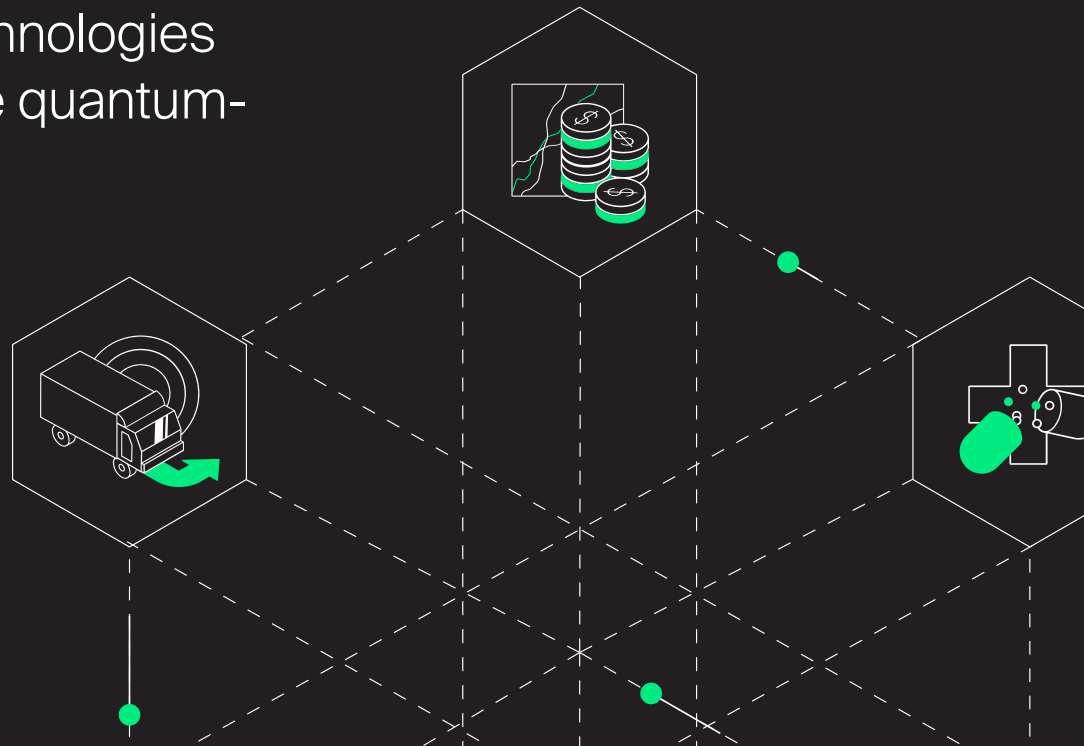
ZAPATA

The First Annual Report on **Enterprise Quantum Computing Adoption**

Quantum computing moves from the fringes to the short list of transformational technologies as early adopters expect to become quantum-capable in the next two years.

December 2021



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Executive Summary and Key Findings

Executive Summary and Key Findings

Early enterprise adopters of quantum computing are moving past the exploration stage, building the applications and teams they will need to leverage quantum technology and gain a competitive advantage. Following close behind, other enterprises acknowledge they must address quantum's promise to disrupt — and are beginning to take concrete steps to investigate exactly where it can impact their businesses.

All organizations believe it is still too early to tell which technology platforms will be the ultimate winners, and are concerned about being locked in with the wrong partners. For more insight on how far along organizations are in their adoption of quantum computing and the challenges they're facing, in December 2021 Zapata Computing commissioned a survey of 300 leaders at large global enterprises (CIOs, CTOs and other VP-level and above executives) with estimated 2021 revenues of over USD $250 million, and estimated computing budgets over $1M.

The results paint a clear picture of the momentum in the market, but draw a line between those enterprises playing to win now, and those that don't yet have a clear approach for taking advantage of quantum computing.

Below are the top 10 takeaways from this report:

1. Quantum Has Moved From the Enterprise Fringes to the Core of the Analytics Agenda

- The quantum naysayers are now a minority. 74% of enterprise leaders agree that "those who fail to adopt quantum computing solutions will fall behind."
- Quantum is now moving beyond the planning stage. 69% of enterprises across the globe reveal they have adopted or are planning to adopt quantum computing in the next year. Those who have already adopted in some form are close to one-third of the market at 29%.
- US respondents led in quantum adoption, followed closely by Canada and China. However, given the small sample sizes from several countries, our global data may not line up with other reports.

2. Early Quantum Adopters Set the Stage for Their Peers Across the Globe

- Enterprises leading in quantum adoption are setting the example for the rest of the market — they are already on the way to an advantage, with 12% of early and advanced quantum adopters expecting to achieve some form of competitive advantage within the next year; and 41% expecting some form of competitive advantage within two years. The long-held belief that quantum is years — if not decades — away, is no more.
    - American companies report being the closest to a quantum competitive advantage, with 12% of enterprises that have started on the path to quantum adoption expecting to achieve an advantage within one year, if they haven't already.
    - Germany is the most bullish on achieving competitive advantage with quantum within two years, with 44% of German respondents predicting an advantage within two years, followed by Canada at 38%, the UK and Australia at 33% each, and the US at 31%.

- The driving motivator behind quantum's adoption is that quantum is poised to deliver better business performance and results, according to 60% of those who are already investing in quantum or are planning to in the next year.

3. Lessons Learned From Those Furthest Along in Quantum Adoption

- The most advanced quantum adopters are 70% more likely than all enterprise leaders to invest in quantum for workforce development.
- The most advanced quantum adopters and those who are investing more than $1 million are more motivated by their first-mover advantage compared to the rest. Those already investing over $1M in quantum are also 50% more likely to do it to block intellectual property (IP) than anyone else. Given the mosaic of early technology adopters among the global sample (44% vs. those adopting with the majority or later at 56%), quantum is indeed becoming the new competitive weapon within the enterprise tech arsenal.

4. Machine Learning Paves the Quantum Way in the Near Term, Especially in the US.

- Machine learning (ML) and data analytics problems are the top use cases for early and more advanced adopters of quantum computing, particularly in the US, where 71% of enterprises are investing in ML and data analytics problems compared to 51% worldwide. This is intuitive because enterprises already have ML talent, algorithms and applications in place. Machine learning is also the most likely use case to deliver near-term value for businesses because areas where classical ML struggles — such as generative models in unsupervised and semi-supervised learning for augmenting datasets in predictive models — are better suited for quantum devices.

5. Quantum Investments Are Getting Serious

- 28% of global enterprises on the path to quantum adoption are investing more than $1 million in quantum computing. This is a turning point from the ~$100K R&D budgets of the past.
- The early adopters of technology more broadly are investing the most in quantum computing. 37% of early tech adopters have quantum budgets over $1M, vs. 13% for late tech adopters.

6. Quantum is a Trusted Team Sport

- A whopping 96% agree that their organization could not successfully adopt quantum computing without the help of a trusted technology partner.
- When choosing an outside partner, enterprises look first and foremost at forward compatibility of the partner's solutions at 48%, followed by ease of use of solutions at 42%, and ease of solution integration at 41%.
- Published research was rated as fourth at 38%, indicating that quantum is moving beyond the academic realm and into practical enterprise reality.

7. What Are the Most Advanced Quantum Adopters Doing to Prepare?

- Quantum-adopting enterprises are preparing on multiple fronts: 51% are identifying talent/building an internal team; 49% are experimenting and

building proofs of concept; 48% are running experiments on quantum hardware or simulators, and 46% are building new applications.

8. Vendor Love and Vendor Jitters: Vendor Lock-in Is the Biggest Concern

- Enterprises want to have their cake and eat it too: while almost all (96%) say they need help from a trusted vendor to succeed in their quantum initiatives, 73% are concerned about vendor lock-in. Another 39% cited vendor lock-in concerns as a hurdle to adoption.
- The most advanced quantum adopters are also much more likely to be concerned about vendor lock-in, with 92% concerned compared to the 73% concerned among all quantum adopting organizations. These organizations don't want to lose flexibility — since quantum is not general-purpose (much like bare metal vs. branded servers vs. HPC), they don't want to be locked into a proprietary methodology or solution.

9. Complexity Is the Greatest Barrier to Quantum Adoption

- The biggest hurdle to quantum adoption is the complexity of integrating quantum computing with the existing enterprise IT stack, a hurdle shared by 49% of respondents.
- The complexity of quantum computing is undeniable, and enterprise IT architectures were already complex. Yet, early and more advanced quantum adopters are working through these complexities, mostly with the help of outside vendors. Managing this complexity calls for new workflows to orchestrate the intersection of new quantum and existing classical components.

10. Quantum Computing Still Ain't Easy to Explain

- 96% of respondents would need more than 10 minutes to explain quantum computing to a friend at a party.

Detailed **Findings**

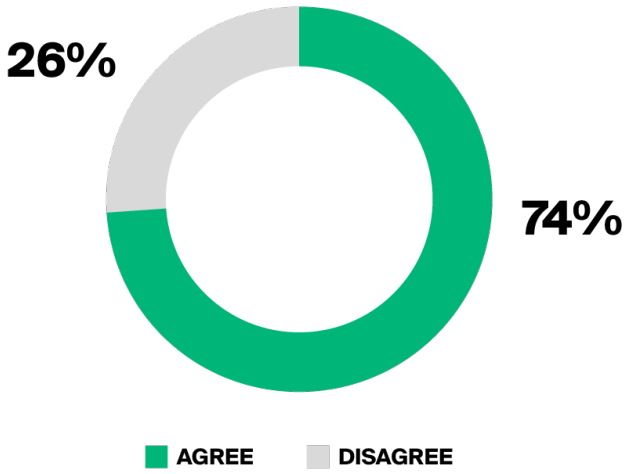
Detailed Findings

1. Quantum Perceptions and Adoption

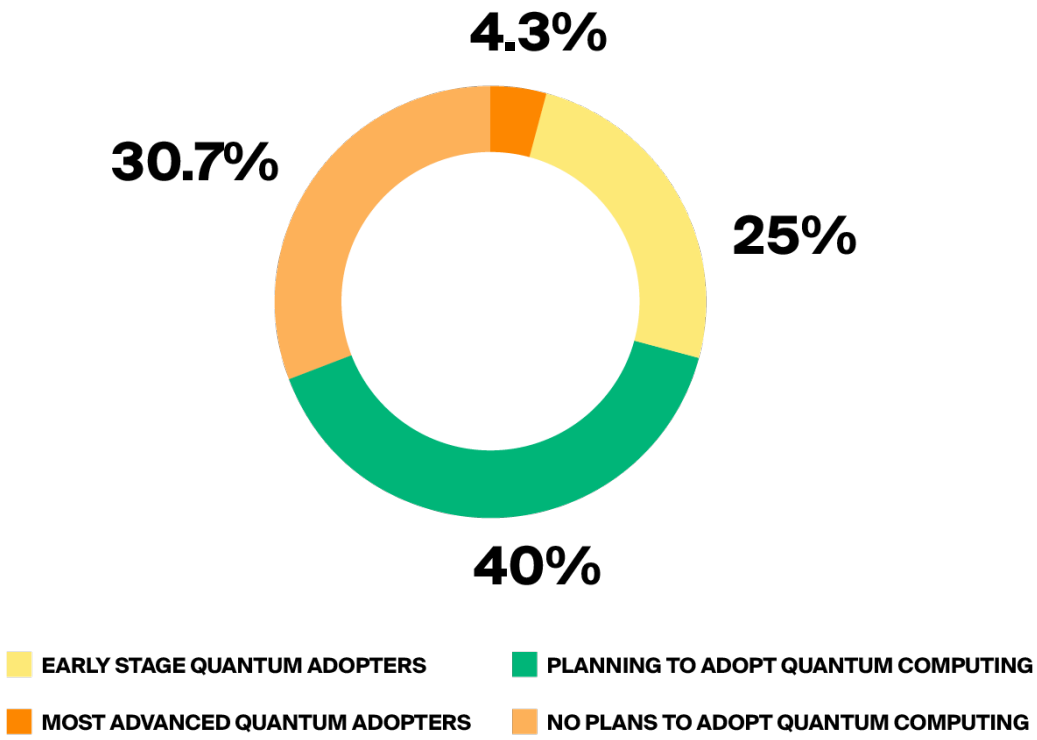
74% of respondents agree that those who fail to adopt quantum computing solutions will fall behind.

