Our research shows that start-ups and large companies also made progress in 2024 within quantum control solutions—the hardware and software that enable quantum systems to perform critical functions such as qubit initialization, gate operations, error correction, and readouts. For example, Australian start-up Q-CTRL partnered with Nvidia and OQC to overcome computational bottlenecks in error suppression.[4] Other companies also made progress, including IBM, Keysight, Kipu Quantum, Quantum Machines, Qedma, and Zurich Instruments.

The critical role of error correction

Error correction, a critical element of quantum control, emerged as a key innovation in 2024, with Google's Willow quantum computing chip demonstrating significant advancements in error correction and performance. With 105 physical qubits, Willow can perform certain complex calculations exponentially faster than supercomputers and with a low error rate.[5] Start-ups, too, showed progress on error correction. For example, Alice & Bob presented a new quantum error correction architecture,[6] Riverlane unveiled a hardware-based quantum error decoder with enhanced speed and efficiency,[7] QuEra launched a logical quantum processor based on reconfigurable atom arrays,[8] and Atom Computing collaborated with Microsoft to deliver quantum error correction.[9]

As the number of qubits grows, effective error correction—as well as suppression and mitigation—is no longer optional. Ensuring QT systems are less prone to error is essential for achieving the stability and accuracy needed to deploy quantum applications at scale.

Progress on patents

With an eye to cementing early advantage in the QT sector, companies are patenting their breakthroughs. Our research shows a 13 percent increase in the number of QT patents granted in 2024 compared to a year earlier (Exhibit 3). IBM had the highest number (191), followed by Google with 168.

On a country level, China and the United States filed the most QT patent applications in 2024, with China leading in quantum computing patents (Exhibit 4). Meanwhile, the United States led in quantum communication patents, propelled by the efforts of national labs such as the National Institute of Standards and Technology and research institutes. These advancements highlight the United States' strategic focus on advancing the field of quantum security.

Gaining traction in quantum communication

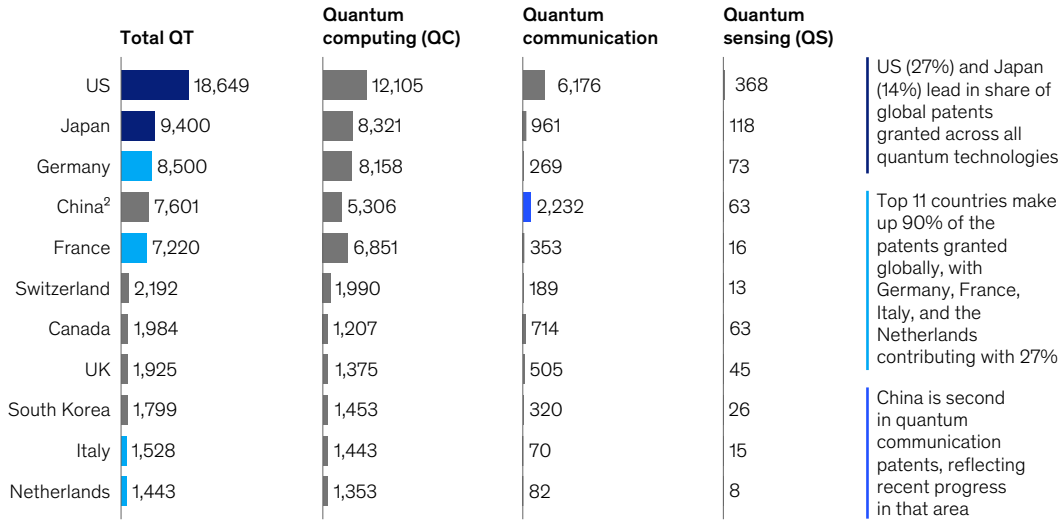
The potential arrival of Q-Day, when quantum computers become powerful enough to break current encryption standards and critical digital infrastructure worldwide, represents a major shift in security. Companies will need to rethink their global security strategies—and adopting

[4] "Q-CTRL, NVIDIA, and OQC collaborate to accelerate quantum error suppression," *Quantum Computing Report,* March 21, 2025.
[5] *The Keyword,* "Meet Willow, our state-of-the-art quantum chip," blog entry by Hartmut Neven, Google, December 9, 2024.
[6] "Alice & Bob advance quantum computing with fewer qubits needed for error correction," Alice & Bob, January 23, 2024.
[7] Ben Barber et al., "A real-time, scalable, fast and resource-efficient decoder for a quantum computer," *Nature Electronics,* 2025, Volume 8.
[8] Dolev Bluvstein et al., "Logical quantum processor based on reconfigurable atom arrays," *Nature,* 2024, Volume 626.
[9] John Timmer, "Microsoft and Atom Computing combine for quantum error correction demo," *Ars Technica,* November 19, 2024.

