Mapping the global quantum ecosystem

A comprehensive analysis based on innovation, firm, investment, skills, trade and policy data

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Forewords

The year 2025 marks a century since the initial development of quantum mechanics. Today, quantum technologies are being developed using these principles to expand the frontiers of human knowledge and solve complex problems beyond the reach of conventional digital technologies. Quantum technologies have the potential to enable powerful new forms of computing, safeguard critical communications and achieve levels of precision in sensing and measurement that enable groundbreaking advancements, ranging from medical imaging to navigation to environmental monitoring.

Governments across the world have acknowledged the potential of quantum technologies to reshape industries and drive scientific breakthroughs and are taking policy action. Over 30 countries have formulated tailored policies to support the responsible development and adoption of quantum technologies, including 18 OECD countries that have comprehensive national quantum strategies.

To support the design and implementation of these policies, this report provides a comprehensive overview of the ecosystems that sustain quantum technologies. It charts the development of quantum technologies through a dynamic network of actors: research institutions, innovative start-ups, established firms, investors, and public authorities. It also provides new analysis, including on investment patterns and skills demand, as well as initial evidence on trade flows related to equipment, goods and raw materials that are relevant for quantum technologies. Based on this analysis, the report provides key insights for governments seeking to design policies that foster innovation and presents an assessment of government efforts to promote and stimulate the development of quantum technologies.

This study was prepared in collaboration with the European Patent Office (EPO) and draws on multiple data sources to shed light on the science, firms, investments, skills, trade flows, and policies that characterise the quantum ecosystem. This collaboration provides unique insights into the evolution of quantum technologies' ecosystems, underscoring the value of international co-operation in building a robust evidence base for sound policymaking in fast-moving fields.

Building on related OECD work, including our Quantum Technologies Policy Primer (2025) and Overview of National Strategies and Policies for Quantum Technologies (2025), this report contributes to the Organisation's effort to deepen the evidence base and promote international co-operation among its membership to identify policies and best practices for the responsible development and deployment of quantum technologies.

We are committed to helping policymakers navigate the opportunities and challenges of this new frontier, and to shape a quantum technology-enabled future that delivers broad benefits for our economies and societies.

Mathias Cormann
OECD Secretary General

Quantum technologies have the potential to drive broad societal progress. They could deliver unprecedented advances in communication security, computational performance and sensing capabilities, with benefits reaching from defence to healthcare and environmental protection. Mario Draghi's landmark report identifies quantum technologies as a strategic priority, underscoring their importance for Europe's industrial competitiveness and technological sovereignty.

Despite their transformative promise, quantum technologies are still at an early stage of maturity. Policymakers, research organisations, startups and established companies dedicate considerable resources to creating a quantum ecosystem aimed at bringing quantum science to market. There is a pressing need to monitor progress across this increasingly complex landscape to better co-ordinate efforts and help turn the quantum promise into reality.

The EPO and the OECD have joined forces to produce a new study on the occasion of the United Nations' proclamation of 2025 as the International Year of Quantum Science and Technology. Bringing together their complementary expertise, the two organisations provide an unprecedented overview of the global quantum ecosystem. The study is unique in its breadth and depth, offering a comprehensive analysis of patenting activity, investment, skills, supply chains and policy trends. It is intended to serve as a valuable compass for the quantum community in the years ahead.

The study shows that the quantum ecosystem is expanding rapidly, with strong growth in innovation, new firm creation and investment, particularly in quantum computing. Europe has a solid base of quantum startups driving these advancements, but these attract less investment than their counterparts in the US. Large established firms operating primarily outside quantum contribute substantially to the ecosystem and will play a key role in bringing quantum solutions to market. Despite rapid progress, the field remains focused on technology development over commercialisation and rising dependence on a few strategic suppliers is adding to systemic vulnerabilities. Public policies have so far focused mainly on supporting research and development, but future efforts will have to expand beyond that to sustain Europe's progress in quantum.

As part of this broader effort to support European competitiveness, the EPO's Observatory on Patents and Technology has launched a new platform on quantum technologies, offering a unique lens on technological developments, and has updated the Deep Tech Finder with an extended quantum filter to help identify startups innovating in this field. These resources can be found at epo.org/trends-quantum. Together, these tools reinforce the role of patents as a cornerstone for advancing quantum technologies, helping innovators bring discoveries from the lab to the market.

In carrying out this project, the EPO's Observatory benefited from the support of 14 national patent offices: Austria, Belgium, Croatia, Cyprus, Czech Republic, Finland, France, Latvia, Luxembourg, Monaco, Netherlands, Slovenia, Spain, and the United Kingdom. We look forward to continuing this fruitful co-operation.

António Campinos
President, European Patent Office

Executive summary

Quantum technology areas, namely quantum communication, quantum computing (including simulation) and quantum sensing, hold the potential to have a profound impact on the economy, society, science and security across a broad range of industries and applications.

As a result, the quantum technology ecosystem (hereafter "quantum ecosystem") comprising a diverse array of stakeholders including large multinational enterprises (MNEs), small and medium-sized enterprises (SMEs), startups, universities, public research organisations (PROs) and investment firms – has become a strategic area of interest. Despite its early stage of technological maturity and the limited commercialisation to date of most quantum technologies, understanding the structure and dynamics of this ecosystem is critical to anticipating its future evolution and policy needs.

Taking an ecosystem perspective, this report outlines the complex web of actors and relationships underpinning modern industrial production and identifies major challenges such as barriers to technology development and diffusion, as well as the lack of skills or access to critical inputs. It draws on multiple data sources to capture the various dimensions of the quantum ecosystem, underscoring its richness and complexity.

The report describes the current state of technological development in the quantum field based on patent data and identifies the main ecosystem stakeholders involved, distinguishing between a core group of companies whose primary activity is to develop quantum and quantum enabling technologies and a broader ecosystem of organisations contributing to quantum development while pursuing other primary business objectives.

