QUANTUM FUTURES: INTERNATIONAL DEVELOPMENT AND THE QUANTUM COMPUTING TRANSITION

Executive Summary

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Quantum computing is poised to transform the digital landscape over the next several decades. What will be the impacts of quantum computing on global development? How can USAID and other development actors ensure the benefits from quantum computing are distributed equitably and its risks managed proactively?

To address this question, USAID commissioned a research report that surveys the landscape of quantum computing as it relates to global development. The report highlights key challenges and makes recommendations for USAID and development practitioners more broadly.

BACKGROUND

Quantum computing is an emerging technology that seeks to exploit the laws of quantum mechanics to process information with unprecedented speed and efficiency. Given the rate of advancement in quantum technologies, experts in industry and academia expect that—in the next several decades, if not sooner—quantum computers will outperform today's most powerful computers by a wide margin.

Quantum computers will play an important role in simulating and optimizing complex systems—including in drug development, logistics, and forecasting—with profound economic implications. One of the clearest and most worrisome applications of this computing power is that it could break the existing encryption protocols that keep our information systems and critical datasets safe. This poses a significant national security threat for any country.

Yet, like many advanced technologies, quantum technology development mirrors global inequality. The capital costs to build a quantum computer are immense. Only a handful of quantum computers are under development, owned by some of the world's largest technology firms. Wealthy governments, too, are competing for superiority in quantum technologies, and public investments and startup activity in North America, China, and Europe dominate the landscape. Yet, the threats and opportunities posed by the emergence of quantum technologies will be felt globally.

Without concerted intervention in several key areas, this existing global inequality will build upon itself. While the benefits of quantum technologies will accrue to developed countries, the opportunity costs and risks will accrue to less developed countries.

THE CHALLENGES

The report identifies three challenges that development practitioners should pay special attention to: cybersecurity, talent scarcity in quantum computing, and lack of innovation ecosystems for quantum computing in developing countries

Cybersecurity risks from quantum computing.

Current encryption protocols used for messaging, financial transactions, and data storage will be compromised with the advent of quantum computers. This threatens present-day financial and encrypted messaging systems. Low- and middle-income countries may be vulnerable to cybersecurity threats, introducing large-scale risks to personal and national security data. Post-quantum cryptographic systems offer some ability to mitigate the cybersecurity risks of future computing advances; developers and operators of critical information systems should adopt post-quantum cryptographic protocols as soon as possible.

Global talent scarcity in quantum computing.

Talent required to accelerate progress in quantum computing remains in short supply in both developed and developing countries. However, developing countries face much stronger headwinds without improvements in science, technology, engineering, and mathematics (STEM) curricula and learning outcomes at the secondary and post-secondary levels. Low levels of digital literacy also make populations in these countries more vulnerable to data breaches and other cybersecurity risks.

Lack of innovation ecosystems for quantum computing in developing countries.

In developed countries, research and development in quantum computing has been driven by public investments and through startup activity predominantly centered in North America, China, and Europe. Combined with the skilled labor gap in developing countries, this has worrying long-term implications for global development, as the economic competitiveness on offer through advances in quantum computing are unlikely to be shared globally. Failing to implement proactive measures to strengthen quantum research and development may therefore significantly exacerbate economic inequality between countries.

RECOMMENDATIONS: BUILDING AN INCLUSIVE, GLOBAL QUANTUM FUTURE

Regardless of when quantum technologies become mainstream, development practitioners and agencies should make sound investments that can mitigate risks from this new technology and enable developing countries to leverage its potential.

The following recommendations illustrate concrete steps that development organizations, policymakers, and institutions must consider to remain resilient and secure in the post-quantum era:

1. **Invest in quantum-ready cybersecurity.**
   USAID and other development agencies should partner with technical experts to help governments and the private sector in developing countries transition to quantum computing-resistant cryptographic protocols. As this research shows, investments in cybersecurity cannot wait until after the development of functional quantum computers; instead, investments must be made now to be prepared. Our key recommendations are:

   - Develop a "Quantum Risk Audit" protocol and engage governments and non-governmental organizations (NGOs) in low- and middle-income countries (LMICs) to proactively conduct the audits on existing digital infrastructure.
   - Establish a "Global Quantum Transition Taskforce" that supports governments and NGOs in LMICs to transition to quantum-safe encryption protocols.
   - Strengthen the cybersecurity capacity of the public sector in LMICs by further supporting technical experts to work with USAID Missions in partner countries. USAID has been supporting cybersecurity capacity-building efforts through the Digital APEX program, and this work should be sustained and expanded to meet the needs of the post-quantum era.
   - Work with ministries of technology or digital transformation to promote public awareness of cybersecurity risks from quantum computing in the next decade.

RECOMMENDATIONS: CONT'D

2. **Develop a global talent pipeline for quantum computing.**
   USAID and other development organizations can play roles in building an ecosystem of workforce development, from investing in better STEM learning outcomes to supporting upskilling programs to meet the talent needs of the quantum computing transition. Our key recommendations are:

   - Support universities in LMICs to launch new master's programs in quantum computing and new MS/MBA programs through "Quantum Workforce Development" grants.
   - Fund pilots to evaluate the effectiveness of bootcamps in upskilling the current STEM workforce for jobs in quantum computing.
   - Support awareness campaigns and scholarships that promote the promise of quantum computing to attract talented youth in developing countries to pursue careers in quantum computing and adjacent fields.

3. **Build a research and development ecosystem for inclusive quantum innovation.**
   USAID and other development organizations can support research and innovation in quantum computing by facilitating greater collaboration between researchers in the United States and countries where USAID operates. Existing USAID programs like the Partnerships for Enhanced Engagement in Research (PEER) have been supporting scientists and engineers in USAID partner countries. This can be leveraged to build global partnerships for quantum computing research in developing countries. USAID can also act as an investor for quantum computing startups focused on key development challenges through funding programs that would be designed along the lines of the agency's open innovation program, Development Innovation Ventures. Our key recommendations are:

   - Leverage existing USAID programs like PEER to support collaboration between U.S.-based quantum researchers and their LMIC counterparts.
   - Provide grants to select universities in developing countries to launch interdisciplinary programs in quantum computing. The grants can support establishment costs and early faculty hires to attract top talent.
   - Fund an annual "Quantum Computing for Development" conference or create such a track at an existing technology and international development conference; this will seed new collaborations between researchers, industry experts, and policymakers.

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If you are interested in learning more about quantum computing and international development, please contact: digitaldevelopment@usaid.gov