Researching the Global Quantum Computing Landscape

Engagement Challenges and Opportunities

Anders Liman[1]

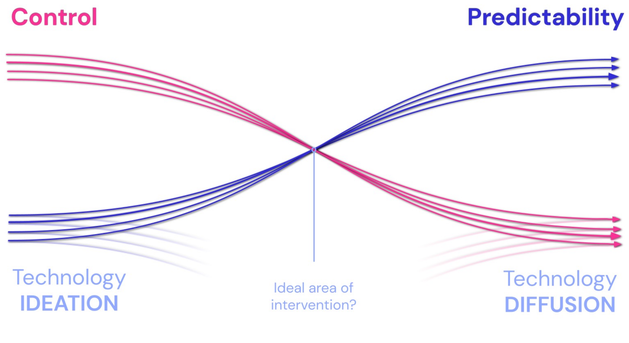
[1]Duke Science & Society (M.A. Candidate in Technology Ethics & Science Policy)

Duke SCIENCE & SOCIETY

in collaboration with Google

Background

Despite being a nascent field, Quantum Computing (QC) presents tremendous promise. It is predicted to be useful for applications from accelerated machine learning, to discovery of new materials, to design of fusion energy systems. However, it also poses some potential threats. Many believe QC could exacerbate the digital divide; it is also predicted to break existing encryption, thereby threatening cybersecurity. In its current state, QC faces the Collingridge dilemma:



Adapted from Besti, F. & Samorè, F. (2018). Responsibility driven design for the future self-driving society. Fondazione Giannino Bassetti

This research provides a concise yet comprehensive overview of the engagement landscape in QC.

It proceeds by:

(1) **surveying national (and international) QC initiatives and prominent stakeholders in corresponding regions**;

(2) **analyzing common motivations driving various QC stakeholders**;

(3) **identifying challenges and opportunities in the field**; and

(4) **arguing for an appropriate framing of QC**.

Overview

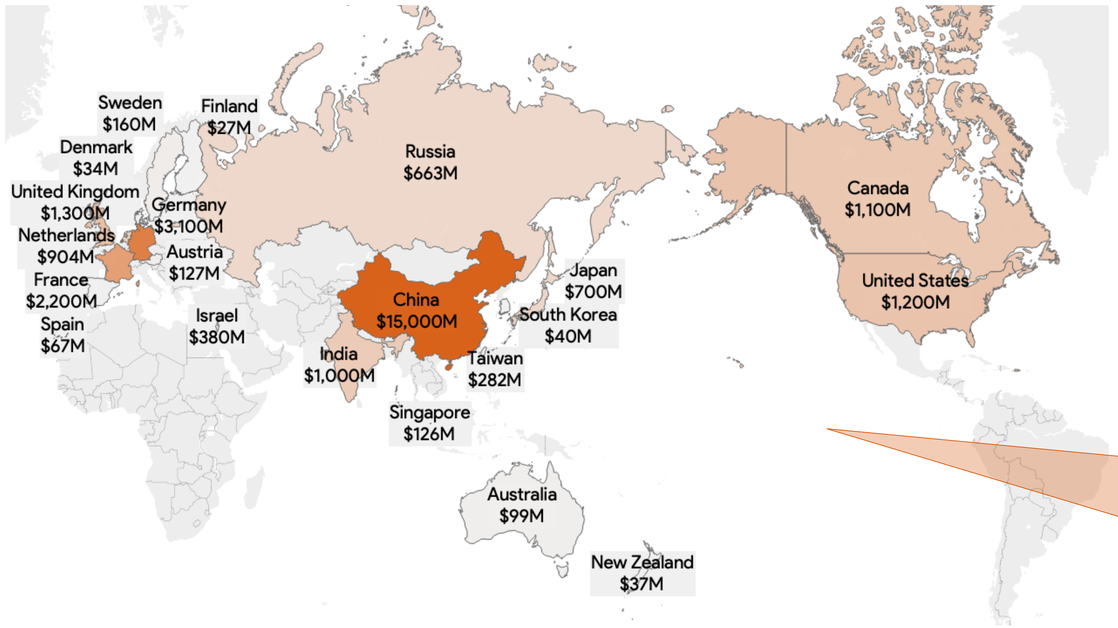
Governments around the world have recently announced initiatives to facilitate and accelerate R&D efforts in QC and other quantum technologies.

