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BLACK & WHITE PAPER

Enterprises Are Preparing to Quantum Leap Today

SEPTEMBER 2020

About this paper

A Black & White paper is a study based on primary research survey data that assesses the market dynamics of a key enterprise technology segment through the lens of the "on the ground" experience and opinions of real practitioners — what they are doing, and why they are doing it.

ABOUT THE AUTHORS

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Introduction

The business case for quantum computing is a strong one – a practical quantum computer would open the door to incredible opportunities in physics, chemistry, machine learning, finance, healthcare and beyond. While no panacea, viable quantum computing would increase our ability to attack previously insurmountable computational challenges, from the structure of materials and the optimization of complex routes to the folding of proteins, which would be impractically time-consuming or impossible even with the most powerful deterministic computers we all use today.

In a nutshell, a quantum computer allows us to exploit uncertainty in the characteristics of minute particles by performing operations on this uncertainty. Once these operations are performed, the characteristics of the particle can be measured, and a result obtained. The key part to remember is that a quantum computer allows a multiple of states to be encoded in this uncertainty and then evaluated once, as opposed to a traditional computer, where each state must be encoded and evaluated separately. If the problem is complex, it might take millennia for a traditional computer to evaluate every state, but a quantum computer with enough capacity could solve it within hours.

The practicalities are what make quantum computing challenging to implement. The math shows that quantum computing is a viable model for solving highly complex problems. But in practice, controlling and manipulating these particles requires such precision that even tiny errors can have significant impacts. Today, some problems can be solved using some quantum computing approaches. As refinements to quantum computing hardware reduce errors in computation, many more problems will become ripe for quantum computing to help solve.

But what do enterprises think? Are they considering quantum opportunities now, and what do they believe the future holds? In 2020, D-Wave commissioned 451 Research to survey 253 enterprise decision-makers based in the US, UK, Germany and France on their quantum computing experiences and the potential for the quantum computing market. (More detail on the study and respondents can be found in the Methodology section at the end of this paper.) To ensure an unbiased study, respondents did not know the survey was being conducted for D-Wave, and D-Wave was not involved in choosing specific respondents. In terms of organizations surveyed, 94% of respondents work for companies that have more than $1bn in revenue. The 10 largest industries represented, in descending order, were Software & Internet, Manufacturing, Retail, Financial Services, Chemicals, Healthcare, Insurance, Telecommunications, Transportation and Oil & Gas.

The study findings reveal that enterprises are interested in quantum computing and perceive it as providing a competitive edge. A surprisingly large amount of organizations are already experimenting today, and the majority have use cases in mind for where quantum computing could make an impact. This impact will be greatest in solving complex problems, many of which are being abandoned by enterprises today, despite quantum computing potentially offering a solution. Optimization problems in particular are seen as being the most valuable to solve via quantum computing. Considering that enterprises are leveraging quantum computing to obtain a competitive advantage, those not experimenting now may be at a disadvantage in the future.
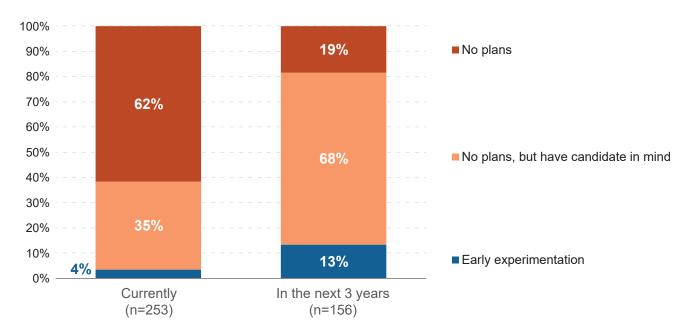
Key Findings

Enterprises Are Experimenting With Quantum Computing for a Competitive Advantage

Figure 1: Quantum Computing Use – Now and in Three Years

Source: 451 Research and D-Wave, Quantum Computing Survey, 2020
Q. What is the use of quantum computing in your organization?
Q. Do you have plans to introduce quantum computing in your organization in the next three years?
Base: All Respondents