These results suggest that we are past the point of speculation on the value of quantum computing to gain business advantage. It's no longer a matter of **if** quantum will provide an advantage, but **when.** Those skeptical about quantum's near-term potential are now in the minority. Enterprises cannot afford to stand on the sidelines if they want an advantage over their competitors.

Agree or disagree with the following statement?
"Organizations that fail to adopt quantum computing will fall behind others."

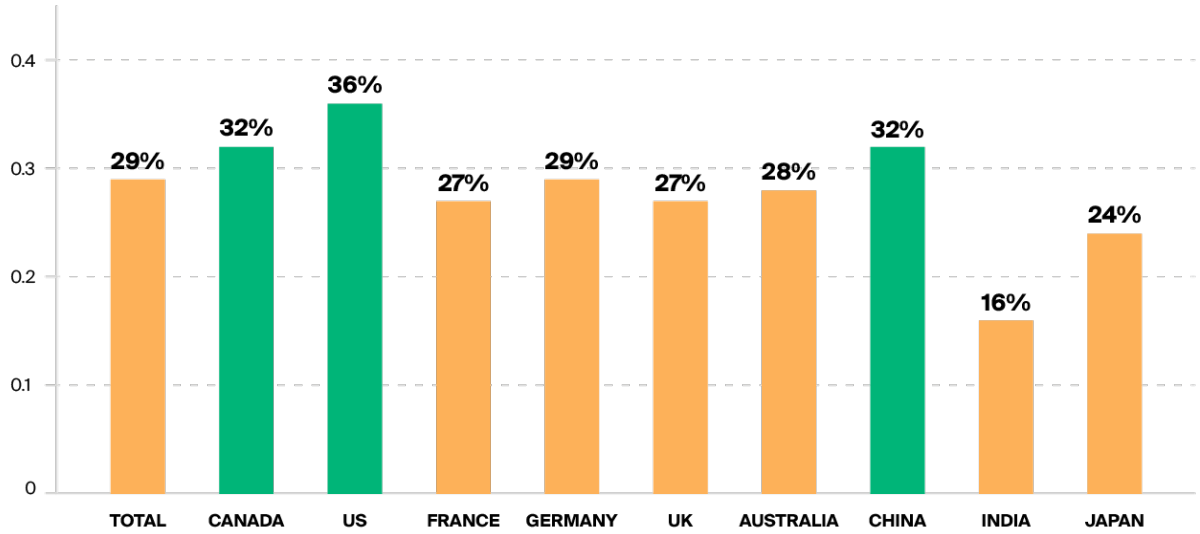


Quantum Adoption in the Enterprise Globally



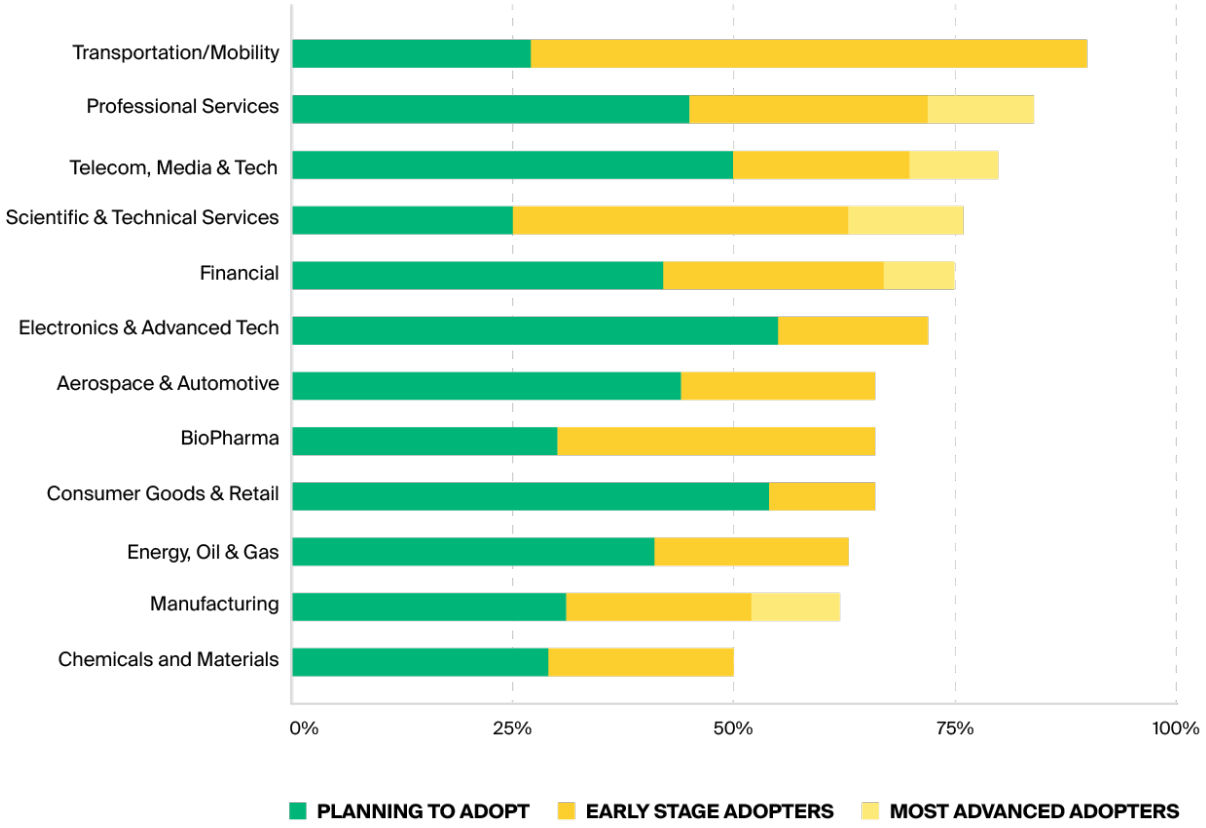
Quantum is moving past the planning stage. Worldwide, 29% of enterprises are already in the early or more advanced stages of quantum adoption, with another 40% to follow in the next year.

Quantum Adoption by Country



The US is the global leader in quantum adoption, with 36% of organizations in the early or more advanced stages of adoption. Chinese and Canadian enterprises are close behind at 32%.

Quantum Adoption by Industry



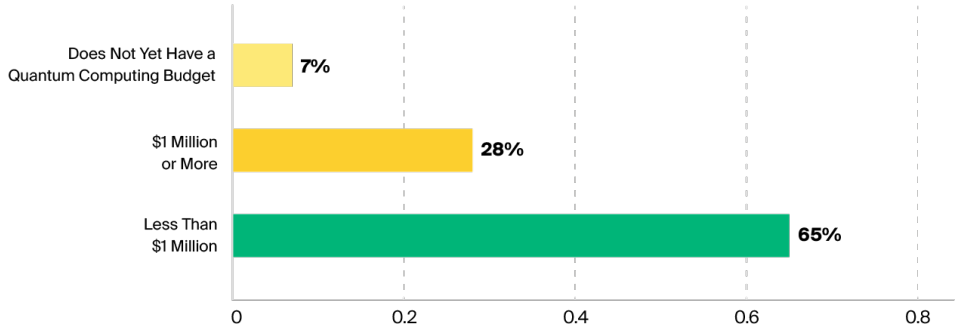
The transportation industry has taken the lead in plans to adopt quantum computing. This is likely a response to the ongoing supply chain crisis, as quantum computing has the potential to optimize logistics networks to dramatically reduce costs and increase efficiency.

The transportation industry also has the greatest proportion of early-stage adopters within the industry (63%), followed by scientific and technical services (38%) and BioPharma (36%), where quantum has the potential to accelerate drug discovery.

The professional services industry has the most advanced adopters (24%), followed by science and technical services (13%); telecom, media and tech (10%); manufacturing (10%) and finance (8%).

2. Investments in Quantum Capabilities

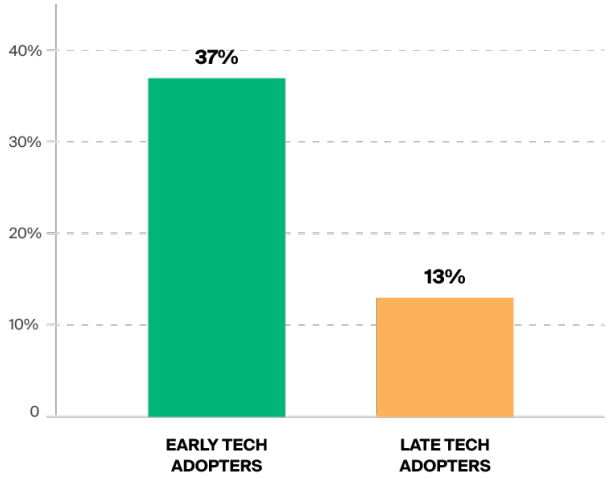
Quantum computing budgets among organizations that have started adopting or plan to adopt quantum computing



28% of Global Enterprises on the Path to Quantum Adoption Are Investing More Than $1 Million in Quantum Computing

Organizations are ramping up their quantum investments significantly beyond the ~$100K R&D budgets of the past, representing a turning point in adoption.