It documents current investment trends as well as the workforce skills and occupational profiles associated with these stakeholders. Despite the currently limited size of this market, the report also presents preliminary evidence on trade in quantum-relevant goods and reviews government policy measures supporting quantum development, with a focus on public R&D funding.

Key findings

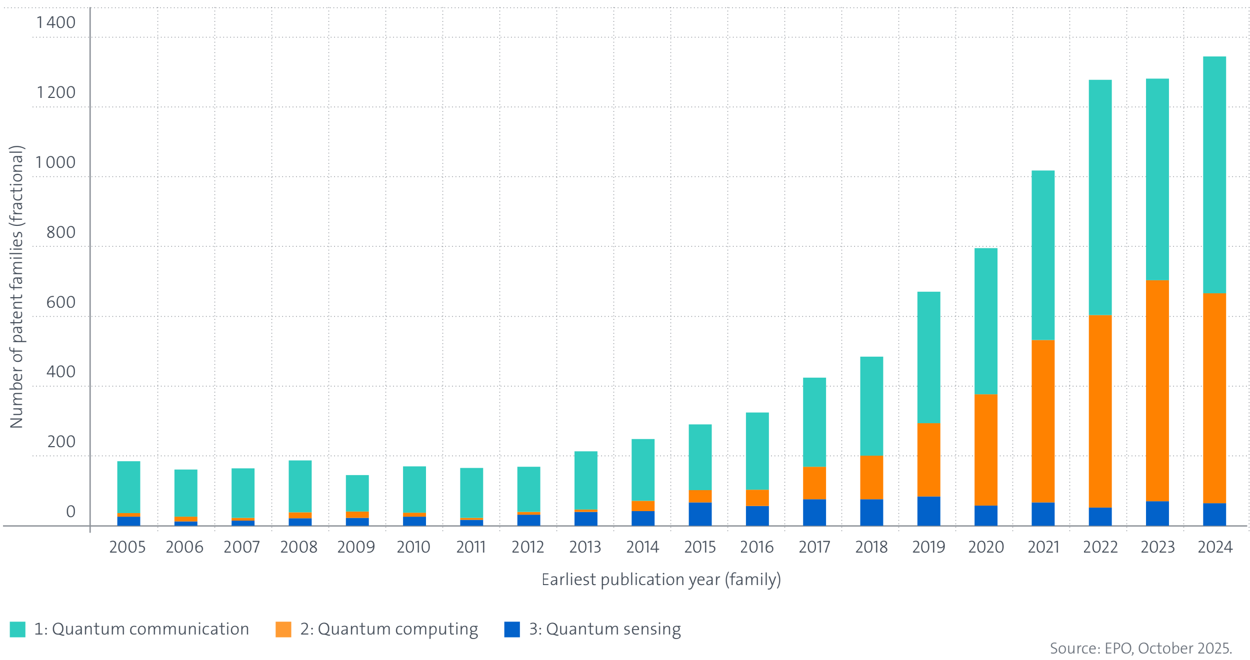
1. Rapid but uneven growth across technologies

The ecosystem is expanding rapidly, reflected in rising firm entry, increasing investment – both venture and corporate – and strong growth in innovation activity across multiple competing alternative technologies within each quantum domain. While quantum communication remains central in terms of both firm creation and patenting activity, quantum computing is currently the most dynamic area, driving the sharpest increases in both firm creation and patenting.

Figure E1 shows that the number of international patent families (IPFs) in quantum increased sevenfold between 2005 and 2024, with most of this growth concentrated in the last decade. Since 2014 quantum IPFs have expanded at a compound annual growth rate (CAGR) of 20%, far outpacing the 2% growth observed across all technologies. Quantum communication generated the largest number of yearly IPFs until 2022, when it was overtaken by quantum computing. Among all fields, quantum computing has shown the most dynamic growth over the last decade, expanding nearly 20-fold since 2014, compared with a threefold increase in communication and a 50% rise in sensing. Figure E2 shows a similar acceleration in firm creation across quantum areas until 2021 (more recent data on firm entry is probably incomplete due to lags between firm creation and their inclusion in databases).

