Technology Business Perspectives on Quantum Communication – A Survey-Based Study

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Abstract

The aim of this survey-based study is to provide insights into the current awareness perception and expectations that businesses representatives see in the emerging field of quantum communication technology. Quantum communication is revolutionizing the way we perceive data security, transmission and networking. In a close future we expect to use communication systems that are more secure, efficient, and potentially transformative for various industries.

The study focuses on how businesses are preparing for the potential commercial applications of quantum communication, the challenges they might face in integrating this technology, and their expectations for its impact on specific sectors.

A further development of the study on larger population and diverse regions would provide relevant information for policy makers in shaping policies and funding strategies to promote the growth of quantum communication.

Key words: technological capabilities, private investment, governmental investment, defense, scalability
J.E.L. classification: L63, L86, O31, O33

1. Introduction

Quantum communication is an emerging field that leverages quantum mechanics to revolutionize secure data exchange by introducing new paradigms for secure information exchange, through the incorporation of quantum mechanics principles like entanglement and superposition. Quantum communication is emerging as a transformative technology with the potential to revolutionize secure data transmission, cryptographic protocols, and network infrastructure. Unlike classical communication systems, quantum communication leverages principles such as quantum entanglement and superposition enable ultra-secure communication channels resistant to eavesdropping. With advancements in quantum key distribution (QKD) and satellite-based quantum networks, governments, research institutions, and technology firms are investing heavily in the development and commercialization of quantum communication technologies.

Despite the rapid scientific progress in quantum communication, its adoption and commercialization remain in early stages, influenced by technological, economic, and regulatory factors. Businesses operating in the technology sector must navigate the uncertainties associated with quantum readiness, infrastructure costs, and the potential disruption of classical encryption systems.

Understanding the perspectives of industry stakeholders, ranging from startups and telecommunications firms to cybersecurity enterprises, is crucial for assessing the commercial viability and strategic positioning of quantum communication technologies.

This paper presents a survey results supporting awareness and perception of respondents on quantum related businesses, as well as the anticipation of further technological developments from the perspective of business opportunities. By gathering insights from industry professionals and

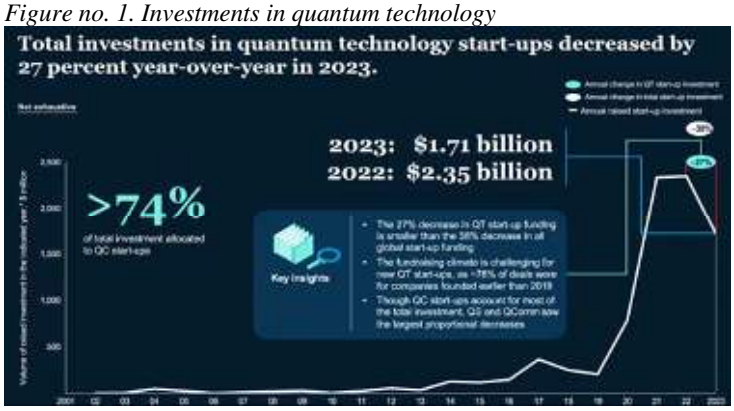
researchers, we assess the key drivers, barriers, and expected market trajectories. The findings aim to contribute to a deeper understanding of how businesses perceive the opportunities and challenges of quantum communication.

2. Literature review

A structured literature review on quantum communication's fundamental principles and industry, highlighting the transformative effect of the advancement of technology in communication, was made by Aware and Pande (2023). Seskir and Aydinoglu (2021) have analyzed over 49,000 articles on quantum technologies, clustering them into quantum communication, computation, and physical systems. Relevant published research provides an extensive account of quantum communication theory, emphasizing modern approaches and covering classical communication, entanglement, and private communication (Khatri & Wilde, 2020). Chen (2021) described the progress in quantum communication and computing, focusing on applications like teleportation, cryptography, and quantum networks while Gisin and Thew, (2010) explore the transformative impact of quantum communication technologies on society and the economy.

