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Quantum Computing: The Next Legal Frontier for International Arbitration
by G.L. Benton

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by Gary L. Benton[*]

Abstract

Quantum computing is emerging as one of the most consequential technological developments of the coming decades, yet its implications for international dispute resolution remain largely unexplored. This article examines the development of quantum computing, its accelerating commercialization, and the legal disputes likely to arise as quantum technologies reshape global industries.

Unlike AI, which accelerates existing classical computing processes, quantum computing transforms computation at its most fundamental level, enabling calculations impossible for our current computers. As most computer users have come to learn, AI is software that enables computers to process, analyze, and predict information in ways that mimic aspects of human intelligence. Quantum computing, by contrast, transforms computation at its foundation using atoms, electrons, or other subatomic particles to perform calculations that our current computers cannot accomplish regardless of how sophisticated the AI software may be. Thus AI primarily affects how disputes are analyzed and resolved, while quantum computing will affect the types of disputes that arise. This distinction matters for the legal practice and dispute management: AI is already shaping how lawyers work, while quantum computing will reshape the underlying industries and infrastructure from which disputes arise.

Private venture investment is surging, and the United States, the European Union, and China have collectively committed tens of billions of dollars to national quantum programs. Commercial applications are emerging across industries including materials, pharmaceuticals, finance, cybersecurity, defense, logistics, and telecommunications, each sector generating its own distinct categories of dispute.

For arbitration practitioners, the stakes are substantial. Quantum advances will generate complex cross-border disputes involving intellectual property, cybersecurity liability, investment treaty obligations, and regulatory compliance. International arbitration, with its flexibility, neutrality, technical adaptability, and global enforceability, is positioned to serve as the primary forum for resolving the disputes of the quantum era. The article prepares practitioners for a quantum future that has already arrived.

I. Introduction

The legal sector is intensely focused on artificial intelligence (“AI”), yet another technological shift, one potentially even more consequential, is approaching. AI occupies today’s center stage in legal discourse, reshaping research techniques, document automation, case analysis, and

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predictive modeling in dispute resolution. AI has already had a transformative influence on dispute resolution and will continue to do so. Yet, AI remains fundamentally constrained by today's computers. [1] While AI improves how existing computers process and analyze information, it does not change the underlying architecture of computing.[2] The next legal frontier, quantum computing, radically alters the foundations of computing itself.[3]

AI is a set of techniques, including pattern recognition, prediction, and language modeling, that make today's computers more capable. AI can analyze a contract, predict a dispute outcome, or identify patterns in financial data, but it operates on the same principles that have defined modern computers for nearly a century.

Quantum computing is fundamentally different from AI and the world of computing today. It is grounded in quantum mechanics rather than classical logic, representing an entirely new computing paradigm.[4] Quantum computers manipulate particles, such as atoms, electrons, ions, and photons, to process exponentially many states simultaneously.[5] This means quantum computing does not merely improve on what computers can do; rather, it makes possible computations that today's computers, even those using AI, cannot solve.[6]

This distinction matters because many of the world's most complex scientific, industrial, and societal challenges may soon be solved by quantum computing. Quantum computing makes it possible to perform calculations in minutes or hours that today's supercomputers could not complete in billions of years.[7] Accordingly, quantum computing is poised to define the next major technological era.

In the digital age, the legal profession has adapted to innovations that have reshaped the practice of law— email, the Internet, online research databases, e-discovery, mobile technologies, cloud-based systems, and now AI. Each innovation has been met with limited understanding, followed by incremental adoption, and eventual integration into daily legal work. These developments have expanded communication, improved workflows, increased analytical capabilities, and enhanced efficiency. Yet none of these developments, despite their remarkable impacts, altered the underlying nature of computing itself.[8] Quantum computing represents the first transformation of computational foundations since the digital age began.[9]

The rise of quantum computing marks a transformative moment. Quantum capabilities have the potential to reshape major global industries including materials sciences, life sciences, information technology, defense, logistics, energy, finance, and telecommunications, to name just a few.[10] Quantum computing will also usher in an array of new legal disputes involving contracts, intellectual property, cybersecurity, investment and regulatory compliance matters.

[1] IBM Research, Classical vs. Quantum Computing: Technical Primer (2023).
[2] U.S. National Quantum Coordination Office, Quantum Frontiers Report (2023).
[3] World Economic Forum, Quantum Economy Outlook (2024).
[4] Mermin, Quantum Computer Science (Cambridge Univ. Press 2007); Nielsen & Chuang, Quantum Computation and Quantum Information (2010).
[5] Google Quantum AI, "Quantum Supremacy Using a Programmable Superconducting Processor," Nature 574 (2019).
[6] Scott Aaronson, "The Limits of Classical Simulation," Nature Physics (2021).
[7] National Academies, Quantum Computing: Progress and Prospects (2019).
[8] IBM Research, Classical vs. Quantum Computing: Technical Primer (2023).
[9] U.S. National Quantum Coordination Office, Quantum Frontiers Report (2023).
[10] McKinsey & Co., Quantum Technology Monitor (2024).

At the same time, governments increasingly view quantum technologies as strategic national assets. States are adopting export controls, investment-screening mechanisms, and technology-transfer restrictions governing quantum hardware, software, and research collaboration. These regulatory measures introduce new legal tensions between national security objectives and the interests of multinational investors and technology companies. As these controls expand, they are likely to generate investor-state disputes concerning investment protections, licensing regimes, and cross-border technology development.

These dynamics underscore the importance of international arbitration as a neutral forum capable of resolving disputes that span legal systems, regulatory regimes, and national security considerations. International arbitration, with its flexibility, neutrality, technical orientation, and global enforceability, is positioned to be the primary forum for resolving disputes arising from quantum technologies.

These developments will be particularly significant in sectors central to international investment and infrastructure development, including energy systems, telecommunications networks, semiconductor manufacturing, and advanced materials production. Quantum technologies are likely to influence strategic supply chains, national security policies, and cross-border investment flows, increasing the likelihood of disputes involving long-term infrastructure projects, technology licensing, state regulation, and investment protections. As these sectors intersect with evolving quantum capabilities, arbitration will increasingly serve as the forum for resolving disputes at the intersection of advanced technology, global commerce, and public policy.

This article provides an overview of quantum computing for legal and arbitration practitioners. It addresses basic principles underlying quantum systems, traces the evolution of quantum research, analyzes commercialization, examines emerging legal and regulatory implications, and considers the likely legal impacts, particularly with respect to international arbitration. The article's central focus is an analysis of how quantum technologies will reshape arbitration practice, including with respect to evidence, procedure, and tribunal decision-making. The aim is to prepare practitioners for a future that is already beginning to unfold, one in which quantum computing moves beyond theory to become a leading driver of global commerce and a defining source of domestic and cross-border disputes.

II. Basics of Quantum Computing

What is Quantum Computing?

Quantum computers differ from today's "classical computers" at a fundamental level. Today's computers process information using "bits" – such as stored electrical charges that exist as either 0 or 1. Every calculation performed by a classical computer is built from combinations of these binary choices, step by step. The most basic math computation uses two bits, and by scaling that simple method, our phones and laptops can perform billions of operations per second.