Figure E1

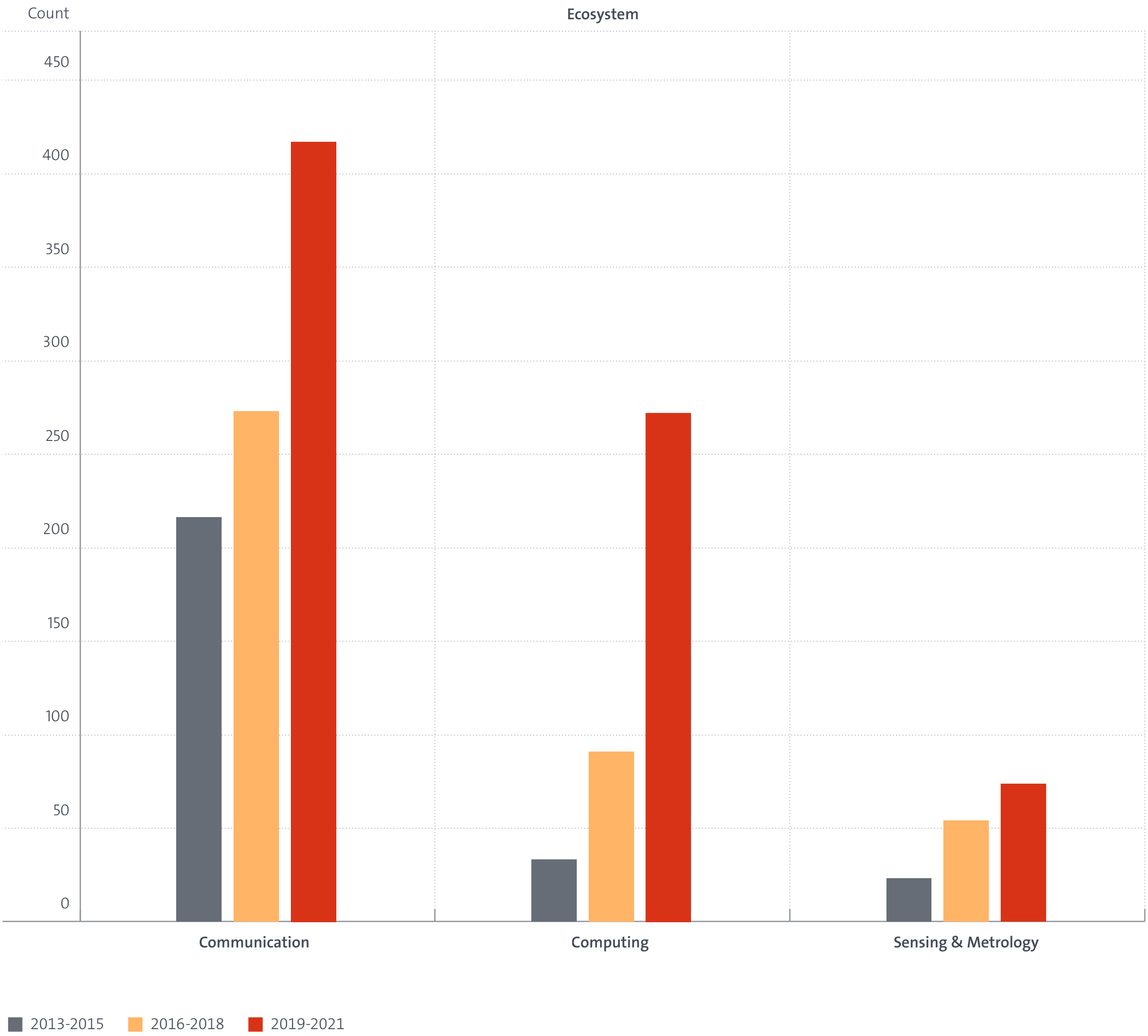
Trends in IPFs in quantum technologies by quantum area



Source: EPO, October 2025.

Figure E2

Quantum ecosystem entries by main technology: 2013-2021



Notes: The figure shows only firms with a quantum patent. Entry is defined as the year of a firm's first quantum patent. The definition of the main technology of a company is based on the technology with the strongest representation in its patent portfolio as of the latest available date (2025). If a firm has the same number of patents across multiple technologies, it is assigned proportionally across the categories.

Source: OECD calculations based on OECD, STI Micro-data Lab and Orbis, Bureau van Dijk, October 2025.

2. Young firms focused on quantum development coexist alongside diversified, established companies

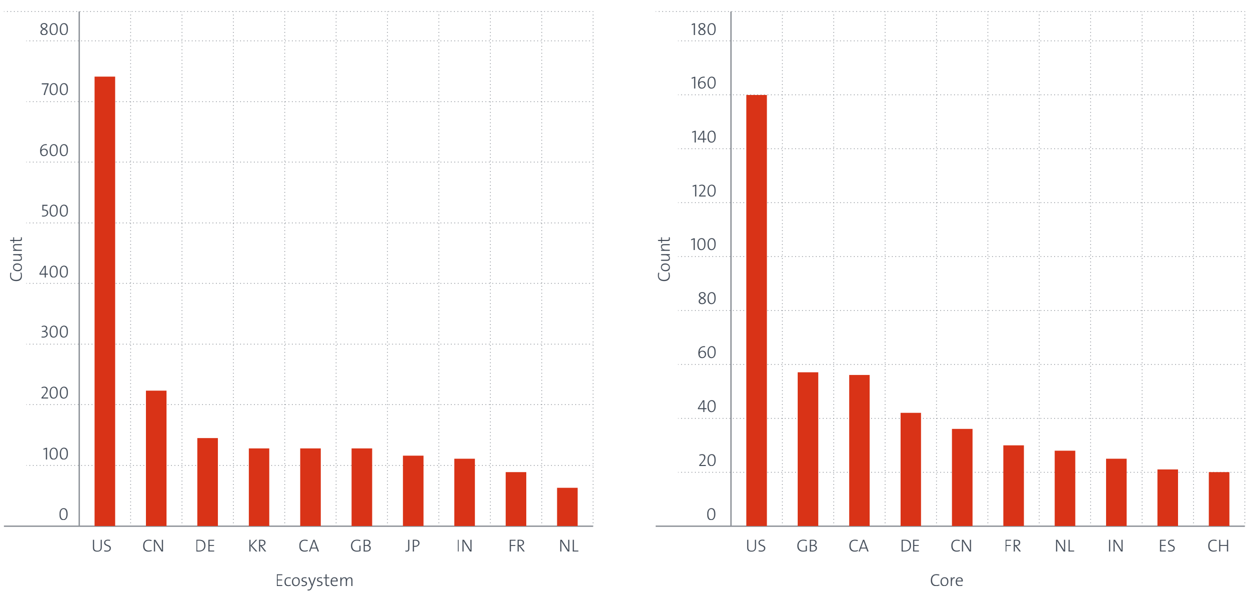
The field is characterised by the coexistence within the broad ecosystem of a relatively small number of "core" companies whose primary activity is to develop quantum and quantum-enabling technologies, and a plethora of non-core organisations composed of large established companies, universities and PROs moving into the quantum space. The broader ecosystem plays a pivotal role in both innovation and shaping labour demand, as most patents and quantum-related job postings originate from firms whose main business lies outside quantum technologies. This underscores the relevance of large, established players operating outside the core, and the potential of firms developing specific quantum applications for their own use to drive the ecosystem's growth.