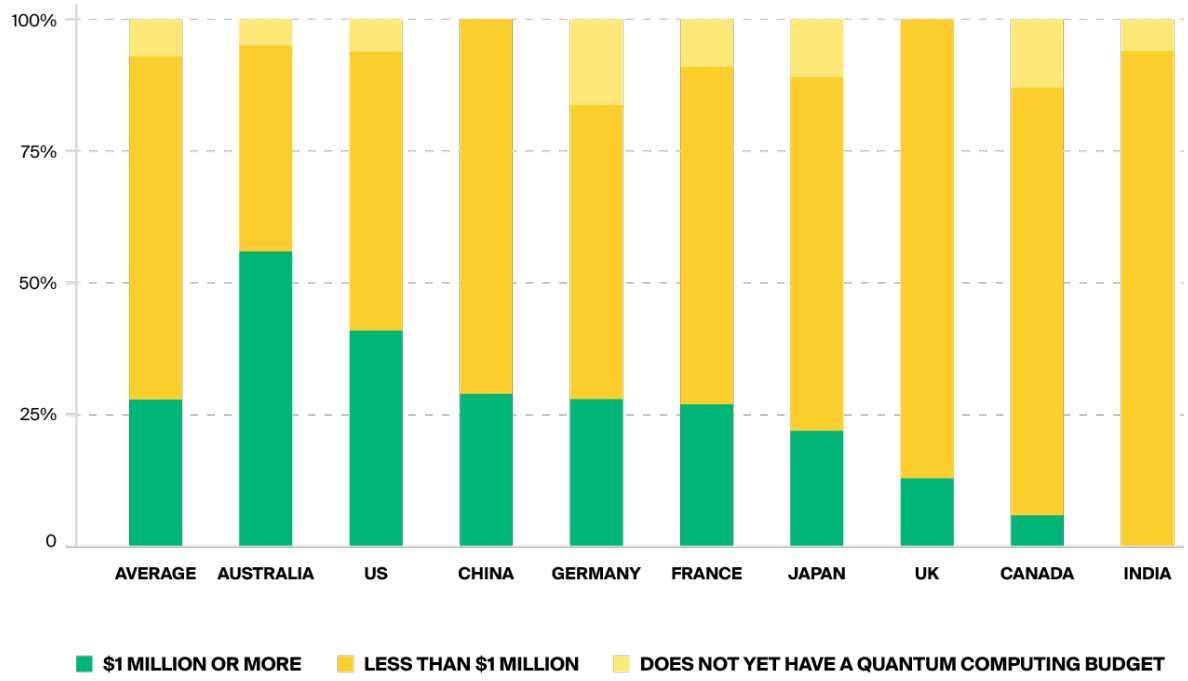
Percentage of organizations with quantum budgetsover $1 million: Early tech adopters vs Late tech adopters



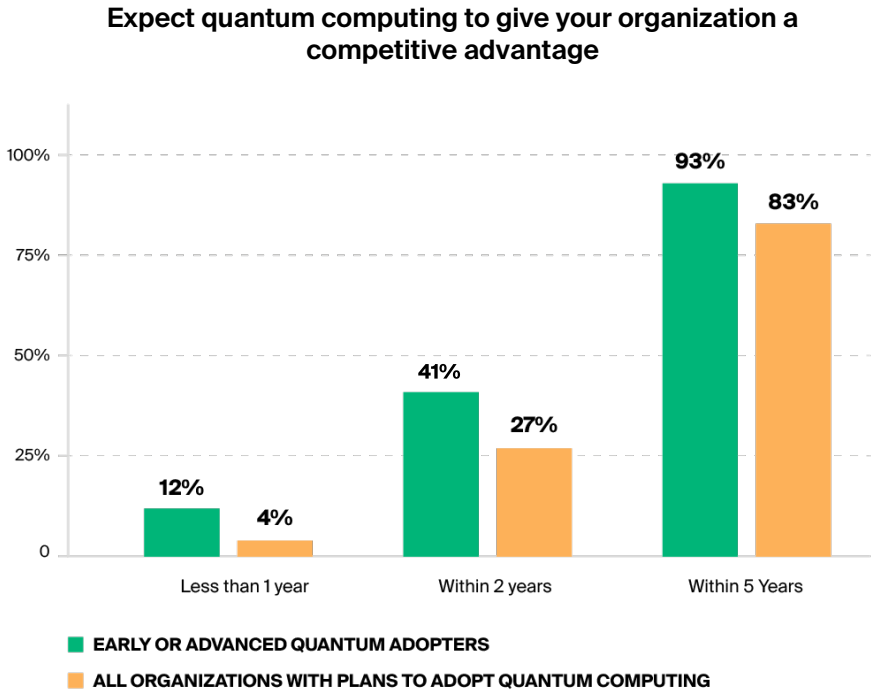
Organizations that are generally the earliest adopters of new technologies are more than twice as likely to invest more than $1 million in quantum computing than their late adopter peers.

Australian and American Enterprise Respondents Lead in Quantum Investments[1]

1. Among organizations that have adopted or have plans to adopt quantum computing.



3. Timeline to a Quantum Competitive Advantage

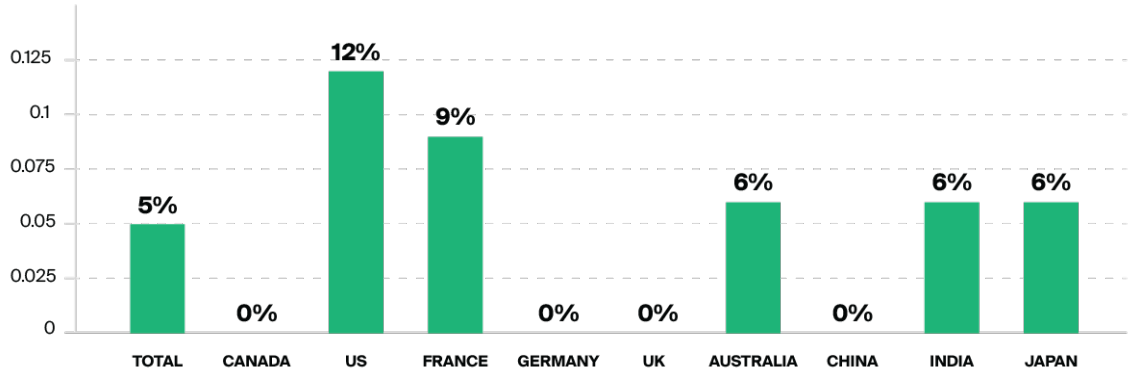


12% of Quantum Adopters Expect to Gain a Competitive Advantage Within One Year

41% of organizations that have started adopting quantum computing expect to gain a competitive advantage within two years, 93% say within five years.

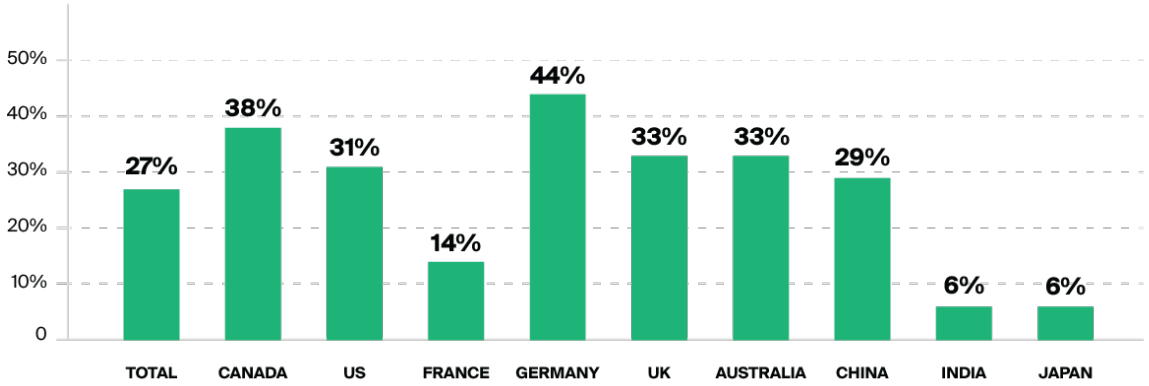
As the top tenth percentile of enterprises achieve an expected competitive advantage over the next year, the pressure will be on for others to follow. Quantum adoption will be analogous to that of AI, but perhaps with a longer path to ROI and with a more limited talent pool. The technology's usefulness to the enterprise is expected to accelerate exponentially, so any work done now to learn and apply quantum or quantum-inspired (classical) methods could have an immense impact later. Enterprises that haven't already started should make it a top priority in 2022 — or risk falling behind.

Many companies expect competitive advantage in less than a year or have already achieved an advantage



American companies report being the closest to a quantum competitive advantage, with 12% of enterprises that have started on the path to quantum adoption expecting to achieve an advantage within one year, if they haven't already. However, only the future will tell who will get ahead of the global quantum race within a year.

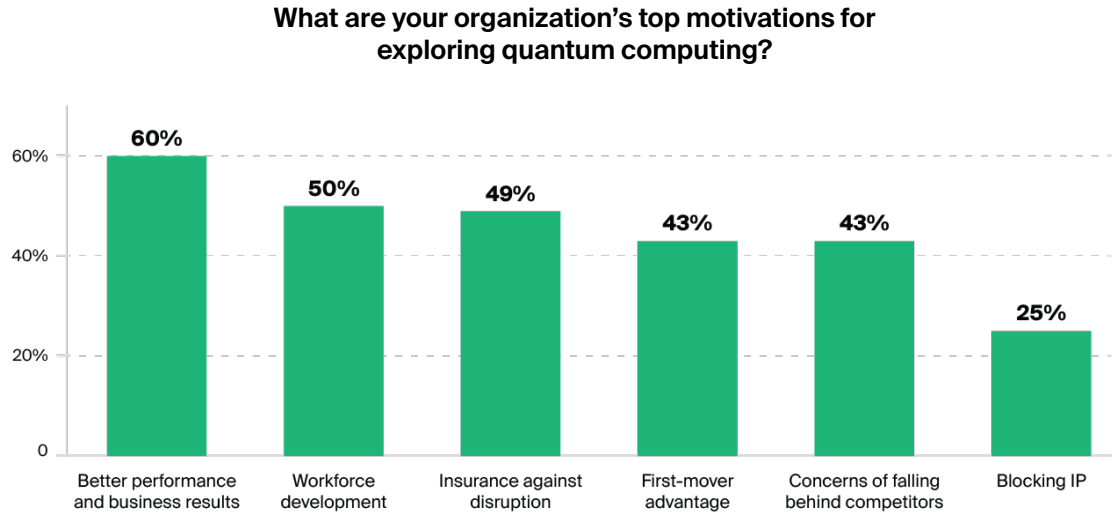
Expect to have a competitive advantage within next 2 years



When you extend the timeframe to two years, German companies are the most bullish about a near-term quantum advantage.