As impressive as that sounds, quantum computing is even more impressive. Quantum computing relies on quantum physics, the behavior of matter at extremely small scales, using particles such as atoms, electrons, or photons for units of computation.[11] Quantum computers

[11] J. Preskill, "Quantum Computing in the NISQ Era," Quantum (2018).

use these quantum particles, called "qubits," which can represent 0, 1, or a combination of both at the same time.[12] This allows quantum computers to achieve exponentially greater processing than classical computers. The difference is often described through three core concepts: superposition, entanglement, and interference; but for present purposes, it is sufficient to understand that their combined effect is the ability to evaluate many possibilities simultaneously and identify the most likely outcome.[13]

When multiple qubits interact, the number of possible states in the system doubles with each qubit. 10 bits in a classical computer can represent 1 of 1,024 possible states. In a quantum system, 10 qubits represent all 1,024 possible states at once. With 300 qubits, which is at the scale university research groups have now surpassed, the number of states is greater than all the atoms in the observable universe.[14]

Thus, while classical computers process billions of operations per second, they still search for answers one step at a time; a quantum computer searches all possible answers simultaneously, making certain problems that take classical computers billions of years solvable in hours.

Legal practitioners don't need to master the physics, but it is useful to have this basic understanding to appreciate why quantum computing differs from current classical computing. Consider a few practical comparisons:

- Breaking the widely used modern-day RSA-2048 security encryption would take a classical supercomputer billions of years; a sufficiently advanced quantum computer could potentially do so in a few days or weeks.[15]
- Modeling the behavior of a moderately complex molecule exceeds the capacity of today's classical computers; a quantum computer can potentially model quantum behavior in minutes to hours.[16]
- Searching a database of a trillion entries, for example, a genome data set or years of global financial transactions, would take a trillion steps on a classical computer;

[12] Mermin, Quantum Computer Science (2007).
[13] Superposition describes the nature of quantum particles existing in multiple states at once. To illustrate superposition, think of a spinning coin that is potentially either heads or tails but exists as both until the spinning ends. Another illustration of superposition is the famous thought experiment by Austrian physicist Erwin Schrödinger involving an imagined sealed box containing a cat in which the cat would be simultaneously both dead and alive until it was observed. Simply, superposition means that a qubit can exist in an infinite number of positions at once – and quantum computers can do computation on those multiple positions all at once rather than doing a binary 0 or 1 calculation.
Quantum computers also leverage entanglement, a uniquely quantum effect in which the state of one qubit instantly correlates with the state of another, even after they are physically separated. For example, researchers can cause two electrons to interact in a way that links their magnetic orientation: once linked, measuring the spin of one immediately tells us the spin of the other. Entanglement allows quantum computers to coordinate operations across many qubits at the same time, multiplying computational power.
Interference is the third core concept in quantum computing. Quantum particles naturally behave like waves that can overlap and add together or cancel each other out. Quantum computers use specially designed quantum algorithms to control how quantum states combine, guiding probability computation so that the correct solutions are amplified and incorrect ones are suppressed. This allows a quantum computer to reach the most likely solution from the vast possibilities created by superposition and entanglement.
[14] QuEra Computing, "Large-Scale Neutral-Atom Quantum Systems" (2024).
[15] P. Shor, "Polynomial-Time Algorithms for Prime Factorization," FOCS (1994).
[16] Reiher et al., "Quantum Chemistry on Quantum Computers," PNAS (2017).

> a quantum computer could potentially perform continual searches every second providing solutions to problems beyond the power of classical computers.[17]

In this sense, quantum computers are not only "more powerful" than classical computers; they can solve fundamentally different categories of problems.[18] For example, quantum computers can potentially support the discovery of new life-saving drugs, accelerate the discovery of new clean energy solutions, and help solve climate change problems. In the legal sector, quantum computers have the potential to model complex simulations involving financial risk, market behavior, and scientific processes that may be relevant to finance, energy, patent, and other technology-related disputes.[19]

But Quantum Computers are Hard to Build

Despite their promise, quantum computers are extraordinarily hard to build. Qubits are fragile. They maintain their quantum states only for short intervals before being disrupted by the environment, a phenomenon known as "decoherence."[20] Even minor disturbances, such as temperature fluctuations, vibration, or electromagnetic activity, can collapse a qubit's state.

Quantum computers are also prone to errors. Unlike classical transistors, which operate with near-perfect reliability, quantum operations are imprecise. To address this, researchers are developing error correction techniques that combine many physical qubits into more reliable "logical" qubits. Depending on the architecture, one logical qubit may require hundreds or thousands of physical qubits. Given the increased scale and complexity of the systems required. no reliably functional logical qubits have yet been built.[21] But many advances are being achieved.

Although researchers have demonstrated core concepts, we are only at the very earliest stage of quantum computing development, the equivalent of the late 1950s and early 1960s where vacuum tubes were still being used in large, mainframe computers then limited to academic labs, government facilities, and specialized industries.[22] Costs remain high, and continued innovation is needed to make quantum computing affordable and commercially useful. These obstacles also carry significant business and legal implications, including delays, performance disputes, and disagreements over responsibility for unmet expectations. Researchers and entrepreneurs have struggled to strike the right balance, with some overstating near-term capabilities and others understating the long-term potential.[23]

The reality is that quantum computers today are limited in capability. Yet progress has been steady and is attracting substantial investment; if the technology matures, it is widely expected to advance faster than classical computing.[24] By some predictions, we will see early commercial uses of quantum computers within five years.[25]

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[17] L.K. Grover, 'A Fast Quantum Mechanical Algorithm for Database Search,' Proceedings of the 28th ACM Symposium on the Theory of Computing (1996).
[18] McKinsey, Quantum Technology Monitor (2024).
[19] Nature, "Practical Applications of NISQ Devices" (2024).
[20] Google Quantum AI, "Cryogenic Requirements for Superconducting Systems" (2023).
[21] IBM Research, "Error Mitigation Advances," Nature Physics (2023).
[22] National Academies, Quantum Computing: Progress and Prospects (2019).
[23] Boston Consulting Group, Commercial Readiness of Quantum Computing (2024).
[24] IBM Quantum Roadmap (2023–2024); McKinsey, Quantum Technology Monitor (2024–2025).
[25] BCG, "The Coming Quantum Leap in Industry" (2024).

III. Quantum Computing Development to Date

Research and Development

Quantum computing has progressed from foundational theory to early-stage commercial deployment, with research, development, and commercialization spanning academic laboratories, government research institutes, multinational corporations, and specialized startups.

