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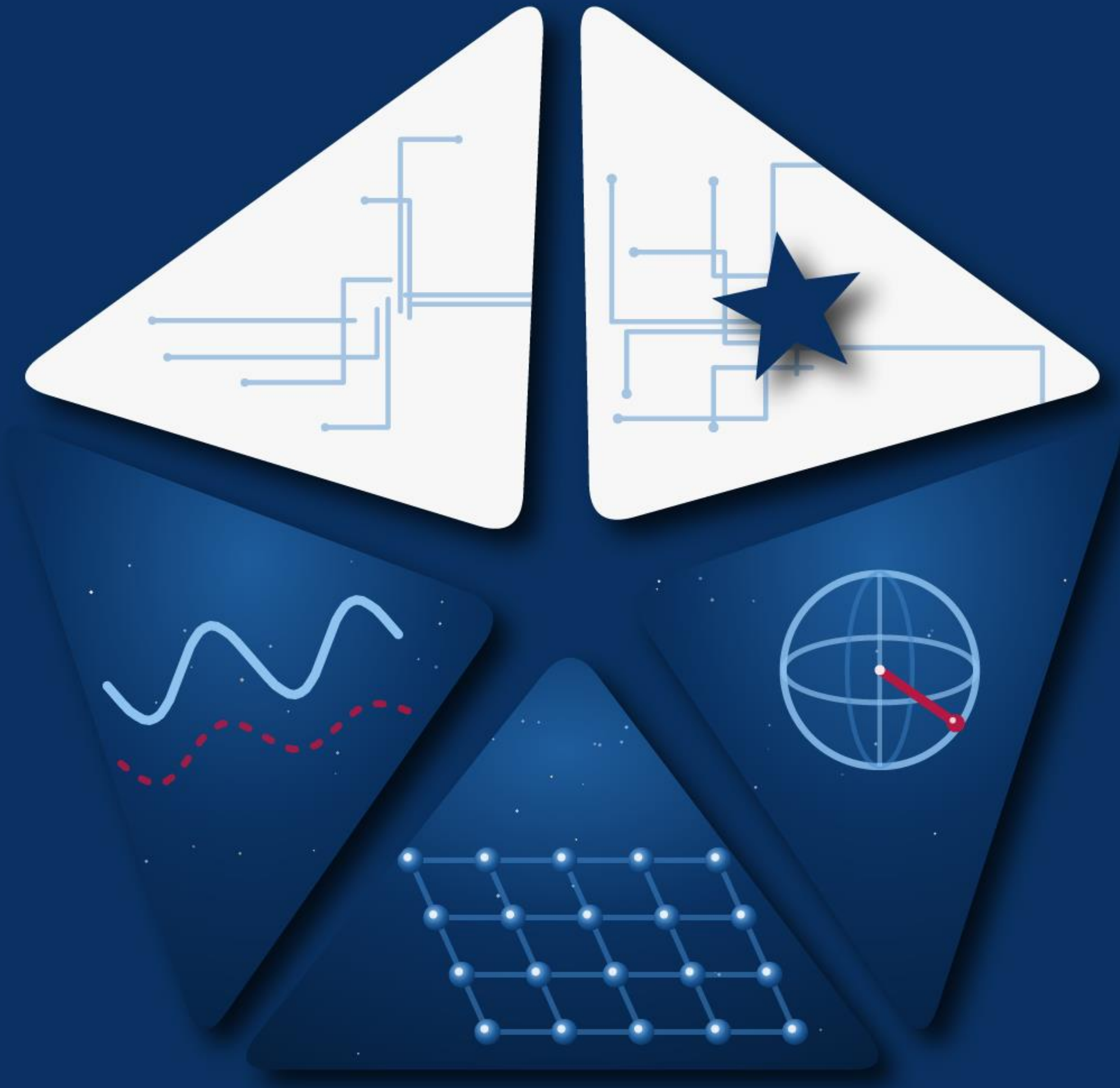
SPECIAL COMPETITIVE STUDIES PROJECT



Quantifying the Competition

Assessing Leadership in Quantum Technologies

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Assessing Leadership in Quantum Technologies

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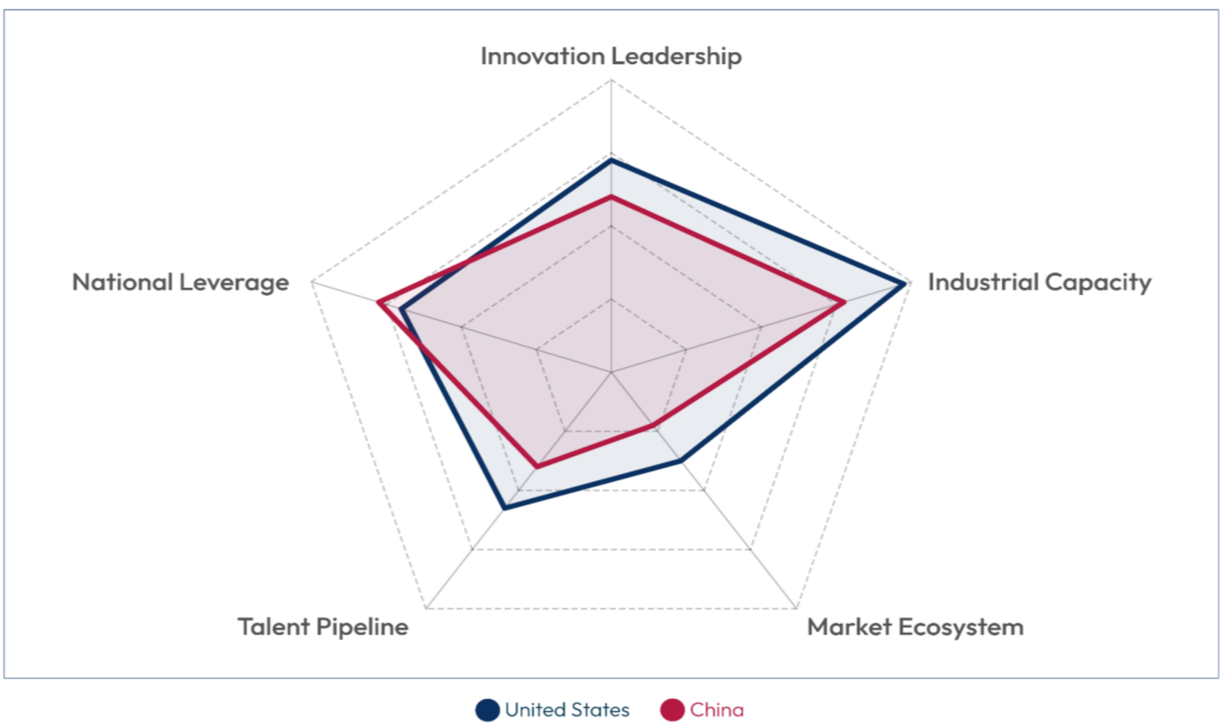
Executive Summary

Quantum information science, engineering, and technology (QISET) is emerging as a battleground in the U.S.–China technology competition. In the struggle for leadership in QISET, there may not be a single, obvious moment of victory or defeat. There will likely be gradual shifts that reshape the balance of power as nations secure an edge in quantum sensing, computing, networking, and materials. As a result, the country that leads in deploying practical quantum systems will gain enduring economic and national security advantages. These systems are interconnected and their development is tightly coupled. As a result, their policies are often tackled as a single block, and therefore, the quantum portfolio is assessed under a unified lens.

As a whole, the United States currently maintains a slight lead in QISET, driven by strengths in innovation, software, private capital, and key elements of the supply chain. However, this lead is eroding. China is executing a coordinated, state-backed strategy that integrates research, industrial policy, talent development, and infrastructure deployment into a unified national effort.

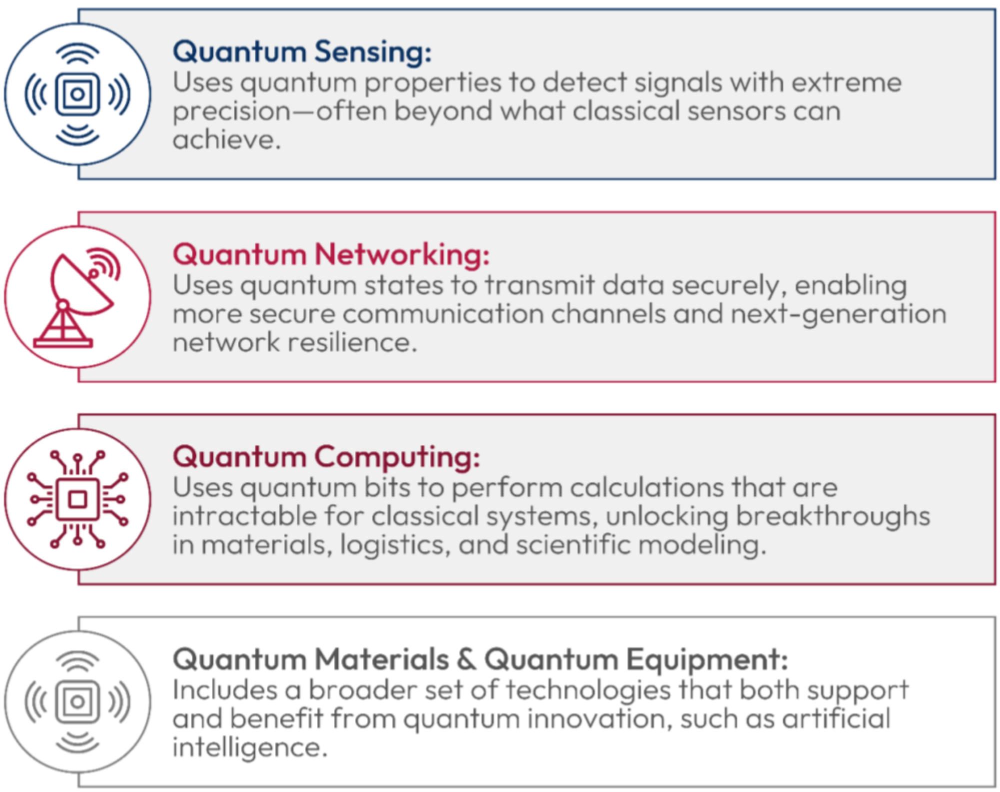
Tech Scorecard: Quantum Information Science, Engineering, and Technology (QISET)



Looking ahead, the trajectory of the quantum competition will hinge on three factors: the pace at which technologies move from the lab to the field, the ability to sustain investment through inevitable periods of slow progress, and the extent to which the United States can leverage alliances to build a resilient quantum ecosystem. Overall leadership in this space will go not to the country with the most scientific breakthroughs, but to the one that can produce operational quantum systems at scale.

Scope Note

This assessment will evaluate and compare leadership in QISET between the United States and the People's Republic of China. QISET is the interdisciplinary field that applies the principles of quantum physics to the generation, storage, processing, transmission, and sensing of information. It encompasses three primary subfields—quantum sensing, quantum networking, and quantum computing—and is underpinned by specialized materials and equipment. This assessment looks across these subfields to determine which nation has a competitive edge in the sector as a whole.



- Quantum sensing leverages the extreme sensitivity of quantum systems to environmental disturbances to measure physical quantities—such as time, gravity, and magnetic fields—with precision beyond even the most cutting-edge tools. Applications include atomic clocks, gravimeters, magnetometers, and GPS-denied navigation systems.
- Quantum networking encompasses the infrastructure and protocols required to transmit information between nodes using quantum principles. The physical size of quantum networks can range from data links within a single chip to distributed quantum internets

spanning thousands of miles. Today, advances in connectors, relays, and repeaters are beginning to create quantum counterparts to classical telecommunications networks, enabling local and enterprise-scale links across data centers and distributed cloud campuses, as well as larger state- and national-scale communications networks.

- Quantum computing harnesses quantum objects[1] and logic operations to perform computations. Whereas classical bits exist as either 0 or 1, quantum bits (or “qubits”) can occupy multiple states simultaneously. Coordinating these states across many qubits can greatly expand computational capability. This subfield includes hardware platforms, software, algorithm development, and the longer-term pursuit of “fault-tolerant” systems capable of detecting and correcting errors during computation. A major milestone will be the demonstration of quantum systems that outperform classical systems on tasks of practical significance.

Central to these three domains is a broader set of technologies that both support and benefit from quantum innovation. New materials with breakthrough properties rooted in quantum principles may have dual applications, improving legacy infrastructure while enabling quantum systems. Specialized equipment will likewise evolve symbiotically with other critical technologies, as advances in lasers, cryogenics, nanofabrication, photonics, and artificial intelligence are both driving and being driven by quantum innovation.

[1] A quantum object is any physical item whose behavior follows quantum principles, such as photons and ions.

Introduction: What it Means to Lose the Quantum Race

Imagine a near future where a nation can detect submarines without sonar, direct its missiles without GPS, and communicate with its forces in ways that are impossible to intercept.[2] In this future, the nation's pharmaceutical industry emerges as the preeminent vehicle for the discovery of life-saving therapeutics, not because it has better scientists, but because it has better instruments.[3] The clockwork of this nation's economy, from supply chain logistics to financial decisions, is optimized in ways others cannot replicate, giving it a durable edge over the rest.[4] This type of future will not materialize overnight, but will instead take shape subtly and incrementally, making the long-term race to lead in QISET one of the most consequential competitions of our era.

Quantum technologies under development today are being designed to manipulate individual particles—atomic or subatomic—to process, transmit, and measure information in ways that exceed the limits of classical technology. It is not one technology, but a family of related disciplines: quantum computing, quantum sensing, quantum networking, and supporting technologies. Each discipline operates on distinct timelines, and, critically, is dual-use: engineered for commercial products and foundational science, but convertible to military and intelligence applications with the same underlying hardware. For example, a quantum computer that optimizes supply chains for a logistics firm is the same machine that could, at sufficient scale, unravel the encryption protecting military communications.

For Washington, the strategic stakes include sustaining military and economic might, protecting critical infrastructure and information, and preserving America's innovative edge.[5] While Beijing recognizes these stakes, too, it also views QISET as a means to achieve geopolitical ends.[6] For the People's Republic of China, quantum sensing could give the People's Liberation Army Navy advantages in the undersea domain.[7] Equipment central to quantum systems, such as lasers, can be manufactured at a fraction of the cost and in far greater numbers in China, giving it outsized influence over the quantum infrastructure, and, therefore, the information security of partner nations.[8] Quantum computing, even before it reaches cryptographic relevance, will generate

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[2] Kelley M. Sayler, Defense Primer: Quantum Technology, Congressional Research Service (2024).
[3] Henning Soller, et al., The Quantum Revolution in Pharma: Faster, Smarter, and More Precise, McKinsey & Company (2025).
[4] Frank Phillipson, Quantum Computing In Logistics and Supply Chain Management - an Overview, Maastricht University (2025).
[5] National Strategic Overview for Quantum Information Science, National Science & Technology Council (2018).
[6] Sam Howell, The Quest for Qubits, Center for a New American Security at 16 (2024).
[7] Matt Swayne, China Tests Drone-Mounted Quantum Sensor That Could Reshape Submarine Detection, Quantum Insider (2025); Eric Hundman, China's Air Defense Radar Industrial Base, China Aerospace Studies Institute at 23 (2025).
[8] *See the "Industrial Capacity" section of this report for more information.*

advantages in materials science, precision manufacturing, and AI model training that translate directly into economic and military power.[9]

As a result, China is investing in quantum and integrating research funding, industrial capability, talent acquisition, and market development into a coherent campaign to become the world's dominant quantum power. The United States is also advancing its quantum ecosystem, but the competition is closer than most policymakers recognize, and the consequences of losing are not abstract.

Losing the quantum race does not look like a single dramatic defeat. Instead, it looks like a slow accumulation of asymmetries: sensing gaps, communications vulnerabilities, computing lags, and a widening dependency on quantum-enabled infrastructure that others construct and control. Moreover, it would cause allies to make different choices about whose communications networks to connect to. Ultimately, losing means the erosion of the technological overmatch that has underpinned U.S. national security strategy for a generation.