Today, more than one in three enterprises (35%) surveyed are already experimenting with quantum computing, and 4% are developing their own quantum computing applications. Within three years, 68% of enterprises are set to be considering quantum computing as a solution to a specific business problem. While 62% of enterprises are not using quantum computing in 2020, by mid-2023 only 19% of organizations will have no plans or candidates for quantum computing. Clearly, quantum computing has made an impact on the mindset of organizational decision-makers, and the majority are keeping an open mind with regard to how it might impact them over the next few years.
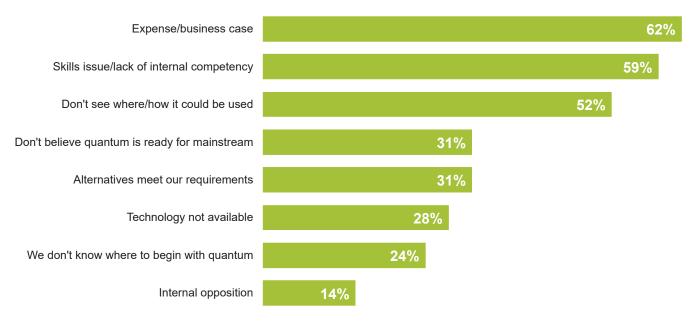
Notably, respondents in the transportation, insurance, financial services and chemical industries were more likely than other respondents to indicate an intent to begin using quantum computing for their businesses within the next three years. These industries, not coincidentally, are among the most likely to have business problems that are already expressible in – or can translate easily to – algorithms that match up with the capabilities of near-term quantum computers.

There were naysayers too, of course. But only 29 of our sample of 253 respondents said they weren't using or considering quantum computing, and the top reason cited by these respondents was expense – 62% said the expense of using quantum computing couldn't be justified in the business case. However, we believe cloud-based quantum computers could address such challenges through SaaS consumption, and would also help address skills gaps, which was an issue raised by 59% of respondents as a challenge to adoption. Meanwhile, only nine respondents said they didn't believe quantum computing was ready for the mainstream.

Figure 2: Reasons for Not Using Quantum Computing
Source: 451 Research and D-Wave, Quantum Computing Survey, 2020
Q. Why are you not using or considering quantum computing?
Base: All Respondents (n=29)

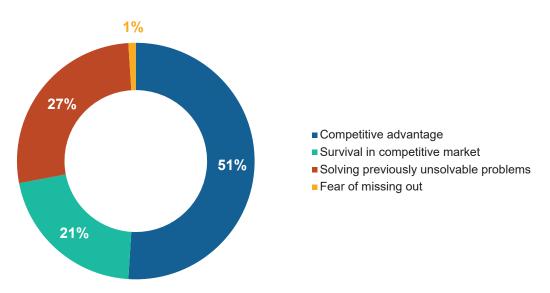| Reason	Percentage
Expense/business case	62%
Skills issue/lack of internal competency	59%
Don't see where/how it could be used	52%
Don't believe quantum is ready for mainstream	31%
Alternatives meet our requirements	31%
Technology not available	28%
We don't know where to begin with quantum	24%
Internal opposition	14%

Most of our survey respondents view solving these problems as a way of differentiating themselves. Over half of respondents say their overall interest in quantum computing is about giving themselves a competitive advantage in the market, with 21% stating that it could help them survive against competitors. This demonstrates that quantum computing isn't just a mechanism for solving academic or theoretical problems – organizations' interest in quantum computing is tied to driving a tangible, financial return. In fact our respondents believe that solving these problems can increase profitability: 78% see quantum computing having a significant impact on creating a new product, and 67% see it as having a significant impact on a faster time to market.

Figure 3: Drivers of Interest in Quantum Computing
Source: 451 Research and D-Wave, Quantum Computing Survey, 2020
Q. What primarily drives your interest in quantum computing?
Base: All Respondents (n=253)

- ■ Competitive advantage
- ■ Survival in competitive market
- ■ Solving previously unsolvable problems
- ■ Fear of missing out

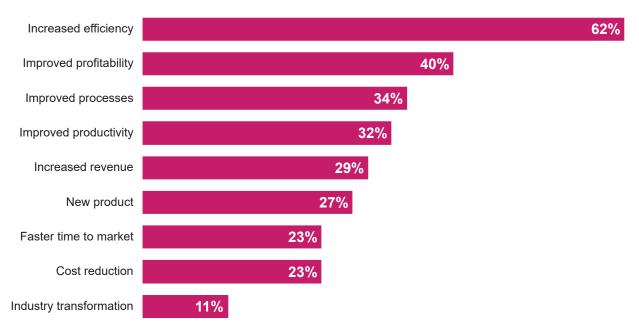# Quantum Computing Helps Overcome Complexity Barriers

How could quantum computers be leveraged to drive a competitive advantage? How might such an advantage be obtained? The primary goal for our study respondents is to increase efficiency – to solve problems more quickly, while using fewer resources. This can translate into business benefits, with improvements in profitability, processes, productivity and revenue all high on the list of drivers selected by respondents.

