REGIONAL APPROACH: GEOPOLITICS AND GOVERNANCE

Challenges to the governance of quantum technologies in Europe

Per què és necessari avançar cap a una direcció i una coordinació estratègiques?

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Light, space and quantum computers. Conceptualization: Luisa Quiroga

Market forecasts place quantum technologies at the centre of economic growth in the next decade. McKinsey, for instance, predicts that the impact of quantum computing alone will reach $1.3 trillion by 2035, with financial services and the chemical industry expected to reap the greatest benefits. [1] Quantum technologies rely on the principles of quantum mechanics and offer unprecedented levels of performance that could enable breakthroughs in scientific research, industrial applications and national security.

However, quantum technologies also pose significant challenges and risks. For example, while still in an experimental stage, research suggests that quantum computers will be able to break 1 in 7 public-key cryptographic systems, with the number rising as high as 1 in 2 by 2031, [2] although research published in January 2023 [3] by Chinese scholars suggests that this scenario could become reality even sooner. Quantum artificial intelligence (AI), moreover, has the potential to enhance services optimisation and better inform policymaking in areas such as natural disaster prevention. However, it also has a potential impact on social engineering activities and the spread of disinformation.

For all of these reasons, quantum technologies are rapidly emerging as a strategic priority

for many countries around the world. But despite the economic omens and the disruption, a number of challenges must be met if the potential of quantum technologies is to be unleashed. Although some of these challenges relate to global technological governance, such as developing technical standards or addressing ethical concerns, in this paper we will be examining the specific issues that affect Europe's position in the global quantum technology race.

National quantum technology programmes and international competition

Global investment efforts in quantum technologies are estimated to be close to $30 billion in public funding and over $7.7 billion in equity, most of which goes into quantum computing start-ups (83.5%), followed by quantum communications. (15.27%). [4] Investments in quantum technologies vary significantly by geographical location, however.

China, for instance, has made significant investments in quantum technology. Since launching the National Laboratory for Quantum Information Sciences (NLQIS) in 2016, it has committed $15.3 billion of government funding, making it the largest investor in quantum technologies as well as the protagonist of breakthroughs in quantum communications. Also in 2016, the satellite Micius was launched as part of the Quantum Experiments at Space Scale (QUESS) programme, which was able to establish a communication channel using quantum key distribution (QKD). Since then, China has been able to establish an ever-expanding quantum integrated network already thousands of kilometres long. [5]

The United States is another significant player. The National Quantum Initiative passed by Congress in 2018 paved the way for the allocation of $1.9 billion in public funding of scientific research and commercialisation. The United States is home to almost 30% of quantum start-ups and boasts a dynamic business ecosystem that can leverage private investment. Several other policies have been implemented to expedite the deployment of quantum technologies, including the proposed Quantum Sandbox for Near-Term Applications Act of 2023. [6] In addition, the country has enacted sector-specific policies such as the 2022 Quantum Computing Cybersecurity Preparedness Act, [7] which supports the adoption of post-quantum cryptography by public agencies and bodies; and the 2022 Chips and Science Act, [8] aimed at improving America's position in the global semiconductor market, including the field of quantum chips.

> Quantum technologies are rapidly emerging as a strategic priority for many countries around the world

In addition to China and the United States, other countries [9] are making significant strides in quantum research and technological applications. For instance, the United

Kingdom has recently unveiled its National Quantum Strategy [10] and pledged to invest $3.12 billion (£2.5 billion) in public funds over the next decade. Japan has committed $700 million to its Quantum Leap Flagship Programme, while Singapore aims to become one of the world's most quantum-safe countries with an investment of $109 million.

Quantum tech governance in Europe: the need for a final push

Apart from these national initiatives, the European Union (EU) has also made significant efforts in the field of quantum technologies. In fact, when national investment and EU funding are combined, the EU is the second-largest public investor in quantum technologies, with a total investment of $7.2 billion. Additionally, the EU boasts the highest concentration of quantum technology talent in the world and is currently ranked number two in university quantum technology programmes. [11]

The European Union was among the first international players to recognise the strategic significance of quantum technologies. Following the publication of a 2016 manifesto which acknowledged the strategic importance of quantum technologies, the EU allocated an additional $1.1 billion in funding (€1 billion) to the Quantum Flagship programme to be invested in different strategic areas. But while Quantum Flagship has been instrumental in coordinating research efforts, with its 2019 Strategy Research Agenda and 2022 Strategic Research and Industry Agenda, a number of challenges are preventing the EU from fully reaping the benefits of its investments in quantum technologies. These challenges must be addressed if the EU wishes to become a global player in quantum technologies.

