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European Commission

SCIENCE FOR POLICY BRIEF

EU role in the global quantum race

HIGHLIGHTS

- There are over 440 companies operating in quantum worldwide and the EU is home to a 32% of the total.
- EU firms tend to be smaller and younger than companies in other jurisdictions.
- In the period 2012-24, global private venture capital investments amounted to €6bn and investments from the public sector reached €36bn.
- The majority of private investments is from domestic later-stage venture capital and has shifted towards scaling up existing businesses with a cross-border dimension.
- Global patenting experienced a slowdown starting from 2021; nevertheless, the EU displayed a positive and stable growth in this area.
- China dominates quantum patenting activities (46% share of total patents), followed by US (23%), and then by Japan and the EU (6% each).

EU QUANTUM TECHNOLOGY: AN OVERVIEW

This policy brief provides an overview of the current state of quantum technology, examining the public and private funding, the innovation potential, and the market perspectives across four key areas of the quantum sector: quantum computing, quantum communication (and more specifically quantum key distribution, post-quantum cryptography), and quantum sensing.

The analysis delves into the **geographical distribution** of quantum companies, their **investment patterns** (with a focus on venture capital), and their activity in intellectual property protection.

Quantum technologies have emerged as a highly dynamic and promising field, attracting significant attention and investment. The United Nations has designated 2025 as the International Year of Quantum Science and Technology, while the European Commission has identified quantum technology as a critical area essential for EU economic security.

The advent of quantum technology has the potential to revolutionize the sectors of computing, communication, and sensing. The impact can extend in many other sectors (e.g., healthcare, finance, transportation), by enabling unprecedented tasks such as **complex computations** and **faster disease diagnosis**.

As the world enters a new quantum era, it is essential for the European Union to capitalize on this opportunity to enhance the development and application of quantum technologies, establishing itself as a global leader in the field. By doing so, the EU can unlock the full potential of quantum innovation, drive economic growth, and ensure that its citizens benefit from this ground breaking technology.

GLOBAL LANDSCAPE OF QUANTUM COMPANIES

A global mapping of the second quantum revolution industry has identified over 440 companies worldwide, ranging from tech giants like Microsoft and Amazon with dedicated quantum departments, to small startups developing specialized quantum applications. The majority of these companies operate in quantum computing (64%), followed by post quantum cryptography (15%), quantum sensing (11%) and quantum key distribution (10%).

The EU (see *Figure 1*) is home to a significant share of these companies, corresponding to 32% of the global total, surpassing the United States (27%) and China (5%[1]). However, **EU-based companies tend to be smaller and younger** compared to their counterparts in China and the US. Notably, only 13% of EU companies are classified as large or medium-sized, whereas 29% of US companies and a substantial 82% of Chinese companies fall into this category.

Despite this disparity, the EU has seen a surge in quantum company creation, with 60% of EU-based quantum companies established after 2018 (as shown in *Figure 2).*

This trend suggests that while the EU may have been slower to invest in the quantum sector initially, it has since then gained momentum. In contrast, the global pace of company creation slowed down after 2018, likely due to the lack of clear commercial applications

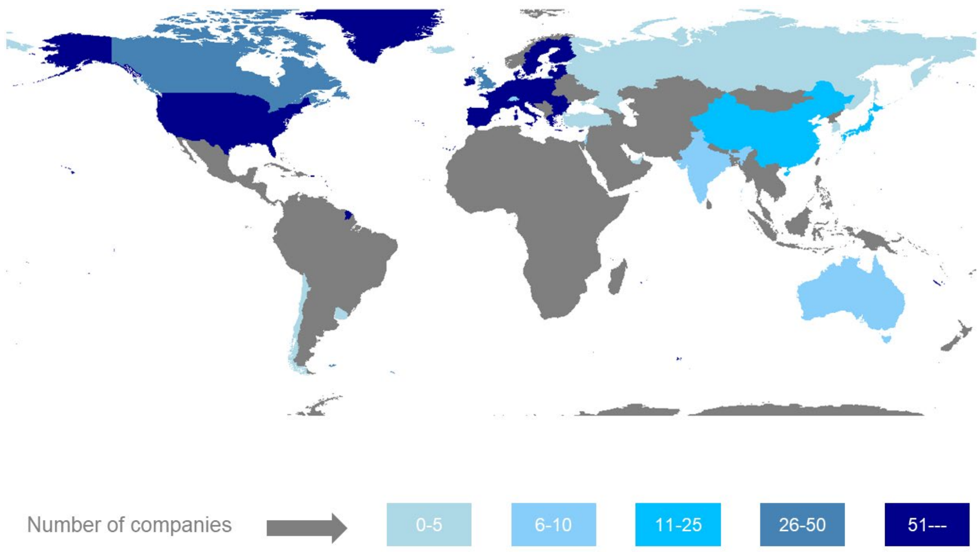

Figure 1: Quantum companies by country of origin

The map illustrates the distribution of companies across countries, color-coded to indicate the number of companies per country, with darker colours representing higher concentrations of companies.