Understanding what is actually at stake and how close the contest is requires clarity about what QISET is, where each of its component technologies stands today, and how the United States and China are positioning themselves for the decade ahead.

[9] Kelley M. Sayler, Defense Primer: Quantum Technology, Congressional Research Service (2024).

Background: The Two Geographies of Quantum Innovation

As Washington and Beijing set policies that calibrate for quantum leadership, much of where the quantum technologies are actually being innovated, tested, and deployed is happening deeper in each nation's respective ecosystems. These two ecosystems are structurally distinct.[10]

The American model is decentralized.

The United States' quantum ecosystem is the product of decades of federally funded basic research at National Laboratories and research universities, as well as a private sector featuring significant corporate investments and venture-backed quantum startups pursuing a range of hardware and software designs.[11] Consequently, the American quantum ecosystem is decentralized—geographically dispersed and commercially competitive in ways that generate both extraordinary dynamism and meaningful coordination challenges.

As a result, American quantum capability is distributed across the country. For example, the Boston–Cambridge corridor anchors a dense cluster of activity driven by MIT, Harvard, and an expanding constellation of startups and spinouts operating in quantum computing, sensing, and networking.[12] Chicago anchors a regional economic development initiative, the Illinois Quantum Microelectronics Park, as well as a federally designated quantum "Tech Hub" through Argonne National Laboratory, Fermilab, and the Chicago Quantum Exchange, which extends to Indiana's quantum community.[13] Colorado's Boulder–Denver corridor serves as a cluster for some atomic systems, hosting the National Institute of Standards and Technology (NIST) and major hardware manufacturers.[14] Northern New Mexico boasts Los Alamos National Laboratory, Sandia National Laboratories, and Kirtland Air Force Base—a key Air Force Research Laboratory—making the Colorado–New Mexico region home to another federally designated quantum Tech Hub: Elevate Quantum.[15] In San Francisco, preeminent research institutions operate side-by-side with major international commercial players and the private investment community.[16] The greater Maryland area, fuelled by a pool of federal talent, a range of federal research centers, and access to federal customers, is rapidly growing, evidenced by the Potomac Quantum

[10] Global Innovation Hubs Index 2025, Center for Industrial Development and Environmental Governance (CIDEG), Tsinghua University and Nature Research Intelligence at 32–43 (2025).
[11] Sam Howell, The Quest for Qubits, Center for a New American Security at 11–15 (2024).
[12] Massachusetts Quantum Computing Ecosystem Study, The Innovation Institute at 16 (2023).
[13] About Us, Illinois Quantum and Microelectronics Park (last accessed 2026); The Bloch Tech Hub, U.S. Economic Development Administration (last accessed 2026).
[14] The Boulder Blueprint, Special Competitive Studies Project (2025).
[15] AFRL Quantum Labs, Air Force Research Laboratory (last accessed 2026); Elevate Quantum Tech Hub, U.S. Economic Development Administration (last accessed 2026).
[16] Quantum Clusters: Ranking the World's Deep-Tech Epicentres, European Centre for International Political Economy (2025).

Innovation Center and the University of Maryland's Capital of Quantum initiative.[17] New York's quantum ecosystem spans Brookhaven National Laboratory in Long Island, to the Air Force Research Laboratory in Rome, and the Poughkeepsie computing center in between.[18] Additional nodes span Montana, Tennessee, Florida, and beyond.[19] America's model is networked and pluralistic.

Whereas the Chinese model is concentrated.

By contrast, China's quantum ecosystem is a three-legged stool, with the first leg firmly grounded in the Yangtze River Delta: Hefei, the capital city of Anhui Province. Reportedly funded at roughly $10 billion, Hefei, locally known as "Quantum Avenue," was designated a node of strategic technological investment by the central government and backed by institutional infrastructure, talent recruitment, and capital at a scale that no free-market mechanism would have produced.[20] The University of Science and Technology of China (USTC), based in Hefei and an anchor for the hub, has served as the intellectual engine of Chinese quantum science for more than two decades.[21] Clustered around USTC are the Hefei National Laboratory and companies such as Origin Quantum, QuantumCTek, and Chinaprosp, which manufacture indigenous quantum computers, communication hardware, and high-precision temperature and magnetic sensors, respectively.[22] Together with Beijing and Shanghai, the three quantum hubs anchored by Hefei capture an overwhelming majority of China's quantum capabilities. Beijing has strengths in basic research due to an array of Chinese Academy of Science centers, select State Key Laboratories, the Beijing Academy of Quantum Information Science, and several

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[17] About, Potomac Quantum Innovation Center (last accessed 2026); Governor Moore announces $1 Billion "Capital of Quantum" Initiative, The Office of Governor Wes Moore (2025).
[18] Quantum, Brookhaven National Laboratory (last accessed 2026); AFRL Quantum Labs, Air Force Research Laboratory (last accessed 2026); IBM Sets the Course to Build World's First Large-Scale, Fault-Tolerant Quantum Computer at New IBM Quantum Data Center, IBM (2025).
[19] Our Mission, Montana Photonic and Quantum Alliance (last accessed 2026); Tennessee Commits $20M to New Quantum Initiative as EPB Secures $4M Federal Grant, Quantum Insider (2026); About, Florida Alliance for Quantum Technology (last accessed 2026); Hideki Tomoshige, Innovation Lightbulb: U.S. Federal Investments in Quantum Technology Research and Infrastructure, Center for Strategic & International Studies (2025).
[20] Jeffrey Lin & P.W. Singer, China is Opening a New Quantum Research Supercenter?, Popular Science (2021); Hodan Omaar & Martin Makaryan, How Innovative Is China in Quantum?, Information Technology & Innovation Foundation (2024).
[21] Hodan Omaar & Martin Makaryan, How Innovative Is China in Quantum?, Information Technology & Innovation Foundation (2024).
[22] Hideki Tomoshige & Phillip Singerman, Understanding China's Quest for Quantum Advancement, Center for Strategic & International Studies (2026); Sam Howell, The Quest for Qubits, Center for a New American Security (2024); Testimony of Edward Parker before the U.S.-China Economic and Security Review Commission, The Chinese Industrial Base and Military Deployment of Quantum Technology (2024).

prestigious universities.[23] Ventures spun out of these institutions are often incubated in nearby economic development zones. Shanghai, meanwhile, provides a space for commercial initiatives to grow, with easier access to international entities and established research institutions, like Fudan University, to draw from.[24] National, provincial, and local governments consistently turn to these centers to expand China's quantum ambitions.

This structural difference has strategic implications.

Both the American and Chinese quantum ecosystems embody genuine strengths and limitations, and the outcome of the competition between them will be determined not by which model is better in theory but by which proves more capable of rapidly solving the specific technological problems blocking the achievement of practical and powerful quantum applications.

The sections that follow examine these dynamics in greater detail, assessing the current state of play across the specific domains of quantum computing, sensing, networking, and enabling technologies, and drawing conclusions about where the competition is closest, where American advantages are most durable, and where the risks of falling behind are most acute.

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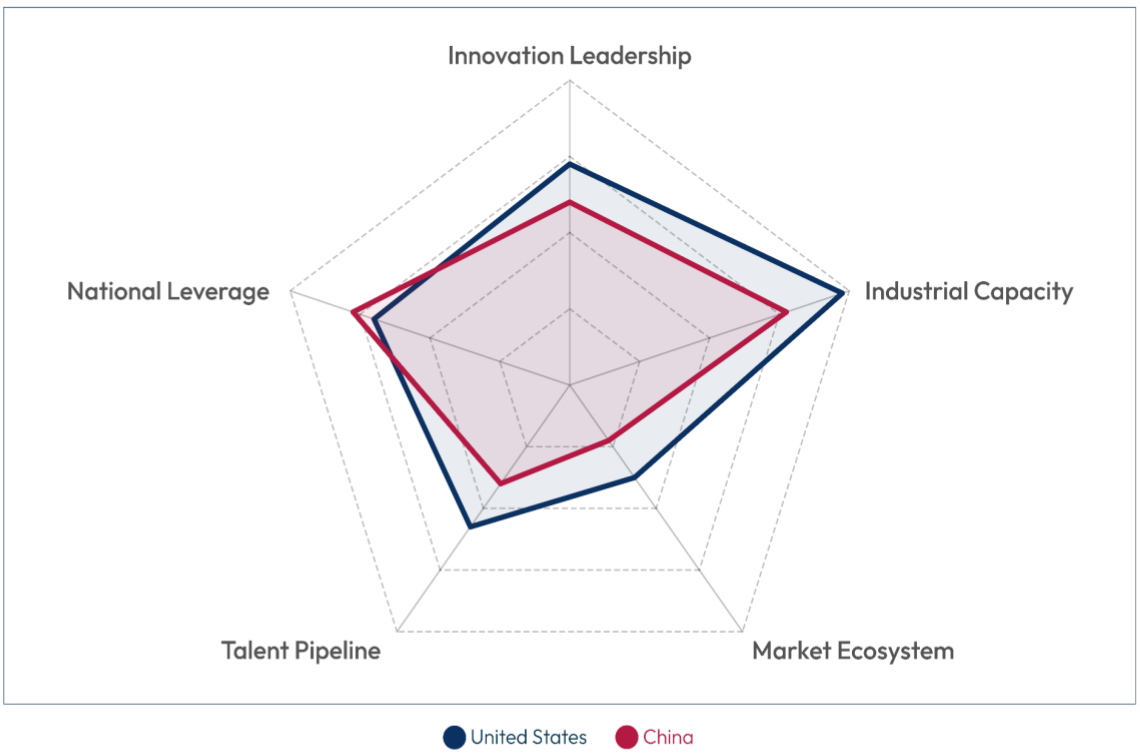
[23] Hideki Tomoshige & Phillip Singerman, Understanding China's Quest for Quantum Advancement, Center for Strategic & International Studies (2026).

[24] Sam Howell, The Quest for Qubits, Center for a New American Security at 20 (2024); Jeroen Groenewegen-Lau & Antonia Hmaidi, China's Long View on Quantum Tech Has the US and EU Playing Catch-Up, MERICS at 9 (2024); Quantum China: The Future For China's Technological And Economic Development?, Quantum Zeitgeist (2023).

SCSP Tech Scorecard: America maintains a slight lead in QISET

Looking at the sector as a whole, the United States currently is slightly ahead of China in QISET, with an edge in Innovation Leadership, Industrial Capacity, Market Ecosystem, and Talent Pipeline—key indicators of advantage in a technology. American strengths in quantum software, supply chain control, and private capital are measurable. Yet China is tracking the United States closely on nearly every axis, and current trends suggest the United States' lead could vanish in a matter of years.

Tech Scorecard: Quantum Information Science, Engineering, and Technology (QISET)



What is the SCSP Tech Scorecard?

SCSP developed a comparative analysis framework to provide a comprehensive view of the state of the tech competition between the United States and China across a variety of key technologies.[25] The scorecard compares quantitative and qualitative metrics across the five categories SCSP has determined are needed for technology leadership: Innovation Leadership, Industrial Capacity, Market Ecosystem, Talent Pipeline, and National Leverage.

The specific metrics considered are technology-specific and will vary between reports based on the technology readiness level and resource needs of each technology. Data are compiled from open source analysis, subscriptions, and expert surveys.

For more information, see the appendix.

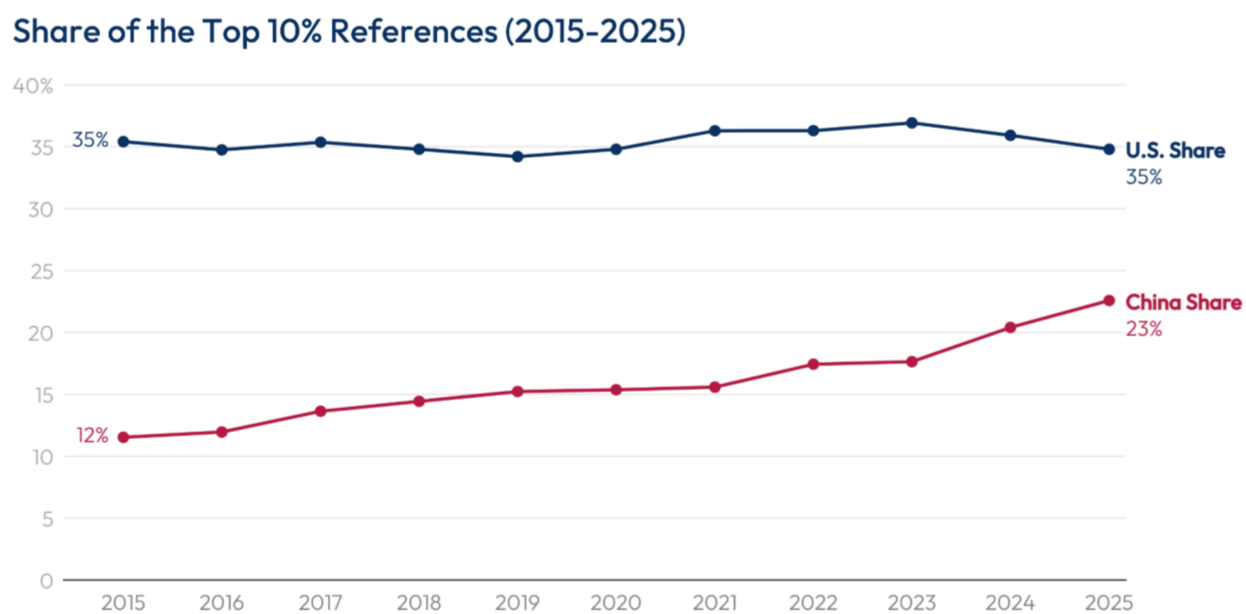
[25] Tech Scorecard Methodology, Special Competitive Studies Project (2026).

Innovation Leadership: U.S. Dominance in QISET Innovation Narrows

Leader: United States	*Trending Towards: Contested*

The United States retains a meaningful lead in quantum innovation, but that lead is diminishing across several dimensions.

As an emerging technology, quantum innovation begins with fundamental research.[26] One reliable proxy for scientific influence is the citation record: specifically, how often a country's research becomes the foundation for subsequent work. An examination of this record shows that researchers affiliated with American institutions account for 35% of the top 10% most-cited quantum papers referenced in 2025 publications—a figure that has held roughly steady over the past decade. Researchers affiliated with Chinese institutions now account for 23%, a share that has doubled over the same period. This comparison encapsulates the defining trend of the quantum competition: the United States is not declining in absolute terms, but China's influence is rising at the highest echelons of scientific output.

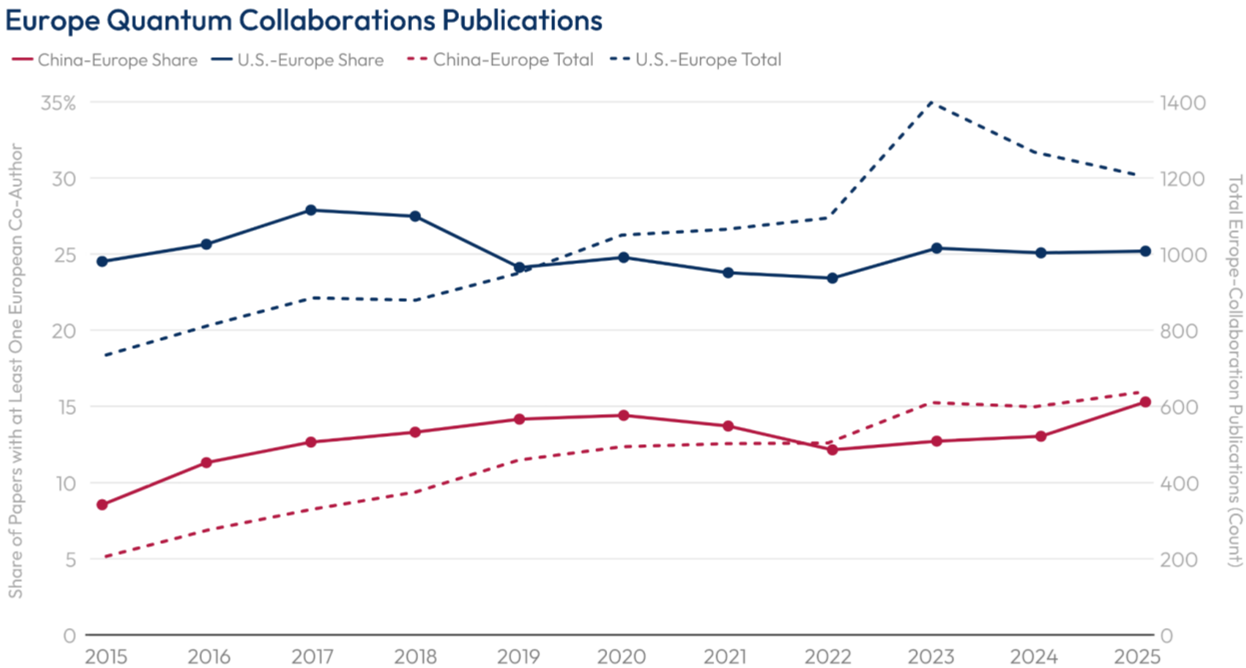


Source: SCSP analysis using an open-source dataset from OpenAlex.