According to Gisin and Thew (2010) "first applications have already found their way into niche markets, and university labs are working on futuristic quantum networks", paving the way to effective applications ranging from secure cryptographic systems to quantum networks. Efforts to build quantum communication networks are emerging worldwide, including satellite-based systems and local area networks, aiming to achieve global-scale quantum-secured communication (Xu, 2014). To support the growing field, there is a need to educate future quantum engineers and researchers to overcome the gap between theoretical understanding and real-world applications (Razavi, 2018). Investment in quantum technologies is consistent, of approx. 42 billion USD from public funding. Although private and corporate funding for start-ups slowed from prior years, specialists foreseen a 2035 market size of 11-15 billion USD for quantum communication (McKinsey & Company, 2024). In Figure no. 1 is represented the total investments in quantum technology from 2002 to the most recent available data in 2023.

Figure no. 1. Investments in quantum technology



Source: (McKinsey & Company, 2024)

The investment decrease represented in the above figure can be explained by the challenges like scalability, integration with classical systems, and cost reduction that quantum communication faces (Diamanti, 2021). The rapid advancement of the quantum technologies ecosystem made imperative the assessment of the maturity of these technologies and their imminent acceleration towards commercial viability (Purohit, 2024).

3. Research methodology

The methodology used for this study is based on a survey aimed to gather insights from business representatives about their awareness, perception, and expectations of quantum communication technology. The survey aims to understand a wide range of perspectives on how organizations view

the technology's potential impact on strategy and innovation. The study is targeting professionals from diverse industry sectors and organizational roles and the focus is on businesses' preparedness, perceived benefits, and challenges related to quantum communication.

Regarding the structure, the survey is divided into four main sections with a total of 10 questions. The number was questions was minimized in order The survey starts with demographic questions (3 questions). Such section has the aim to collect background information about respondents, including industry sector, organization size, and role. The next section of the survey is related to awareness on quantum communication, having the aim to gauge respondents' familiarity with quantum communication and their sources of information: *From 1 to 10, how familiar are you with quantum communication technology?* and *What sources of information have contributed to your awareness?*

The next section is inquiring the perception of the respondents in order to understand how respondents view the significance and applications of quantum communication in their industry. *How significant do you think quantum communication will be for your industry?* (1-10 scale); *What specific applications do you foresee for your industry? What benefits do you expect quantum communication to bring?*

The last section of the survey has the aim to assess expectations and challenges of related businesses and explores which sectors might benefit first from quantum communication, as well as identified barriers.

The survey consists in multiple-choice questions and Likert scale ratings (e.g., familiarity and significance ratings) and open-ended questions to collect free-text responses to capture detailed insights on applications and benefits. Multiple-selection questions were also included, for identifying barriers and sectors expected to benefit first.

The survey has been shared with local business representatives in Constanta region, Romania, between start of September to end of November 2024. Participants to the survey came from startups, SMEs, large enterprises, and universities. The dataset included representatives from organizations of all sizes in retail, commerce, education, telecommunications, defense, research, logistics and information technology, ensuring diverse perspectives.

4. Findings

We observed a diverse range of roles across various sectors, with a significant concentration in defense, national security and cybersecurity. Many responses indicated a direct involvement in defense and national security. Cybersecurity is another prominent field with strong emphasis on digital security, possibly in response to the growing need for security in digital infrastructures. Valid replies were also received from organizations involved in technology-driven sectors like cloud computing, but a significant number of responses were submitted by respondents in academic and training roles.

Respondents' awareness of quantum communication (*question 5*) is shaped primarily by three key sources: academic research, industry conferences, and media, with training programs also playing a notable role. The most frequently cited source being academic research, this implies that quantum communication is still a highly specialized and research-driven field and universities, research institutions, and scientific publications are key drivers of knowledge dissemination in this area.

Analysis of responses to "*From 1 to 10, how familiar are you with quantum communication technology? Where 1=I have never heard of it ...10 = Expert*" indicate a moderate to low level of familiarity with quantum communication technology, with ratings between 3 and 5, This suggests that while respondents have some awareness, they do not consider themselves experts, and their understanding remains limited or introductory. Many replies received from the respondents were of 1 meaning a lack of knowledge on what quantum communication technology is. These results are commented below, in the section Limitation of research.