Source: JRC elaboration based on Moody's ORBIS data.

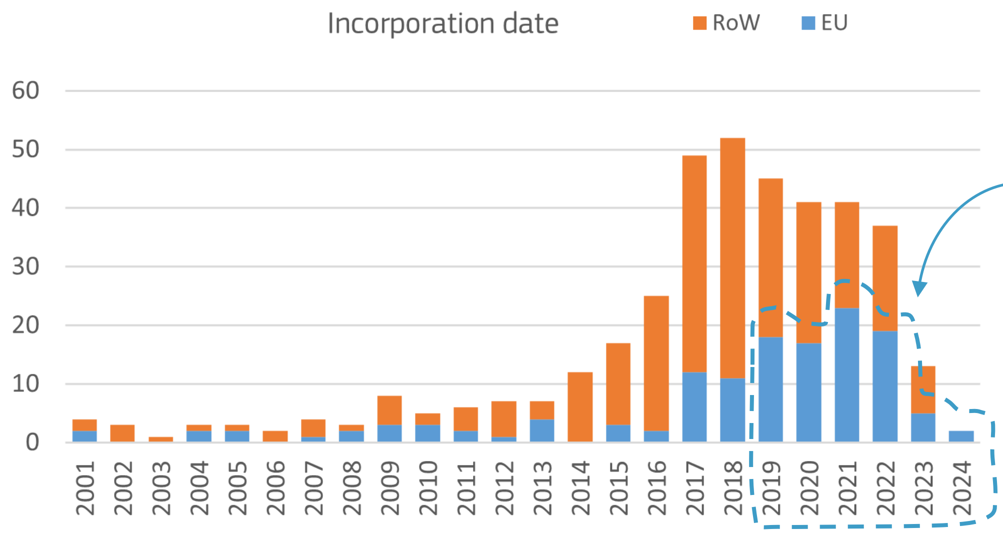

Figure 2: Quantum companies by incorporation date and location

Between 2018 and 2023, the EU has experienced a rise in the creation of Quantum companies.

Source: JRC elaboration based on Moody's ORBIS data.

[1] The figure for China is likely to be underestimated due to the lack of available data. The JRC constantly monitors the quantum landscape adding new companies as soon as they appear in media and specialized literature.

for quantum technology. As a result, there has been a shift in focus from creating new companies to scaling up existing businesses. Venture capitalists, particularly those based in the US, have shown a growing preference for scale-up investments, with early-stage venture capital investments decreasing since 2017. This shift in investment strategy indicates a maturing of the quantum industry for some technologies (e.g. quantum key distribution) as companies seek to commercialize their technologies and achieve greater economies of scale.

VENTURE CAPITAL INVESTMENTS AND PUBLIC INVESTMENTS IN THE SECTOR

Over the past 12 years, quantum companies have received approximately **€6 billion** in private **venture capital** financing[2]. The majority of this private funding, over 75%, has been allocated to quantum computing firms, while quantum sensing and post-quantum cryptography firms have each received around 10% of the total funds. In recent years, there has been a notable shift in investment strategies by venture capitalists, with a growing preference for more established firms. This is evident in the increase in later-stage financing, which exceeded 50% of total venture capital investments in quantum for the first time in 2020. This trend confirms that quantum industry is maturing with investors now favouring more established companies than early-stage startups.

As the quantum industry continues to mature, it is also becoming increasingly global, with venture capitalists looking to invest in quantum companies in the global market. Notably, although most of the total investment between 2012 and 2024 by venture capitalists has been directed towards domestic quantum companies (42%, €2.5 billion), there is evidence of a very recent shift towards increased cross-border investments.

A closer look of the geographical landscape of private investments in quantum companies reveals that between 2012 and 2024, **US-based venture capitalists have been the largest investors in quantum companies by far**, contributing **€2.3 billion** and accounting for **26% of all investment deals** (see *Figure 3*).