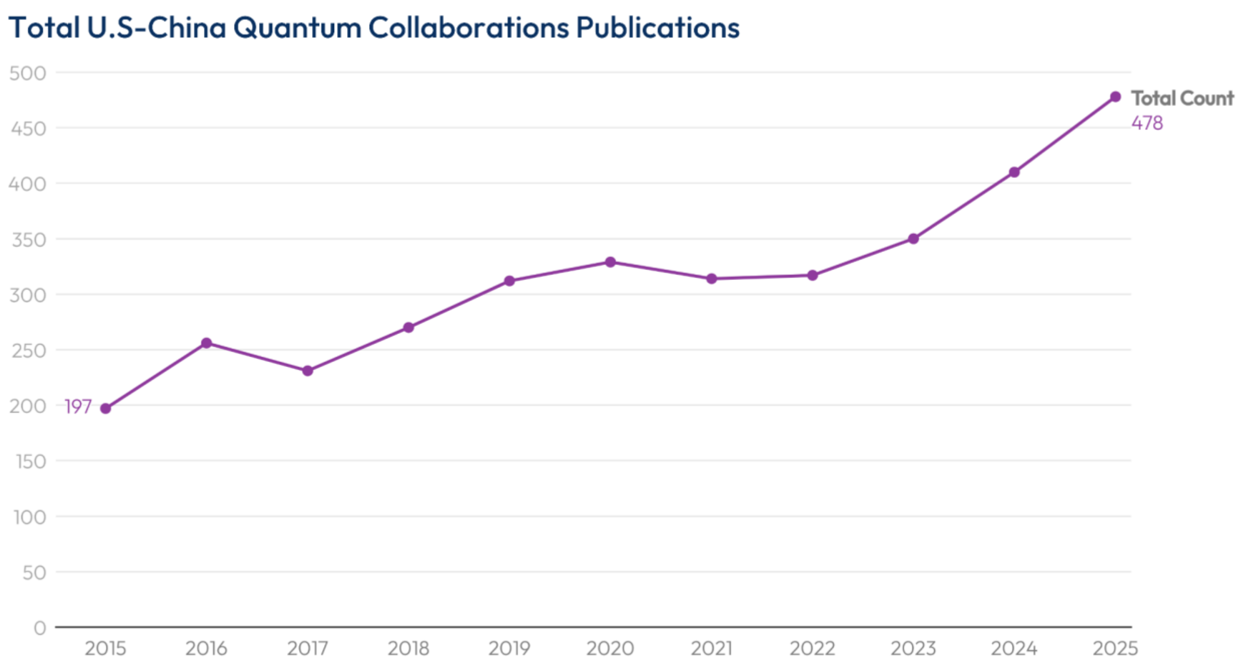
The two countries' approaches to academic research diverge in multiple ways. For example, American QISET researchers engage more frequently with foreign partners. Taking European

[26] Statistics in this section are the product of SCSP's bibliometric analysis of datasets obtained from OpenAlex. See OpenAlex, OpenAlex (last accessed 2026), and Appendix II for more information.

collaborations as an example, roughly 25% of U.S. publications include at least one European co-author, compared to about 15% of Chinese papers.



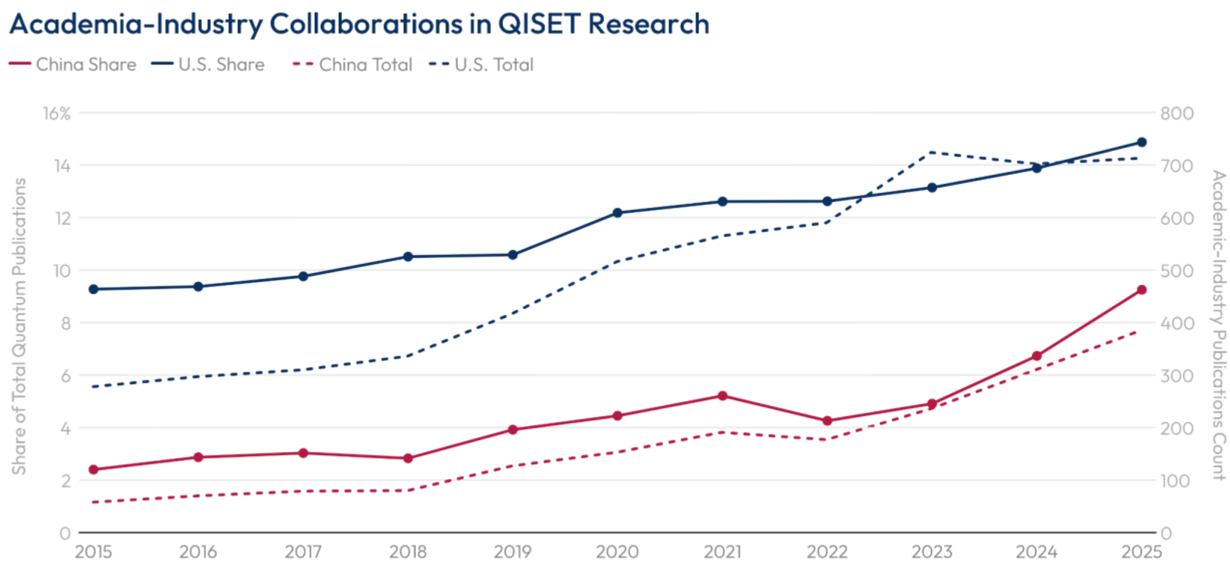
Source: SCSP analysis using an open-source dataset from OpenAlex.



Source: SCSP analysis using an open-source dataset from OpenAlex.

Correspondingly, China's research engages more frequently with domestic partners. More than 65% of Chinese quantum research occurs through collaborations with multiple domestic institutions, compared to barely 35% in the United States. Neither approach is inherently superior, but the American model generates broader international network effects while the Chinese model concentrates resources toward domestic priorities.

The degree to which private industry participates in academic research offers a related signal of commercialization potential. Globally, industry co-authorship is rare: just 3% of all academic papers worldwide include a corporate co-author.[27] Within quantum publications, the United States leads. Approximately one in seven U.S. quantum papers includes industry participation, compared to roughly one in eleven Chinese papers. However, Chinese commercial ventures have expanded their partnerships with universities and state-funded research institutes sharply over the last four years, and if current trends continue, China could reach parity with the United States in commercial research integration by approximately 2029.



Source: SCSP analysis using an open-source dataset from OpenAlex.

The origin of citations further reinforces their different approaches. More than half of citations to Chinese quantum research originate from other Chinese researchers, while the equivalent figure in the United States—the share of citations to U.S. research that originate from other U.S. researchers—is closer to one-third. American research, in other words, generates broader international reach. Changes in that popular metric can indicate longer-term trends in levels of influence. For instance, China's share of the top decile of most-cited quantum papers has climbed from 15% in 2016 to 25% today, approaching the American range of 30–35%. On current trajectories, China could surpass the United States among the most-cited publications within a

[27] Published Corporate Research 'More Reliant' on Academics, Times Higher Education (2021).

few years—suggesting that the influence generated by the sheer scale of its domestic research base may soon outweigh the broader international pull of American research.

Innovation within subfields of QISET is becoming a strategic battleground.

Quantum innovation is broad and deep, but the research and development (R&D) dynamics in a few subfields illustrate core trends that will ultimately determine long-term dominance. The following analysis combines complementary data from publication metrics and patenting statistics to paint a fuller picture of which country leads in specific QISET domains.[28]

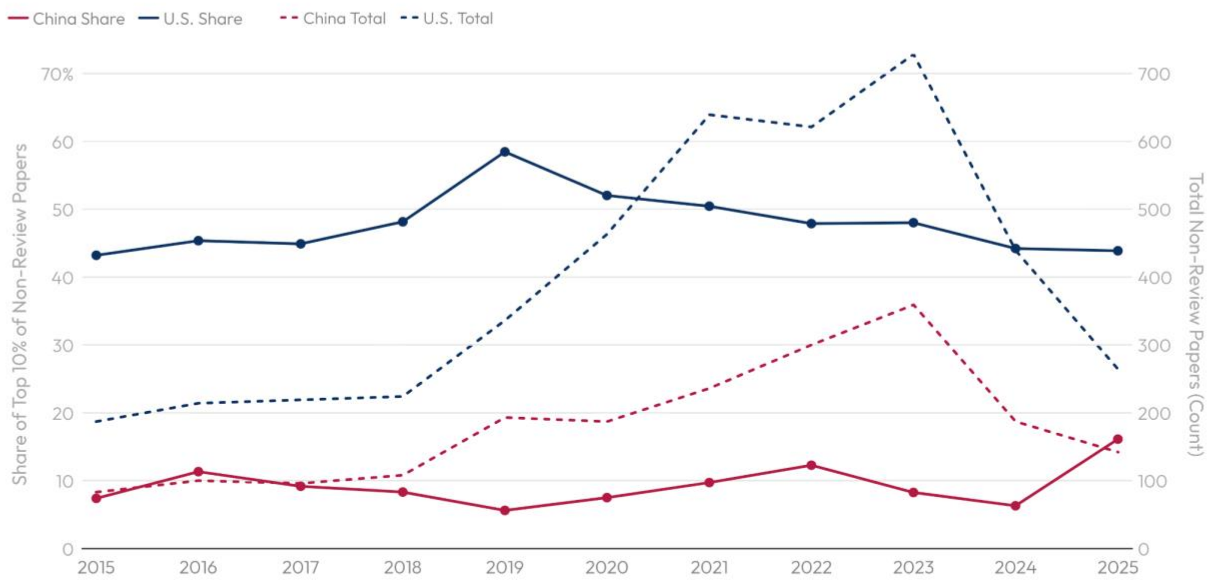
Assessment of Leadership in QISET Subfields

Subfield	Leader	Trending Towards
Error Correction	United States	United States
Specialized Algorithms and Protocols	United States	China
Simulators and Compilers	United States	United States
Advanced Materials	China	China

- **Error Correction**
  Quantum error correction is a capability fundamental to overcoming operational flaws and enabling useful, scalable quantum computers. Here, across scholarly publications and industrial patents, the United States maintains a commanding lead over China. Its share of top publication output in error correction is roughly three times that of China's. Patent activity regarding error correction reinforces this dominance: 55% of the most-cited patents are U.S.-affiliated, compared to 18% for China. Notably, both countries' research output in error correction has declined sharply over the past two years. Still, the conclusion remains clear: at the bleeding edge of fault-tolerant quantum computing, the United States leads.

[28] Patenting statistics in this section are the product of SCSP analysis of datasets obtained from The Lens. See Lens.org, The Lens (last accessed 2026) and Appendix II for more information.

Share of Top 10% Most Cited Non-Review Quantum Error Correction Papers Versus Total



Source: SCSP analysis using an open-source dataset from OpenAlex.

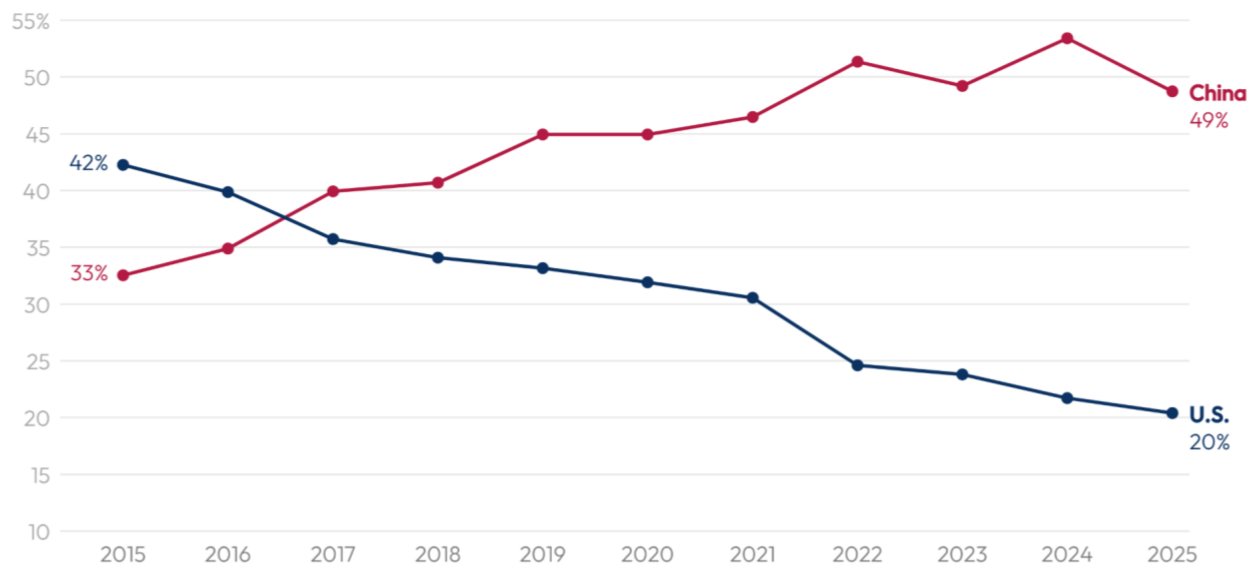
- **Specialized Algorithms and Protocols**
  Quantum-specific algorithms and protocols, which give quantum computers their potential advantage over classical computers, are equally critical. Publications in this area still favor the United States. However, China's share of top algorithm papers has climbed to 20% over the past five years, while the United States' share has declined from 40% to 30%. This shift is already visible in patenting activity: in 2025, China outpaced the United States in algorithm-related patents by a ratio of five to two.

- **Simulators and Compilers**
  Simulators and compilers are conventional software tools that translate hardware architectures into programmable applications and are vital for current implementations, including computers and sensors. Patent data relating to simulators and compilers indicate clear U.S. dominance: U.S.-affiliated researchers have four times as many top patents in simulation as Chinese-affiliated researchers. This reflects the commercial strength of major U.S. firms and a dynamic open-source ecosystem.

- **Advanced Materials**
  Advanced materials—laboratory-grown, custom-designed structures—will be essential for next-generation devices. Here, the data are most concerning for the United States. Chinese researchers now account for roughly 50% of the top-performing quantum materials papers, compared to about 20% for American researchers. This outcome reflects a decade-long trend: the U.S. share of top-performing quantum materials papers has halved, while China's has risen steadily at a rate of 2% per year. China's

strength stems from a coordinated long-term public strategy in which State Key Laboratories, universities, and national entities operate in concert to identify, scale, and propagate new materials platforms.

Share of the Top 10% Most-Cited, Non-Review Quantum Materials Papers



Source: SCSP analysis using an open-source dataset from OpenAlex.

The United States and China diverge when translating ideas from the lab into the field.