The responses collected to the question "*What specific applications of quantum communication do you foresee for your industry?"* highlight security, efficiency, and technological advancement as key drivers of quantum communication adoption. Responses such as High Secure VPN applications, Quantum Key Distribution (QKD), and securing 5G communications, suggest that industries are prioritizing data protection and resilience against cyber threats. The emphasis on critical

infrastructure protection signals that sectors like finance, energy, and telecommunications anticipate quantum communication as a strategic necessity for safeguarding essential services.The mention of autonomous ships requiring continuous data exchange and X-band satellite communication improvements suggests that quantum communication could enhance logistics, defense, and aerospace by enabling secure, high-speed data transfer. Furthermore, the reference to fast and secure satellite media storage and streaming indicates that industries handling large-scale data, such as media, surveillance, and geospatial intelligence, expect quantum communication to drive efficiency and reliability in data-heavy workflows. Finaly, the response about a platform for AI model training and deployment using quantum computing points to the potential for synergies between quantum communication and AI, particularly in cloud computing, research, and high-performance computing applications. From a policy perspective, these responses indicate the need for new regulatory frameworks and investments to support quantum-secure infrastructure. The mention of cybersecurity in student data management highlights concerns about data privacy and compliance, which could lead to new standards for educational institutions and public services. Securing 5G communications and critical infrastructure means that policymakers may need to mandate quantum-safe encryption and ensure that telecommunications and essential services adopt quantum-resistant protocols. As industries explore autonomous systems and AI integration, regulatory bodies may also need to address ethical and security concerns in this regard.

Replies collected to the question *"What benefits do you expect quantum communication to bring to your sector?"* vary from *"security increased", "better education", "faster data analysis and less packet intrusions", "Secure communication between ships and authorities, new skills for students, "secure data transmission, which can significantly improve the security of communications (…) as well as promoting research in these highly relevant fields",* to *"revolutionize cybersecurity by ensuring secure data transmission", "revolutionize areas like distributed computing, cloud computing, and high-performance computing" or "more reliability and efficacity"*. Such replies highlight a strong expectation that quantum communication will enhance security, efficiency, and innovation across various sectors. The emphasis on secure data transmission aligns with growing concerns about cyber threats, while the mention of faster data analysis and reduced packet intrusions suggests potential cost savings and operational improvements, making quantum communication attractive for sectors that rely on real-time decision-making (e.g., logistics, finance, and healthcare). Furthermore, the reference to reliability and efficacy indicate that businesses anticipate fewer disruptions and better performance in critical communication networks. From a policy perspective, the responses indicate that quantum communication is seen as a strategic technology for national security, education, and digital infrastructure. The emphasis on secure communication between ships and authorities underscores its potential role in maritime security and law enforcement, which could drive new regulatory frameworks. The expectation that quantum communication will promote research and education suggests a need for public investment in workforce development to ensure that industries and governments have the necessary skills to adopt these technologies. Policymakers may need to address issues related to data sovereignty, cross-border regulations, and infrastructure investments and governments may push for quantum-safe encryption standards, requiring businesses to adapt to new compliance measures.

Analysis of the responses to "*Which sector do you believe will be the first to benefit from quantum communication?*" indicate a strong consensus that security-driven sectors will be the earliest adopters of quantum communication. The most frequently mentioned sectors were defense and national security, cybersecurity and telecommunications with additional mentions of cloud computing, financial services and data centers.

The replies collected to the last question "*What do you perceive as the main barriers to adopting quantum communication*?" highlight several barriers to adopting quantum communication, with a clear focus on infrastructure, costs, and workforce issues. Prevalence of „*high costs*" appear in almost every response and is related to financial constraints which are a major concern across responders that hold various roles in the organization. The high initial investment needed for quantum communication infrastructure, research, and development could deter many organizations from adopting this technology and cost-effective solutions, funding, or financial models (such as public-private partnerships) might be necessary to overcome this barrier. Many responses also cite „*lack of infrastructure*" as a key barrier which relates to lack of physical specialized infrastructure (e.g.,