EU-based counterparties, while investing a lower total amount of €1 billion, have participated in a larger share of deals, representing 27% of all investments. This suggests a landscape where **US capital tends to flow in fewer but larger investments**, whereas **EU investors are spreading their capital across a wide range of transactions.**

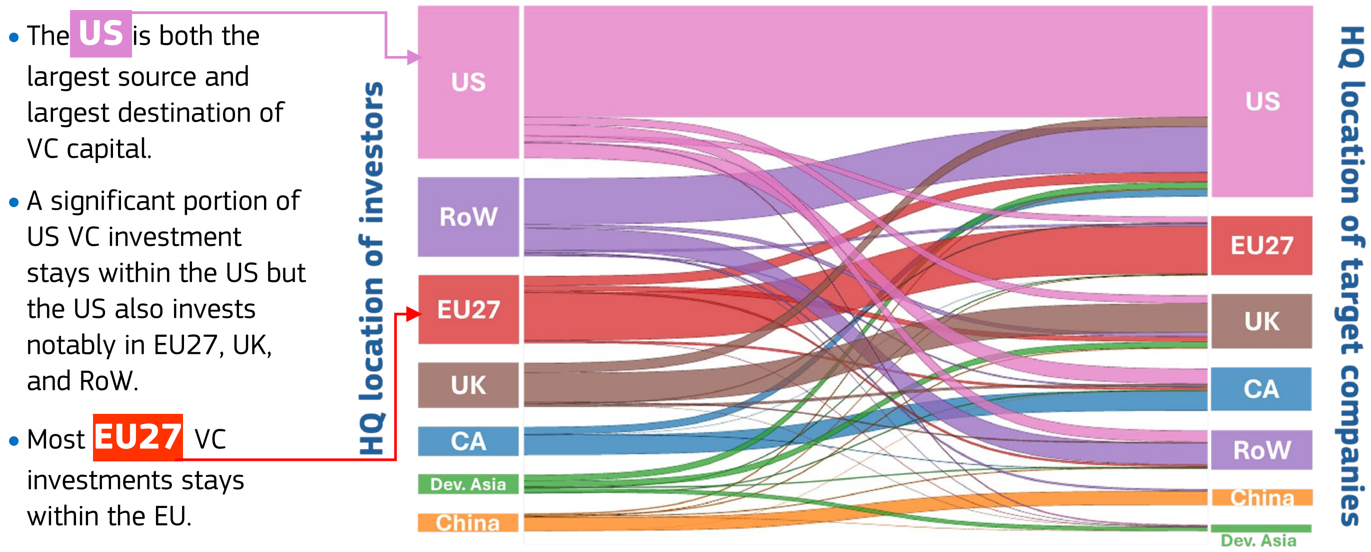

Figure 3: Intra-country/region and cross-country/region flows of venture capital investment values (2012-2024)

Source: JRC elaboration based on Pitchbook data.
Notes: About 36% of VC transactions do not report the value of the investment. The "Developed Asia" category includes Japan, Taiwan, South Korea, and Singapore. China includes Hong Kong. RoW: Rest of the World. CA: Canada.

[2] This figure and the other aggregated values are obtained by aggregating deal level data from Pitchbook database. About 36% of venture capital transactions in the database, uniformly distributed, do not report the value of the investment, therefore the figure is likely an underestimation.

The distribution of funding also reflects this pattern, with US quantum firms receiving the largest share of investments, totalling €2.9 billion. EU quantum firms come in second, securing €862 million. Interestingly, EU companies have primarily attracted investments from US- and UK-based venture capitalists, while EU venture capitalists, when investing abroad, have focused on US- and UK-based quantum companies suggesting a strategy to access cutting-edge technologies outside EU.

When discussing the development of a critical technology like quantum, the role of public investments and national programs is also a crucial aspect to consider. Indeed, the public sector has been actively engaged in supporting the growth of this industry, with estimated investments reaching approximately €36 billion at the end of 2024[3].

Several countries have defined national strategies and allocated specific funds for research and development activities. While the US accounts for about 12% of the total, the EU contributes 25% of these estimated investments with around €9 billion.