The quantum industrial ecosystem comprises 4 622 organisations, including 830 core companies whose activities are primarily or entirely focused on quantum technologies. Core quantum firms are typically startups that rely heavily on early-stage investment and public funding. While these are poised to play a key role in translating deep tech research from universities into market applications, the broader ecosystem (including both public research organisations, PROs and large established companies) accounts for the majority of quantum activity. These non-core organisations whose main area of activity lies outside quantum represent more than 80% of the quantum ecosystem, accounting for most quantum-related patents and jobs created. Large established companies outside the core are likely to be well positioned for commercialisation once quantum technologies mature, as they will be able to integrate quantum advancements into their existing operations without facing the scaling challenges typical of startups.

The relative importance of core quantum players varies significantly across countries, with the United States having a lower share of core companies in its ecosystem than most European countries and Canada. These differences may signal how strongly national ecosystems will eventually rely on scaling up their startups to bring quantum technologies to market. However, this interpretation should be made with caution, as the broader ecosystem in each country includes not only large firms that are well positioned for commercialisation but also public research organisations with different roles and incentives.

Figure E3

Number of firms in the quantum ecosystem entering the quantum field by country: 2015-2024



Notes: The figure shows the top ten countries by total entries in the ecosystem and founding in the core portion within the period 2015-2024. This includes 1 872 of the 4 622 firms included in the quantum ecosystem, and 475 of the 830 quantum-focused firms (other firms were founded before 2015).

Source: OECD calculations based on OECD, STI Micro-data Lab, October 2025.

3. Geographical concentration but strong international competition

The United States stands out as the leading player across all quantum domains in terms of firm entries, innovation output and total investment mobilised. Other countries, including Canada and the United Kingdom with their strong revealed technological advantage (RTA) and dense cluster of core firms, but also China, Germany, Japan and Korea (which stands out particularly for quantum communication) with their broad industrial base and rich patent portfolios, also play major and complementary roles in the emerging global quantum landscape.

Figure E4 shows that the United States accounts for the largest share of patenting activity in quantum, although its share has declined from 41% in 2015-2019 to 31% in 2020-2024. Europe follows with an increasing share of IPFs, driven mainly by Germany, the United Kingdom, and France. Japan ranks as the second-largest national IPF filer, followed by China and Korea. In terms of technological specialisation, Canada has the highest RTA, followed by the United Kingdom, Finland, the United States, France and the Netherlands.

Figure E4

Contribution of quantum IPFs by region with RTA by region

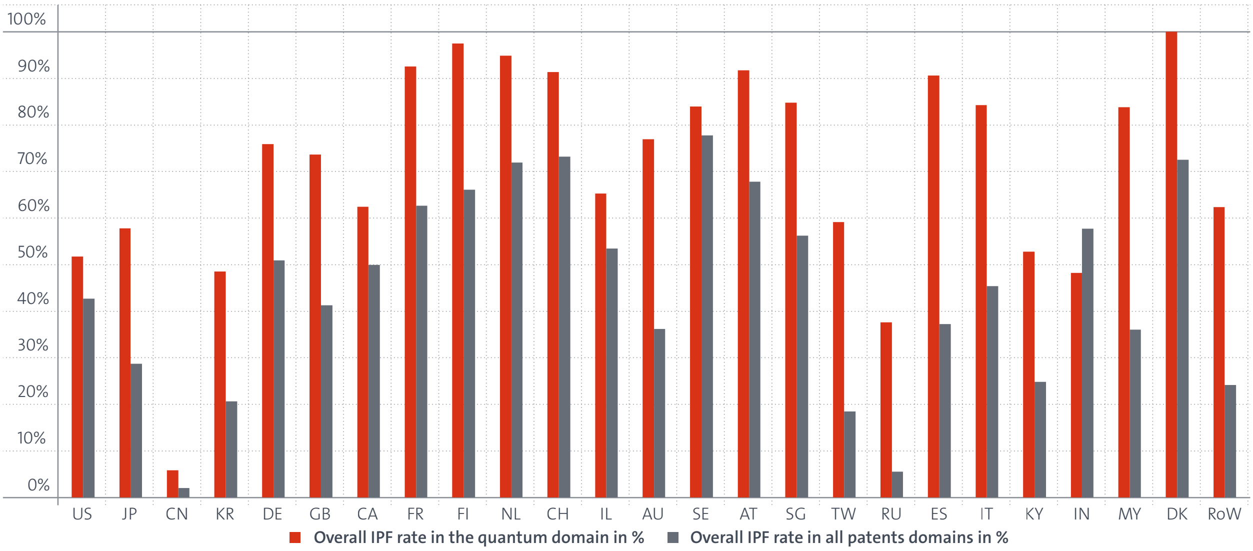
Notes: The graph shows the percentage of global IPFs on the left and the revealed technological advantage (RTA) on the right by applicant country for two time periods. The RTA indicates each country's degree of specialisation in quantum by comparing its patent share in quantum to its global patent share. An RTA above one indicates that the country is more specialised in quantum than the global average.

Source: EPO, October 2025.

The internationalisation rate, which is the percentage of IPFs compared to all patent families, is particularly high in the quantum domain (31.2%) compared to all patent domains (12.0%). Figure E5 compares the internationalisation rate of the quantum domain with that of all domains, by applicant location, ordered by each location's share of IPFs. The high internationalisation rate highlights the strategic importance that applicants across locations attribute to the quantum domain and the strong international competition between inventors.