Figure 4: Perceived Benefits of Quantum Computing

Source: 451 Research and D-Wave, Quantum Computing Survey, 2020
Q. What would be the benefits of solving these problems? (Projects that were abandoned due to: a) the problem required too much capacity to solve; b) the problem couldn't be efficiently coded as it was too complex or; c) the problem would take too long to solve to provide a useful result)
Base: All Respondents (n=253)

Benefit	Percentage
Increased efficiency	62%
Improved profitability	40%
Improved processes	34%
Improved productivity	32%
Increased revenue	29%
New product	27%
Faster time to market	23%
Cost reduction	23%
Industry transformation	11%

We asked our study sample group if they had abandoned projects in the last three years because a) the problem required too much capacity to solve, b) the problem couldn't be efficiently coded since it was too complex or, c) the problem would take too long to solve to provide a useful result. On average, 36% of respondents said they had abandoned projects because of these issues.
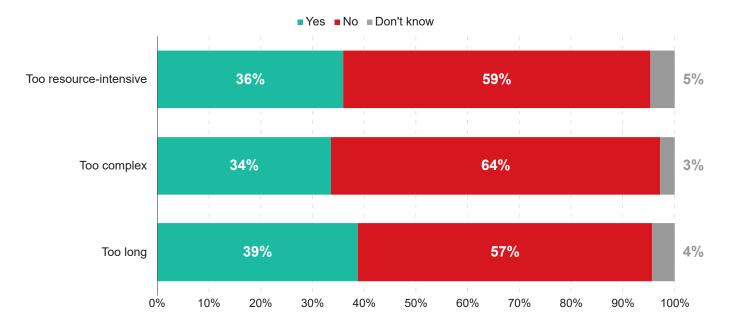
In fact, our respondents stated that one in five projects, on average, had been abandoned over the past three years because of issues of capacity, complexity or timeliness. In practice, many problems faced by our respondents encompass all three of these issues.

Figure 5: Reasons Why Projects Have Been Abandoned
Source: 451 Research and D-Wave, Quantum Computing Survey, 2020
Q. In the last three years have you abandoned projects because the capacity needed to solve a computational problem would be too great to deliver a return on the investment?
Q. In the last three years have you abandoned projects because they were deemed too complex to solve using current technology?
Q. In the last three years have you abandoned projects because the time needed to solve a computational problem would be too great to deliver a return on the investment?
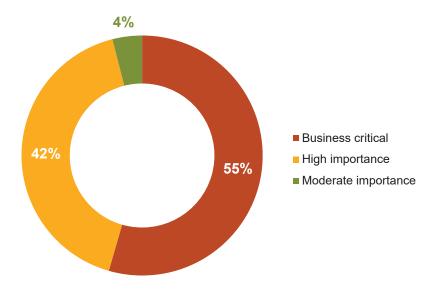*Base: All respondents (n=253)*

Solving these problems would be a real boon to the organizations that face them: 97% of respondents stated that solving complex computational problems was either business-critical or of high importance. Meanwhile, 70% said that R&D was extremely important to their business.

Figure 6: Importance of Solving Complex Computational Problems
Source: 451 Research and D-Wave, Quantum Computing Survey, 2020
Q. How important is the solving of complex computational problems to your organization?
Base: All respondents (n=253)

- Business critical
- High importance
- Moderate importance

4%
55%
42%

Optimization Problems Are Seen as Key Use Case for Quantum Computing

When we look at use cases for quantum computing today, problems around optimization that involve a large number of variables and a huge number of potential combinations stand out. Most of these applications are focused on finding the optimum configuration (such as in allocating resources or determining best routing for logistics) or considering the aggregate effect of a multitude of possibilities (such as risk assessment in financial forecasting, or assessing tiny changes in the behavior of fluids or chemical structures).

Figure 7: Current Use Cases for Large-Scale Computations
Source: 451 Research and D-Wave, Quantum Computing Survey, 2020
Q. How are you using large-scale computations today?
Base: All respondents (n=253)

Use Case	Percentage
Resource Scheduling	64%
Financial forecasting/risk assessment	57%
Optimization Problems	51%
Logistics management	50%
AI/ML	40%
Materials science	21%
Fluid dynamics	15%
Chemical engineering	12%
Pharmaceutical development	9%