4. Why Quantum: Benefits and Motivators

Quantum Adoption Is Primarily Motivated by Better Business Results

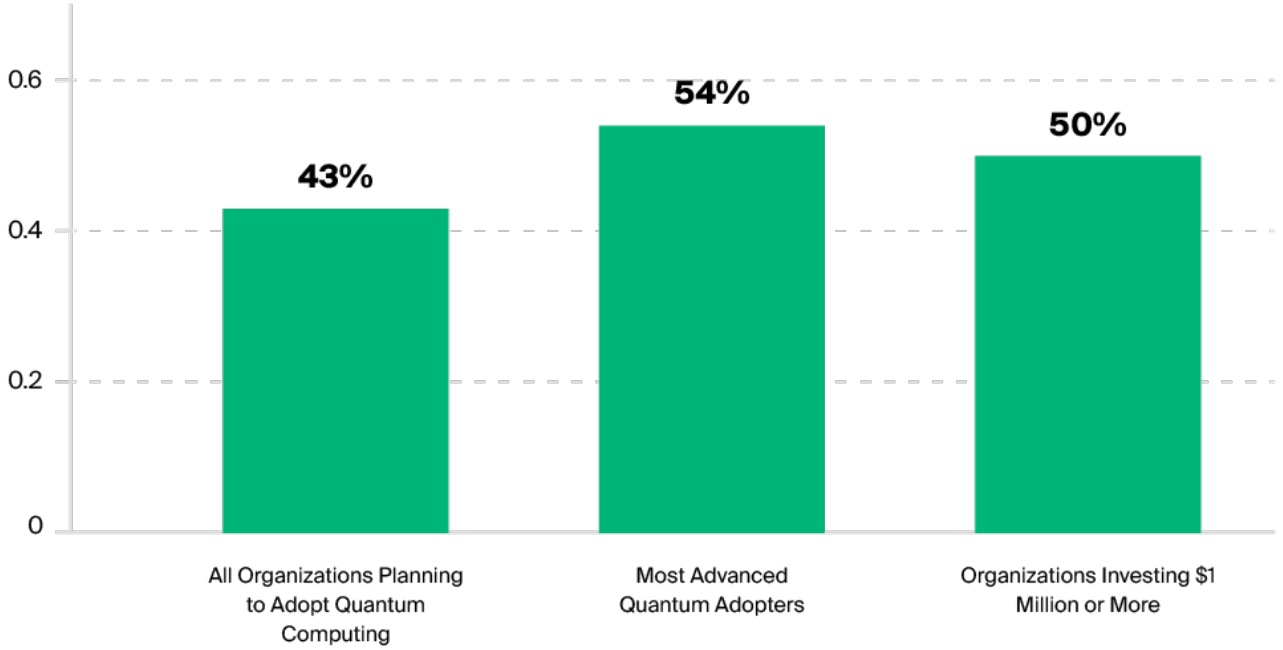


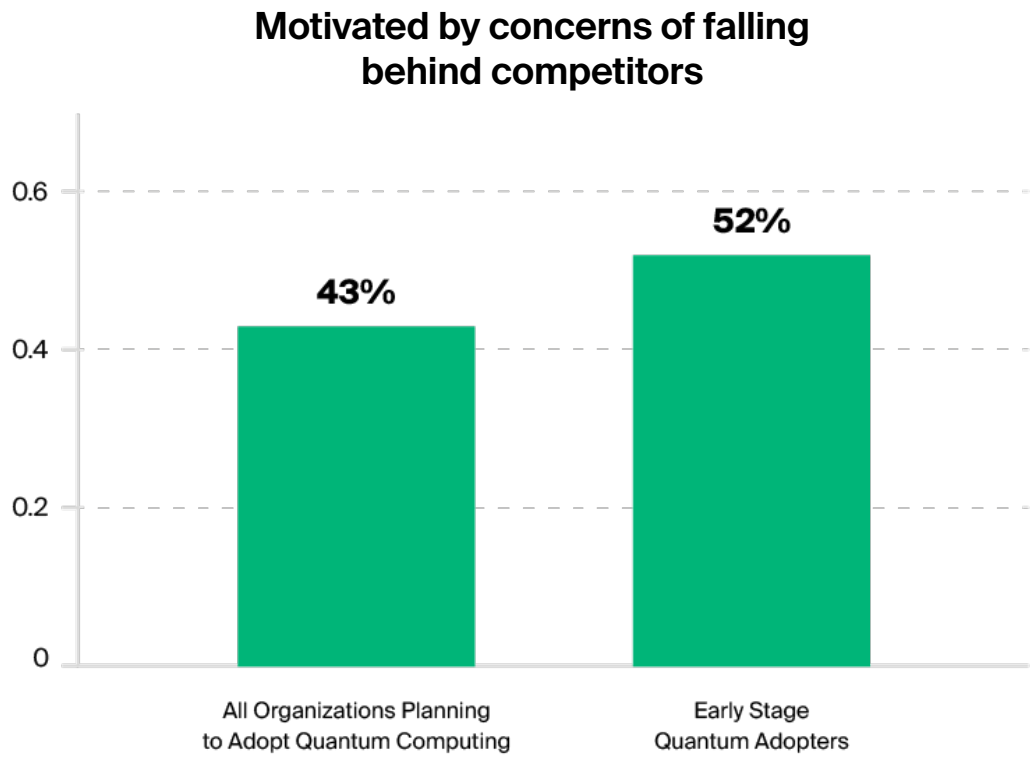
Although enterprises are motivated in part by concerns over falling behind competitors, the potential business value is the leading motivation for quantum adoption. The value to be gained from quantum is immense and spans many industries, with use cases including financial portfolio optimization, drug discovery and supply chain optimization — of particular importance in light of the ongoing supply chain crisis.

Workforce development was the next most common motivation for quantum adoption among respondents. Enterprises recognize that quantum computing has massive disruption potential, and want to start developing their quantum-ready workforce now to get ahead of it.

That said, we need to unpack the "insurance against disruption" mindset that came in as the third leading motivation. Playing not to lose is not the same as playing to win. We've seen this time and time again with new technologies, from e-commerce to cloud computing, big data and, more recently, AI and machine learning. Building complex computing capabilities can't be done overnight, and quantum is no different. Dabbling in proof of concepts is not enough. Enterprises need to start building the infrastructure, partnerships and workforce for quantum well ahead of the deployment phase, or they will already be behind the curve.

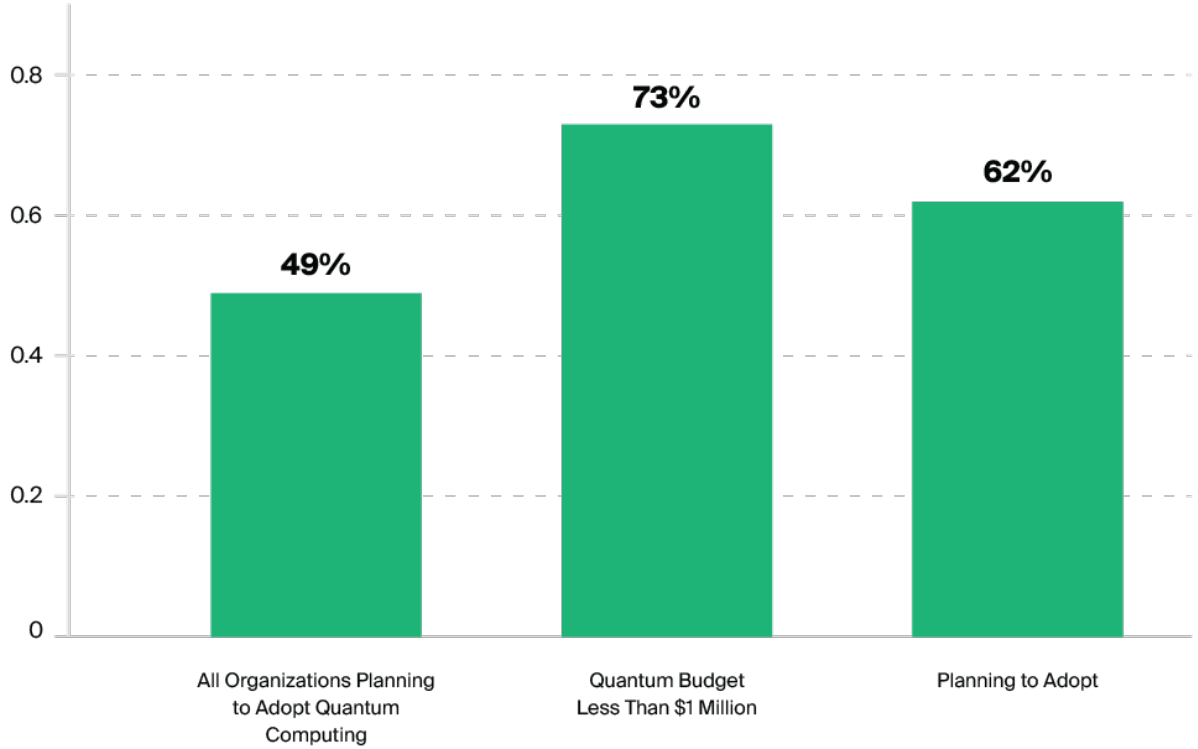
Motivated by first-mover advantage





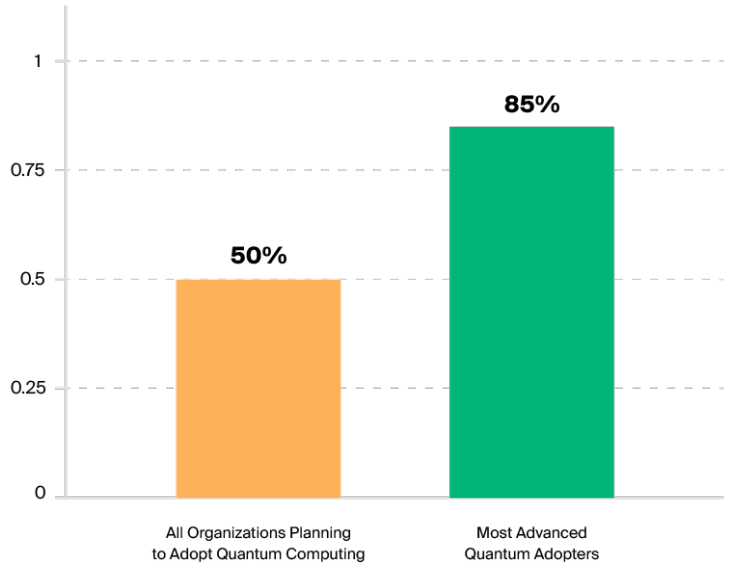
First-mover advantage is a greater motivator for those in the more advanced stages of quantum adoption and those with larger quantum computing budgets. In contrast, those motivated by concerns about falling behind competitors are more likely to be early stage adopters. Those that are furthest ahead are not simply concerned about falling behind, they are playing to win.