Figure E5

Internationalisation rate per applicant location in the quantum domain compared to all domains

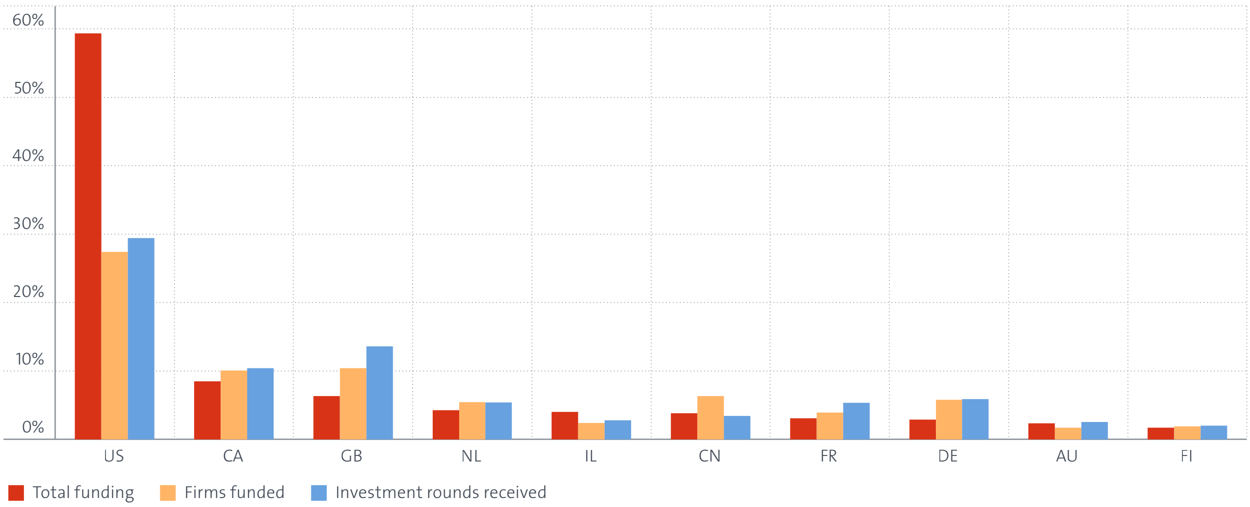


Source: EPO, October 2025.

Figure E6 shows that the distribution of funding only partially mirrors the distribution of patents and startups, with the US playing a disproportionately prominent role. Around 60% of total quantum funding ever recorded went to US-based companies, even though the US is home to only approximately 30% of all quantum IPFs and startups. This discrepancy comes from larger average deals, as the US represents also around 30% of the global number of deals recorded in quantum. Similarly, other countries, like Israel, appear to be particularly attractive in terms of funding compared to the number of startups they hold.

Figure E6

Country shares in global quantum funding, firms funded and investments rounds



Notes: The figure shows funding to core quantum companies. “Total funding” denotes the proportion of overall international funding to quantum firms that was received by firms in a given country. “Firms funded” refers to the proportion of a country’s core quantum firms, relative to the global total of funded firms, that obtained some form of funding. Finally, “Investment rounds received” represents the proportion of all international investments in quantum firms that was directed to those located in a given country.

Source: OECD calculations based on OECD, STI Micro-data Lab, October 2025.

4. High technological complexity and skill requirements

The industry remains strongly science-driven, with highly educated founders and a workforce concentrated in technical and research roles. The composition of job vacancies and the scientific character of quantum patenting both point to a continued focus on technology development rather than commercialisation.

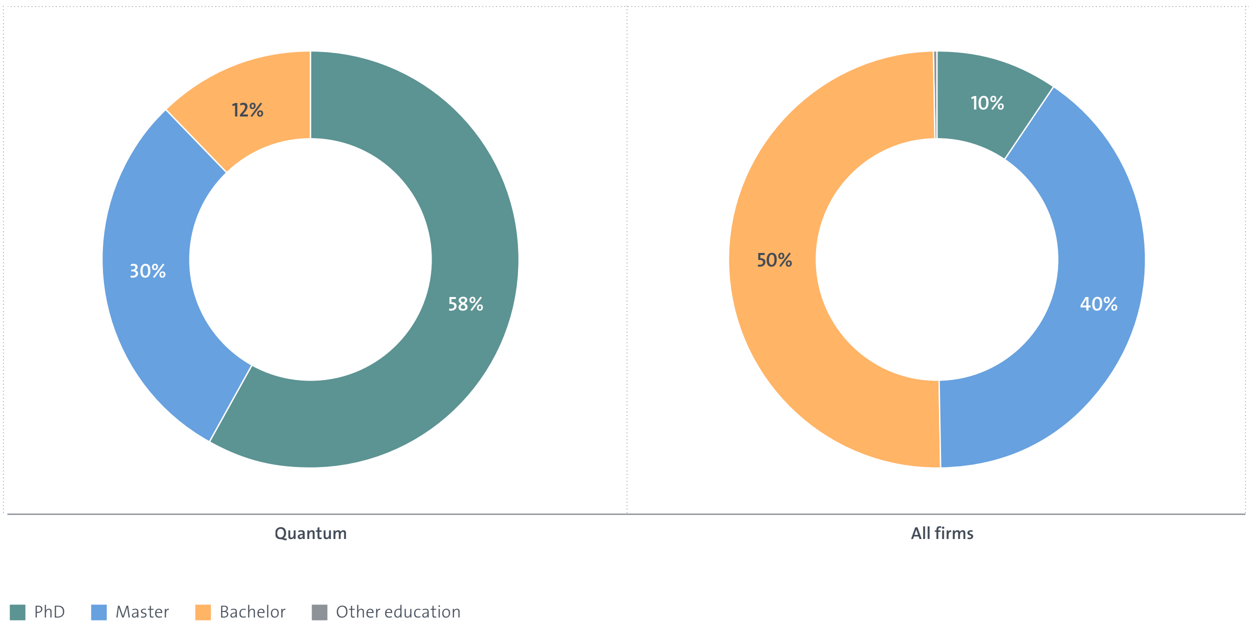
Founders of core quantum firms are more highly educated than the general population of non-quantum companies, as shown in Figure E7, with over half holding a PhD degree, versus just 10% for the general population. Employees of quantum firms also typically possess advanced scientific and engineering qualifications. Job postings reveal that demand for quantum-related skills is heavily concentrated in a small number of technical and research-oriented occupations such as computer science (26%), science and research (25%) and education and training (10%). By contrast, commercialisation-oriented occupations such as business management, marketing and sales account for less than 10% of vacancies altogether.