quantum communication networks) and indicate that quantum communication is not yet widely accessible and requires substantial investment in new technology, networks, and facilities. Organizations might face challenges in scaling up quantum communication systems without substantial upgrades to their existing infrastructure. The "*lack of skilled workforce"* is also frequently mentioned, especially in technical and academic roles, in line with a clear gap in the availability of skilled professionals who can design, implement, and maintain quantum communication systems. This result suggests a need for education, training, and talent development in quantum technologies to support future adoption. Organizational inertia can be another significant challenge in adopting disruptive technologies. Companies might need to focus on changing management strategies, leadership buy-in, and educating stakeholders to overcome this barrier. With quantum communication still being an emerging field, the uncertainty regarding its financial benefits (e.g., whether it can provide a competitive advantage or cost savings) could hinder adoption. "*Interoperability with existing systems*" is noted as a barrier by some respondents, particularly in executive and academic roles. Overall, the responses highlight significant barriers to adopting quantum communication, particularly related to costs, infrastructure, and workforce issues. Future businesses related to quantum communication technologies must focus on overcoming these barriers through education, strategic investments, and clear communication of the long-term value of quantum communication.

5. Limitation of research

The survey highlights a significant gap in awareness about quantum communication. While 43 replies were received in total, the sample size was reduced by 77% due to a high non-completion rate. Only 10 responses were considered valid as they provided insights from individuals aware of quantum communication concept while the rest of 33 respondents have replied with "1" at the question "*From 1 to 10, how familiar are you with quantum communication technology*?", where 1 indicated the total lack of knowledge on quantum communication and therefore they ended survey completition.

Such results highlights a significant lack of awareness about quantum communication within the target population of businesses representatives and employees in Constanta county, Romania, for the 2024 period. The majority's unfamiliarity with quantum communication suggests that local businesses and industries may not yet recognize its potential economic implications. This could signal a need for increased education, outreach, and investment in awareness campaigns to bridge the knowledge gap. A small sample size can't capture the full range of the national industry perspectives, leading to potential bias, therefore the study needs to expand the target group with respondents outside Constanta County.

6. Conclusions

The survey-based study on business perspectives in quantum communication aimed to gather and analyse responses from local industry leaders, researchers, and technology companies to understand their perspectives on the current state of quantum communication related businesses. The aim of the survey was to envision the readiness of industries to adopt quantum communication technology. The small number of respondents familiar with the concept of quantum communication may indicate that such concept is still in its infancy in terms of adoption and understanding. Expanding participation will enhance the survey's impact and reliability, making it more useful for guiding strategic decisions in quantum communication adoption. Policymakers and industry leaders must account for this knowledge gap when planning strategies for quantum technology integration. Related to the structure of the respondents, the consistent representation from the Education sector indicates a growing academic focus on quantum communication, which is crucial for research and workforce development, while the inclusion of telecommunications, defense research, and IT reflects the sectors where quantum communication has practical and strategic significance. Results of the survey indicate several challenges in quantum communication related business like the technical, regulatory, and financial barriers to the widespread adoption, beside issues with scalability, reliability, and the need for specialized hardware.

However, the literature review indicates a potential market for quantum communication solutions. Future business opportunities arise from quantum communication, including partnerships, product development, and consulting services, encouraged by the governmental and private investments in research and commercialization. Quantum communication services have the potential to improve sectors like finance, healthcare, telecommunications, defense, transport and supply chain, suggesting the possibility of disruptive innovations or market shifts.

Businesses see quantum communication as a way to enhance security and efficiency, while policymakers must prepare for regulatory challenges, workforce development, and infrastructure investments to maximize its benefits. They anticipate enhanced security, efficiency, and new technological capabilities, while policymakers should focus on regulatory adaptation, investment in quantum infrastructure, and workforce development to maximize the benefits of quantum communication.

We consider the survey provided primary insights into industry perspectives, and represents a starting point for extensive research helping researchers and policymakers understand the current landscape and readiness for quantum communication. The expansion of the responders' target group could bring valuable input to guide businesses, researchers, and governments in addressing challenges and prioritizing resources for quantum communication development.

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