Motivated by insurance against disruption



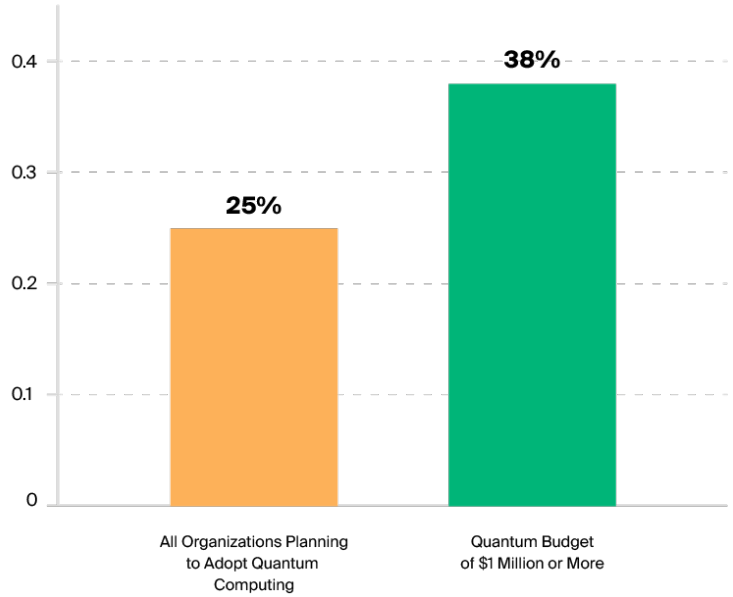
The majority of organizations motivated by 'insurance against disruption' are those investing less than $1 million (73%) and those still in the planning to adopt stage (62%). These organizations are the ones playing not to lose, and will likely fall behind those that are motivated by gaining a first-mover advantage.

Motivated by workforce development



85% of the most advanced quantum adopters are motivated by workforce development, compared to 50% of all organizations on the path to quantum adoption.

Motivated by blocking IP



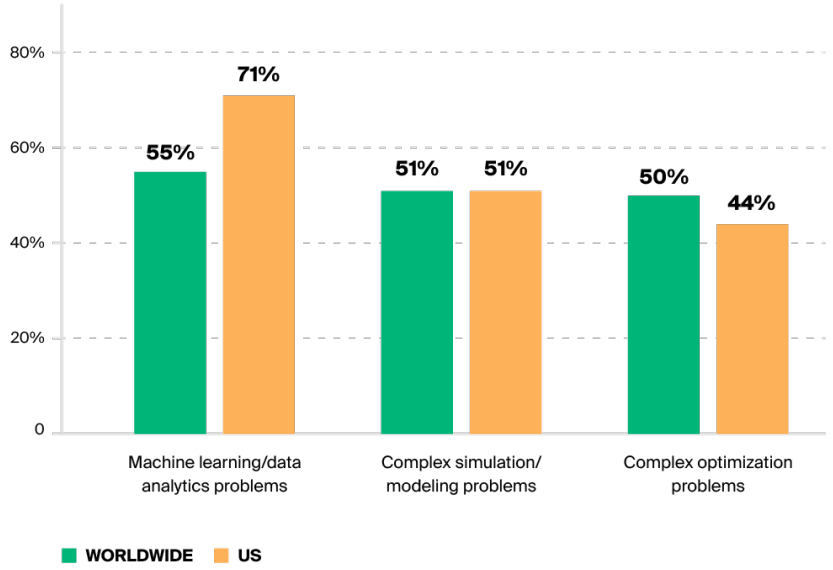
Organizations with quantum budgets of $1 million or more are 50% more likely than the average quantum-adopting organization to be motivated by blocking IP.

5. Top Quantum Use Cases

Machine learning and data analytics problems are the top use cases for early adopters of quantum computing, particularly in the US where enterprises are further along in their quantum adoption. This is intuitive because enterprises already have ML talent, algorithms and applications in place. The results reinforce the idea that data has become the primary driver of business decisions, and enterprises are looking to quantum to give them an edge in analyzing this data to make more informed decisions — and faster, too.

Machine learning is also the most likely use case to deliver near-term value for businesses because areas where classical ML struggles — such as generative models in unsupervised and semi-supervised learning for augmenting datasets in predictive models — are better suited for quantum devices.

What kind of problems are organizations most interested in building quantum applications to solve for?

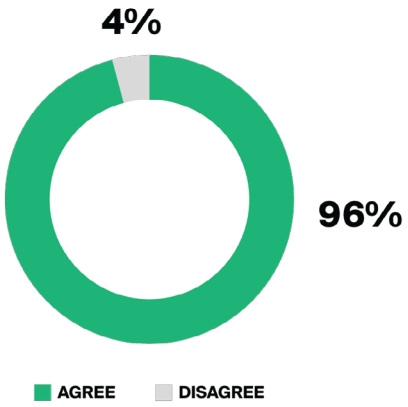


6. Quantum Is a Team Sport: The Role of Quantum Vendors

96% of organizations could not successfully adopt quantum computing without the help of a trusted vendor.

Given the complexity of quantum computing and the limited pool of quantum-skilled scientists and engineers, picking the right partner is one of the most important decisions a would-be quantum adopter can make. The last thing organizations want is to spend considerable time and resources implementing one vendor's technology when a superior option could come out the following year.

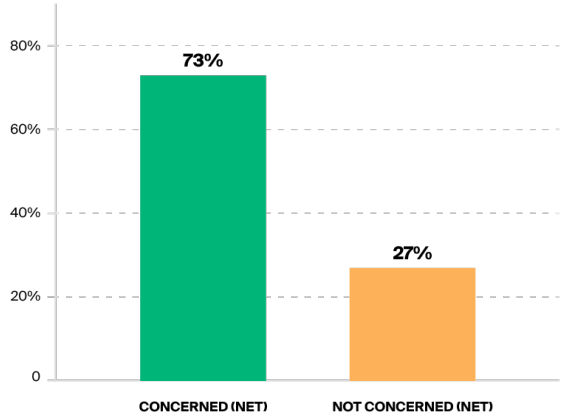
Agree or disagree with the following statement: "My organization could not successfully adopt quantum computing without the help of a trusted vendor."



73% of respondents were at least somewhat concerned about getting locked-in with a full-stack quantum vendor, while 47% were very or extremely concerned.

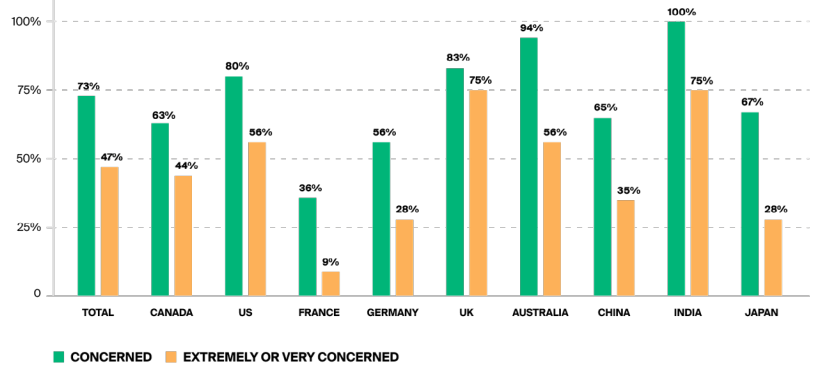
39% of quantum-adopting organizations cited vendor lock-in concerns as a major hurdle to adoption.

How concerned are you about getting locked in with a full-stack quantum vendor for your organization's quantum computing needs? full-stack quantum vendor = cloud provider that offers quantum or hardware-software provider



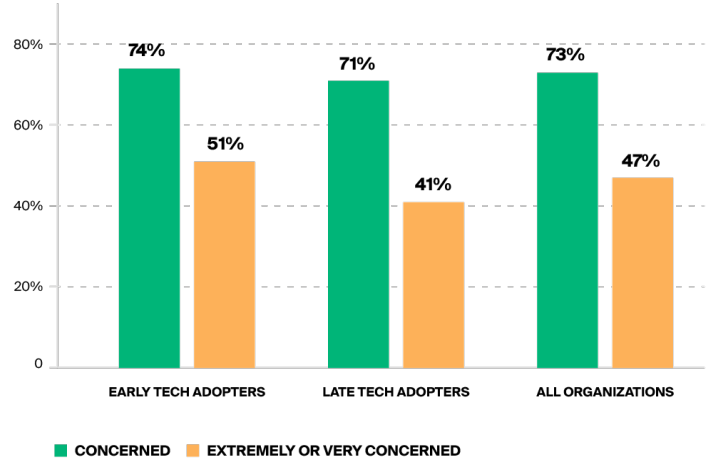
These concerns over vendor lock-in are legitimate and call for a hardware-agnostic – and flexible – approach to quantum computing. To mitigate lock-in concerns, quantum applications need to be interoperable with both different quantum hardware devices and different classical computing resources. Some quantum devices are better for specific use cases than others, so organizations will need the flexibility to swap devices in and out of their workflows as their needs change and the technology matures.

Vendor lock-in concerns by country



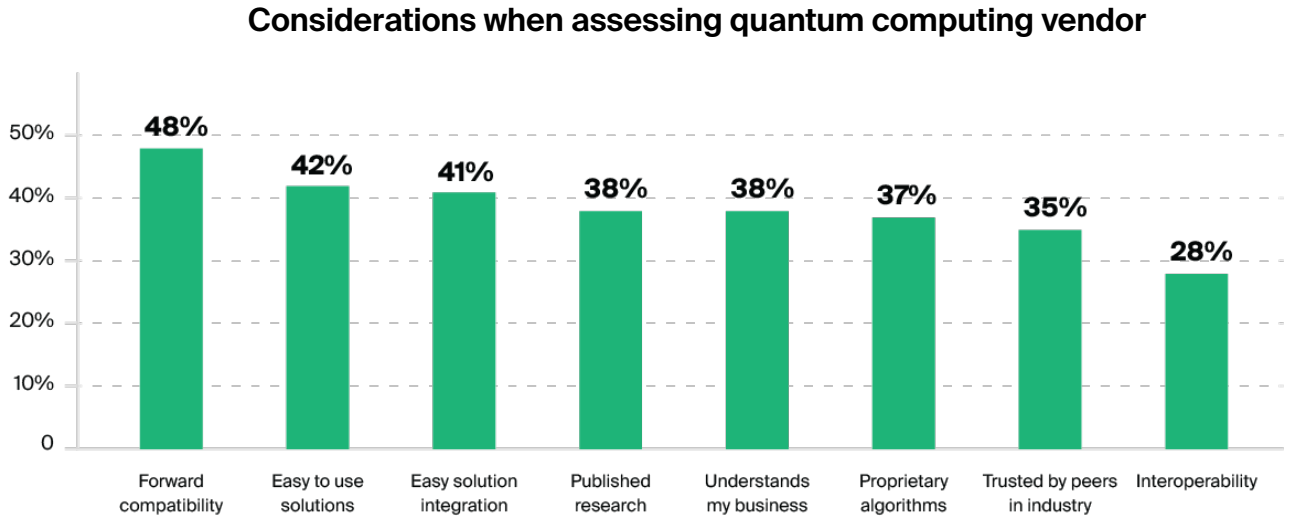
Vendor lock-in concerns were highest in India, Australia, the UK, and the US.

Vendor lock-in concerns by general tech adoption tendency



74% of organizations that generally adopt new technologies early are concerned with vendor lock in, compared to 71% of late tech adopters. However, 51% of early adopters are very or extremely concerned compared to 41% of late adopters, which indicates they were likely exposed to early iterations of hardware and software and watched the technology mature around them.