Among them are ***UK's NQTP (GBP 1B, 2014)***, ***US's NQI Act (USD 1.2B, 2018)***, and ***EU's QF (EUR 1B, 2018)***.

More recently, ***Germany (EUR 2B, 2021)*** and ***France (EUR 1.8B, 2021)*** announced two of the largest investments to date.

Smaller countries like ***Singapore (SGD 121.6M, 2018)***, ***Israel (ILS 1.25B, 2018)***, and the ***Netherlands (EUR 615M, 2021)*** also launched their own versions of quantum initiatives.

In addition, some countries have developed (or are developing) national strategies to stipulate specific approaches (e.g., ***Australia***, ***Canada***).



National initiatives and investments in quantum computing, quantum information science, and broader quantum technologies in the past 10 years.

Notes:

(1) Currency in USD

(2) European Union Quantum Flagship ~$1.1B (not incl'd)

Challenges & Opportunities

Challenges

Players approach QC with different motivations, and therefore have **different interests**. Some may even have **competing ideals**.

Hype has helped industry and academics to secure funding, but also contributed to the **exaggeration** of the technology's promise and potential.

If commercially **relevant NISQ* applications** aren't identified soon, investment in the field may dry up.

Most countries do not have all **workforce and infrastructure** components necessary for effective QC R&D.

Opportunities

Academic, industry, and governmental players should seek to foster **cross-sector partnerships** and **strategic international collaborations**.

Academics and companies should report findings and achievements **honestly**. Standards agencies should work to develop **common metrics and standards**.

Companies should take the initiative to **collaborate with other industries** to identify commercially relevant applications.

Countries should look to **upskill existing workforce** in adjacent fields and **nurture future workforce** in weaker areas.

*NISQ: Noisy Intermediate-Scale Quantum

Motivations

Depending on the nation and sector, different stakeholders may articulate different motivations and to different degrees. Moreover, many stakeholders have more than one motivation.

(1) **Scientific Innovation** — desire to advance science and technological development; *prominent among **academics***.

(2) **Economic Potential** — economic promise of quantum computing applications; *prominent among **industry***.

(3) **National Security** — prudence to protect a nation's security from potential harms; *prominent in the **US***.

(4) **Digital Sovereignty** — commitment to a state's exclusive and ultimate governing power; *prominent in the **EU**, **RU**, **CN***.

Conclusion

Despite the field's infancy, many stakeholders—from different sectors and with various motivations—are involved and invested in QC R&D efforts.

Effective QC R&D and related policies pose challenges such as **balancing competing interests and ideals**, **moderating hype**, **identifying commercially-relevant applications**, and **addressing workforce gaps**.

Correspondingly, they present opportunities such as **fostering cross-sector and international partnerships**, **engaging in public education**, **developing meaningful common standards**, **facilitating interdisciplinary collaboration**, and **promoting workforce development**.

Ultimately, ***a proper and apt framing*** of the technology is integral to setting appropriate expectations for and realizing the promises of QC.

Acknowledgements:

The author would like to express sincere gratitude to the following organizations and individuals for their valuable insights which prove integral to this research: Google Quantum AI team, Google Government Affairs and Public Policy team, Thomas Monz (AQT), Christina C. C. Willis (ColdQuanta), Lamont Silves (IonQ), Ken Brown (Duke University), Jonathan Felbinger (QED-C / SRI International), Carl Williams (CJW Quantum Consulting), Matt Trevithick (DCVC), and David Moehring (Cambium Capital).

The author would also like to express sincere gratitude to the following individuals for their support and counsel throughout the research: Kate Weber (Google), Ashley Zlatinov (Google), Charina Chou (Google), Lee Tiedrich (Duke University), and Buz Waitzkin (Duke University).