EU interest vs. national interest

In 2021, many EU countries created national research programmes dedicated to boosting quantum research, thanks partly to funding made available for digital-related activities under commitments they were obliged to honour while spending post-pandemic recovery funds. Austria, Finland, France, Hungary, Spain and Portugal created national quantum research programmes, while Germany, Slovakia and the Netherlands had dedicated quantum strategic documents from before the COVID-19 pandemic. However, there are two potential issues that could become problematic in the long run.

Firstly, different strategic priorities and interests in the development of quantum technologies may impact EU Member States' support for quantum-related initiatives at EU level and lead to conflicts in defining a common agenda. While some applications, such as quantum information technologies to support cyber resilience, have clearly won more support than others, major differences remain as to which technologies should be part of the transition to quantum-resistant information systems and for which uses. France, for instance, is not particularly favourable to the use of quantum key distribution (QKD). [12]

Secondly, different countries have different views on how scientific collaboration should look in an age of intense geoeconomic confrontation. Although the European Union

promotes “open strategic autonomy”, interpretation of the term is not the same for all the Member States. European Union countries investing in quantum technologies can be divided into two groups: “Internationalists” and “Europeanists”. The first group maintains relatively open policies for collaborating with non-EU countries in quantum research; Denmark, for instance, signed a joint cooperation statement with the United States in July 2022. [13] The second group is led by countries like France, which maintains a “French first, but made in Europe” policy. These countries prioritise their national ecosystems and collaborate with other EU countries but may be hesitant to share resources with non-EU countries.

> Taking national investment and european funding into account the EU is the second-largest public investor in quantum technologies

Although quantum technologies are still in a prototype phase, these different views on strategic scientific collaboration could potentially weaken Europe’s position in the global quantum technology market. The countries of the EU could develop different levels of dependency on foreign actors that would make the EU more vulnerable. These differential levels of interdependency could also compromise policymaking at EU level, especially in debates around EU trade restrictions and the overall trade policy agenda.

Access to funding

The absence of a shared agenda and coordinated national interests in scientific partnerships during a period of heightened international competition could lead to increased competition between EU countries as well as difficulties for the EU to maintain a single voice on critical issues such as trade policy or designing procurement rules.

One of the main challenges facing the European quantum technology market is the difficulty of accessing private funding. Although public funding is abundant, private investment remains scarce. While Europe has implemented various national and EU programmes aimed at reinforcing support for start-ups, almost half the global private investment in quantum start-ups has been made in the United States. [14] Even though Europe and Canada are among the regions with the most quantum start-up launches, EU companies face challenges in scaling up, often resulting in companies moving abroad, primarily to the United States, or being acquired by larger players. This trend is a recurring theme in European technology ecosystems and unfortunately appears to be replicating itself as the quantum technology market expands.

The European mindset

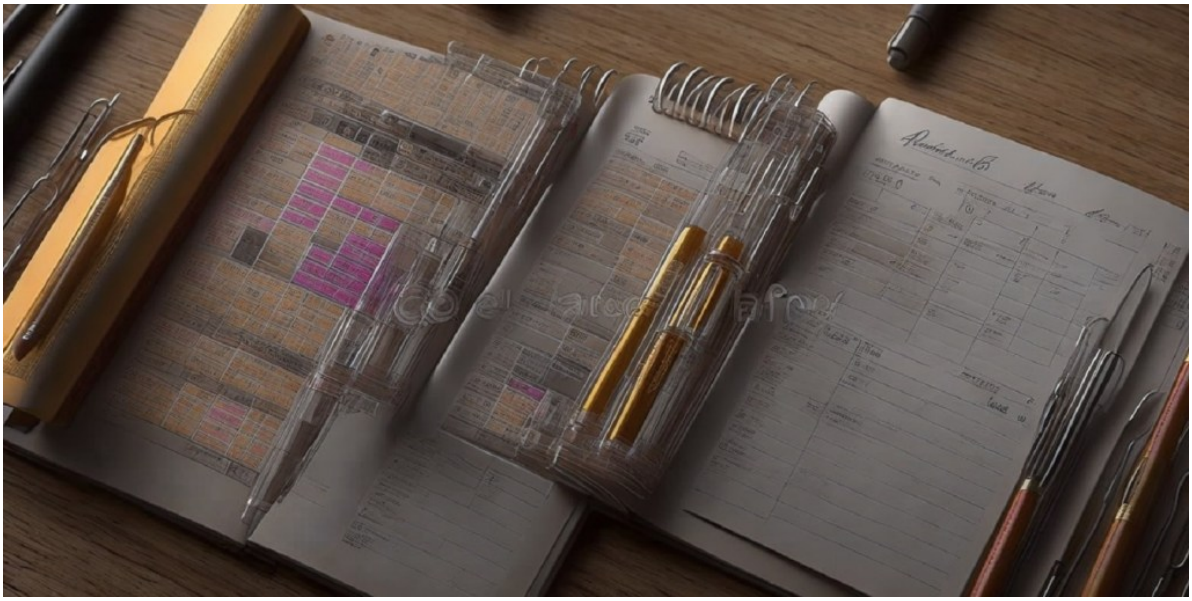
The third big challenge is the European mindset. While there is increasing recognition of the importance of quantum technologies and more public policies are created around them, they are still largely viewed as tools for maintaining scientific excellence and

competitiveness.