Forward compatibility is the top consideration in selecting a quantum vendor

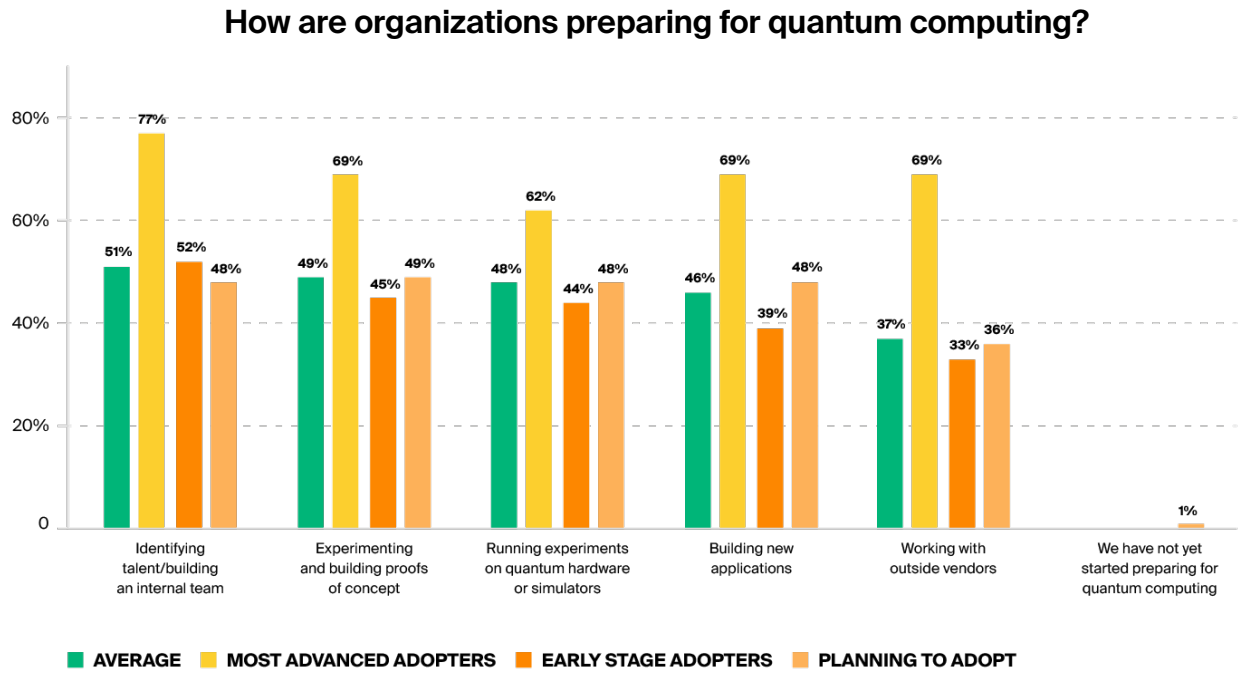


Vendor lock-in concerns reappear in the top considerations for choosing a vendor, with forward compatibility ranking highest. Quantum adopters want to be sure that their quantum strategy will be able to grow with their organization as the technology matures. And importantly, to be certain that the software they build today can be useful tomorrow.

As later findings will show, complexity is a major hurdle to quantum adoption, so it stands to reason that ease-of-use considerations will also rank highly on quantum buyers' minds. In fact, among organizations that have already begun adopting quantum computing, ease-of-use was the top consideration, edging out forward compatibility. It's an open question whether quantum computing will ever be "easy to use," but technology partners should prioritize helping customers make sense of the complexity.

Given the inflated hype around quantum computing, it makes sense that published research (37%) and proprietary algorithms (37%) would also be among buyers' top considerations for quantum vendors.

7. Becoming Quantum Capable

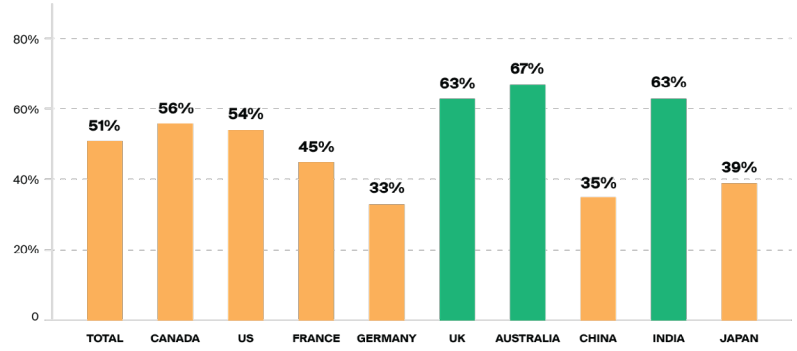


The Most Advanced Quantum Adopters Take the Lead by Developing Quantum Workforce, Working with Outside Vendors and Building Applications

A strong majority of the organizations furthest along the path to a quantum competitive advantage are well on their way to building the internal workforce necessary to harness quantum computing. But they aren't doing it alone: the most advanced quantum adopters are nearly twice as likely as the rest to be working with outside vendors to build their quantum capabilities.

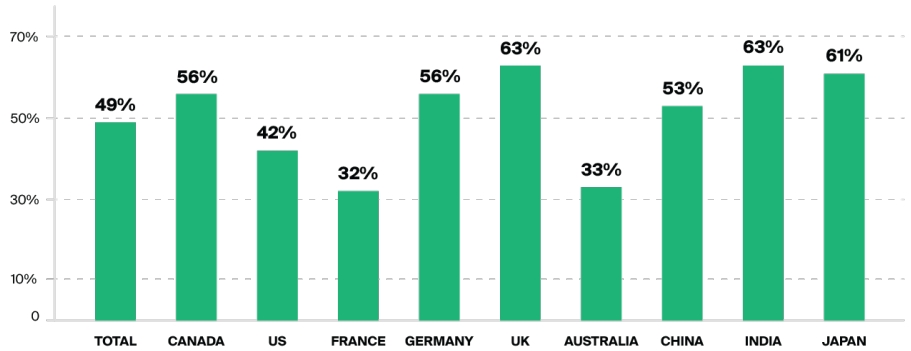
Organizations are investing in capability building across multiple dimensions and getting hands-on with proofs of concept, experiments and pilot applications. However, most quantum adopters are still in the experimental phase or are still identifying talent and building teams. These are important first steps, but to gain an advantage, enterprises will need to go further: identifying use cases, building quantum-classical workflows and piloting production-ready applications.

Identifying talent/building an internal team by country



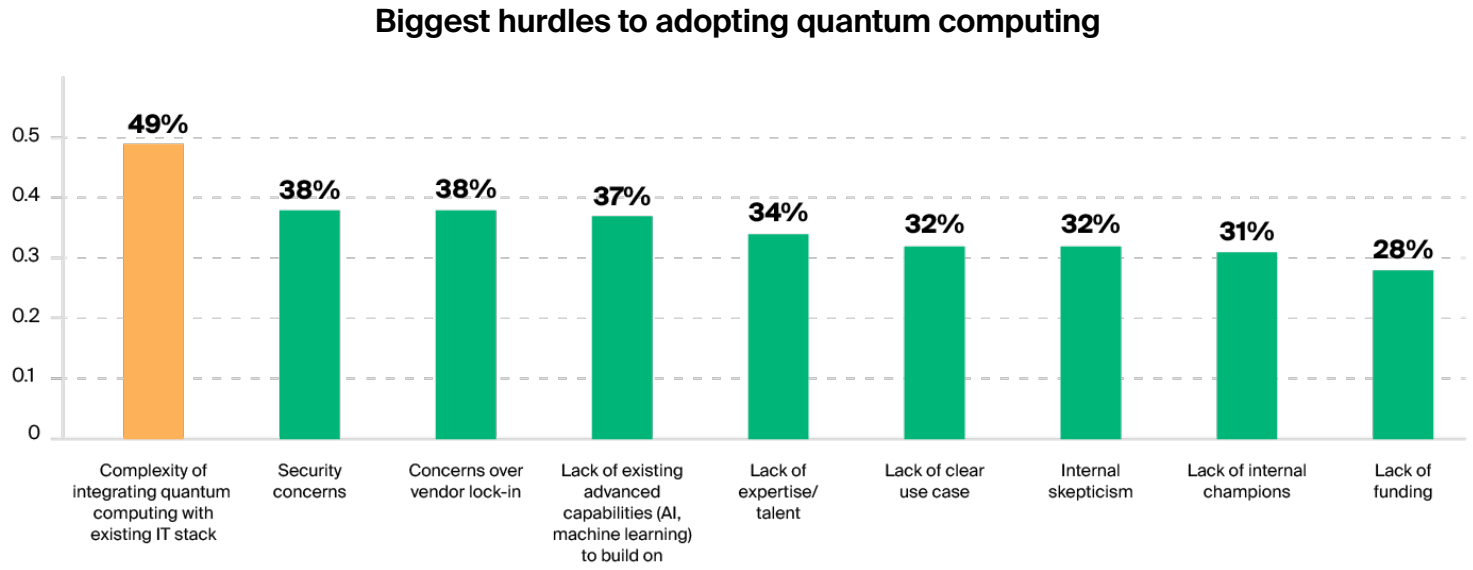
Enterprises in the UK, Australia and India are outpacing the world in building their internal quantum workforce.

Experimenting and building proofs of concept by country



Many enterprises are still focused on experimenting and building proofs of concept.

8. Top Hurdles to Quantum Adoption



Hurdle #1: The Complexity of IT Integration

The complexity of integrating quantum computing with existing IT infrastructure was the most cited hurdle to quantum adoption (49%) among organizations that have adopted or planned to adopt quantum computing. Among those that did not plan to adopt, lack of compatibility with the current IT stack (46%) was the second most common reason for not adopting behind the cost to adopt and maintain hardware (47%).

The implication is that while many enterprises understand they won't simply "rip and replace" their high-performance classical computers (HPC) with quantum devices and expect results, just as many seemingly do not. Adding quantum computing to an existing IT stack will result in an unconventional architecture for the foreseeable future – it will not be a swap with even the most powerful HPC resources.

Quantum computing doesn't work in a vacuum; it will always require a hybrid model combining both novel quantum resources and existing classical resources. And for at least the next several years, quantum devices will be accessed remotely through software platforms or directly (Quantum Computing-as-a-Service), exacerbating security, data management and compliance issues. Given that the quantum market is largely driven by hardware providers, these findings call for a new approach that prioritizes integration with organizations' existing classical IT stack.

Classical resources will still process data both before and after it goes through quantum algorithms — think data warehousing processes, database queries, dashboards to present the results, and any domain-specific calculations that need to happen before and after the quantum subroutine. Any quantum speed-up should not be offset by the overhead of pre- and post-processing steps. One way to minimize the overhead is to have data flowing efficiently through the process in an automated quantum-classical workflow. A workflow-based approach will also enable enterprises to easily swap in new, more powerful quantum devices as they come out, future-proofing their advantage.