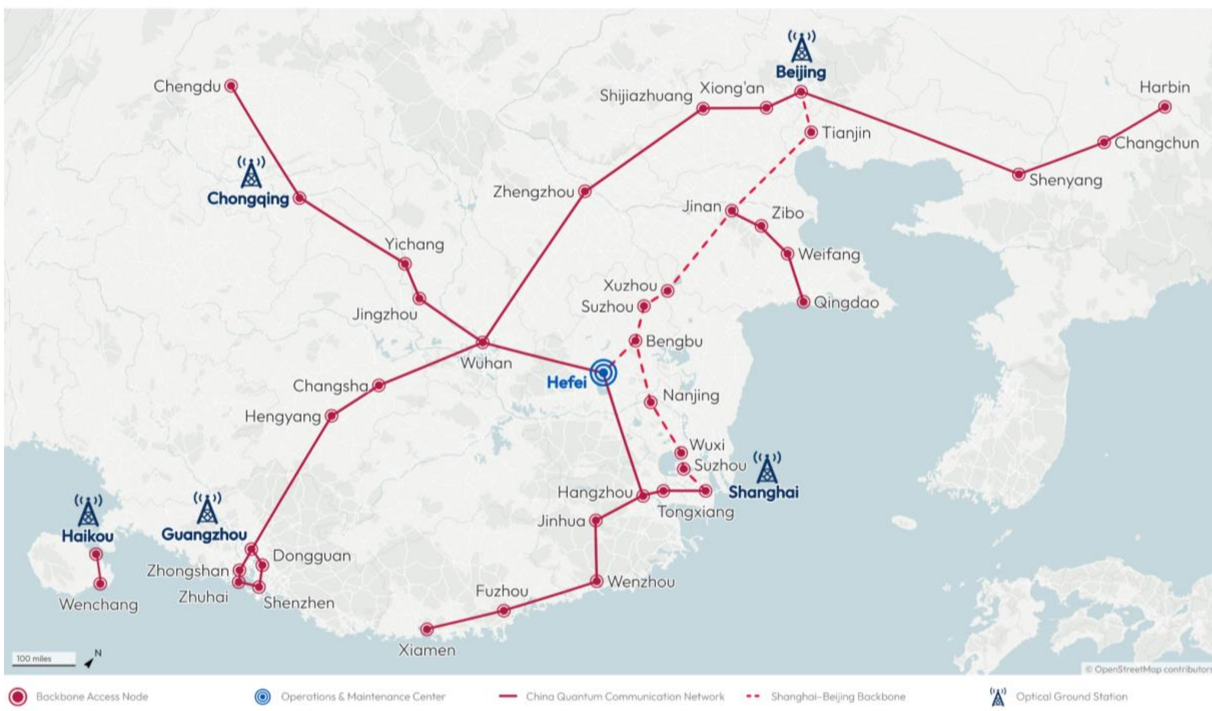
The structural differences between the United States and China become most visible and most consequential when quantum innovations move from laboratory research to field deployment. China's lead in long-distance quantum networking, particularly terrestrial and satellite-based systems, is a clear example of that asymmetry. Whereas U.S. and allied intelligence agencies look at quantum-enhanced telecommunications with suspicion, Beijing often frames these tools as a foundation for a future quantum internet, and is poised to benefit from centralized planning that supports rapid national-scale buildout and its broader push for sovereign control over information flows.[29] In line with a broader push toward self-reliance, manifested recently in Beijing's 15th Five-Year Plan, China is pursuing this indigenous hardware in parallel with homegrown standards architectures out of concern that quantum-era communication standards shaped through Western-led processes could embed long-term U.S. influence.

China has demonstrated ground-based communications under a model called quantum key distribution (QKD) across 6,277 miles of fiber and relays. Separately, it has deployed direct

[29] Applications of Quantum Technologies, U.S. Department of Defense, Defense Science Board (2019); Quantum Networking Technologies, Government Communications Headquarters, National Cyber Security Centre (2025).

quantum-based communication—i.e., a method of directly sending quantum information without classical bits—over 186 miles.[30] At this time, the United States has no reported direct quantum network, and simpler terrestrial information transmission remains limited to shorter testbeds: 124 miles under the Chicago Quantum Network, 98 miles at Brookhaven National Laboratory, and around 13 miles between Illinois and Indiana.[31] The National Security Agency has cautioned that QKD presents both opportunities and implementation challenges, so, to date, the United States has not prioritized QKD. These numbers illustrate that when it comes to turning quantum innovation into country-scale infrastructure, China eclipses the United States because it prioritizes QKD.[32]

China's Quantum Communications Network



Source: Hao-Ze Chen, et al., Implementation of Carrier-Grade Quantum Communication Networks Over 10000 km, npj Quantum Information (2025).

The United States enjoys a slight lead in quantum computing hardware performance.

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[30] Hao-Ze Chen, et al., Implementation of Carrier-Grade Quantum Communication Networks Over 10000 km, npj Quantum Information (2025); Yilin Yang, et al., A 300-km Fully-Connected Quantum Secure Direct Communication Network, Science Bulletin (2025).
[31] Quantum Networking: Findings and Recommendations for Growing American Leadership, National Quantum Initiative Advisory Committee (2024).
[32] Quantum Key Distribution (QKD) and Quantum Cryptography (QC), National Security Agency/Central Security Service (last accessed 2026).

Quantum computing hardware presents a different picture: American innovation remains strong and measurably ahead in several key benchmarks, but China is catching up. The United States leads in building quantum systems whose primary components operate with high accuracy and last longer before degrading. The United States was also the first to publicly demonstrate key milestones in error-correction, and stands on par with China on computational benchmarks that measure how long primary components remain stable for computation.[33] These achievements reflect strengths in precision engineering and ecosystem-driven innovation.

The decisive line for utility-scale machines runs through quantum error correction, and here, U.S. firms are shaping the field.[34] Google's "Willow" processor first demonstrated a critical milestone in this area; comparable results on China's Zuchongzhi 3.2 platform appeared approximately a year and a half later.[35] However, scalable, commercially useful quantum computing ultimately depends on sustained technical improvements in specialized hardware and firmware updates. Early U.S. leadership in demonstrated error correction provides a meaningful advantage. Yet China's rapid progress suggests that this advantage may not be permanent.

Overall, the United States remains the ecosystem that is leading in commercial integration and error correction, while China is the materials-dominant, scale-driven power. Nonetheless, a nation's ability to translate cutting-edge research into sustainable capabilities is more important to the technology competition than its leadership in innovative R&D.

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[33] Metrics to evaluate computing performance include *fidelity,* or accuracy, which reaches 99.998% in some U.S.-made systems and 99.911% in state-of-the-art Chinese systems; *lifetime*, or how long qubits last before degrading, which is 1.68 milliseconds in U.S. machines compared to 1.2 milliseconds in Chinese machines; and *coherence*, or how long qubits remain stable, with 600 seconds in the best U.S. publications versus 37,700 seconds in Chinese bleeding-edge research. *See* David A. Rower, et al., Suppressing Counter-Rotating Errors for Fast Single-Qubit Gates with Fluxonium, PRX Quantum (2024); IonQ Achieves Landmark Result, Setting New World Record in Quantum Computing Performance, IonQ (2025); Tan He, et al., Experimental Quantum Error Correction below the Surface Code Threshold via All-Microwave Leakage Suppression, Physical Review Letters (2025); Dongxin Gao, Establishing a New Benchmark in Quantum Computational Advantage with 105-qubit Zuchongzhi 3.0 Processor, Physical Review Letters (2025); Pengfei Wang, et al., Single Ion Qubit with Estimated Coherence Time Exceeding One Hour, Nature Communications (2021); Matthew P. Bland, et al., Millisecond Lifetimes and Coherence Times in 2D Transmon Qubits, Nature (2025); J.J. Bollinger, et al., A 303-MHz Frequency Standard Based on Trapped Be/sup +/ ions, IEEE (1991); Jiahao Pi, et al., Beyond-Ten-Hour Coherence in a Decoherence-Free Trapped-Ion Clock Qubit, arXiv (2026).

[34] The Quantum Error Correction Report 2025, Riverlane (2025).

[35] Google Quantum AI and Collaborators, Quantum Error Correction Below the Surface Code Threshold, Nature (2025); Tan He, et al., Experimental Quantum Error Correction below the Surface Code Threshold via All-Microwave Leakage Suppression, Physical Review Letters (2025).

Industrial Capacity: The United States is Ahead, but China is Cutting Costs

Leader: United States	***Trending Towards: Contested***

If Innovation Leadership reveals competing research strengths between the United States and China, Industrial Capacity reveals different advantages in how they translate research into tangible manufacturing capabilities and supply chain control. China's model compresses cost, centralizes production, and aligns infrastructure with state direction. The American model distributes capability, leverages allied networks, and dominates enabling software platforms. In both countries, quantum activity is overwhelmingly clustered, which is a hallmark of tight integration and efficiency: 99% of commercialization-focused funding in China and 98% in the United States is co-located with established quantum hubs.[36] Yet the geography of each country's quantum ecosystems is a product of two distinct industrial systems operating by different rules. As quantum transitions from experimental science to industrial infrastructure, these structural differences may prove as consequential as the innovations themselves.

The United States has mature cleanroom infrastructure, but China is cutting the costs of production.

Quantum hardware manufacturing depends on high-grade cleanrooms—facilities engineered to eliminate microscopic contaminants across a wide range of R&D and manufacturing applications, such as semiconductor fabrication and pharmaceutical production. The cleanrooms required to build quantum products, needed everywhere from academic research to industry manufacturing, are crucial for limiting disruption to fragile devices and thus have tighter requirements than most, placing them in a higher-end category. The United States has a head start compared to China in terms of total cleanroom infrastructure, possessing a mature cleanroom construction industry, with an annual market size of roughly $2 billion and decades of technical experience.[37] Specifically, high-quality American-made cleanrooms typically cost between $800 and $1,000 per square foot, while lower-grade facilities range from $300 to $400 per square foot.[38]

China's cleanroom market is smaller, approximately $900 million, and historically dominated by lower-grade industrial facilities unsuitable for quantum applications.[39] Now, this dynamic is

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[36] Fredrik Erixon, et al., Quantum Clusters: Ranking the World's Deep-Tech Epicentres, European Centre for International Political Economy (2025)
[37] Cleanroom Construction News and Industry Updates 2025, ACH Engineering Inc. (2025).
[38] Jason Peng, Modular Cleanroom Cost Per Square Foot: Complete 2026 Guide, Deiiang Company (2025); Prefabricated Cleanroom Cost Per Square Foot: Real Budget Data by ISO Class & Industry, Qualia (2025); The Global Construction Newsletter Q1 2023, Compass International Inc. (2025).
[39] China Cleanroom Technology Market Size & Outlook, 2025-2030, Grand View Horizon (2025); Analysis of the Industry Chain Map, Development Status and Future Trends of China's Cleanroom Engineering Industry in 2024, Hejie Electronic Purification Engineering Company (last accessed 2026).

changing, partially due to growing industrial capability to produce the requisite high-tech equipment.[40] In 2025, high-quality cleanroom construction in China cost approximately $150 per square foot, representing a 12% decline since 2022, with airborne molecular contamination control systems falling in cost by more than 40% due to supply-chain localization.[41] The cost for a lower-grade cleanroom is considerably less, reaching as low as $50 per square foot.[42] Regional governments, particularly in the Yangtze River Delta, offer subsidies of up to 30% of construction costs, underscoring state prioritization.[43] In absolute terms, American cleanroom-building firms remain more established and technically experienced. In terms of cost, China is building advanced fabrication capacity at a fraction of U.S. construction costs as a result of onshoring critical components and economies of scale, compressing the capital barrier to scaling quantum hardware manufacturing.

For now, some supply chain chokepoints favor the United States.

Industrial capacity ultimately depends on secure access to strategic inputs, and the structure of quantum supply chains reveals significant imbalances in each country's resilience. Since quantum technology includes many different technical approaches and applications, there is no single quantum supply chain. Instead, there are several, each with distinct, and at times overlapping, critical nodes. As a result, definitively assessing supply chain risks can be difficult while the underlying technologies and manufacturing pathways remain in flux.[44] Highlighted below is a selected subset of inputs that are relevant to the development of prominent quantum computing modalities.[45]

- **Helium-3**
  Helium-3, a critical input for the dilution refrigerators that cool superconducting quantum processors to operational temperatures, is scarce, reliant on nuclear power agreements, and subject to government allocation regimes.[46] When securing a helium-3 supply chain, the United States retains three structural advantages: domestic production capacity, federal allocation authority and price controls for critical uses, and diversified sourcing through allied suppliers.

[40] 2021 China Clean Room Engineering Industry Overview, Lead Leo (last accessed 2026).
[41] The Ultimate Guide to Cleanroom Classification and Cost! Price Per Square Meter Revealed,Hanheng Environment (2025).
[42] How to Make a Preliminary Estimate for a Cleanroom, Kangjing Construction (2025); Analysis of the Construction Cost of the Thousand-Level Electronic Semiconductor Purification Workshop: How Much Per Square Meter?, TianLan Architecture (2025).
[43] Budget Planning Guide for the Construction of a Class 100 Chip Cleanroom, Hejie Technology Electronic Purification Engineering (2025).
[44] Chris Miller, The Quantum Supply Chain, Chris Miller's Newsletter (2025).
[45] See the Market Ecosystem section of this report for further discussion of how superconducting is the most prominent quantum computing modality being deployed today.
[46] Sarah Newbury, Evaluation of Earth's Helium Supply, Princeton Plasma Physics Lab (2012).

It benefits from partial domestic production through the Department of Energy's Isotope Program which collects helium-3 as a byproduct of the nuclear weapons maintenance process at Savannah River Site.[47] A single entity is contracted as the primary commercial processor, which, through a single New Jersey facility, distributes this supply domestically under federal oversight at price caps set by the U.S. government for national-interest applications.[48] In 2025, preferential federal pricing has been reported to be as low as about $1,000 per liter, while broader commercial market prices cluster around $2,500 per liter.[49]

As demand exceeds domestic supply, the United States remains an importer.[50] In 2024, over half of its roughly $22 million in helium-3 imports came from Canada, with France a close second supplier. A typical route may involve sourcing helium-3 from Canada and processing it in France before global distribution. Commercial resale pricing can vary significantly depending on logistics and packaging: small-volume deliveries may reach $6,000–$7,000 per liter due to fixed handling, transport, and tariff overhead, whereas bulk purchases can reduce effective per-liter cost closer to $3,000. Russia—once a supplier—has largely exited Western markets, contributing to volatility.[51]

China's position is more constrained. Nearly all of its helium-3 supply is imported, historically from Russia and, to a much lesser extent, France.[52] A 2023 procurement notice from the Beijing Academy for Quantum Information Science explicitly stated that only the United States and Russia produce helium-3 at scale, and that U.S. export restrictions left Russia as China's sole viable supplier at the time.[53] Pricing for helium-3

[47] Supply and Demand of Helium-3 (He-3), National Isotope Development Center (last accessed 2026).
[48] Managing Critical Isotopes Weaknesses in DOE's Management of Helium-3 Delayed the Federal Response to a Critical Supply Shortage, United States Government Accountability Office (2011).
[49] N66001-24-Q-6328 - Notice of Intent to Award Sole Source Order to LINDE GAS & EQUIPMENT INC, HigherGov (2025); Edelgas Publishes Comprehensive Market Report on Helium-3: Unveiling Key Insights into a Rare and Vital Isotope, Edelgas Group (2024); Pulsar Helium Announces Helium-3 Discovery at Jetstream #1, Topaz Project, Minnesota, Yahoo Finance (2025).
[50] Helium-3, Observatory of Economic Complexity (2024).
[51] SCSP conversation with private quantum supplier. See also Helium-3 (HS: 284540) Product Trade, Exporters and Importers, The Observatory of Economic Complexity (OEC) (last accessed 2026); Jakub Niechcial, et al., Operational Costs of He3 Separation Using the Superfluidity of He4, Energies (2020); Matt Swayne, Bluefors Enters Deal to Secure Lunar Helium-3 Supply From Interlune, Quantum Insider (2025); Helium-3 and Quantum Computing: Necessity, Supply and Scaling, Magna Petra (last accessed 2026); Russia Imposes Temporary Export Controls on Helium, Reuters (2026); Lawrence Haynes, 2026 Helium Shortage: Why Recovery Will Take Years, Not Weeks, WestAir (2026); Mineral Commodity Summaries 2026 - Helium and Rare Gases, U.S. Geological Survey (2026).
[52] U.S. helium-3 imports from Russia and France equal $14.9M and $273,000 out of $15.2M total imports in 2025, respectively. See Helium-3, Observatory of Economic Complexity (2024).
[53] 北京量子信息科学研究院氦3气体单一来源采购公示 [Beijing Academy of Quantum Information Sciences Helium 3 Gas Single-Source Procurement Announcement], China Government Procurement Network, Chinese Ministry of Finance (2023).

within China reflects this dependence. Institutional procurements between 2023 and 2024 show Chinese buyers paying approximately $3,200–$3,400 per liter, consistently above typical U.S. commercial averages and well above U.S. federally capped rates.[54] China's constraints are so high that they motivate, in part, the country's space program towards mining helium-3 on the Moon.[55] Helium-3 is a strategic chokepoint for quantum computing at scale, as dilution refrigerators are foundational infrastructure. Today, this chokepoint favors the United States.