Quantum computing emerged from research at leading institutions, including Harvard, MIT, Caltech, Stanford, and Oxford, from the mid-1980s through the 2010s.[26] These institutions demonstrated entangled qubits, early quantum logic gates, and the first error-correction codes, establishing that quantum systems could be created, controlled, and measured.[27] A pivotal milestone was "Shor's algorithm" in 1994, which showed that quantum systems could solve certain computational problems exponentially faster than classical computers.[28]

By the 2010s, major technology companies had entered the field aggressively. IBM developed cloud-accessible superconducting quantum processors.[29] Google advanced coherence and gate fidelity in its superconducting architecture, culminating in its 2019 claim of "quantum supremacy," meaning the ability to solve problems that existing classical supercomputers cannot.[30]

Progress accelerated after 2020 as IBM, Google, QuEra, IonQ, and Quantinuum advanced processor scale and fidelity, with cloud service platforms now widely available.[31] By 2023–2024, systems reached the hundreds-to-thousands-of-qubit range, with improved error mitigation enabling more reliable results for targeted tasks.[32]

In 2025, a Harvard–MIT–QuEra collaboration demonstrated a programmable system with approximately 3,000 qubits capable of continuous operation for more than two hours, marking a significant step toward scalable, stable quantum systems.[33] It demonstrates that quantum computing has moved beyond small, laboratory-scale demonstrations toward engineered systems capable of sustaining large-scale quantum operations over extended periods.

As quantum systems leap forward in 2026, leading research groups have reported their systems crossed into what is called the "fault tolerant foundation era," where increasing qubits reduces

[26] Caltech Institute for Quantum Information and Matter, Research Overview (2010–2020).

[27] P. Shor, "Fault-Tolerant Quantum Computation," FOCS (1996); Steane, "Error Correcting Codes," Phys. Rev. Lett. (1996).

[28] P. Shor, "Polynomial-Time Algorithms for Prime Factorization," FOCS (1994).

[29] IBM Quantum Experience, "Open Access Quantum Devices" (2016–2024).

[30] Google Quantum AI, "Quantum Supremacy Using a Programmable Superconducting Processor," Nature (2019).

[31] In 2020, researchers at Harvard and MIT demonstrated programmable quantum processors with more than 200 qubits.[31] By 2021, IBM had released a 127-qubit processor, while companies such as IonQ and Quantinuum were reporting steady improvements in qubit performance, operational fidelity, and system stability.[31] In 2022 and 2023, Google, IBM, and several academic groups announced major progress in error-mitigation techniques, enabling so-called noisy intermediate-scale quantum (NISQ) devices to produce more reliable results on targeted simulation tasks.

[32] In 2024-2024, IBM had announced processors in the 400- to 1,000-plus-qubit range, and companies such as QuEra were operating cloud-accessible quantum platforms supporting experiments with hundreds of qubits. Amazon (AWS) and Microsoft are also leading players in the field.

[33] QuEra–Harvard–MIT Announcement, "3,000-Qubit Neutral-Atom Processor" (2025).

rather than amplifies error rates.[34] Researchers and companies are beginning to deliver quantum-enhanced results in sensing, communications, chemistry, materials modeling, and complex optimization problems, early signals that real commercial value is emerging.[35]

These developments indicate a transition from experimental science toward targeted, industrial applications. Some researchers are considering use cases for the current NISQ quantum computers, despite their high error rates, where modest quantum effects can accelerate classical computing.[36] But most analysts expect the momentum to accelerate as the technology progresses toward error-corrected, fault-tolerant quantum systems. AI-driven machine learning techniques are contributing to this progress.[37]

One consideration is how to measure development milestones. Google's claim of "quantum supremacy" drew significant public attention, but the term has become controversial because it refers only to a quantum device performing an experimental task faster than a classical supercomputer, not to any task of practical value.

The increasingly preferred benchmark is "quantum advantage," which describes a quantum system outperforming classical computers on a problem of genuine scientific or commercial significance and doing so at lower computational cost. Although this threshold may take time to achieve, there is wide expectation that quantum computing will reach quantum advantage in targeted domains, delivering capabilities that classical systems cannot match. As that occurs, it will confer significant advantages on companies and governments that have adopted quantum strategies.[38]

Diverse Approaches

Several technical approaches are competing for dominance, including superconducting qubits (IBM, Google), neutral atoms (QuEra), trapped ions (IonQ, Quantinuum), photonic qubits (PsiQuantum), and semiconductor spin qubits (Intel, Diraq).[39] Each offers different trade-offs

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[34] McKinsey, Quantum Technology Monitor (2025-2026); Google Quantum AI, "Progress Toward Fault Tolerant Quantum Computing (2025-2026).
[35] Nature, "Quantum Sensing and Communications Breakthroughs" (2025).
[36] John Preskill, "Quantum Computing in the NISQ era and beyond," Quantum 2, 79 (2018)
[37] Z. Wang & H. Tang, "Artificial Intelligence for Quantum Error Correction," arXiv (2024)
[38] McKinsey, Quantum Technology Monitor (2024–2025).
[39] The approaches include:

- Superconducting qubits: This approach uses tiny superconducting circuits cooled near absolute zero, with quantum states manipulated by microwave pulses. Drawing heavily on semiconductor engineering, it has received substantial corporate investment; IBM and Google are leading developers in this space.
- Neutral atoms: These systems trap individual atoms using laser-based optical tweezers and have demonstrated impressive scalability in recent research. Much of the rapid progress in this area has come from Harvard, MIT, and the company QuEra.
- Trapped ions: This method suspends electrically charged atoms in electromagnetic traps and controls them with ultra-stable lasers. Although it remains one of the highest-fidelity approaches, industry attention is shifting toward more easily scalable platforms. The most advanced trapped-ion systems to date have been developed by IonQ and Quantinuum.
- Photonic qubits: Photonic systems encode quantum information in single particles of light and manipulate them through optical circuits on semiconductor chips. This approach benefits from compatibility with existing telecom and semiconductor infrastructure. PsiQuantum is the leading company pursuing this pathway.
- Quantum dots and spin qubits: These platforms control individual electrons confined in nanoscale semiconductor structures using electric or magnetic fields. They offer strong potential for large-scale chip-based integration, although maintaining consistent control over each qubit remains a technical challenge. Significant advances are being driven by Intel and Diraq.

in speed, fidelity, scalability, and operating environment. It remains too early to predict which architecture will prevail, and the competition among them is itself a source of significant IP and investment disputes.[40]

Looking Forward

Many anticipate the first stable logical qubits within five to ten years. Although it is uncertain which technology approach will take the lead, early quantum solutions are expected to appear in chemistry, materials science, life sciences, and telecommunications. Researchers are already finding practical uses for today's NISQ devices for targeted simulation, sensing and other communications tasks.[41]

Within ten to fifteen years, early fault-tolerant systems may begin solving narrowly defined commercial problems in a wide array of industry sectors. This stage of development will also raise new concerns for existing cybersecurity protocols because they are vulnerable to quantum advances.[42]

Within fifteen to twenty years, fully fault-tolerant quantum computers could enable breakthroughs across major industries, including in life sciences, telecommunications, defense, energy, finance, and the environment.[43]

IV. Commercialization Opportunities

Commercialization of quantum computing is already underway across multiple sectors and will be a primary source of future disputes.