Yudong Cao
CTO of Zapata Computing

Sidebar: 96% of enterprise executives surveyed would need more than 10 minutes to explain quantum computing to a friend at a party

Yes, quantum computing is complex, and yes, enterprises will need ample time to develop their quantum strategy before they can deploy it. Here are a few resources to help wrap your head around quantum computing. Hint: focus on what you can do with quantum, not the physics of how it works — you'll save yourself a lot of time:

Quantum Computing Is Coming. What Can It Do?
Harvard Business Review | hbr.org/2021/07/quantum-computing-is-coming-what-can-it-do

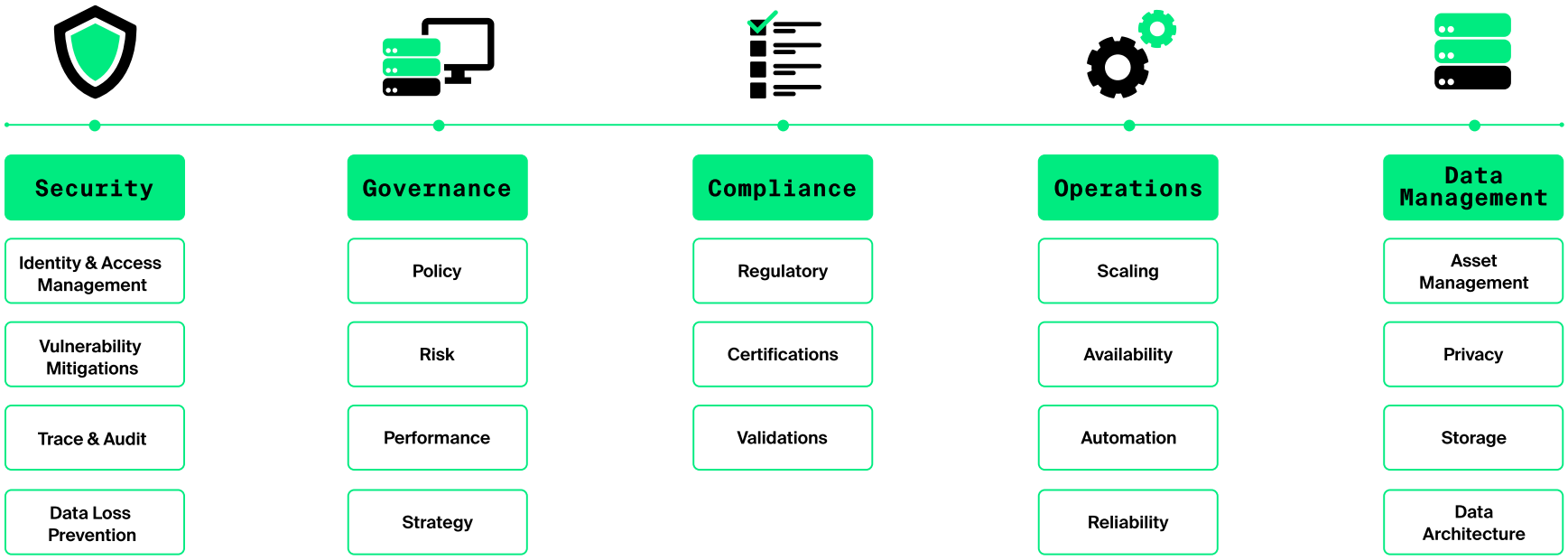
What is Quantum Computing?
IBM | www.ibm.com/quantum-computing/what-is-quantum-computing/

Could Quantum Computing Be the Technology That Drives Your Quantum Leap Forward?
EY | https://www.ey.com/en_us/disruption/could-quantum-computing-be-the-technology-that-drives-your-quantum-leap-forward

5 Common Quantum Computing Questions from Enterprise Customers, Answered
Zapata Computing | www.zapatacomputing.com/quantum-computing-answers/

43% of Quantum Adopters Cite Security Concerns as a Barrier to Adoption

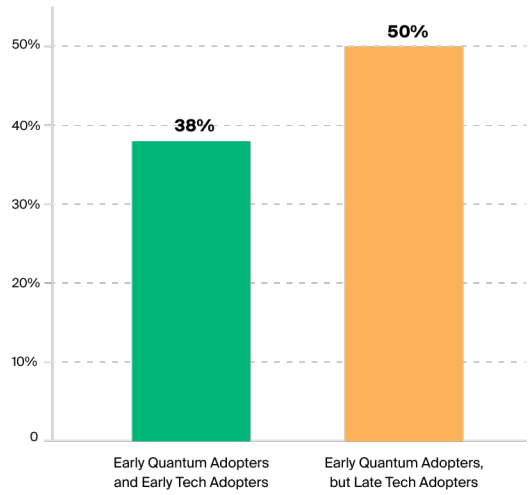
All the security concerns that come with cloud-based enterprise IT solutions apply to quantum computing as well, and in fact are magnified by quantum. Security isn't the only concern shared with more familiar enterprise IT deployments. Governance, compliance, operations and data management are also important considerations for quantum deployment in the enterprise environment.



While not specifically called out in the survey, encryption is a notable area of concern as quantum promises future approaches to break current encryption standards. Not surprisingly, quantum-resistant encryption algorithms are of interest in that area. This aspect of security in relation to quantum computing bears watching closely.

Regardless of what the future holds for encryption, for the time being, enterprises will need capabilities in place to manage data access, mitigate vulnerabilities, and trace and audit breaches.

Organizations citing lack of existing capabilities (AI, ML) to build on as a barrier to adoption

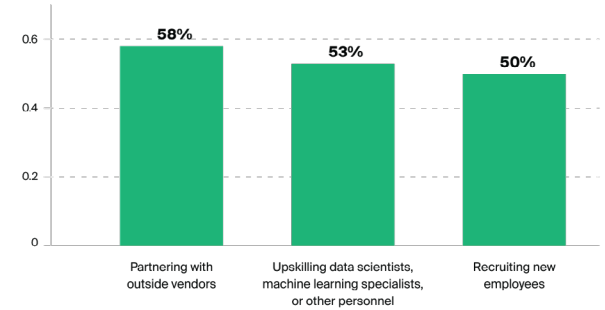


37% of Organizations Cite a Lack of Advanced Capabilities to Build On as a Hurdle to Quantum Adoption

Among early quantum adopters, those that are generally late to adopt new technologies are much more likely to cite a lack of advanced capabilities to build on as a barrier to quantum adoption. These organizations are finding out the hard way that quantum adoption has to build on the adoption of earlier technologies such as AI and ML.

These findings further drive home the point that quantum won't work in a vacuum. It won't be a replacement for AI and ML, rather it will help organizations overcome bottlenecks in their existing AI and ML processes. Organizations that have yet to adopt AI and ML will struggle to adopt quantum computing without maturing their data analytics capabilities to catch up with their peers.

How are you building the quantum computing team?

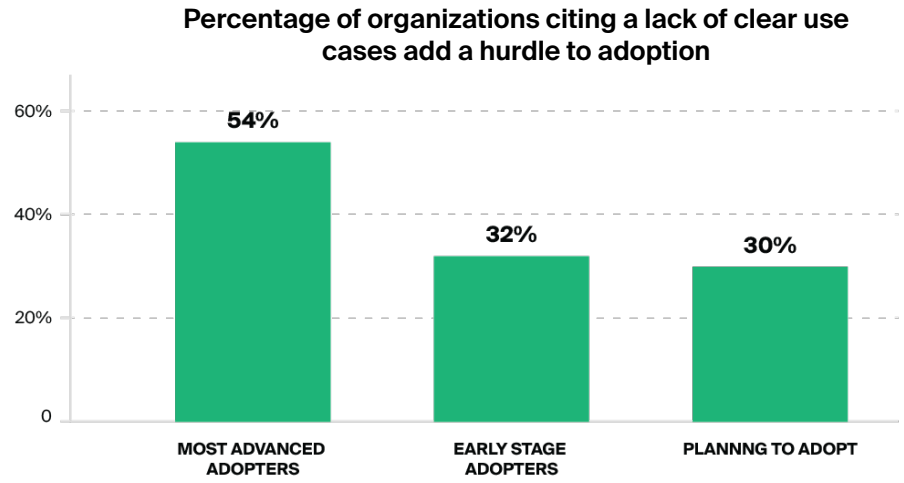


34% of Quantum Adopters Cite a Lack of Expertise and Talent as a Hurdle to Quantum Adoption

Of those organizations that were building a quantum team, most indicated they were partnering with outside vendors (58%), followed by those upskilling their existing team (53%) — data scientists, machine learning specialists and other personnel with relevant background.

The two go hand in hand. Internal personnel are in the best position to understand their organization's unique challenges and the existing capabilities that can be augmented with quantum. However, outside partners can help train internal staff and help answer the thornier implementation questions: Which use cases are best for quantum, and which would be better solved with classical computing? Which device is best suited for the tasks at hand? How should quantum workflows be structured? Guidance from external experts can help shorten the path to quantum advantage.

32% of Quantum Adopters Cite a Lack of Clear Use Cases



Perhaps surprisingly, the organizations furthest along in quantum adoption were the ones most likely to cite a lack of clear use cases as a hurdle to adoption. This may reflect the common misunderstanding that quantum is simply a replacement for HPC, rather than a unique form of compute with specialized use cases that cannot currently be addressed.

Leaders can easily find their industry's use cases for quantum computing online. But what's less clear is which use cases are worth pursuing, and within what time horizon. Depending on the organization, some use cases may be more feasible in the near term than others, while other use cases may be more valuable. Consulting with quantum experts is a crucial step to determine which problems are worth investing in.

"Optimization problems that employ quantum and quantum-inspired machine learning methods are the most promising and attractive use cases in the next 24 months."
- Christopher Savoie
CEO of Zapata Computing

Business leaders should also be involved in identifying and prioritizing—based on the potential value at stake—use cases for quantum computing, as they have more visibility into the organization's operations and potential economic impact. If quantum computing is isolated in R&D departments, it may never grow beyond experiments and proofs of concept. Commitment (via funding, personnel resources and other concrete actions) and domain expertise from executive leadership are essential for success with enterprise quantum computing.

Conclusion

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The current survey shows that the early adopters of quantum computing technologies expect to achieve a competitive advantage over their peers very soon. A majority of global enterprises are now planning to adopt quantum computing or have already started, and once the early leaders achieve an advantage, there will be a profound urgency for others to accelerate their quantum adoption strategies.

Still, the survey also revealed a number of key barriers for enterprises to overcome on their path to a quantum competitive advantage. The complexity of the technology remains the greatest hurdle to overcome, so early adopters are partnering with outside vendors to manage it. However, vendor lock-in will be an ongoing concern, and enterprises will want flexibility and forward compatibility with any vendor they work with.