- **Dilution Refrigerators**
  The dilution refrigerator market itself tilts towards the United States thanks to a small number of specialized manufacturers.[56] A Finnish dilution refrigeration company with major manufacturing facilities in New York is seen as an industry leader. It anchors a trio of industry incumbents—the other two being British and American, respectively—all of which are U.S.-aligned entities. The Finnish group has shipped over 1,500 systems worldwide and dramatically expanded its production footprint in 2024. Lead times typically range from six to nine months, as production relies on key facilities and processes that can't be quickly expanded. Many innovative emerging players are also American, suggesting that growth opportunities in the market also favor the United States.

  The enabling technology for modern dilution refrigerators is the pulse-tube cryocooler, which allows quantum systems to operate continuously. This supply chain favors the United States and its allies. Market reports describe a concentrated industry in which the top five pulse-tube cryocooler manufacturers—in Japan, the United States, Europe, and Germany—hold more than 60 percent of global share.[57] China has capable emerging firms, and Chinese suppliers are building domestic alternatives for cryogenic equipment, which industry sources describe as a late-developing domestic-substitution effort following foreign restrictions and import constraints.[58]

  The U.S. dilution refrigerator market has grown from roughly $49 million in 2021 to nearly $66 million in 2025, with projections exceeding $119 million by 2033. China's

[54] 氦3气体采购项目 [Helium-3 Gas Procurement Project], Bidding Center of SUSTech Asset Management (2024). In China, retail market listings for helium-3 in early 2026 range from $3,200 to $4,300 per liter. *See*, e.g., 氦-3 [Helium-3], ChemicalBook (last accessed 2026).
[55] Zang Chunlei & Yu Sinan, China Makes Huge Progress in Studies of Lunar Samples, People's Daily Online (2024).
[56] Prineha Narang & Joshua Levine, The Supply Chain Chokepoints in Quantum, War on the Rocks (2025).
[57] Global Pulse-tube Cryocoolers Market 2025 by Manufacturers, Regions, Type and Application, Forecast to 203, Global Info Research (2025).
[58] 脉冲管制冷机（PTR）应用价值高 近二十年我国市场变化大 [Pulse Tube Refrigerators (PTR) Have High Application Value, the Chinese Market Has Undergone Significant Changes in the Past Two Decades], Newsijie (2025).

market, smaller but faster growing, expanded from $12 million to nearly $19 million over the same period and is projected to surpass $43 million by 2033.[59] China only began delivering domestically produced industrial-grade dilution refrigerators in 2024, including a system for the Yangtze River Delta Quantum Center.[60] Unlike in the West, where specialized cryogenic firms thrive independently, many Chinese quantum companies are developing their own cryogenic capabilities.[61] This shift has been driven both by tighter U.S. export controls introduced in 2023 and by China's broader long-term push for technological self-reliance.[62] As a result, Chinese quantum-focused companies are getting more involved in the supply chain and finding ways to enter the market despite starting later than the established Western players.

- **Lasers**
  Lasers are important inputs for several quantum platforms, including parts of quantum sensing, quantum networking, precision timing, and some forms of quantum computing. Trade output is one way to compare U.S. and Chinese capabilities in this space. Tracking trade proxies for "lasers other than laser diodes," while broader than quantum-grade lasers, captures many high-value scientific and industrial laser sources.[63] In 2024, the United States exported roughly $1.36 billion in this category across about 326,000 items, implying an average export value above $4,000 per unit. China exported roughly $672 million in the same category; using China-reported volume of 15.7 million units, this implies an average export value below $50 per unit.[64] China's direct trade with the United States reinforces the imbalance: it imported roughly $276 million of these lasers from the United States across only about 29,000 items, while exporting roughly $112 million to the United States across about 4.3 million items.[65] The strategic takeaway is clear: the United States remains stronger in high-value laser sources and systems, while China is stronger in volume-oriented laser production.

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[59] Dilution Refrigerators Market Analysis 2026, Cognitive Market Research (2026).
[60] 中国电科16所：让超导量子计算用上"国产大冰箱" [China Electronics Technology Group Corporation (CETC) 16th Research Institute: Enabling Superconducting Quantum Computing to Utilize "Domestically Produced Large Refrigerators"], State Administration of Science, Technology and Industry for National Defense (2024).
[61] Matt Swayne, Reports: China Mass Producing Dilution Refrigerator Critical To Superconducting Quantum Computing, Quantum Insider (2025).
[62] Taking a Look at China's Quantum Ecosystem, Special Competitive Studies Project (2026).
[63] United States Lasers, Other than Laser Diodes Exports by Country in 2024, World Integrated Trade Solution (last accessed 2026).
[64] 海关统计数据在线查询平台 [Customs Statistics Online Query Platform], General Administration of Customs of the People's Republic of China (last accessed 2026).
[65] 90132000-激光器，激光二极管除外 [90132000 - Lasers, Excluding Laser Diodes], Import and Export Information (last accessed 2026).

The quantum-relevant laser market looks even more favorable to the United States and allied suppliers. The most important products are not broad industrial cutting lasers, but highly stable and precisely controlled light sources used in advanced research and specialized quantum systems. Market research places the tunable diode-laser market at roughly $100 million today, with leadership concentrated among U.S., German, and Japanese firms, followed by a small number of emerging Chinese suppliers.[66] Pulsed fiber-laser markets are larger, with recent estimates clustering around roughly $1 billion.[67] Titanium-sapphire lasers, another high-end source, show a similar geography: one market analysis estimates the global market at about $1.8 billion in 2025 and identifies four leading suppliers—two American, one French, and one British—that collectively account for roughly 61 percent of revenues.[68] These are overwhelmingly U.S. and allied firms.

This points to a split laser supply chain. China has built major industrial scale in commercial laser equipment and lower-cost laser production, but the Western ecosystem remains deeper in specialized photonics inputs for frontier quantum systems. The Western and allied quantum photonics supply chain has been described as strong and resilient: geographically, the United States stands out as a major photonics hub, with over 150 optics and photonics suppliers; Germany's Berlin region is a dense European node; and Japan and South Korea are leading Asian photonics players.[69] China is present, with tens of suppliers, but it is not yet the leading Asian photonics ecosystem for quantum-relevant components. For policymakers, the takeaway is straightforward: China's strength is scale; the United States and its allies retain the advantage in the specialized, high-performance laser stack that quantum systems depend on.

- **Radio Frequency Wiring**
  Superconducting radio frequency (RF) wiring is a crucial communication backbone for some quantum technologies. As demand grows and quantum technology matures, the RF wiring supply chain is becoming more resilient. Before 2022, the United States' inventory was fragile, relying on a narrow set of foreign manufacturers in Japan, the

[66] Global Tunable External Cavity Diode Laser Market Research Report 2025, QY Research (2025); 2025年可调谐外腔半导体激光器(ECDL)市场占有率&行业规模分析报告 [2025 Market Share & Industry Size Analysis Report for Tunable External Cavity Semiconductor Lasers (ECDL)], QY Research Information Consulting (2025).
[67] Mode-Locked Fiber Lasers Market Size, Share, Forecast 2032, Market Intelligence (2025); Mode Locked Lasers Market, Dataintelo (2026).
[68] Ti Sapphire Laser Market, Dataintelo (2026).
[69] Doug Finke, Watching Over the Quantum Technology Supply Chain, Laser Focus World (2024).

United Kingdom, and the Netherlands, alongside limited sourcing from Chinese brands. Disruptions in these channels risked bottlenecks for U.S. quantum hardware programs.[70]

By 2025, that landscape has shifted materially. At least three manufacturers have emerged as U.S.-based suppliers in response to rising demand from quantum computing firms.[71] Major multinational component providers in Europe have also expanded product lines explicitly tailored to cryogenic and quantum environments, and incumbent suppliers in Japan have deepened participation.

China fields capable RF suppliers as well, often competing with the United States on cost and production scale, reflecting China's systemic strengths in industrial manufacturing.[72] However, the United States retains a qualitative edge in high-performance RF components critical for leading-edge quantum systems, resting on significant capital infusion into domestic specialty manufacturers and unrestricted access to top-tier allied suppliers.

The United States also dominates software and cloud.

Software ecosystems determine who controls the architecture of quantum development. In this layer of the stack—programming languages, simulation tools, developer communities, and cloud access—the asymmetry is stark. Global survey data from quantum technologists primarily in Western countries and India shows overwhelming reliance on U.S.-affiliated software platforms.[73] IBM's Qiskit, Google's Cirq, and Xanadu's PennyLane dominate research workflows.[74] Cloud tools frequently accessed by developers include IBM Quantum, Amazon Braket, Microsoft Azure Quantum, Xanadu, qBraid, and D-Wave—all Western platforms.

Adoption metrics reinforce this dominance. Looking at the open-sourced quantum software ecosystem, U.S. quantum software tools are much more widely followed than Chinese tools. On GitHub, a cloud-based software repository, U.S. quantum software tools have ten times more followers than Chinese ones. Even counting China's Gitee site, which is China's GitHub

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[70] Maybell Quantum Industries, Inc., Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) (last accessed 2026).
[71] The manufacturers are located in Colorado, Connecticut, and Montana, respectively. *See* Wiring Solutions, Maybell Quantum (last accessed 2026); .086 Coaxial Cable – 50 Ω Semi-Rigid NbTi – Low-Loss, Superconducting, Ez Form Cable, Trexon (last accessed 2026); Cryogenic Cable Options, Quantum Coax (last accessed 2026).
[72] The RF wiring suppliers are located in Shaanxi Province, Guangdong Province, and Jiangsu Province, respectively. See 低温超导量子传输 [Low-Temperature Superconducting Quantum Transport], Forstar (Xi'an Fujida Cable Co., Ltd.) (last accessed 2026); Cryogenic Cables & Assemblies, Vinstronics (last accessed 2026); 量子计算低温器件 [Quantum Computing Cryogenic Devices], Talent Microwave (Suzhou Tailai Microwave Technology Co., Ltd.) (last accessed 2026).
[73] 2025 Quantum Open Source Survey, Unitary Foundation (2025).
[74] Xanadu is Canadian. *See* Xanadu, Xanadu (last accessed 2026).

equivalent, U.S.-developed tools still lead by about two-to-one.[75] The download data tells a similar story. Between August 2025 and February 2026, the top two U.S. quantum code packages had roughly 200 times more downloads than the most-used Chinese package.[76] In December 2025 alone, downloads of Qiskit, a software development kit for quantum computing, exceeded 450,000, compared to just over 4,000 for PyQPanda, China's comparable software development kit.[77] Together, these metrics show that U.S. quantum software enjoys both far greater community interest and active adoption worldwide.

China's domestic alternatives are real but narrower in scope. Origin Quantum has developed products described as China's first domestically produced quantum operating system, yet these platforms remain largely tied to specific hardware providers and lack the cross-platform universality of their American counterparts.[78]

Chinese reporting has acknowledged a key weakness in the country's quantum ecosystem: dependence on foreign software platforms. IBM's integrated stack— spanning chips, Qiskit, and cloud access—has attracted an outsized share of global developer activity, while Chinese firms lag in toolchains, developer scale, and cross-platform compatibility.[79] That reliance became clear in 2022, when IBM blocked Chinese researchers' access to its quantum cloud services due to national security concerns.[80] The broader advantage extends into the classical infrastructure underpinning quantum R&D, with roughly three-quarters of quantum processor operators reporting using Nvidia's CUDA-Q in research and hardware workflows, reinforcing U.S.-aligned dominance across critical ecosystem layers.[81]

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[75] Gitee is China's GitHub equivalent. See Rita Liao, China is Building a GitHub Alternative Called Gitee, TechCrunch (2020).
[76] SCSP analysis using pypistats package. See Pypistats, Python Software Foundation (last accessed 2026).
[77] SCSP analysis performed using pepy.tech. See Pepy.tech, Pepy.tech (last accessed 2026).
[78] Origin Pilot: China's First Quantum Computer Operating System Now Available for Download, Origin Quantum (2026).
[79] Quantum Computing Breakthrough Roadmap, Xinhua (2026).
[80] IBM Quantum Cloud prohibits Chinese IP access. Where can quantum computers still be used?, SECRSS (2022).
[81] NVIDIA CUDA-Q, Nvidia (last accessed 2026).

Software ecosystems create lock-in effects. Programming languages, APIs, developer documentation, and cloud integrations shape how researchers design experiments, benchmark hardware, and train new engineers. Once a global developer base standardizes certain toolchains, they gain influence and create a higher cost to replace. China is accelerating efforts to onshore its software stack, particularly after access restrictions highlighted its vulnerability. But at present, the United States and its allies control the dominant programming environments, simulation frameworks, and cloud architectures that define day-to-day quantum development worldwide.

In hardware, the competition is close. In software and cloud control, the divide remains wide and self-reinforcing.

Market Ecosystem: China is Catching Up to the U.S. Private Sector

Leader: United States	***Trending Towards: Contested***

Decades of sustained scientific innovation and investment into industrial capacity across quantum hardware, software, and enabling technologies are now translating into tangible market activity in both countries. Throughout 2025, quantum technologies have moved beyond laboratory settings into early-stage commercialization, as evidenced by partnerships with cloud-based service platforms, telecom fiber deployments, and healthcare equipment contracts. Cloud-based quantum computing platforms have helped lower the barrier to entry for academic research by providing remote access to quantum hardware, development tools, and simulators without the need for costly, specialized equipment. Expanded access, sustained investment, and technological breakthroughs have catalyzed quantum market growth, driven primarily by rising commercial interest in quantum computing and sensing. As a result, the global quantum technologies market reached $1.9 billion at the end of 2025, and the projected market value is estimated to grow up to $97 billion by 2035.[82]

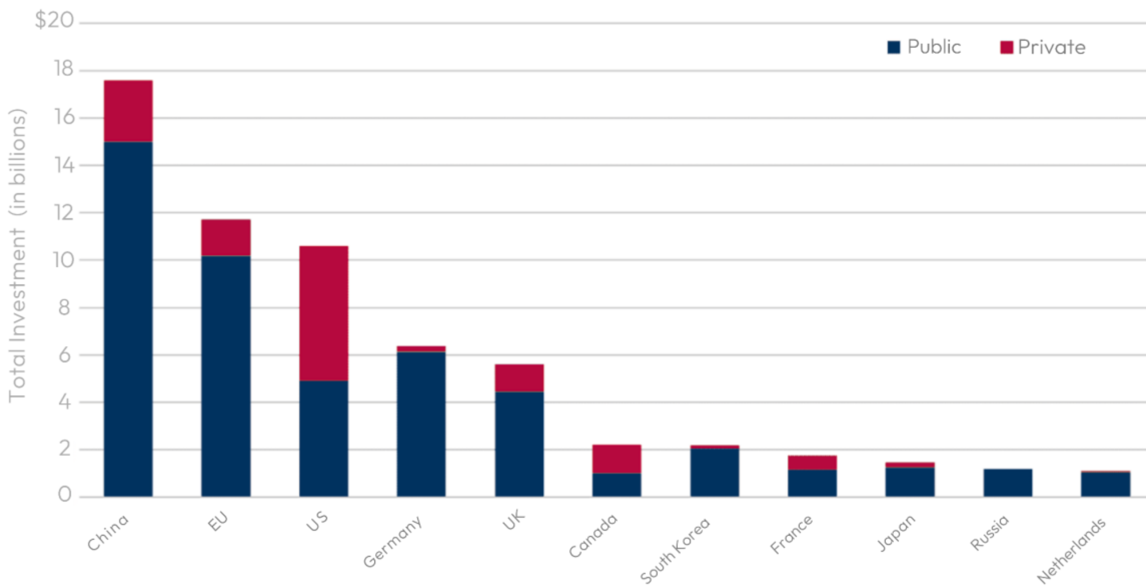
Total investment skews towards China.