Exhibit 3

The United States and Japan lead other countries in the number of patents granted for quantum technology.

Quantum technology (QT) patents granted, by company HQ location, 2000–24[1]



Note: Nonexhaustive; figures may not sum, because of rounding.
[1]The number of patents granted in 2024 is incomplete because it takes time to publish patents.
[2]China's current patent activity does not accurately reflect ongoing efforts in patent applications aimed at gaining market access.
Source: Patsnap, accessed March 2025

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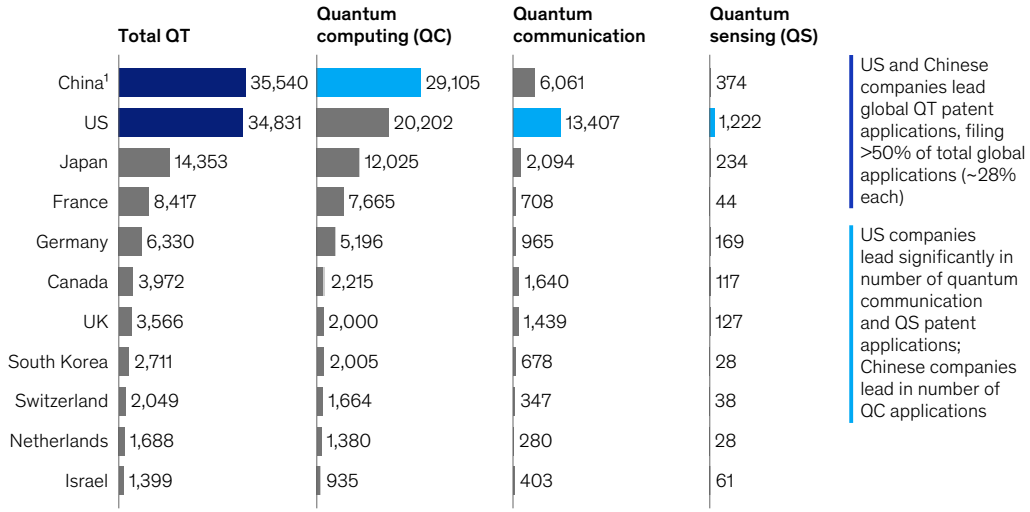
Exhibit 4

The United States and China lead other countries in the number of quantum technology patent requests filed.

Quantum technology (QT) patent applications, by company HQ location, 2000–24



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[1]China's current patent activity does not accurately reflect ongoing efforts in patent applications aimed at gaining market access.
Source: Patsnap, accessed March 2025

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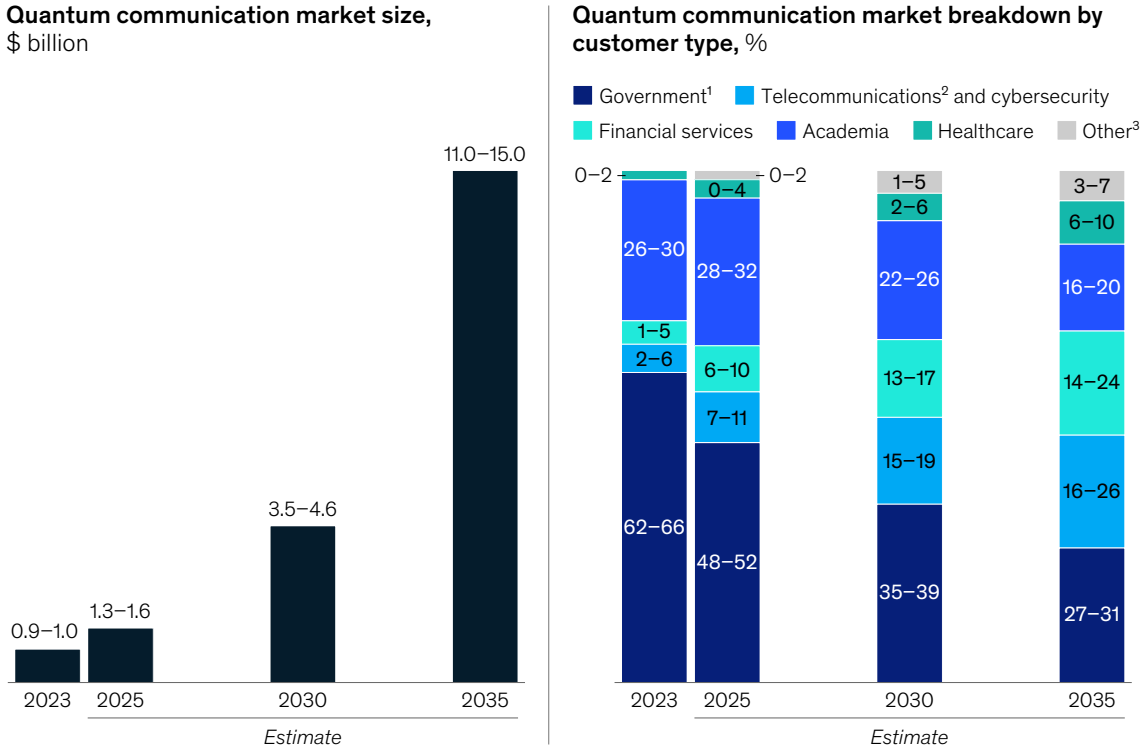
quantum communication will be a cornerstone of their new approach. Quantum communication technologies allow the secure transfer of quantum information at scale, and the market is growing quickly.