Investment in quantum computing

Quantum computing is expected to transform industries that depend on complex modeling, optimization, simulation, and secure communication.[44] As the technology advances from university-led experimental platforms to early commercial readiness, its most immediate impact will be felt in sectors where classical computing faces hard physical limits.[45] The convergence of scientific, industrial, and governmental interest underscores the expectation that quantum capability will alter competitive landscapes and introduce new legal, regulatory, and contractual challenges.[46]

[40] Each approach has its own strengths and challenges. Superconducting systems offer fast operations and have attracted significant investment, but they require extreme cryogenic temperatures and complex control electronics. Neutral-atom platforms can create highly scalable arrays, yet they depend on sophisticated laser systems that add operational complexity. Trapped-ion systems are extremely precise, but their architecture is difficult to scale to large sizes. Photonic qubits are naturally robust and compatible with telecom technologies but generating and controlling individual photons remains challenging. Quantum-dot and spin-based systems promise strong scalability within semiconductor manufacturing, but reliably controlling large numbers of qubits on a chip is still a major technical hurdle.

[41] IBM, Google, Quantinuum Public Roadmaps (2023–2026).

[42] Boston Consulting Group, Commercial Readiness of Quantum Computing (2024).

[43] U.S. National Quantum Initiative Reports (2024–2025).

[44] McKinsey, Quantum Technology Monitor (2024–2025).

[45] Preskill, "Quantum Computing in the NISQ Era," Quantum (2018).

[46] BCG, The Coming Quantum Leap in Industry (2024).

Venture investment continues to grow, with over $1 billion in annual funding backing the wide array of hardware and software companies entering the space.[47] A small number of quantum-focused companies have now entered the public markets, reflecting substantial investor interest in returns from quantum infrastructure investment. Academic research has primed a wide array of quantum hardware and software startups, along with cryogenic-engineering firms, quantum-algorithm developers, quantum-networking platforms, and hybrid systems.[48]

At present, publicly disclosed investment in AI exceeds quantum investing. AI offers more immediate commercial deployment in classical computers, but the gap will undoubtedly narrow as AI spending normalizes and quantum computing moves from R&D to development. AI and quantum computing are complementary, and are expected to converge as quantum hardware matures, with AI-enhanced quantum systems unlocking new capabilities.

Government investment in quantum technologies has already expanded significantly, with publicly disclosed national programs now receiving tens of billions of dollars globally.[49] The United States has allocated several billion dollars under the National Quantum Initiative and related defense and research programs, the European Union's Quantum Flagship program targets roughly €1 billion over ten years, and China is estimated to be investing well over $10 billion through large-scale national laboratories and infrastructure projects, reflecting a broad governmental consensus that quantum computing and quantum technologies are strategically critical for economic competitiveness and national security.[50] Given these national security considerations, there is likely substantially more being invested in classified quantum computing projects.

Key Industry Sectors:

Chemicals and Materials

Quantum simulation represents a transformative leap by providing more accurate modeling of molecular interactions, accelerating breakthroughs in pharmaceuticals, advanced materials, and next-generation battery technologies.[51] Leading collaborations, such as IBM with the Cleveland Clinic, Google with Caltech, and Harvard with Merck, demonstrate that industry and academia are already integrating quantum tools into early-stage research.[52] These partnerships reflect the growing belief that quantum-accelerated discovery will shorten development cycles. These collaborations will generate disputes over IP ownership, milestone definitions, and commercialization rights as the research moves from lab to market.

Life Sciences

Quantum modeling may significantly reduce drug-development timelines, enhance protein-folding predictions, and support precision-medicine applications through more accurate

[47] PitchBook, "Quantum Computing Venture Funding Report" (2024).
[48] QEDC, Industry Landscape Report (2023); MIT, Caltech, Harvard TTO Publications (2020–2025).
[49] OECD, Quantum Technology Policy Overview (2024).
[50] U.S. National Quantum Initiative Act Reports (2023–2025); European Commission, "Quantum Flagship" (2018–2024); Nature, "China's Quantum Investments" (2023).
[51] Reiher et al., "Quantum Chemistry on Quantum Computers," PNAS (2017); IBM Research, "Quantum Chemistry for Industrial Applications" (2022–2024); Nature Chemistry, Quantum Materials Overview (2024).
[52] IBM–Cleveland Clinic; Google–Caltech; Harvard–Merck collaborations (2022–2025); McKinsey, Biopharma and Quantum Computing (2024).

biological simulations.[53] As computational biology becomes increasingly central to innovation, quantum capability may become a defining strategic asset for research institutions and biotechnology companies alike. Quantum-accelerated drug discovery will generate disputes over patent priority, data ownership, and liability for quantum-assisted outputs.

Cybersecurity

The impact on cybersecurity will be profound. Quantum computing poses a threat to our current encryption systems that rely on factoring algorithms and other complex mathematical problems to secure systems.[54] Current public-key encryption algorithms, such as RSA and ECC, which now can only be broken by computers working thousands of years, will be at risk of being hacked within days or hours. Bad actors are reportedly implementing "harvest now, decrypt later" strategies collecting encrypted data now to decrypt when quantum tools become available.[55] To address these threats, post-quantum security (quantum-safe security) solutions which are intended to remain secure against future quantum computers are now being developed.

Quantum also offers the opportunity for security using quantum technologies, such as quantum key distribution (QKD). Governments, telecommunications companies, and critical-infrastructure operators are already testing QKD-enabled networks, anticipating a future in which quantum-resistant security frameworks become essential for national security and commercial continuity.[56] Many of these developments will give rise to complex contractual and regulatory legal disputes.

Finance and Insurance

Financial institutions are exploring quantum algorithms to improve portfolio optimization.[57] For institutions competing in markets driven by microsecond-level dynamics, even incremental quantum improvements may have substantial commercial implications. Failures in quantum-enhanced trading will give rise to liability claims and regulatory claims.

Likewise, in the insurance sector, quantum computing may transform risk modeling and fraud detection, likely generating a variety of claims.[58]

Telecommunications

The telecommunications sector is preparing for quantum computing's impact on both network performance and network security.[59] Quantum-enabled communication protocols, including QKD, may eventually support ultra-secure data channels resistant to interception or decryption. At the same time, quantum-enhanced optimization and simulation tools may improve traffic

[53] Nature Biotechnology, "Quantum Computing in Drug Discovery" (2023); MIT Computational Biology Group Quantum Simulation Reports (2024); McKinsey, Quantum in Life Sciences (2024).
[54] NIST, "The Quantum Threat to Cryptography" (2022–2024).
[55] NSA, "Harvest Now, Decrypt Later Advisory" (2023); ENISA, "Quantum Transition Risk Assessment" (2023).
[56] Gisin, "Quantum Cryptography," Rev. Mod. Phys. (2002); Toshiba QKD Field Trials (2022–2025); ITU, "Quantum Communications Standards Roadmap" (2023–2025).
[57] JPMorgan Chase, Quantum Finance Reports (2021–2024); IBM Institute for Business Value, Quantum Advantage in Finance (2024).
[58] Swiss Re, "Quantum Computing and Emerging Insurance Risks" (2024).
[59] BT, Verizon, SK Telecom quantum-network announcements (2022–2025); IEEE Communications Society, Quantum Network Optimization Papers (2023–2024); NIST PQC Transition Guidelines (2024).

routing, spectrum allocation, and network resource management across increasingly complex global infrastructure. Major carriers and equipment manufacturers are already engaged in early quantum-network pilots, anticipating a future in which quantum-secure communication becomes essential for protecting critical data flows in financial services, defense, and cloud computing. [60] Quantum networking is also emerging as a field enabling improved communications and distribution.