In China, quantum technology is a key priority area in industrial policy, with special State-led projects and initiatives aimed at driving growth and innovation and an ambitious plan to create a general quantum computer and simulator by 2030. Announced figures range from $3 billion to $15 billion in investments.[4]

Notable examples of China's public financial support for high-tech industries, including quantum technology, are:

- the upcoming National Venture Capital Guidance Fund, which is expected to mobilise around RMB 1 trillion (€123.6 billion) in funding for "hard tech";
- the expanded Central Bank's preferential loans program, offering RMB 800 billion (around €100 billion) in support for high-tech;
- the ongoing issuance of dedicated science and technology bonds – only in May 2025, 100 institutions already issued bonds for high-tech firm worth more than RMB 250 billion (around €30 billion).

These initiatives demonstrate China's commitment to advancing innovation in high tech, including in quantum technologies. Quantifying China's support for quantum technology is challenging, due to the lack of clear distinctions between public and private investments, as well as the absence of a unified national quantum strategy or flagship program.[5]

While non-EU public investment tends to focus on supporting a few specific technologies, in the EU public investments are smaller in scale and more widely dispersed, both geographically and across technological areas. This trend is especially visible for example in the field of quantum computing, where the EU supports all of the different platforms across a variety of countries.

INNOVATION AND KNOWLEDGE CREATION

In the rapidly evolving field of quantum technology, innovation is crucial for remaining competitive and unlocking its full potential. As R&D expenditure data is often scarce, particularly for small companies, the number of granted and filed patents provides an indication of the expected development in the sector. Countries with a significant number of patents in a specific technology area are likely to possess the necessary knowledge and skills to become strong players in that field.

A detailed analysis of patents in quantum technology reveals a significant surge in patent filings, with approximately 30,000 patent families registered between 2017 and 2024. The distribution of these patents is as follows: 59% in quantum computing, 27% in quantum key distribution, 10% in quantum sensing, and 4% in post-quantum cryptography.

China has emerged as a leader in the field, particularly in quantum key distribution, where it accounts for 46% of global patents (see ***Figure 4)***. Companies like Quantum CTek are driving this growth. The US follows with 23% of global patents, driven by major companies such as IBM, Microsoft, Google, and Intel.

3 Source: The total public funding includes investments from Member States, EC and ESA projects. See Quantum technologies in the banking sector, however please note that information on various national programme is scarce.

4 How Innovative Is China in Quantum? | ITIF

5 Notwithstanding the absence of a declared or published national strategy, China holds the largest ground-based quantum communication network (spanning over 2000 km) and the only worldwide operational satellite based quantum key distribution system.

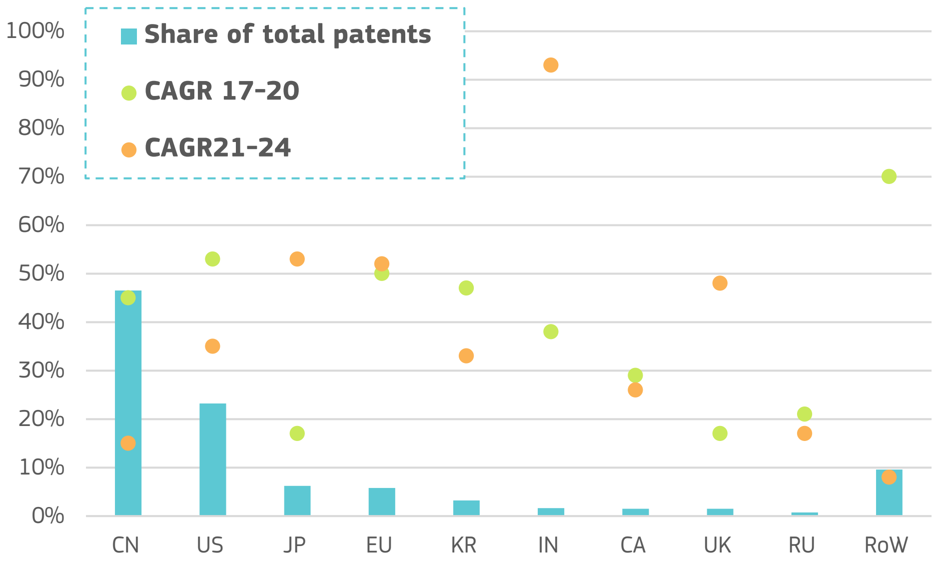

Figure 4: *Knowledge creation*

The bars represent the share of the number of patents per country as a percentage of the total number of patents. The green points indicate the compound annual growth rate (CAGR) from 2017 to 2020, while the orange points indicate the CAGR from 2021 to 2024.

Source: JRC elaboration based on ORBIS IP data.