By analyzing current product offerings and emerging technological trends, we estimate that the total quantum communication market size was $1.2 billion in 2024 and that it will reach $10.5 billion to $14.9 billion by 2035—representing a CAGR of 22 to 25 percent over the next decade (Exhibit 5).

The quantum communication landscape comprises three key categories—security, networks, and services. Within these, we analyzed six important verticals—quantum key distribution solutions, post-quantum cryptography (PQC), modular interconnects, regional networks, quantum global internet, and quantum communication services. In 2024, the vertical with the most commercial maturity was PQC, which focuses on building algorithms to withstand attacks from quantum computers. PQC technology is critical to ensure data security on Q-day and beyond.

Exhibit 5

The quantum communication market is projected to reach $11 billion to $15 billion by 2035.



[1]Includes defense.
[2]Includes public cloud providers.
[3]Includes manufacturing, automative, insurance, etc.
Source: Press search; McKinsey analysis

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Our research shows that governments are currently the largest purchasers of quantum communication technologies, at approximately 57 percent of all purchases in 2024, but the private sector is increasingly adopting the technology. By 2035, for instance, our analysis shows that the telecommunications sector is expected to account for 16 to 26 percent of overall spending on quantum communication products.

The quantum communication value chain ranges from components, hardware, and application software to quantum network operators and services. Hardware is still emerging but holds significant promise. For instance, long-distance communication requires quantum repeaters, or hardware devices that amplify the signal. Start-ups and big-tech players alike are racing to develop repeaters and other hardware, even while the software market itself is still small. Doing so will allow companies to get ahead in the quantum communication market and be ready with their hardware devices when the software side catches up.

Advances in quantum sensing

Quantum sensing has entered a pivotal phase, and real-world application development will be central to unlocking its full potential. The field saw significant breakthroughs in 2024 and early 2025, particularly in use cases across defense and semiconductors. With quantum sensing technology maturing beyond foundational research, the focus is now on production and deployment. Notable advances over the past year include NASA's first demonstration of an ultracold quantum sensor in space; Q-CTRL's use of quantum magnetometers to navigate GPS-denied environments; QuantumDiamonds' launch of a diamond-based microscopy tool for semiconductor failure analysis; and SandboxAQ's introduction of AQNav, a real-time, AI-driven quantum navigation system.[10]

Looking ahead

QT delivers value not only on its own but also by unlocking powerful synergies with other cutting-edge technologies. Our research explores how QT could both influence and be shaped by four key innovation domains: AI and machine learning, robotics, sustainability and climate tech, and cryptography and cybersecurity.

— *AI and machine learning* have the potential to accelerate quantum hardware development through AI-driven material discovery, while quantum computing offers transformative leaps in computational power that could redefine the scale and speed of AI model training.

— *Robotics* plays a key role in advancing quantum technology by streamlining the manufacturing of quantum components. In turn, robotics can potentially benefit from all three pillars of quantum technology: Quantum computing can boost computing power and software optimization, quantum communication can support secure networks, and quantum sensors can enhance the precision of robots.

— *Sustainability and climate tech* stand to benefit from quantum advances, particularly in computing, because these advances can accelerate material discovery, improve modeling of complex systems such as molecular interactions or climate forecasting, and optimize production processes.

— *Cryptography and cybersecurity* could be fundamentally reshaped by quantum technology, posing new risks—such as QT's potential ability to break current encryption—while also boosting next-generation protections, including key distribution, random-number generation, and cryptographic methods designed to withstand quantum attacks.

[10] "NASA demonstrates 'ultra-cool' quantum sensor for first time in space," NASA Jet Propulsion Laboratory, August 13, 2024; "Q-CTRL overcomes GPS-denial with quantum sensing, achieves quantum advantage," Q-CTRL, April 14, 2025; "Launch of the world's first commercial quantum device for semiconductor failure analysis," QuantumDiamonds, September 26, 2024; "SandboxAQ announces AQNav—world's first commercial real-time navigation system powered by AI and quantum to address GPS jamming," SandboxAQ, June 25, 2024.

For the full set of insights and data, download the entire *Quantum Technology Monitor.*

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