Defense

Quantum computing is poised to reshape the defense sector by enabling computational capabilities far beyond current classical limits, particularly in cryptanalysis, optimization, and sensor fusion. [61] Breakthroughs in quantum algorithms will compel defense systems to accelerate migration to post-quantum cryptographic standards. At the same time, quantum optimization could dramatically improve logistics, targeting, and real-time battlefield decision-support by evaluating vast combinatorial scenarios in parallel. Quantum-enhanced sensing also offers the potential for radar systems with unprecedented resolution, navigation independent of GPS, and detection of stealth aircraft or submarines. Together, these advances promise a step-change in strategic capabilities while triggering a global race to secure quantum advantage.[62] Defense sector quantum contracts, often involving classified specifications and dual use components, will generate disputes that intersect export controls, investment treaty protections, national security concerns.

Aeronautics, Satellites and Space

Quantum computing stands to accelerate the design, simulation, and operation of next-generation aircraft and spacecraft by transforming high-fidelity modeling of materials, aerodynamics, and propulsion systems. [63] Quantum-enhanced sensing and communication architectures promise more secure satellite networks, deep-space navigation without GPS dependence, and improved Earth-observation capabilities.[64] As a result, quantum technologies are increasingly seen as strategic enablers for competitiveness across commercial aviation, space exploration, and defense-aerospace programs.[65]

Logistics and Supply Chain

Industries built on optimization and logistics stand to benefit from quantum approaches capable of addressing problems that scale exponentially. Supply-chain management, air-traffic routing, manufacturing schedules, and transportation networks all involve computational challenges that quickly exceed classical capacity. Quantum algorithms may provide the first practical methods for redefining efficiency standards across global operations. [66] But disputes over

[60] ITU, QKD Integration Reports (2024).
[61] DARPA, "Quantum Sensing Programs Overview" (2023); NSA, "Post-Quantum Cryptography Migration Strategy" (2024); RAND Corporation, Quantum Technologies and Defense Applications (2024); ESA, "Quantum Satellite Communications" (2024).
[62] CSIS, "Quantum Technologies and National Security" (2024).
[63] NASA JPL, Quantum Simulation Reports (2024).
[64] China Micius Satellite Experiments (2017–2024).
[65] BCG, "Quantum in Aerospace & Defense" (2024).
[66] BCG, Logistics and Quantum Optimization (2024); MIT Operations Research Center, Quantum Optimization Papers (2024); IBM Quantum, "Optimization Benchmarks" (2024).

quantum optimization systems that will arise when promised efficiency gains fail to materialize will present novel quantum challenges for arbitral tribunals.

Energy, Climate and Environment

Quantum algorithms may support the oil and gas sector through quantum simulation to improve subsurface modeling and fluid dynamic predictions. It may also lead to the discovery of high-efficiency photovoltaic materials, improved carbon-capture compounds, and catalysts for clean hydrogen production. Quantum optimization may also enhance the management of power grids, renewable-energy integration, and large-scale storage systems.[67]

Quantum computing may also influence climate modeling and environmental technologies, areas where classical computation increasingly confronts insurmountable complexity. Quantum simulation could improve the accuracy of climate models by capturing atmospheric chemistry, ocean dynamics, and long-term feedback cycles that remain computationally prohibitive for classical systems. These applications reflect the emerging view that quantum capability could accelerate innovation in climate mitigation and adaptation, supporting global efforts to transition toward sustainable and resilient energy infrastructures.[68]

In sum, quantum computing will influence many major industries. From optimizing manufacturing processes to simulating climate models, to extending exploration in space, the opportunities for quantum computing and the likelihood of contractual, regulatory, and cross-border disputes are significant. These developments will directly shape how disputes are resolved.

V. Impacts on Arbitration Practice

For arbitration practitioners, the significance of quantum computing is immediate and practical. It introduces disputes involving technologies that most tribunals have never encountered, while simultaneously altering the procedural and evidentiary assumptions on which arbitration depends. This section examines those impacts and identifies the principal ways in which quantum technologies will reshape arbitration practice.

Quantum computing will influence arbitration in two distinct and profound ways. First, it will generate an array of disputes across industries transformed by quantum technologies. Second, it will reshape how arbitration is practiced, managed, and conceptualized. While practitioners are not likely to have quantum computers on their desktops anytime soon, the ripple effects of quantum capabilities will reach every stage of the arbitral process, from case preparation to tribunal deliberations to institutional rulemaking. Accordingly, quantum computing will not simply create new disputes; it will redefine the tools, expectations, and professional standards that shape arbitration itself. Arbitration will be asked to resolve disputes that arise from not only what quantum technologies do, but also from what they make possible.

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[67] Shell & MIT Energy Initiative, Quantum Modeling Research (2023); DOE, “Quantum for Energy Systems” (2024).

[68] Nature Climate, “Quantum Approaches to Climate Modeling” (2024); IPCC, “Emerging Computational Methods for Climate Prediction” (2023).

Ethics and Professional Responsibility

Quantum computing will raise new ethical and professional-responsibility issues that parallel, and likely exceed, those prompted by AI. As quantum-enabled tools emerge, including advanced research platforms, document-review systems, scientific and financial modeling engines, outcome-prediction tools, and settlement analytics, lawyers and arbitrators will require updated standards governing their use. These developments will raise new questions concerning disclosure obligations, confidentiality and privilege, the adequacy of quantum-resilient safeguards, counsel's competence in identifying quantum-related risks, and the reasonableness of relying on quantum-generated models in legal decision-making. The arbitration community will need to define the appropriate boundaries and expectations surrounding these tools. Undoubtedly, national courts and bar associations will contribute their own views.

Expert Evidence and Technical Complexity

Quantum-related disputes will demand expert testimony at a level of technical sophistication rarely encountered in commercial arbitration. As parties present issues concerning novel scientific concepts unfamiliar to most legal practitioners, tribunals will be expected to interpret these concepts with confidence and precision.[69] The effective management of such cases may require early definition of key technical questions, tribunal-appointed experts or advisors, concurrent expert testimony, and strengthened protective measures for proprietary experimental information. Arbitrators with experience in advanced technologies—such as semiconductors, telecommunications, AI, and materials science—will be increasingly sought to navigate this evidence.

Consider for example a dispute over whether a quantum computing vendor's system achieved a contracted fault tolerance threshold. The claimant's expert may argue that qubit coherence degraded below specification under real-world operating conditions; the respondent's expert may contend the threshold measured correctly under standardized protocols. The Tribunal must not only evaluate competing expert methodologies but must determine whether the contractual performance standard was measured with sufficient precision to be enforceable. Thus, the Tribunal's task requires understanding of both technical matters and quantum computing contracting practice. This type of dispute has no close analog in current technology arbitration and illustrates why quantum literacy will be a practical necessity for arbitrators in quantum-related cases.