The high educational level and strong research orientation of quantum founders and employees are reflected in the scientific character of quantum patenting. As shown in Figure E8, a significantly larger share of quantum patents cite non-patent literature (NPL) compared with patents in other technology fields. This indicates a close proximity between quantum innovation and scientific research, as most NPL citations refer to academic journals and other outputs from basic research.

Both the composition of quantum-related vacancies and the strong scientific focus of quantum patents suggests that the industry remains primarily oriented toward advancing the development of quantum technologies, although some firms outside core companies have started applying quantum technologies to specific activities, including optimisation, cryptography and financial modelling.

Figure E7

Highest educational achievement of quantum firms' founders

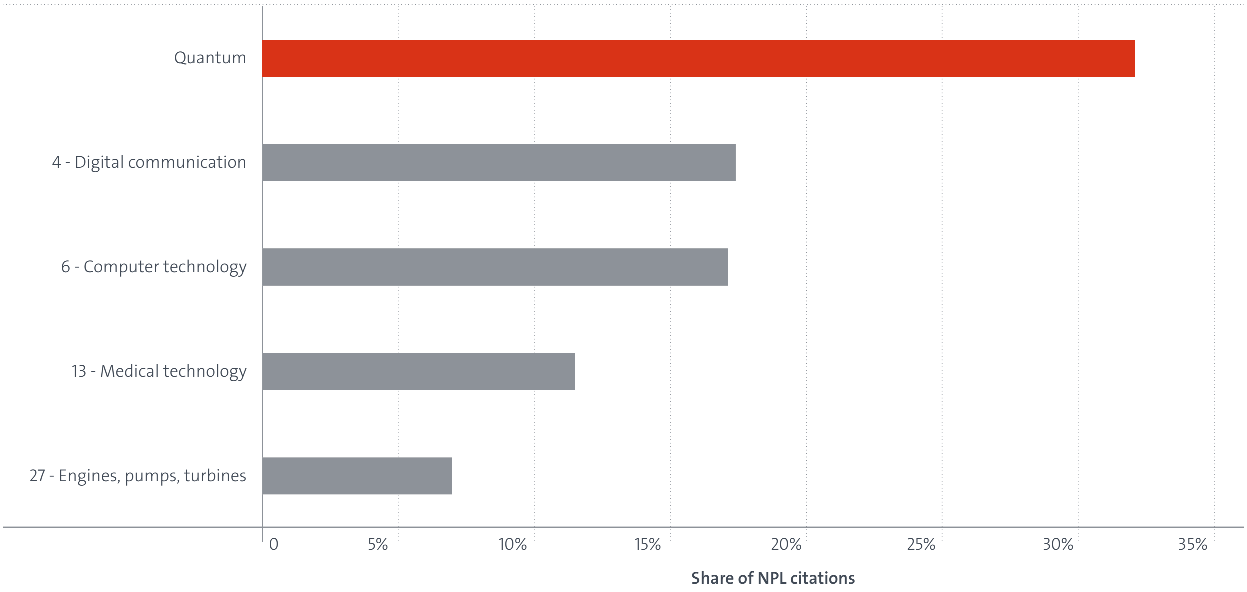


Notes: The figure includes information on 657 out of 1 208 identified founders of core quantum firms. For the remaining ones, information on maximum education achievement is unavailable. Other education includes high school; Bachelor includes bachelor's, graduate, JD and DUT degrees; Master includes master, MBA, MSc, postgraduate and LLM degrees; PhD includes PhDs. All firms refer to all companies with founder information available in Crunchbase.

Source: OECD calculations based on OECD, STI Micro-data Lab, October 2025.

Figure E8

NPL backward citation rate in quantum vs other technology fields: 2005-2024



Notes: This figure shows the percentage of citations in the patent application to non-patent literature (NPL) out of the total number of backward citations by both quantum patents (in red) and a selection of other major technological areas (in grey) according to the WIPO technology fields.

Source: EPO, October 2025.

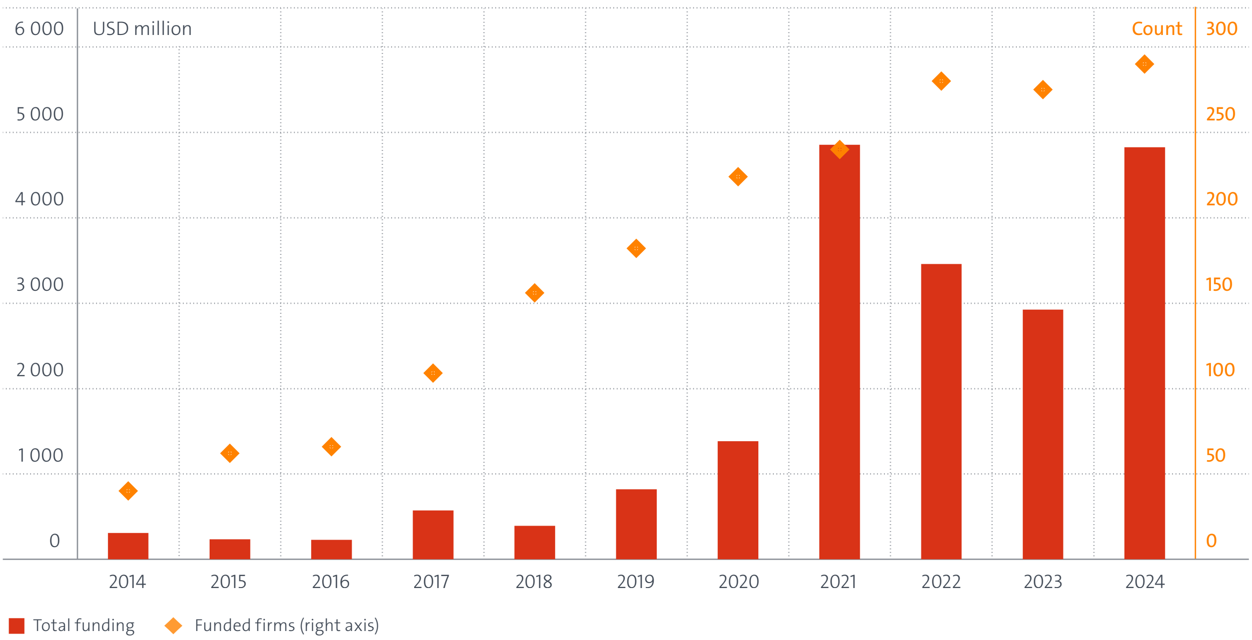
5. Challenges to scaling-up and commercialisation