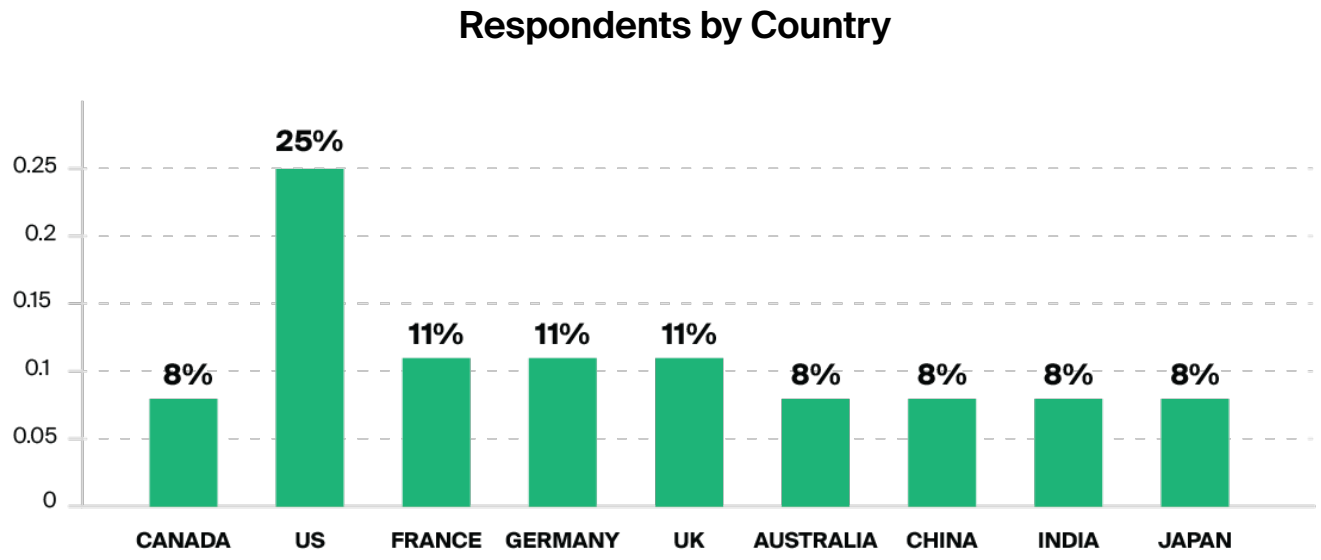
The results call for a new, application-based, hardware-agnostic approach to quantum computing that is driven by compelling business problems, prioritizes interoperability with existing classical compute resources and forward compatibility with future quantum technologies.

At Zapata, we see many parallels between the survey results and patterns we see in our customers' work in quantum. We commissioned this survey of enterprise decision-makers to help us understand and support our customers and ecosystem partners on their quantum journeys. We invite comments, questions and challenges to the data here as our 300 responses may not have included your organization.

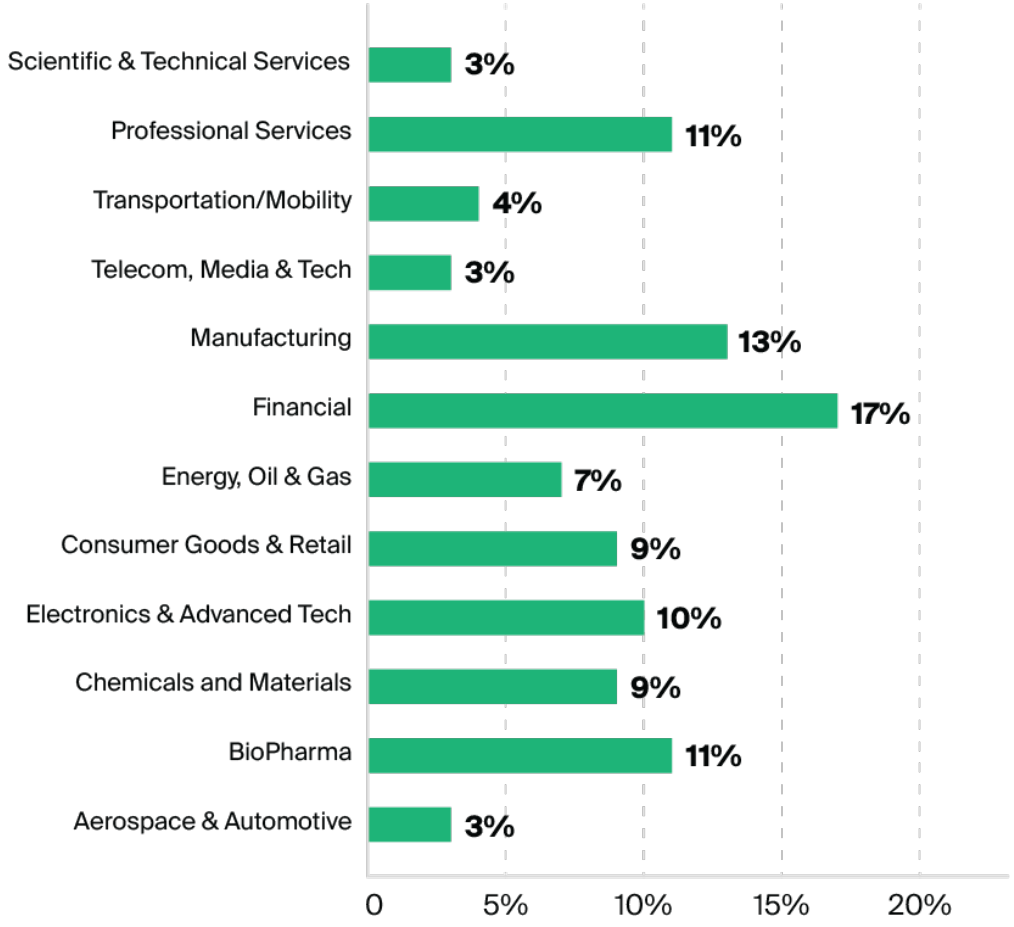
Appendix

Appendix

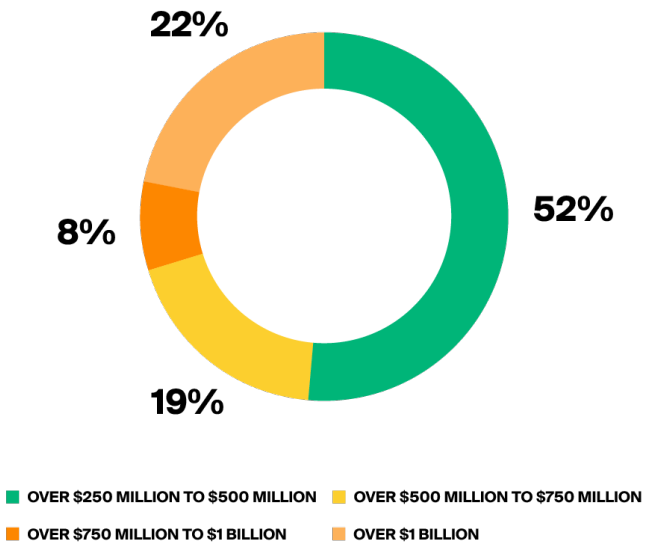
Survey Participants: Demographics



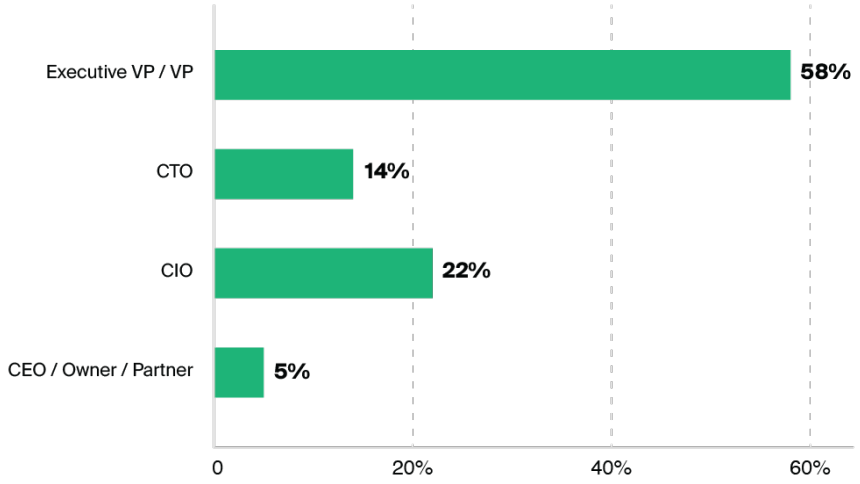
Respondents by Industry



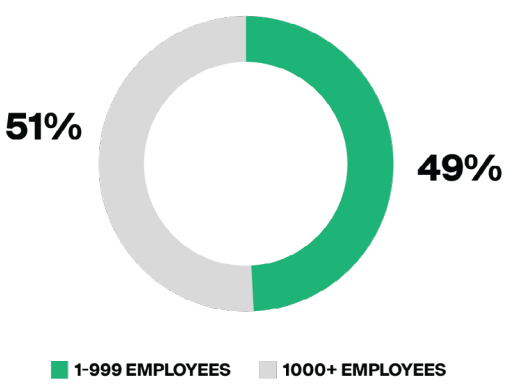
Respondents by Revenue



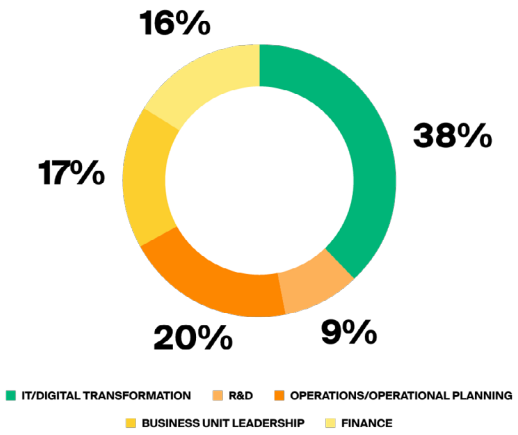
Respondents by Seniority



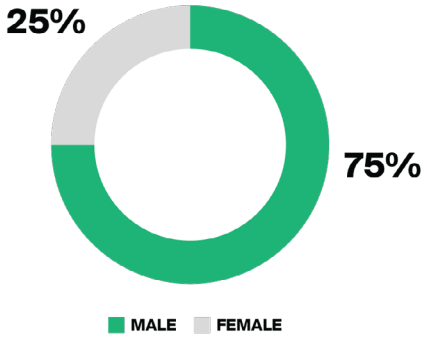
Respondents by Company Size



Respondents by Business Unit



Respondents by Gender



About **Zapata Computing**

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Zapata Computing, Inc. builds quantum-ready applications™ for enterprise on Orquestra®, the only computational workflow platform for quantum computing. Orquestra integrates best-in-class classical and quantum technology, including Zapata's leading-edge algorithms, open-source libraries in Python, and more. Zapata has pioneered new quantum-classical methods in ML, optimization and simulation to maximize value from near-term quantum devices, and partners closely with hardware providers across the quantum ecosystem such as Amazon, D-Wave, Google, Honeywell, IBM, IonQ and Rigetti. Learn more at ZapataComputing.com.

For more information, contact Mick Emmett at mick.emmett@zapatacomputing.com

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