Confidentiality, Privilege and Evidence Handling

Quantum computing introduces unique challenges for confidentiality, privilege, and evidentiary management. Because future fault-tolerant quantum computers may be capable of decrypting materials protected by today's widely used encryption standards, tribunals will need to consider whether filings, evidence, and deliberations require quantum-resilient protections. Questions will also arise regarding the authenticity of electronically stored information in an era of shifting encryption regimes, the handling of proprietary algorithms and experimental data, and the limits imposed by trade-secret obligations, export-control laws, and national-

[69] Nature, "Complexity of Quantum Experiments" (2023); Google Quantum AI, "Benchmarking Quantum Processors" (2023).

security restrictions. These considerations will shape procedural orders and the tribunal's management of evidence.

As an example, a party submits encrypted communications as evidence in a quantum IP dispute. The opposing party argues the encryption standard, RSA-2048, the standard used for nearly all protected communications today, cannot be presumed secure given the adversary's known access to early quantum decryption tools, and requests an independent forensic review of whether the communications were compromised prior to submission. The Tribunal must consider whether this concern has a sufficient evidentiary basis to warrant review, what standard governs the integrity of electronically stored evidence in a post-quantum security environment, and whether the protective order governing the proceeding must be upgraded. Current practice provides no guidance on any of these questions.

Arbitration Proceedings and Procedural Innovation

The arbitration process itself will evolve as quantum technologies mature. Tribunals may need to adopt quantum-safe communication platforms, enhanced confidentiality protocols, and specialized procedures for handling sensitive quantum-related materials. Regulatory compliance may restrict the movement of evidence across borders or mandate the use of post-quantum cryptographic tools. Arbitrators may encounter situations in which key evidence cannot be transmitted or reviewed due to export-control or classification constraints. Arbitral institutions are likely to update their protocols to address these developments, much as they have done with cybersecurity and AI.

As an example, a Tribunal seated in Paris handling a quantum computing sector joint venture or M&A dispute may find that one party's key technical witnesses are subject to U.S. export control restrictions that prohibit them from discussing certain quantum hardware specifications outside a classified setting. The Tribunal must determine how to conduct examination of those witnesses, whether a Confidentiality Order can adequately substitute for classified environment procedures, and whether an award that necessarily references technical content can be provided given likely enforcement in other jurisdictions. These are not hypothetical concerns; analogous issues have already arisen in defense technology disputes and quantum disputes will intensify them considerably.

Arbitrator Selection and Tribunal Composition

The increasing technical complexity of quantum-related disputes will influence the selection of arbitrators and the composition of tribunals. Parties may prioritize arbitrators with relevant scientific or engineering literacy. Institutions may look to specialized panels for quantum-related disputes, reflecting the recognition that effective adjudication in this field requires deep and evolving technical understanding.[70]

The non-profit Silicon Valley Arbitration and Mediation Center (SVAMC) has already begun addressing this need through its global Tech List of leading technology neutrals. Administering institutions are expected to develop analogous resources focused on their institution-specific panels as quantum disputes mature. The practical question for parties today is whether their standard arbitration clause designating favored institutional rules, seat and governing law are

[70] One such list is being developed through the SVAMC List of the World's Leading Technology Neutrals (the "Tech List"), Quantum Study Group. https://svamc.org

adequate for disputes that may involve quantum performance metrics, post-quantum encryption obligations, or export controlled technical evidence that could not have been anticipated when those clauses were drafted.

Quantum Tools in Advocacy and Case Preparation

As quantum computing advances, lawyers and experts may begin to incorporate quantum-enabled tools into litigation and arbitration practice. These may include quantum-accelerated legal research, quantum-assisted document analysis, enhanced scientific and financial modeling, and predictive tools for case assessment and settlement valuation. The adoption of such tools will raise questions about their reliability, admissibility, fairness, and the extent to which parties must disclose their use, mirroring the discussion surrounding the use and disclosure of AI in proceedings today.[71]

Cross-Border Constraints and Jurisdictional Issues

Quantum disputes often involve components, data, and hardware subject to stringent export controls, national-security requirements, and data-localization mandates. Arbitrators may encounter evidence that cannot be transported or reviewed outside specific jurisdictions, witnesses constrained by security-clearance obligations, or conflicting national laws governing disclosure. These factors may influence the selection of the seat, the conduct of hearings, the tribunal's procedural orders, and the types of relief that may be granted.

These constraints may also influence how arbitral institutions and tribunals design procedures for technology-related disputes. Cases involving quantum technologies may require specialized confidentiality frameworks, data-localization safeguards, and protective orders addressing export-controlled technical information. Tribunals may also confront situations in which critical evidence cannot be freely transmitted across borders because it relates to sensitive quantum research or national-security technologies.

Practitioner Implications

Quantum computing will reshape arbitration practice in ways that both parallel and meaningfully exceed the transformation brought about by AI. The parallels are real: like AI, quantum computing will generate questions about disclosure obligations, technical competence, the admissibility of machine-generated analysis, and the reliability of outputs that practitioners and tribunals cannot independently verify. But quantum computing's impacts go further in two respects. First, unlike AI, which operates as a tool within arbitration proceedings, quantum computing will transform the industries and infrastructure that generate the disputes themselves, producing a new category of subject-matter complexity without precedent in commercial arbitration. Second, quantum capabilities will directly threaten the integrity of the communications and encryption systems that arbitration proceedings depend on, requiring the field to adapt its own procedural and security infrastructure in ways that AI has not demanded.

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[71] SVAMC Guidelines on the Use of AI in International Arbitration (2024); CIArb Guidelines on the use of AI in Arbitration (2025).

Lawyers will need fluency in quantum-related risk assessment, cybersecurity compliance, technology contracting, intellectual-property strategy, cross-border data governance, and regulatory requirements. Corporate counsel will evaluate quantum-readiness strategies, negotiate quantum-specific warranties, and advise boards on emerging liabilities. Regulators will intensify oversight of quantum exports, cryptographic standards, and national-security implications. For arbitration practitioners, quantum-era disputes will combine high-stakes commercial claims with highly technical scientific and engineering evidence. Arbitrators and counsel who develop skill sets with respect to the legal issues relating to quantum technologies will play an essential role in resolving these disputes.

Taken together, these developments demonstrate that quantum computing will not only generate new categories of disputes but will require arbitration itself to adapt in structure, procedure, and professional expectations.

VI. Legal Impacts

Where the prior section addresses how arbitration practice will evolve, this section examines the broader categories of disputes quantum technologies are likely to generate.

Quantum computing represents a generational technological shift, one that may reshape the legal landscape more profoundly than the Internet or AI. While the Internet and AI extend the analytical capacity of classical computers, quantum computing introduces an entirely different computational paradigm. It promises to solve categories of problems that classical computers cannot address and to transform industries dependent on simulation, optimization, secure communication, and high-complexity modeling.[72] These shifts will, in turn, reshape legal obligations, regulatory structures, commercial relationships, and dispute-resolution processes worldwide.[73]

These impacts span a wide range of dispute categories: university and government research collaborations, private and public company investment, cybersecurity, commercial contracts, business torts, intellectual property, supply chains, regulatory compliance, real estate and environmental matters, employment and international security.