Both public and private investment in quantum technologies has accelerated in recent years as technical progress has underscored the field's long-term strategic and commercial value. In the United States, the commercial ecosystem is driven predominantly by private capital, with private sector investment totaling approximately $5.3 billion in announced funding as of 2024.[83] China's state-led model, by contrast, leaves comparatively limited space for independent private investment, with private funding totaling roughly $2.5 billion over the same period.[84] This divergence is further evident when viewing market valuations, where the combined $7.18 billion valuation of the top 10 quantum computing companies in China amounts to just 17% of the market capitalization of the top 5 publicly traded pure-play quantum companies in the United States.[85]

[82] State of the Global Quantum Industry, QED-C at 1 (2026); Henning Soller, et al., The Year of Quantum: From concept to reality in 2025, McKinsey & Company (2025).
[83] Fredrik Erixon, et al., Benchmarking Quantum Technology Performance: Governments, Industry, Academia and their Role in Shaping our Technological Future, European Centre for International Political Economy (2025).
[84] Fredrik Erixon, et al., Benchmarking Quantum Technology Performance: Governments, Industry, Academia and their Role in Shaping our Technological Future, European Centre for International Political Economy (2025).
[85] Looking at China's quantum computing from the top 10 valuations: When academicians, professors, and returnee scientists start companies, European Central Station (2026).

On the public side, China has committed substantial state resources to quantum development, with approximately $15 billion in total reported government funding as of 2024.[86] In the United States, the federal government has emerged as a buyer of quantum technologies: procurement data through FY2025 show the government purchasing approximately $77.6 million in quantum computing, sensing, and networking solutions, reflecting active demand for deployable quantum capabilities across federal agencies.[87] For example, the U.S. Department of Commerce recently announced a $2 billion in equity stakes across nine U.S. quantum computing companies.[88] Not accounting for this new commitment, total public and private funding estimates indicate that the United States has invested approximately $10.2 billion into quantum technologies. However, China leads with nearly $18 billion—though the composition of that investment and the market structures it produces differ substantially between the two.[89]

Total Announced Public and Private Investment in Quantum, up to 2024 (in billions USD)



Source: Fredrik Erixon, et al., Benchmarking Quantum Technology Performance: Governments, Industry, Academia and their Role in Shaping our Technological Future, European Centre For International Political Economy (2025).

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[86] Hodan Omaar & Martin Makaryan, How Innovative Is China in Quantum?, Information Technology Innovation Foundation (2024).
[87] Quantum Computing Contracts (Total Funding in FY 2025), USA Spending (last accessed 2026); Quantum Sensing Contracts (Total Funding in FY 2025), USA Spending (last accessed 2026); Quantum Networking Contracts (Total Funding in FY 2025), USA Spending (last accessed 2026).
[88] Department of Commerce announces Letters of Intent With 9 Companies for $2 Billion to Accelerate U.S. Leadership in Quantum Computing, National Institute of Standards and Technology (2026).
[89] Fredrik Erixon, et al., Benchmarking Quantum Technology Performance: Governments, Industry, Academia and their Role in Shaping our Technological Future, European Centre for International Political Economy (2025).

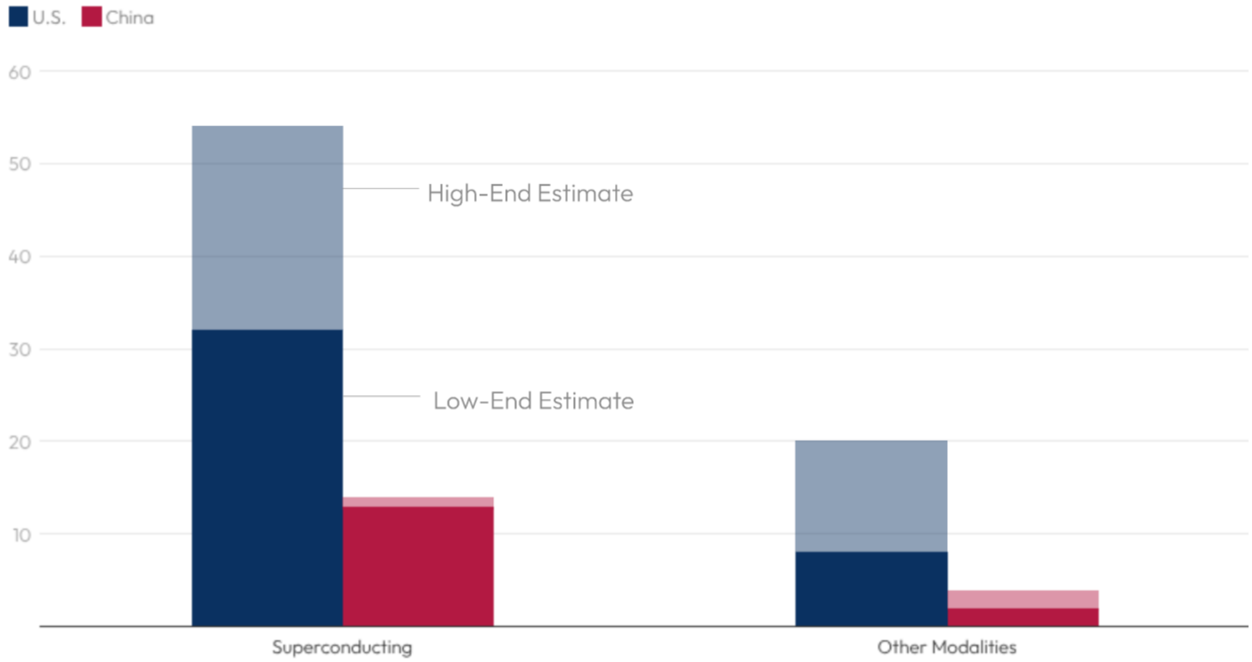
U.S. private capital drives the market as China absorbs financial risks for technology deployment.

Despite its potential across defense, finance, and pharmaceutical applications—with projections suggesting a contribution of $200 to $500 billion in value to the life sciences industry by 2035—quantum platforms' current readiness levels remain uneven across computing, networking, and sensing.[90] The uneven maturity of quantum technologies constrains near-term commercialization by misaligning layers of the technology stack, especially where computing and networking lag behind sensing, complicating the development of commercially viable end-to-end solutions and reinforcing reliance on government support and cloud-based intermediaries. In China, this dynamic can be seen in the state's role as a primary absorber of early market risk, including the acquisition of quantum computing assets from private firms such as Alibaba and Baidu by state-affiliated institutions—underscoring the government's function as both principal investor and end user during early stages of technological maturity.[91]

Nonetheless, practical quantum systems were deployed across both countries throughout 2025, providing early access to users in industry, government, and academia. Estimates suggest between 39 and 73 quantum computers have been deployed by U.S. entities, compared to approximately 15 to 18 in China.[92] The Chinese total may be understated. Heightened technology competition and export-control pressures have coincided with reduced visibility into parts of China's advanced technology ecosystem, particularly, the country's high performance computing industry, making it difficult to determine the full extent of China's quantum computer deployments from public sources.[93] While these deployments remain modest relative to long-term ambitions, they reflect meaningful transitions from experimental research toward early operational use.

[90] Henning Soller & Michael Bogobowicz, The quantum revolution in pharma: Faster, smarter, and more precise, McKinsey and Company (2025).
[91] Edd Gent, Alibaba and Baidu Cash Out on Quantum Computing Stakes But Tencent and Beijing Double Down, IEEE Spectrum (2024).
[92] How Many Quantum Computers Are There in the World? Estimates Suggest Over 100 in 2025, Quantum Zeitgeist (2025); Brian N. Siegelwax, China's Mightiest Quantum Computers, Quantum Dragon (2025).
[93] Stu Woo, China Is Getting Secretive About Its Supercomputers ,The Wall Street Journal (2024); Agam Shah, China's HPC Iron Curtain Creating a Top500 Problem, HPC Wire (2023).

Estimated Deployed Quantum Computers by U.S. and Chinese Entities by Modality



Sources: How Many Quantum Computers Are There in the World? Estimates Suggest Over 100 in 2025, Quantum Zeitgeist (2025); Brian N. Siegelwax, China's Mightiest Quantum Computers, Quantum Dragon (2025).

In quantum sensing, there is a clear divergence in who drives the market. The United States leads with substantial private sector backing—approximately $309 million invested across three major fundraising rounds in 2024.[94] By contrast, China's quantum sensing ecosystem, while rapidly expanding, saw four fundraising rounds totaling roughly $38 million over the same period, pointing to an ecosystem with more limited private investment and a stronger reliance on government-linked players such as CIQTEK rather than independent commercial dynamics.[95]

In quantum networking, the divergence is even more pronounced, with China holding a decisive operational and market lead. China's leadership in quantum networking is creating a rapidly emerging domestic market for quantum networking services. This is evidenced through the QKD trunk line connecting Beijing, Jinan, Hefei, and Shanghai, China's continued quantum communication space efforts, and China Telecom's integration of the trunk line with its national fiber infrastructure which positions the operator as a gateway for commercial adoption.[96]

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[94] 2025 Global Quantum Sensing Industry Development Outlook, ICV TAnK (2025).
[95] 2025 Global Quantum Sensing Industry Development Outlook, ICV TAnK (2025).
[96] Yang Li, et al. Microsatellite-Based Real-Time Quantum Key Distribution, Nature (2025); Elizabeth Gabney, Mini-Satellite Paves the Way for Quantum Messaging Anywhere on Earth, Nature News (2025); China opens 2,000-km quantum communication line, The State Council Information Office People's

Together, these investments establish a scalable platform for quantum networking services, signaling clear opportunities for domestic market growth, cross-industry adoption, and potential international partnerships in the quantum networking sector.

By contrast, large-scale commercial quantum networking deployment in the United States remains limited, reflecting early-stage market demand due to scalability and infrastructure challenges and a more decentralized approach to national-level coordination and deployment. As a result, quantum network deployments in the United States remain confined to regional testbeds, pilot programs, experimental research networks, and early- to mid-stage ventures rather than national-scale commercial deployments.

Republic of China (last accessed 2026); Taking a Look at China's Quantum Ecosystem, Special Competitive Studies Project (2026); Yang Li, et al. Microsatellite-Based Real-Time Quantum Key Distribution, Nature (2025); Elizabeth Gabney, Mini-Satellite Paves the Way for Quantum Messaging Anywhere on Earth, Nature News (2025).

Talent Pipeline: While the United States Leads, Long-Term Advantage is Uncertain

Leader: United States	***Trending Towards: Contested***

As quantum technologies continue to mature beyond laboratory demonstrations, the ability to mobilize multidisciplinary talent at scale may prove more consequential than excellence in fundamental research alone. While the United States maintains advantages in training elite researchers within a diverse ecosystem, China has built more integrated mechanisms for channeling talent toward state-prioritized applications.

America's expansive university system differs from China's centralized talent pipeline.

At the frontier of quantum science, the United States retains an advantage in the breadth of its university programs. American universities were the first in the world to offer undergraduate degrees in quantum sciences in 2015.[97] Today, 61 institutions offer quantum information science and engineering programs, supported by more than 500 dedicated quantum courses and over 8,000 courses mentioning quantum topics across physics, engineering, chemistry, and computer science programs.[98] The United States is one of a few countries that offer explicit "quantum" master's programs, accounting for roughly 13% of such programs worldwide.[99] This expansive academic ecosystem is reinforced through federal investments—the National Quantum Initiative Act (NQIA) of 2018 and the CHIPS and Science Act—that connect basic research, National Laboratories, and workforce development into coordinated frameworks.[100]

The U.S. system's openness to international talent amplifies these advantages. U.S. postsecondary institutions award roughly half of physics PhDs to non–U.S. citizens, and Chinese nationals alone account for nearly 30 percent of those degrees, positioning the United States as a principal training ground for quantum scientists globally.[101]

China's advantage, by contrast, lies in scale. Since 2020, China has awarded over 50% more STEM PhDs annually than the United States in absolute terms. And, since 2000, China's STEM PhD output has grown three times faster than America's.[102] China only began offering

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[97] Greg Austin, Quantum Sensing: Comparing the United States and China, The International Institute for Strategic Studies at 16 (2024).
[98] A.R. Piña, et al., Landscape of Quantum Information Science and Engineering Education: From Physics Foundations to Interdisciplinary Frontiers, Physical Review Physics Education Research (2025).
[99] Quantum Index Report 2025, Massachusetts Institute of Technology at 73 (2025).
[100] Public Law 117-167, CHIPS and Science Act (2022); Public Law 115-368, National Quantum Initiative Act (2018); Quantum Index Report 2025, Massachusetts Institute of Technology (2025).
[101] Patrick Mulvey, et al., International Students in U.S. Physics and Astronomy Graduate Programs: Trends, Visa Risks, and Degree Outcomes, American Institute of Physics (2025).
[102] Trelysa Long, America's Innovation Future Is at Risk Without STEM Growth, Information Technology & Innovation Foundation (2025).

undergraduate degrees in QIS in 2021—six years after the United States—at institutions including the University of Science and Technology of China (USTC) and Tsinghua University.[103] Most importantly, China has achieved notable success in educating quantum talent: a higher proportion of quantum researchers complete their final degrees domestically after studying abroad than scientific researchers in other disciplines.[104] While none of these dynamics necessarily speak to research *quality*, they do suggest China is training a broad STEM talent base that can be drawn upon to form a future quantum workforce that requires scientific expertise in areas like physics or mathematics.[105]

Both nations are making efforts to upskill and train a quantum workforce.

The growth of the quantum industry has drawn attention to its workforce. Currently, approximately 58 percent of founders of quantum companies worldwide hold doctorates.[106] However, as quantum technologies advance toward real-world applications, workforce needs will expand beyond research talent to include the engineers, software developers, technicians, systems integrators, and business professionals needed to build, deploy, and maintain commercial products.[107] Globally, only about 16,500 professionals work in "pure-play" quantum roles, while as many as 200,000 work in positions in quantum-related fields like traditional software development—underscoring the wide base of the QISET workforce.[108]

The United States could be positioned to meet these future needs, as it has cultivated a diverse quantum ecosystem spanning universities, startups, National Laboratories, and established technology firms. U.S. job postings requiring quantum skills have nearly tripled as a share of total postings since 2011, reflecting growing workforce demands.[109] Growth in U.S. undergraduate enrollment in fields such as computer engineering provides a complementary talent base for quantum software and hybrid computing applications.[110] This decentralized structure encourages professionals to pursue diverse technological pathways but disperses

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[103] Greg Austin, Quantum Sensing: Comparing the United States and China, The International Institute for Strategic Studies at 16–17 (2024).
[104] Jeroen Groenewegen-Lau & Antonia Hmaidi, Where China Stands in the Global Race for Talent, MERICS at 12 (2024).
[105] See the "Innovation Leadership" section of this report for the assessment of research quality.
[106] Mapping the Global Quantum Ecosystem, OECD at 77 (2025).
[107] Connecting The Dots: Quantum Learning Through Experiential Activities and Practice, QED-C (2025); Salil Gunashekar & Teodora Chis, Navigating Skills and Talent Development for Quantum Technology: Current Insights and Future Horizons, RAND Europe (2025).
[108] "Pure-play" refers to companies that focus solely on quantum technology. See State of the Global Quantum Industry 2026, QED-C (2026); State of the Global Quantum Industry 2025, QED-C (2025).
[109] Quantum Index Report 2025, Massachusetts Institute of Technology at 67 (2025).
[110] Quantum Index Report 2025, Massachusetts Institute of Technology at 75 (2025); Computing Research News, Computing Research Association (2025); CERP Pulse Survey: A Snapshot of 2025 Undergraduate Computing Enrollment Patterns, Computing Research Association (2025).

expertise across competing institutions in ways that may impede coordinated workforce development toward specific deployment goals.