Recent data on firm entry, investment and job postings require cautious interpretation, but suggest that the pace of growth may have plateaued in recent years. Trade data, albeit of limited in precision, indicate increasing concentration and dependencies in global supply chains for critical quantum components, for example, industrial diamonds, aluminium oxide and oxometallic salts. Advancing toward commercialisation (an increasing but still small focus in firms' job postings) and establishing dominant technological paradigms are important steps for the ecosystem's continued growth.

Figure E9 shows the evolution of total funding received by core quantum firms and the number of firms financed between 2014 and 2024. Overall, funding activity has expanded significantly over the past decade, reflecting growing investor interest in quantum technologies. However, after a sharp rise peaking in 2021, total investment volumes have plateaued, with 2022 and 2023 recording declines before a partial recovery in 2024. This slowdown reflects a reduction in the average deal size rather than a fall in the number of firms funded, which has remained relatively stable.

Figure E9

Total funding to and number of core quantum firms financed: 2014-2024



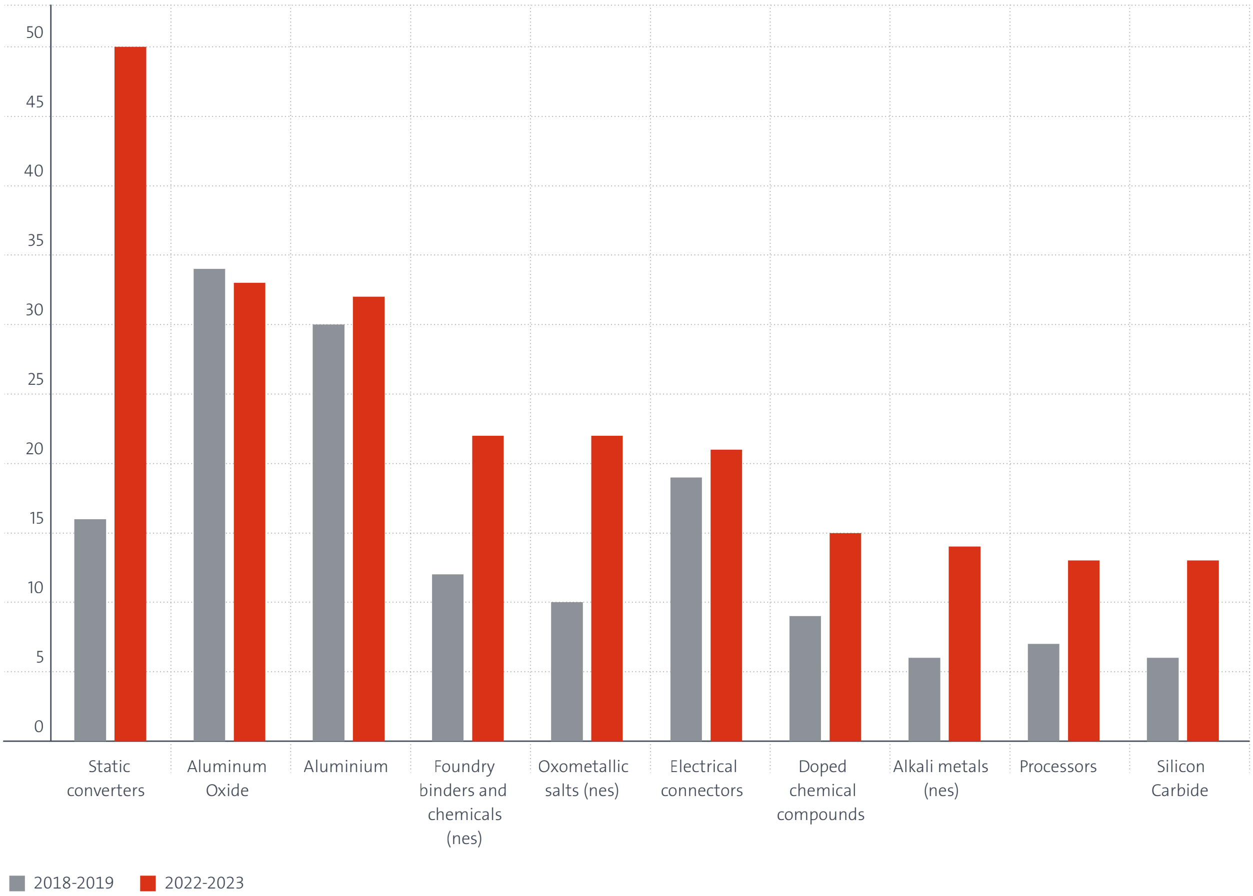
Notes: The figure portrays USD 20.01 billion, equivalent to 85% of total investment recorded.