University Research

Quantum computing is already generating significant transactional activity in academic and national-laboratory settings.[74] Universities and government research institutes are entering into complex collaborations with technology companies, often involving jointly developed systems, shared data, and novel hardware components. These arrangements raise numerous legal issues, including inventorship, allocation of intellectual property rights, ownership of improvements and derivative technologies, publication timing, confidentiality, export controls, and competing claims of technical priority. As the science advances and research partnerships become more ambitious, disputes are emerging over data rights, contribution credits, and commercialization pathways, particularly when multiple institutions or cross-border teams are involved.

[72] Preskill, "Quantum Computing and the Quantum Frontier," Quantum (2018).
[73] Nature, "Quantum Advantage and Industrial Impact" (2023).
[74] OECD, Quantum Policy Outlook (2024); NSF, "Quantum Research Collaborations" (2023); DOE National Labs, Quantum Partnership Releases (2022–2025).

Private and Public Company Investment

Venture investment in quantum computing has accelerated sharply as companies pursue capital-intensive scaling of hardware and software platforms.[75] Investors are negotiating agreements tied to aggressive technical milestones, valuation methodologies based on uncertain scientific timelines, and rights associated with future intellectual property portfolios. For both private and publicly held companies, these pressures create significant potential for disputes when technical progress slows, when milestones prove unrealistic, or when founders and investors disagree over proprietary contributions, disclosures, or governance. The high cost of development, combined with uncertain timelines to profitability, makes the quantum sector especially prone to conflicts involving fiduciary duties, representations and warranties, and exit strategies.

Government Contracting

Government contracting is becoming an increasingly significant driver of quantum development as national security agencies and federal research programs prioritize strategic quantum capabilities.[76] These contracts often contain detailed performance specifications, cybersecurity and data-protection requirements, export-control obligations, and extensive compliance frameworks. Disputes can arise when deliverables fall short, when representations about capabilities or timelines are challenged, or when partners fail to meet technical, reporting, or security obligations. Because many of these programs involve sensitive or classified work, disputes are likely to carry heightened commercial, political, and cross-border implications.

Cybersecurity

As noted, cybersecurity presents the most immediate and widely recognized legal risk associated with quantum computing. Future fault-tolerant quantum machines will be capable of breaking many widely used security algorithms.[77]

This threat affects confidential communications, proprietary business records, regulatory filings, personal data, and cross-border evidence. It will give rise to claims involving negligence, breach of confidentiality, failure to safeguard protected information, data-protection violations, and regulatory noncompliance. Disputes will turn on whether companies acted reasonably in transitioning to post-quantum cybersecurity standards. Governments are already signaling expectations through emerging guidance in the United States, the European Union, Singapore, Japan, and elsewhere.[78] In 2024, the U.S. NIST issued three post-quantum cryptography standards, establishing the first technical framework for quantum resistant encryption.[79] As these standards evolve, companies will face a rising wave of cybersecurity-related claims tied directly to the quantum transition. These claims, particularly those with cross-border data implications, are likely to be resolved in international arbitration.

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[75] PitchBook, "Quantum Investment Data" (2024); BCG, Scaling Quantum Startups (2024).
[76] DARPA, "Quantum Programs Overview" (2023); U.S. GAO, "Federal Quantum Contracts Review" (2024).
[77] NIST PQC Standards Development (2022–2025); NSA, "Quantum Threat Advisory" (2023).
[78] IAPP, "Quantum Cybersecurity Liability" (2024); CISA, "Migration to Post-Quantum Cryptography" (2024).
[79] NIST, Post-Quantum Cryptography Standards: FIPS 203, 204, and 205 (August 2024); NSA, "CNSA 2.0 Compliance Deadlines for National Security Systems" (2024-2025).

Commercial contracts

Commercial contracting will undergo a fundamental transformation as quantum technology enters the marketplace.[80] Early quantum systems differ substantially from traditional information-technology products, and their performance will depend on coherence times, error rates, cryogenic stability, laser control, noise profiles, and the integration between classical and quantum hardware.[81] These characteristics introduce variability not familiar in conventional IT contracting.

As a result, commercial contracts involving quantum systems will increasingly incorporate technical performance criteria such as minimum coherence thresholds, error-rate guarantees, reliability metrics for hybrid classical-quantum workflows, and requirements for error-correction capability. They will also contain obligations relating to uptime, environmental stability, cybersecurity safeguards, data-protection requirements, and compliance with export-control regulations governing quantum technologies. Disputes will naturally arise as early systems fail to meet ambitious performance expectations or when representations about qubit count, algorithmic reliability, or system readiness prove inaccurate.

Collaboration and corporate transactions, such as licensing, joint ventures, mergers and acquisitions, will likely give rise to disputes as companies sort out their business obligations in the space. Transactions may trigger antitrust and competition disputes involving access to proprietary quantum systems, interoperability, participation in emerging standards-setting. As quantum systems move into commercial deployment, insurance claims and coverage disputes are also expected to increase, particularly where quantum-related failures, cybersecurity breaches, or missed performance commitments give rise to conflicts under cyber-risk, liability, or directors-and-officers insurance policies.

Business torts

As with AI, quantum computing will usher in a new generation of business disputes ranging from product and services liability for incorrect or harmful outputs in areas including drug discovery, financial trading strategies, credit scoring, and logistical support, as well as negligence claims against parties accused of misuse or overreliance on quantum models.[82] Duty of care claims may also arise against companies that fail to deploy quantum decision tools.

Intellectual property

As the quantum industry expands, intellectual property will become one of the most active areas of legal conflict.[83] Quantum-related innovation touches virtually every layer of the technology stack, including qubit architectures, fabrication techniques, cryogenic engineering, error-correction protocols, quantum algorithms, classical-quantum orchestration tools, and quantum-networking infrastructure.[84] Disputes will arise over inventorship, improvement

[80] Gartner, "Quantum in the Enterprise" (2025).
[81] Nature Electronics, "Quantum Device Variability" (2024); IEEE Spectrum, "Quantum Hardware Stability" (2023).
[82] Nature Medicine, "Quantum Tools in Drug Discovery" (2024); McKinsey, Quantum in Financial Services (2024); Harvard Business Review, "Decision-Making Tools in the Quantum Era" (20
[83] WIPO, Quantum Patent Landscape (2023).
[84] Nature Reviews Materials, "Quantum Hardware Innovation" (2024).

rights, ownership of derivative works, the scope of licensing rights, and royalty structures. Trade-secret cases can be expected to involve source code, hardware designs, and experimental data.

Supply chain disputes

Quantum hardware depends on components sourced from a small, highly specialized global supply chain, including cryogenic systems, superconducting materials, precision lasers, vacuum chambers, photonic modules, isotopically purified silicon, and nanofabricated chips.[85] Many of these components require long manufacturing lead times and are subject to geopolitical controls. Delays in fabrication, defects in key components, shortages of exotic materials, or incompatibilities in system integration will trigger commercial disputes across multiple jurisdictions. As companies move from prototype development to commercial deployment, contractual disagreements will arise concerning delivery timelines, performance milestones, integration obligations, and risk allocation. As quantum computing is adopted across more industries, supply chain disputes will increase.