China has engineered a more vertically integrated talent pathway from research to deployment. Government-directed industrial hubs co-locate universities, national labs, and startups to create shared infrastructure and talent pools aligned with strategic objectives, enabling rapid mobilization toward targeted applications.[111] Expertise has become even more consolidated as major Chinese tech firms scale back internal quantum efforts to focus on AI and transfer labs, equipment, and personnel into government-backed institutes.[112]

However, China's quantum researchers remain mostly concentrated at universities, and it may struggle to grow its workforce across its quantum ecosystem. For example, in 2023, one Chinese official remarked that the country as a whole had approximately 1,000 quantum computing experts, while noting that IBM alone employed 2,000.[113] While China has deliberately built institutional capacity designed to absorb talent and scale applications, a concentration in a limited number of elite institutions may constrain the development of a diverse workforce needed to address multiple application domains simultaneously.

Both countries, as a result, still face a persistent problem in growing quantum skills, and therefore, have to overcome the challenge of building a comprehensive quantum workforce capable of sustainably supporting long-term technological leadership.[114]

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[111] Hodan Omaar & Martin Makaryan, How Innovative Is China in Quantum?, Information Technology & Innovation Foundation (2024).
[112] Sujai Shivakumar, et al., Quick Take: Quantum Technology Global Competition, Center for Strategic & International Studies (2025); Baidu to Donate Quantum Computing Lab, Equipment to Beijing Institute, Reuters (2024).
[113] Jeroen Groenewegen-Lau & Antonia Hmaidi, Where China Stands in the Global Race for Talent, MERICS at 12 (2024).

[114] Salil Gunashekar & Teodora Chis, Navigating Skills and Talent Development for Quantum Technology: Current Insights and Future Horizons, RAND Europe (2025).

National Leverage: China's Strength is its Government Support for QISET

Leader: China	*Trending Towards: China*

China leads in setting policies and taking actions that can accelerate progress in the field, protect its advantages, and use quantum for geopolitical gain. Centralized planning, sustained state direction, and a multi-decade strategic horizon have enabled China to act on quantum priorities in ways the decentralized U.S. model has not matched. The United States has developed a competitive strategy, but currently lacks the unified national approach that China is successfully implementing. Without a renewed commitment to long-term federal coordination, the United States risks ceding durable influence in quantum technologies to a country whose strategic planning operates on multi-decade time horizons.

China's model turns objectives into action.

China's advantage in national quantum leverage flows from its ability to make strategic, top-down plans anchored in clearly defined national objectives. Beijing views quantum technologies as instruments of political power: securing communications against foreign surveillance, achieving technological self-reliance, and positioning China as the global leader in next-generation technologies.[115] Since 1997, quantum technologies have been mentioned in successive Five-Year Plans, national medium- and long-term science strategies, and major state megaprojects. These plans articulate the state's intended objectives.[116]

This model enables China to mobilize large public resources and sustain long-term investment independent of market cycles or short-term commercial returns, which is useful for driving concerted progress in a domain that requires decadal development horizons. For example, the 11th and 12th Five-Year Plans first executed government priorities by funding the Hefei QKD network and later expanding it into a national quantum communication backbone.[117] Under the 14th Five-Year Plan, China escalated its quantum computing ambitions by supporting the development of superconducting and photonic systems—such as "Tianyan-504," which is a step closer to matching the performance of U.S.-made systems.[118] The recent 15th Five-Year Plan

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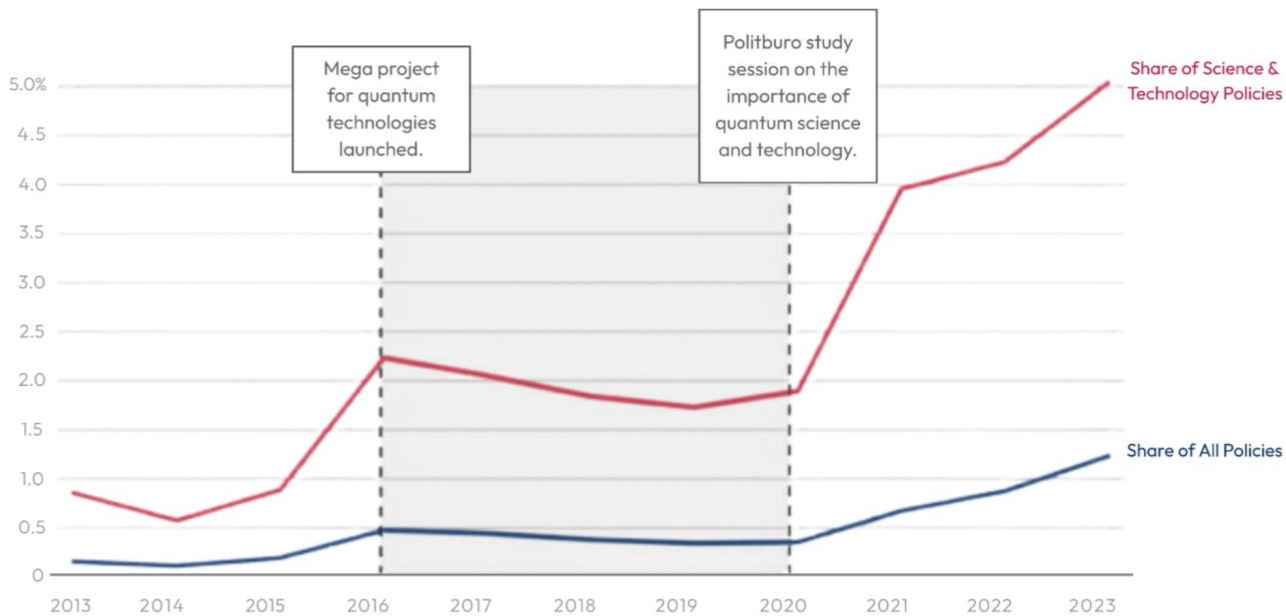
[115] Sam Howell, The Quest for Qubits, Center for a New American Security at 15–16 (2024); Hideki Tomoshige & Phillip Singerman, Understanding China's Quest for Quantum Advancement, Center for Strategic & International Studies (2026).
[116] Joseph Federici, Vying for Quantum Supremacy: U.S.-China Competition in Quantum Technologies, U.S.–China Economic and Security Review Commission at 8 (2025).
[117] Joseph Federici, Vying for Quantum Supremacy: U.S.-China Competition in Quantum Technologies, U.S.-China Economic and Security Review Commission at 9 (2025).
[118] Joseph Federici, Vying for Quantum Supremacy: U.S.-China Competition in Quantum Technologies, U.S.-China Economic and Security Review Commission at 9 (2025); Matt Swayne, China Introduces 504-Qubit Superconducting Chip (2024).

listed quantum first under the "industries of the future" section and second under "frontier technologies," showing an increase in government prioritization of QISET.[119]

Share of China's Policies that Mention Quantum Technologies



Source: Jeroen Groenewegen-Lau & Antonia Hmaidi, China's Long View on Quantum Tech Has the US and EU Playing Catch-Up, MERICS at 6 (2024).

[119] NPC 2026: Documents and Votes, NPC Observer (last accessed 2026); Deciphering the 15th Five Year Plan, MERICS (2026).

Evolution of China's Quantum Policies and Mega Projects

Policy	Key Objectives	Achievements and Related Mega Projects
863 Plan (originally 1986, updated later to inclde QIS) & 973 Plan (1997)	Supporting high-tech R&D; establishing quantum information as frontier science	Laid groundwork for quantum research infrastructure at the University of Science and Technology of China and the Chinese Academy of Sciences through QKD experiments.
11th & 12th Year FYPs (2006-2015)	Advancing quantum communications and building research infrastructure	Launched Hefei QKD network (2008), creating one of the world's first metropolitan-area quantum communication networks; started construction of the Beijing-Shanghai Quantum Secure Communication Backbone (2013-2020), a 2,000-kilometer (1,250-mile) fiber-based QKD network connecting major cities; demonstrated China's early dominance in quantum communication infrastructure.
Strategic Priority Program on Space Science (2011)	Integrating QIS into national space science goals	Launch of Micius (2016), the world's first quantum communications satellite, enabling space-to-ground QKD and entanglement distribution.
13th FYP (2016-2020) & S&T Innovation 2030 Mega Project	Integrating communications, computing, and sensing; moving from R&D to application	Developed two quantum computers, a photonic-based system, Jiuzhang (2010), and a 62-quibit super conducting processor, Zuchongzhi (2021); integrated Micius with ground stations in Beijing, Urumqi, and Vienna, demonstrating intercontinental quantum key exhcange; launched Zhaoshan Long-Baseline Atom Interferometer Gravitation Antenna (ZAIGA), an underground quantum sensing facility for testing precision measurement and gravitational detection technologies.
14th FYP (2021-2025)	"Technological self-reliance" through strengthening the role of state firms and domestic supply chains	Built Tianyan-504 quantum computer, China's first large-scale integration of a laboratory prototype into an operational platform; expanded sensing projects.

Source: Joseph Federici, Vying for Quantum Supremacy: U.S.-China Competition in Quantum Technologies, U.S.–China Economic and Security Review Commission at 9 (2025).

The United States does not have as strong of a unified national approach.

Rather than centrally directing technology strategy, the United States seeks to preserve its leadership by sustaining a dynamic, market-driven innovation ecosystem. The National Quantum Initiative Act (NQIA), enacted in 2018, established a ten-year framework to coordinate federal agencies, expand foundational research funding, create Quantum Information Science Research Centers and other research infrastructure, and develop workforce pipelines.[120] Rather than dictating specific architectures or technological end-states, the NQIA emphasized cross-sector coordination, public–private partnerships, and scientific collaboration.[121] Yet key programmatic provisions under the NQIA expired in 2023, and the overall initiative is scheduled to sunset in 2029.[122] Without renewal or expansion, the United

[120] Public Law 115-368, National Quantum Initiative Act (2018); National Quantum Initiative, National Quantum Coordination Office (2022).
[121] National Quantum Initiative, National Quantum Coordination Office (2022).
[122] Quantum Computing: Concepts, Current State, and Considerations for Congress, Congressional Research Service (2023).

States risks losing long-term strategic coherence in quantum planning. The absence of sustained federal direction may complicate coordination across agencies, weaken workforce development pipelines, and undermine the ability to align quantum advancements with national security priorities in the long run.

Government funding emphasizes China's top-down approach to quantum development.

In China, heavy reliance on public funding reinforces the model of centralized control and long-term planning authority. The Chinese Communist Party is estimated to have spent approximately $15 billion on QISET as of December 2024.[123] Funding is concentrated in state-backed laboratories and national research centers.[124] By directing state resources to nationally designated hubs, China ensures that breakthroughs in quantum communication, computing, and sensing remain embedded within Party-aligned institutions, operationalizing its strategic objectives by minimizing market uncertainty and aligning capital deployment with long-term priorities.[125]

The U.S. Government, by contrast, invests almost $1 billion annually in quantum R&D, totaling roughly $6 billion over the past seven years.[126] U.S. appropriations are distributed across multiple federal agencies—including the Department of War, Department of Energy, National Science Foundation, NASA, and NIST—each funding quantum research consistent with its own mission.[127] Unlike China's longer-term, centrally mandated funding commitments, federal appropriations depend on annual congressional budgeting cycles and legislative reauthorization, inherently introducing uncertainty into long-horizon planning. Significant portions of U.S. quantum R&D investment flow indirectly through public–private partnerships, university consortia, and private firms pursuing varied hardware architectures—a structure that reflects the United States' strategy of sustaining a decentralized, innovation-driven ecosystem rather than directing specific technological end-states.[128]

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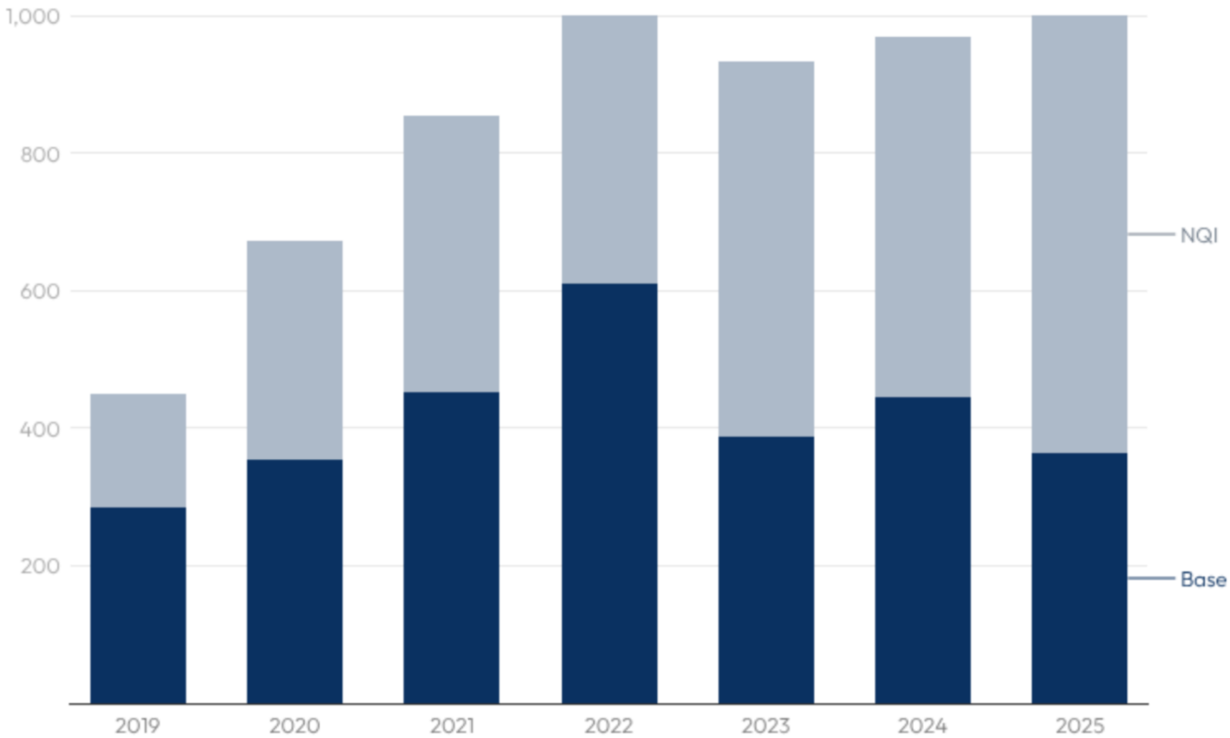
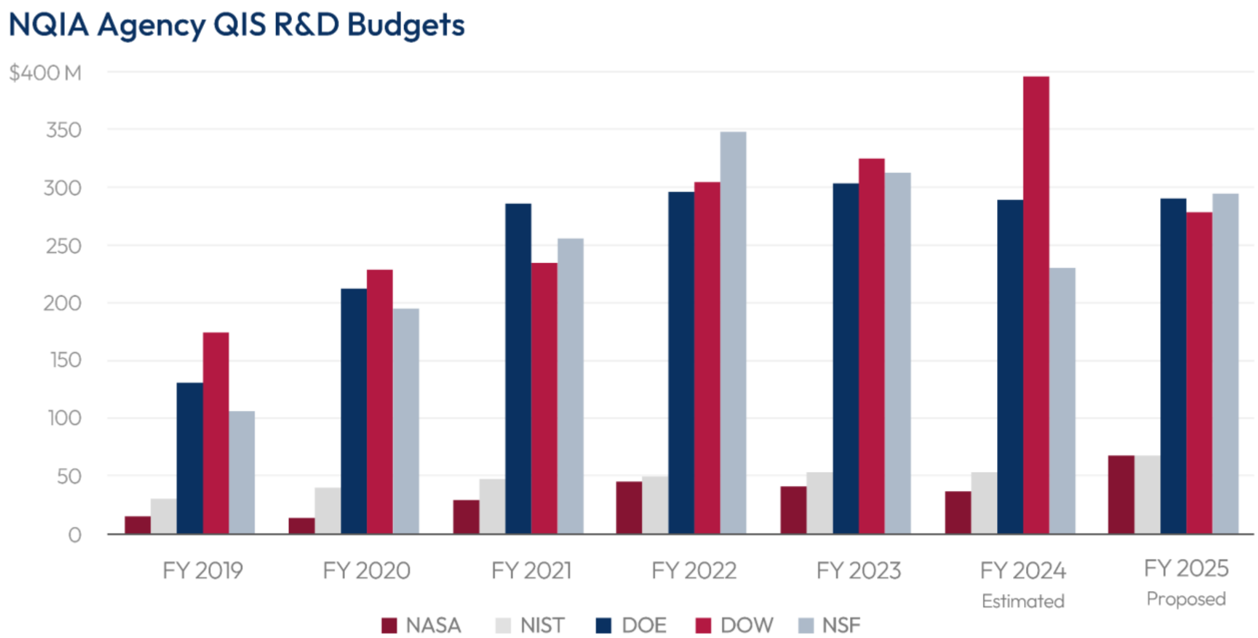
[123] Jeroen Groenewegen-Lau & Antonia Hmaidi, China's Long View on Quantum Tech Has the US and EU Playing Catch-Up, MERICS at 6 (2024).
[124] Sam Howell, The Quest for Qubits, Center for a New American Security (2024); Testimony of Edward Parker before the U.S.-China Economic and Security Review Commission, The Chinese Industrial Base and Military Deployment of Quantum Technology (2024).
[125] Hideki Tomoshige & Phillip Singerman, Understanding China's Quest for Quantum Advancement, Center for Strategic & International Studies (2026).
[126] National Quantum Initiative Supplement to the President's FY 2025 Budget, National Science and Technology Council (2024).
[127] National Quantum Initiative Supplement to the President's FY 2025 Budget, National Science and Technology Council (2024).
[128] Federal R&D Funding, Emerging Technology Policy Careers (last accessed 2026); Hideki Tomoshige, Innovation Lightbulb: U.S. Federal Investments in Quantum Technology Research and Infrastructure, Center for Strategic & International Studies (2025).