It is reassuring that our study respondents are considering such use cases, since the ability to encode multiple states in the uncertainty of particles and then evaluate this once is the key feature of quantum computing. These are mathematically 'hard' problems, which a traditional computer would need to run a vast amount of iterations to solve. The more variables to take into account, the far greater the time and resources need to compute. In practice, traditional computers adopt heuristic approaches with a limited number of variables and states to make an estimate of a best course of action, because processing every possibility might take decades or even millennia. Even with huge capacity, there are problems that can't viably be solved by traditional computers today.
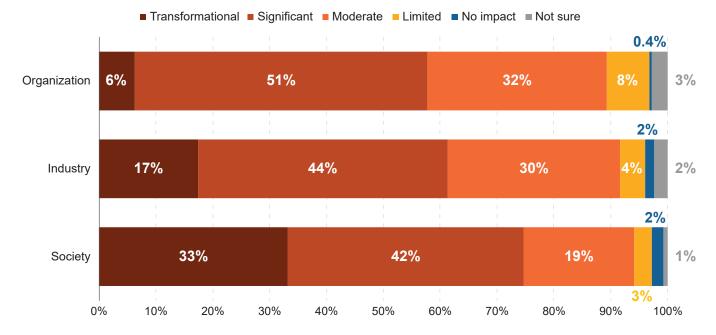
Quantum Knowledge Drives Quantum Benefits

At the outset of this study, our overall aim was to understand how enterprises are using and planning to use quantum computing. The fact that most of our respondents see commercial possibilities within three years' time suggests that enterprises are taking quantum computing seriously.

When we asked our respondents about the impact of quantum computing, the majority expect to see a major effect on their organizations and industries: 58% see quantum computing having a transformational or significant effect on their organization, while 61% believe the same for their industry. And for society as a whole, a third of respondents see quantum computing having a transformational effect, showing that most respondents believe there will be impacts well beyond their areas of expertise.

Figure 8: Expected Impacts of Quantum Computing
Source: 451 Research and D-Wave, Quantum Computing Survey, 2020
Q. Longer-term, what is your view regarding the impact of quantum computing to your organization?
Q. Longer-term, what is your view regarding the impact of quantum computing to your industry?
Q. Longer-term, what is your view regarding the impact of quantum computing to society?
Base: All respondents (n=253)

With regard to expertise, those respondents who rated themselves as knowledgeable about quantum computing are more likely to see opportunities: 64% of knowledgeable respondents said quantum computing would have a transformative or significant impact on their organization, compared with 57% of those with some knowledge of quantum concepts and 46% of those with little awareness of the subject. Quantum computing is a totally different computing model than the traditional computers used at home and work today, and new skills are required to code and analyze problems in the quantum world. Those with some knowledge of quantum computing are inevitably going to spot those problems that could be better solved with a quantum computer.

Conclusions

Many organizations are experimenting with quantum computing today. Over the next three years, the majority of our study respondents will have specific problems in mind for which they believe quantum computing might hold the key. Organizations are currently abandoning projects because they are simply too complex or resource-intensive to effectively address, despite the fact that the resolution of many of these problems is considered business-critical.

Optimization problems in particular were identified by study respondents as being among the most interesting uses for quantum computing. Ultimately, solving these problems doesn't just bring efficiency, it brings competitive advantage – the primary reason our survey respondents are interested in quantum computing.

Building a business case for quantum computing is the biggest challenge to broad adoption perceived by enterprises today. However, since many quantum computers are now accessible in the cloud, with supporting tutorials and documentation, getting started with quantum computing is less a question of opening corporate coffers and more a question of opening the minds of decision-makers to pursue first steps in quantum experimentation.

Organizations that have identified potential use cases should consider starting now. An investment of time in talking to vendors today – and opening minds among business units, data scientists, R&D teams and developers about the possibilities of quantum computing – could pay dividends in the not-too-distant future.

Considering that most enterprises see quantum computing as providing competitive differentiation for their businesses, the risk of not getting started now is that one day you may well be at a disadvantage with regard to your competitors. Study respondents who were more educated on quantum computing were found to be more positive about its benefits. Educating your employees now means they'll be better placed to identify opportunities as they arrive.

Methodology

In Q3 2020, D-Wave commissioned 451 Research to survey 253 decision-makers based in the US, UK, France and Germany, about their views on quantum computing.

All respondents worked for organizations that had at least 1,000 employees and annual revenue over half a billion dollars. Ultimately, 70% of the sample had more than 5,000 employees, and 94% had more than a billion dollars in revenue. Respondents were asked to answer a simple multiple-choice test to confirm their expertise. The study was conducted through a multiple-choice web survey.

Within our survey sample, 13 industry categories were represented. The 10 largest industries, in descending order, were Software & Internet, Manufacturing, Retail, Financial Services, Chemicals, Healthcare, Insurance, Telecommunications, Transportation and Oil & Gas.

To ensure an unbiased study, respondents were not told the survey was being conducted for D-Wave, and D-Wave was not involved in choosing specific respondents. In terms of the individuals surveyed, 59% of respondents were IT executives or management, and 20% were data scientists. Information security and R&D professionals represented 7% and 6% of respondents, respectively.

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