Source: OECD calculations based on OECD, STI Micro-data Lab, October 2025.

Figure E10 presents the number of countries dependent on specific strategic inputs, focusing on those with the highest number of dependencies in 2022-2023. The data reveal that such dependencies have in most cases increased compared to 2018-2019. This trend is most pronounced for static converters, the input with the largest number of dependencies in the latest period, with 50 economies reliant on a strategically important supplier – China in almost 40 of those cases. The next two most critical inputs, aluminium oxide and aluminium (each with around 30 dependencies), have Australia and Russia as key strategic suppliers respectively. Korea emerges as the most critical supplier of oxometallic salts, a product with growing dependency levels. China also plays a central role as a strategic supplier of foundry binders and chemicals and electrical connectors.

Figure E10

Total trade dependencies for quantum-relevant goods by type: 2018-2019 and 2022-2023



Notes: The figure shows the top ten quantum-relevant products by total number of dependencies in 2022-2023.

Source: OECD calculations based on UN BACI database, August 2025.

6. R&D-focused public policies.

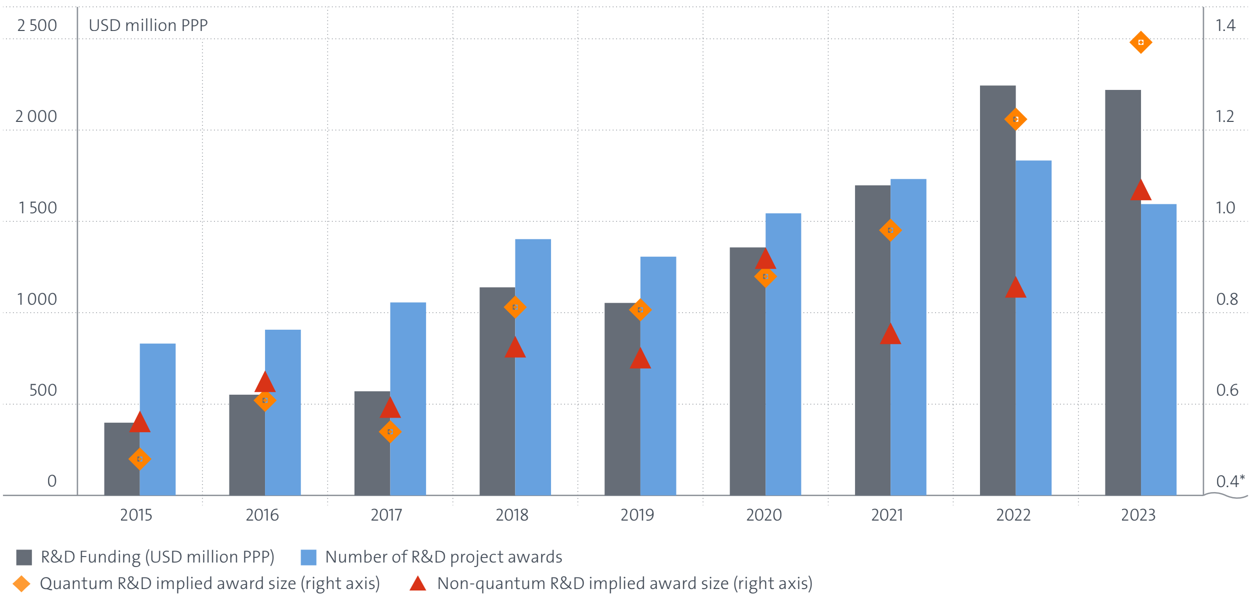
Governments have recognised that quantum technologies are still immature and that the ecosystem faces significant supply-chain vulnerabilities. In response, they have pursued a combination of policy initiatives focused not only on growing levels of public R&D funding but also on strengthening industrial competitiveness, supporting technology adoption and helping firms navigate early experimentation and commercialisation. Public support will need to continue to expand beyond innovativeness to support the ecosystem's continued growth.

The growing strategic importance of quantum technologies is evidenced by the steady adoption of national and supranational quantum strategies over the past decade, with more than 18 OECD countries having implemented such initiatives. These strategies outline priorities for technological development, risk management, stakeholder engagement, and desired policy outcomes.

Consistent with the adoption of formal quantum strategies that emphasise investment in research and innovation, public funding for quantum R&D has risen sharply in recent years. This increase extends beyond countries with dedicated strategies, as many others have also committed significant resources to develop and deploy quantum technologies. Figure E11 shows that the share of quantum R&D funding relative to total R&D funding in the OECD Fundstat database (which covers Government Budget Allocation for R&D) increased steadily over the last decade, from approximately 0.4% in 2015 to 1.1% by 2023, with a peak of 1.2% in 2022. In parallel, the share of quantum-related project awards grew proportionally, reaching nearly 0.8% of all funded projects by the end of the observed period. Notably, the implied award size for quantum R&D peaked in 2023 and has consistently exceeded that of non-quantum R&D projects since 2018 (except in 2020, potentially due to shifting priorities during the COVID-19 pandemic).

Figure E11

Estimated annual quantum R&D size: funding and implied award size 2015-2023



Notes: The OECD Fundstat database comprises R&D funding project award data from 19 OECD countries (AU, AT, BE, CA, CH, CZ, DE, EE, FIN, FR, GB, IR, JP, LT, LV, NO, PT, SE, US) and the European Union (EU) – European Commission (EC) programmes. Over the reference period 2015-2023, during which data coverage is stable, the database covers approximately 51% of the government budget allocation for R&D (GBARD) in these 19 countries (excluding general university funds, GUF), as reported in the Main Science and Technology Indicators (MSTI) Database, oecd.org/sti/msti.htm. R&D funding award data reflect authorisations rather than actual commitments or expenditure. Analysis performed on R&D project awards with available funding information.

Source: OECD analysis of the OECD Fundstat database (v.2024), October 2025

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