U.S. Federal QIS R&D Budgets (in millions USD)



The bar heights represent the total budget for each fiscal year (FY 2019 - 2023 are actual expenditures, FY 2024 is estimated expenditures, and FY 2025 is proposed. The portion of each bar marked "NQI" identifies funding allocated for NQI Act-authorized activities; this additional funding is on top of the budgets for baseline QIS R&D activities.

Source: National Quantum Initiative Supplement to the President's FY 2025 Budget, National Science and Technology Council (2024).



Source: National Quantum Initiative Supplement to the President's FY 2025 Budget, National Science and Technology Council (2024).

Standards-setting can solidify state influence.

National leverage in QISET also plays out in international standards-setting bodies, which shape not only technical interoperability but long-term geopolitical alignment. The United States has exercised influence through institutional leadership: through NIST, the United States convened an open, multi-year competition to evaluate and standardize quantum-resistant cybersecurity protocols, resulting in the first formal PQC standards, which are becoming official baselines around the world.[129] By anchoring the transition to quantum-safe cryptography in a U.S.-led institutional framework, the United States embedded influence into the future cybersecurity architecture without mandating technological pathways or dominating hardware production.

China has pursued leverage through a different sequence. In 2025, China's Institute of Commercial Cryptography Standards launched an independent call for PQC algorithm proposals rather than aligning with NIST's process.[130] At the same time, Beijing has focused

[129] Marin Ivezic, Sovereignty in the PQC Era: Standards, Trust, and Crypto-Agility, PostQuantum (2025); Marin Ivezic, India's Task Force Releases Quantum-Safe Roadmap with 2027–2029 Migration Timeline for CII, PostQuantum (2026).
[130] Hideki Tomoshige & Phillip Singerman, Understanding China's Quest for Quantum Advancement, Center for Strategic & International Studies (2026); Antonia Hmaidi, US-China Competition Could Lead to Sub-Par Quantum Tech Standards, MERICS (2024).

more on QKD rather than PQC.[131] To this end, Chinese representatives have chaired international quantum working groups, proposed a communication security protocol that could make networks quantum-resistant within the International Organization for Standardization, and increased support for domestic firms and experts to participate consistently in international standards meetings—signaling a deliberate effort to shape rulemaking venues.[132] Chinese national authorities have also coordinated the creation of formal technical standards for dilution refrigeration, set to take effect in July 2026, showing how its standardizing efforts extend to explicit quantum hardware.[133]

These efforts reflect a broader strategic logic: standards determine which technical architectures scale globally, whose firms benefit from first-mover advantages, and which states shape interoperability rules.

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[131] Antonia Hmaidi, US-China Competition Could Lead to Sub-Par Quantum Tech Standards, MERICS (2024).

[132] Antonia Hmaidi, US-China Competition Could Lead to Sub-Par Quantum Tech Standards, MERICS (2024); 2025 Annual Report to Congress, U.S.–China Economic and Security Review Commission at 120 (2025).

[133] Liquid Helium Dilution Refrigeration, National Public Service Platform for Standards Information (2025).

Outlook: Wildcards and What to Watch

The quantum competition will not unfold on a single timeline. Progress across sensing, computing, networking, cryptography, and materials will arrive at different moments, carry different risks, and demand different strategic responses. Some technologies are already delivering operational value, and others remain years away from fielded systems. Within each domain, advancement will be uneven: bursts of breakthroughs followed by long stretches of difficult engineering and integration work.

Therefore, the countries best positioned will not necessarily be those that achieve the most impressive scientific results in any single area, but those that can manage this unevenness in deployment timelines effectively and convert laboratory results into dependable systems across the full quantum stack, adapting strategy as the landscape shifts beneath them.

Will quantum technologies come online in the near term?

Quantum sensing is already the most mature and deployable part of this competition, and nations that move early stand to gain durable advantages—in secure timing, navigation without GPS, submarine detection, and precision geological surveys. If countries field these systems at scale over the next several years, it could meaningfully reduce their dependence on vulnerable satellites and reshape military operations in GPS-denied or -degraded environments. The economic spillovers would compound that advantage: greater control over industrial systems, more accurate resource mapping, and improved medical diagnostics could translate into measurable productivity gains across industries.

Quantum computing and networking follow different and far less certain timelines. If an unforeseen breakthrough allows code-breaking-capable computers to arrive earlier than the estimated timeframe of 2035–2040, they could breach trust in legacy IT, but also compress drug discovery timelines and reshape financial modeling and logistics optimization at a scale classical systems cannot match.[134] Countries that achieve cryptographically relevant quantum computers would have powerful incentives to conceal that capability, potentially exploiting it for years before the rest of the world catches on.

At the same time, continued advances in specialized chips and AI-driven optimization are steadily narrowing the range of problems where quantum systems offer a clear edge, effectively moving the goalposts for what "quantum leadership" means in practice. However, these improvements in classical tools can in turn improve quantum systems, as AI systems

[134] Half of respondents to expert surveys estimate it is 50% likely for a quantum computer to break critical encryption codes. See Michele Mosca & Marco Piani, Quantum Threat Timeline Report 2025, Global Risk Institute (2025).

improve hardware calibration, automate error correction, and enable more capable hybrid architectures. If classical and quantum systems continue to mature in parallel, the most consequential near-term gains will likely come not from pure quantum computation but from hybrid platforms that integrate both, and leadership in that integration layer may prove as strategically significant as raw quantum performance.

Will investment hold if breakthroughs stall?

Uneven and uncertain deployment timelines make the field vulnerable to differences between expectation and reality, and where missed milestones, high-profile startup failures, or influential voices publicly questioning near-term commercial viability could trigger a significant contraction in private funding, talent pipelines, and political will. Quantum has already seen this cycle of hype and retrenchment.

If enthusiasm wanes for quantum in the United States, it would not end the competition but tip the scales toward countries with patient, state-backed investment programs—most notably, China—as they would be better insulated from a contraction in private funding than those relying heavily on venture capital and near-term commercial returns. A prolonged downturn could also accelerate talent migration away from quantum research, erode the industrial base needed to support hardware manufacturing, and create gaps in institutional knowledge that are difficult to rebuild quickly. For the United States, sustaining commitment through inevitable setbacks may be as strategically important as achieving any individual technical milestone. While the U.S. government's recent letters of intent to invest $2 billion into domestic quantum companies signal substantial federal interest in the engineering and manufacturing of quantum computers, it will take time to assess the true impact of these awards on the competitive landscape.[135] After all, the risk is not that the technology fails permanently, but that inconsistent investment creates setbacks that competitors do not have to contend with.

Will the United States be able to lead this competition alone?

No single country commands the full quantum stack—foundational research, specialized hardware, cryogenic manufacturing, control electronics, talent, and supply chains—at the scale the competition demands. The United States holds its share of advantages, but these are not self-sustaining, and they do not uniformly extend across every layer of the stack. Therefore, attempting to achieve quantum dominance could be a slow, expensive, and volatile undertaking if the United States decides to go it alone.

[135] Department of Commerce announces Letters of Intent With 9 Companies for $2 Billion to Accelerate U.S. Leadership in Quantum Computing, National Institute of Standards and Technology (2026).

America's allies and partners are therefore central to whether the United States can translate its current edge in quantum into durable technological leadership. If the United States deepens collaboration with trusted partners, it could pool capabilities in ways that no bilateral effort can replicate, reduce vulnerabilities, and accelerate innovation while shaping a broader ecosystem aligned with shared interests and values. This network, properly structured, would function as a force multiplier.

Conclusion

Despite questions about how the quantum race will play out, it is happening *now*. The United States enters this competition with real advantages: a world-class innovation ecosystem, dominant software platforms, and a lead in hardware performance. China is a close competitor whose strategic planning operates on long time horizons; its investment is patient, where America's often changes with the market and government objectives, and its edge in deployment—particularly in quantum networking—is already operational. But advantages are not destinies. While the United States leads today, the final outcome of the geopolitical competition for dominance in QISET is all but clear.

Appendix I: Tech Scorecard Matrix

The Tech Competition Scorecard relied on expert scoring of quantitative and qualitative data across many technology-specific metrics relevant to each category of positional advantage in QISET. Final scores were determined by a weighted average of the metric scores below. The 1-to-5 ranking corresponds to the following rubric:

1. Negligible / Nascent: The country has minimal presence or capability in this metric. The data point is insignificant on a global scale.
2. Emerging / Minor: The country is active but below the global average or industry standard. They are followers or niche players. Performance is functional but clearly inferior to top-tier competitors.
3. Competitive / Mainstream: The country operates at the global industry standard. The metric represents a healthy, functioning ecosystem that meets current market needs but does not differentiate itself as superior.
4. Advanced / Leading: The country is among the top tier globally. The metric shows performance, scale, or quality that exceeds the average and rivals the best.
5. State-of-the-Art / Dominant: The country sets the global benchmark. This metric represents the absolute peak of what is currently possible.

	Metric	Source(s)	Weight	U.S. Score	China Score
Innovation Leadership	Share of Quantum Error-Correcting Codes Publications & Patents	The Lens	High	4	2
	World Share of New Materials	OpenAlex	High	2	5
	Gate Fidelity	MIT; American Physical Society	High	4	2
	Share of Top 10% of Most Frequently Used References Published in the Last 5 Years	OpenAlex	High	4	2
	QKD Land-Based Network Extent	National Quantum Initiative Advisory Committee; Nature	Medium	2	4
	Share of Quantum Algorithms Publications & Patents	The Lens	Medium	3	2
	Best-in-Class Qubit Lifetime	Nature	Medium	4	3
	Share of Articles Co-Authored by Industry & Academia	OpenAlex	Medium	4	2
	Domestic Citation Count	OpenAlex	Medium	4	2
	QKD Free-Space Network Extent	Nature	Low	1	4
	Share of Quantum-Simulating Classical Algorithms Publications & Patents	The Lens	Low	4	2
	Best-in-Class Qubit Coherence	Nature	Low	3	4
	Share of Articles Co-Authored Across Countries	OpenAlex	Low	4	2

Innovation Leadership	Share of Articles Co-Authored Across Institutions	OpenAlex	Low	2	4
	Top Percentile of Most Cited Non-Review Articles	OpenAlex	Low	3	2
Industrial Capacity	Market Share of Quantum Simulating Software	GitHub; Gitee	High	5	2
	Access to Radio Frequency (RF) Technology	Industry Surveys; State Media; Market Reports	High	3	3
	Co-Locality of Research, Development, and Manufacturing Centers	ECIPE	Medium	4	5
	Secure Supply of Critical Materials	SCSP Analysis	Medium	5	3
	Access to Dilution Refrigerators	Industry Surveys; State Media; Market Reports	Medium	4	2
	Clean Room Assembly Cost	Market Reports; State Media Reports	Medium	2	4
	Access to Lasers	World Integrated Trade Solution	Medium	4	3
Market Ecosystem	Private Sector Announced Funding	European Centre for International Political Economy	High	4	2
	Number of Deployed Quantum Computers	Quantum Zeitgeist; Quantum Dragon	Medium	4	2
	Private-Sector Procurement	USASpending.gov	Low	3	4
Talent Pipeline	Explicit Master's Programs for QIS	MIT	Medium	4	1
	Undergraduate Degrees in QIS	The International Institute for Strategic Studies	Medium	4	3

Talent Pipeline	Number of Quantum Computing Experts	MERICS	Medium	4	2
	K-12 Quantum Education Programs	MIT	Medium	3	3
	STEM PhDs Awarded	Information Technology & Innovation Foundation	Low	3	4
	STEM PhD Growth Rate	Information Technology & Innovation Foundation	Low	3	4
National Leverage	PQC Standards Setting Ability	SCSP Analysis	High	5	3
	Estimated Actual Government Funding for QISET	SCSP Analysis	High	3	5
	Quality & Execution of National Technology Policy Strategies for QISET	SCSP Analysis	Medium	3	4
	Public Sector Announced Funding for QISET	SCSP Analysis; U.S.-China Economic & Security Review Commission	Low	3	5

Appendix II: Notes on Methodology

A. Publication statistics in the "Innovation Leadership" section are the product of SCSP's bibliometric analysis of datasets obtained from OpenAlex. Throughout the section, we draw publications from a basket of Topic IDs, an extension of the Open Leiden Rankings, which for quantum publications in this analysis include t10020, t10382, t10425, t10478, t10622, t10682, t11804, t11993, and t12004. We filter by country code for geographic affiliations and collect aggregate metadata and granular work IDs to guard against duplication. Where appropriate, we add additional search terms (e.g., "error correction"), filter to exclude review papers or works published in journals that exclusively distribute review materials, and sort and truncate by citation count. In the *Share of Top 10% References (2015–2025)* graphic specifically, we collect all work IDs matching the basket filter in each given year, and draw up a list of all papers these publications cite in their reference section. We filter this list by publication date in the preceding five years (i.e., the reference must be at most 5 years old), sort by frequency, and truncate to the top 10%. With this shortlist, we then query the country affiliation of the authors' institutions and assign share as the fraction of items on this shortlist with either U.S. or Chinese affiliation. In *Europe Quantum Collaborations Publications*, we look for publications whose authorship affiliations have at least one European co-author. Similarly, for *Academia-Industry Collaboration in QISET Research*, we define an academic affiliation type as education, facility, government, or nonprofit, and an industry affiliation as a company.

B. Patenting statistics in the "Innovation Leadership" section are the product of SCSP analysis of datasets obtained from The Lens. To filter by impact, we sort patents by forward citation count and identify the country affiliation of the top 10% most cited. We use CPC classification codes to filter for error correction (g06n10/70), algorithms (g06n10/60), and simulations (g06n10/80). For U.S. affiliates, we filter by either inventor, applicant or owner country, while for Chinese affiliates, we also include country code "CN" as jurisdiction of patent application. Comparing patenting and publication metrics across geographies can be misleading as there are social and institutional factors that drive output. As a result, these primary sources are viewed holistically.