The EU, while ranking fourth in all four quantum technologies, has experienced a positive and stable growth in quantum patenting. Notably, its compound annual growth rate has more than doubled from 2021 to 2024, driven by an increasing commitment to innovate, as evidenced by the rising volume of pending patents. [6] This growth is remarkable, given the global slowdown in patent filings observed in other major economies, such as China and the US. Another unique feature for the EU market is the strong co-patenting activities, which proves a commitment to international collaboration. Approximately 23% of EU patent applications are co-patented with non-EU partners, primarily from the US. In contrast, co-patenting is less prevalent in other regions, with only 3% of quantum patents in China, 6% in the US, and 9% in Japan involving international collaboration.

The analysis of patent data also suggests that the quantum sector has the potential to have a broader impact across different industries. A significant share of quantum-related patents (35%) is owned by companies that, while not operating in the quantum sector, invest in it to acquire knowledge and expand their business into quantum-related products or enhance their core business operations. This confirms that the quantum sector is not only driving innovation within its own field but also has the potential to transform other industries and create new opportunities for growth and development.

CONCLUSIONS

The European Union is well-positioned to play a leading role in the development of quantum technology, boasting a strong presence of companies, substantial private and public investment, and excellence in research. However, to maintain its competitive edge, the EU must demonstrate a clear commercial potential for quantum technology by translating research into concrete solutions that address specific industry challenges.

As indicated by the EU quantum strategy, the key to unlocking increased investment and driving growth in the quantum sector lies in providing a clear understanding of the value that quantum technology can bring to users. By developing quantum technologies or algorithms that solve real-world problems and meet the needs of industries, the EU companies can showcase the practical applications and attract more funds.

To achieve this, it is essential to foster collaboration between researchers, industry leaders, and private and public investors to identify areas where quantum

[6] These trends may have been stimulated by the EU funded programs and the EU regulatory framework (e.g. the Quantum Technology Flagship, the EuroQCI initiative, the Chips Act and the Horizon Europe programme). Starting from 2017, the Quantum Technology Flagship, and from 2019 the EuroQCI have stimulated a rapid increase in technological readiness level of the technologies, developed by startups (and therefore the underlying patent landscape) and the exchange of ideas and collaborations between industries and institutions certainly encouraged by programs such as EuroQCI or Marie Curie. Especially, the EuroQCI initiative with the establishment of successive rounds of studies favoured cross-country collaboration and exchange.

technology can have a significant impact. By working together, the EU stakeholders can:

- **Develop practical solutions**: Translate research into concrete quantum technologies or algorithms that address specific industry challenges, such as optimization, simulation, or cryptography.
- **Demonstrate value**: Showcase the benefits and value of quantum technology to users, highlighting its potential to improve efficiency, reduce costs, and enhance decision-making.

On the other hand, Commission and MSs should cooperate to:

- **Build a strong ecosystem and avoid fragmentation**: Foster a vibrant ecosystem that brings together researchers, industry leaders, and investors to drive innovation, entrepreneurship, and growth in the quantum sector.
- **Coordinate the national and EC financial efforts** towards an EU quantum strategy, avoiding duplication of efforts and building critical mass and scale.
- **Invest in talent and infrastructure**: Continue to invest in education, research, and infrastructure to support the development of quantum technology and attract top talent to the field. Do it in a coordinate manner within Member States to avoid "subsidy shopping" by companies.
- **Preserve EU technology edge** with a wide range policies and legal instruments coordinated with Member States.

By taking these steps, the EU can capitalize on its strengths in research and innovation, demonstrate the commercial potential of quantum technology, and maintain its position in the global quantum landscape.

REFERENCES

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QUICK GUIDE

Quantum computing uses the principles of quantum mechanics to perform calculations and operations on data, relying on algorithms reaching exponentially faster and more powerful processing than classical computers.

Quantum sensing uses the properties of quantum physics to enhance the sensitivity and precision of sensors.

Quantum communication is an ultra-secure communication system that takes advantage of the principles of quantum mechanics to transfer data in a secure way.

Quantum key distribution is an ultra-secure communication system that takes advantage of the principles of quantum mechanics to encode, transmit and decode cryptographic keys, used to encrypt the digital communications.

Post quantum cryptography refers to cryptographic algorithms that are designed to be resistant to known classical attacks and future quantum computer attacks.

Venture Capital is a form of private equity financing at various stages of companies' life cycles, notably early or later stage financing.

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