Regulatory Oversight

Regulatory oversight of quantum computing is already emerging as a significant source of future legal disputes as governments begin to impose controls on quantum hardware, algorithms, cryptographic standards, and cross-border data flows.[86] National security agencies and export-control authorities are treating quantum technologies as strategic assets, subjecting components such as cryogenic systems, photonic modules, superconducting materials, and quantum-networking technologies to increasingly stringent licensing requirements. In 2024, the U.S. Department of Commerce published an Interim Final Rule imposing specific performance-based export controls on quantum computers, components, software and key manufacturing materials.[87]

As regulators define quantum-safe cryptographic mandates and impose deadlines for migration to post-quantum standards, companies may face enforcement actions or private claims alleging noncompliance, inadequate risk management, or failure to adopt reasonable security practices.

Regulatory disputes will also arise over conflicting export-control rules, especially when multinational companies operate laboratories or supply chains across jurisdictions. Quantum-enabled sensing and communication systems interface with telecommunications law, privacy regulations, and critical-infrastructure protections, raising novel compliance challenges.[88]

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[85] QEDC, Quantum Supply Chain Report (2024); U.S.–EU TTC Joint Quantum Export Controls (2024); BCG, “Commercializing Quantum Hardware” (2024).

[86] Deloitte, Industry Quantum Readiness (2024); OECD, Quantum Regulatory Tracker (2025); BIS ECCN Updates on Quantum Technology (2024); NIST PQC Mandate Planning (2024).

[87] U.S. Dept. of Commerce, Bureau of Industry and Security, Interim Final Rule on Quantum Computing Export Controls, 89 Fed. Reg. (Sept. 2024).

[88] ITU, Quantum Communications Regulation (2024).

In the European Union, the European Commission is expected to establish a formal Quantum Act in 2026 which would establish a binding legislative framework governing the development, deployment, and security of quantum technologies across member states.[89]

As nations expand quantum-related export controls, conflicts between regulatory regimes are likely to emerge, creating direct friction for multinational development and supply-chain operations. These regulatory tensions may increasingly spill into international dispute resolution. Foreign investors involved in quantum research facilities, semiconductor fabrication, cryogenic manufacturing, or quantum-network telecommunications infrastructure may challenge regulatory measures that restrict investment participation, technology transfer, or cross-border collaboration.

As quantum capabilities become more strategically sensitive, tribunals in investment arbitration may face disputes involving export restrictions, national-security reviews, or state intervention in technology and telecommunications markets. Such disputes will require tribunals to reconcile investment protections with evolving doctrines of national security and technological sovereignty.

Real Estate, Environment, and Land Use

Quantum computing requires specialized facilities, depending on the implementation, from cryogenic labs to magnetically shielded rooms to secure data centers. AI has already generated tremendous space and energy infrastructure demands; quantum computing will be expected to continue the trend giving rise to disputes involving siting, leasing, environmental review, permitting and community impact.[90]

Employment and Workforce

We have already seen significant workplace transformation as a result of the implementation of AI. AI's workplace disruption has been concentrated in roles involving information processing, document analysis, coding, research, and customer interaction, areas where AI can replicate human cognitive tasks. Quantum computing's workforce impacts will likely be different; rather than automating existing roles, quantum computing will likely create entirely new technical disciplines involving quantum computers while also disrupting roles in industries transformed by quantum capabilities, such as in pharmaceuticals, finance, and defense.[91]

International Security and Treaties

As states increasingly treat quantum technologies as strategic assets, national restrictions on investment, export, data flows, and technology transfer will begin to intersect with investment treaties and defense cooperation agreements.[92] Measures taken for national security—such as licensing denials, investment blocks, or technology-transfer limitations—may trigger claims of

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[89] EU Quantum Act – Forthcoming Proposal (expected 2026); CMS Law, "Securing Europe's Digital Future: The EU's Strategy for Quantum Technologies and Post-Quantum Cryptography" (2025).

[90] MIT.nano, "Facilities for Quantum Research" (2023); IEA, "Energy Demand of Advanced Computing" (2024); EPA, "Facility Siting and High-Energy Labs" (2024).

[91] World Economic Forum, "Future of Jobs: Quantum Technologies" (2024); PwC, "Workforce Impacts of Quantum Computing" (2024); ILO Emerging Tech Report (2024).

[92] UNCTAD, "Investment Treaties and Emerging Technologies" (2024); ICSID Review, "National Security and Investment Arbitration" (2023).

expropriation, unfair or discriminatory treatment, or breach of state-contractor obligations. These disputes are likely to arise in investor–state arbitrations, where tribunals will be asked to balance commercial expectations against evolving public-policy and security considerations in the quantum era.

VII. Conclusion

Artificial intelligence has already reshaped the practice of law, and its impact will continue to be substantial. Yet quantum computing represents a more profound technological transition.

The distinction deserves emphasis. AI and quantum computing are not simply successive waves of the same phenomenon. AI improves the analytical capacity of existing classical computing systems; it makes lawyers, researchers, and analysts more efficient within an unchanged computational paradigm. Quantum computing replaces the paradigm itself. It is not a faster version of what we have: it is a different form of computation, grounded in physics rather than binary logic, capable of solving problems that no classical system running any AI software could address. It introduces a new computational architecture capable of addressing categories of scientific, industrial, and economic problems that current systems simply cannot resolve.

Quantum computing will transform the underlying industries from which legal disputes arise even more dramatically than AI. It will influence the development of new medicines and materials, alter the security assumptions that underpin global communications, reshape the financial models that drive capital markets, and redefine the form and function of critical infrastructure. As those transformations unfold, they will generate disputes that are more complex and more consequential than those produced by any prior wave of innovation.

The legal profession's challenge is to understand not only each technology on its own terms, but how their convergence will reshape the disputes, the evidence, the tools, and the professional standards that define international arbitration in the decades ahead.

Quantum computing is advancing at a remarkable pace. Milestones reached within the past year indicate that quantum computing is moving beyond long-term aspiration and into the early stages of practical realization. Quantum systems with ever-larger numbers of controllable qubits are transitioning from laboratory prototypes into early commercial and cloud-based offerings. Governments, multinational companies, and investors are committing substantial capital to quantum infrastructure and post-quantum cybersecurity as they prepare for what comes next.

Although the full commercial viability of quantum computing, and the dramatic changes it promises, remain years away, the trajectory of recent progress makes clear that quantum computing is becoming a reality with immediate commercial and legal implications. As AI continues to reshape global industry, quantum computing will profoundly redefine the scope of that transformation by expanding the very limits of what can be computed, modeled, and secured. Quantum computing will generate a new class of complex, cross-border disputes grounded in technologies without precedent.

International arbitration is well positioned to address the disputes that will emerge as quantum technologies advance. Its global reach, procedural flexibility, and demonstrated capacity to manage technically complex matters align with the cross-border and high-stakes nature of quantum development. But the field will need to look ahead. Arbitration practice must adapt to address new forms of risk, heightened evidentiary demands, and evolving expectations of confidentiality and technical literacy as quantum systems develop.

Although the precise trajectory of quantum computing remains uncertain, its significance and implications for dispute resolution are not. As quantum technologies reshape global commerce, infrastructure, and security, arbitration will be the focal point for resolving the disputes that follow. To meet that role, arbitration must evolve, adapting to new risks, more complex evidence, and heightened demands for technical literacy. In doing so, arbitration will not merely respond to the quantum era; it will define it.