Many of the national quantum programmes and university consortia to emerge in recent years tend to focus on basic science research: QCzech in the Czech Republic and HunQuTech in Hungary, for instance. Similar programmes can be found in Slovakia, Finland, Sweden, Portugal and Austria. Unfortunately, these programmes are often run solely by scientists, without the input of a diverse group of stakeholders, and this leads to a lack of strategic vision. Arguably, this lack of multistakeholder governance impacts the strategic priorities of the EU quantum agenda.

A strategic agenda for quantum technologies in Europe

The European Union faces several challenges in developing a coherent strategy and funding scheme for start-ups in the quantum technology sector. These challenges – including geopolitical competition, lack of private funding, and a narrow focus on academic research – emphasise the need for a unified approach to quantum innovation. The EU has already established governance structures for quantum innovation, but additional efforts are needed.



The EU could draw an important lesson from its experience with artificial intelligence (AI), namely, that scientific research and commercialisation should not be seen as separate categories. In the case of AI, experts had long been highlighting its potential for several industries, but the lack of a sense of urgency and awareness delayed action in the EU, resulting in a weaker position in the global AI market. Consequently, not one of the top 30 AI companies in the world is based in the EU. [15]

To avoid a similar failure in the quantum technology sector, the EU needs to prioritise early coordination, strategic direction, and investment in quantum innovation. In this way, the EU could impact the global regulatory landscape and join forces with like-minded countries

to set international standards in the sector

Moreover, the governance of quantum technologies should involve a diverse range of stakeholders, including quantum start-ups, national programmes, the European Commission, and academic and policy experts. The involvement of all these groups would provide insights into the needs and struggles of the quantum industry in Europe, identify obstacles to cooperation, and enable the EU to develop strategies to overcome them. Additionally, closer collaboration between the different technological communities could aid the EU in creating responsible frameworks for quantum technology development, with stakeholders able to identify emerging ethical issues earlier on. While several groups are already investigating ethical concerns, their work sometimes remains confined to academic discussions and fails to reach decision-makers. [16]

Towards a coordinated action plan for quantum in Europe?

The European Commission and the Member States agreed on a Coordinated Plan on Artificial Intelligence in Europe (CPAI) in 2018, following the publication of the communication “Artificial Intelligence for Europe”, [17] which identified a series of actions to boost Europe’s AI industrial base and the establishment of a trustworthy framework.

The CPAI was the first real strategic document to establish clear goals for the development and deployment of AI in Europe, recognising that coordination at EU level was necessary to address the challenges posed by AI systems and benefit from their economic implications. [18]

The plan encouraged Member States to launch national AI strategies with clear investment and implementation goals, which would be monitored by the Commission. It also called for the creation of common European data spaces –that would later be launched as part of the regulatory package of the 2020 EU Data Strategy – and other measures, such as support for AI education programmes and the establishment of a European network of AI research excellence centres. The CPAI has already had some success. A 2022 technical report [19] showed that, by the time of publication, 23 of 27 Member States had published AI strategies, and that implementation was on the right track.

The success of the CPAI could be replicated with quantum technologies, and the EU Commission should prepare a European strategy for quantum technologies that would serve as a starting point for a strategic conversation about the international dimension of the development of quantum technologies, research integrity and conditions for international scientific cooperation. Such a strategy is not in fact so far-fetched. An EU strategy for quantum technologies was already part of the 2020–2024 work plan [20] of the Directorate General of Communications, Networks, Content and Technology (CNECT) of the European Commission.

> It is imperative that the European Union establishes a clear

> governance framework to take its place as a global actor in quantum technologies to influence the way in which they are developed worldwide and to identify emerging ethical issues early on

Subsequent to publication of a strategy with a clear industrial policy and security focus, it would be reasonable to expect the development of a coordinated plan on quantum technologies, similar to the CPAI, that would include appropriate monitoring channels. Such a plan would propose policy measures to strengthen European capacities in key sectors that are closely linked to the advancement of quantum technologies, such as photonics and cryogenics.

Only by establishing a clear governance framework will the EU be able to build sufficient capacities to take its place as a global actor in quantum technologies and be able to influence the way in which quantum technologies are developed worldwide, including the creation of international standards.

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