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When Disruptive Technologies require a National Strategy

In the age of disruptive technologies, governments tread a fine line between the desire to avoid undue interference in the market – and the concern for social and economic harms. Theses are the questions policy makers must examine, when determining whether a technology warrants a comprehensive national strategy

Introduction

In recent years a growing number of governments define and implement national strategies for technologies such as Artificial Intelligence (AI), Quantum, Internet of Things (IoT), Blockchain, and others. Other governments are not doing it, or aren't doing it on a consistent basis. This paper deals with two questions:

- Which technologies "justify" a national strategy?
- What prevents governments from defining such strategies?

Which technologies "justify" a national strategy?

Two tests can be used to determine which technologies justify a national strategy – the "areas of impact" test, and the "need for government intervention" test.

The "areas of impact" test

Disruptive technologies can have an impact in five important areas:

- **National security** – to what extent will having capabilities in the specific technology help national security, or not having them harm it?
- **Public services** (including areas like health, transportation, education, legal, etc.) – to what extent can the technology be used to improve the availability and quality of such public services?
- **Economic growth** – to what extent can developing or using the technology spur economic growth?
- **Employment** – to what extent can the technology impact employment? One can argue that employment is one element of economic growth. But we suggest it should be assessed separately as sometimes a given technology can help economic growth but at least in the short term have a negative impact on employment (if it eliminates certain jobs or occupations).
- **Social and moral values** (e.g. ethics, equality, privacy) – can the technology help promote such values, and is there a risk that it can hurt them?

The more of these areas can be impacted by a specific technology, and the more they can mutually affect each other, the higher the need for a national strategy for that technology.

Assessing the mutual impact of these areas is important to ensure that meeting objectives in one is not at the expense of others. For example – certain applications of big data may impact privacy, and certain AI algorithms may raise ethical concerns. While free market forces will attempt to maximize the economic benefits of such technologies, even at the expense of ethics or privacy, a national strategy should balance between these conflicting objectives and values.

IoT or Industry 4.0 (I4.0) are other examples of the need to balance between these areas. Specifically:

- Economic growth – implementing IoT/I4.0 in manufacturing lines improves productivity, thus contributes to economic growth.
- Employment – IoT/I4.0 may affect employment negatively, as automation may eliminate or reduce the need for human operators.
- Equality – implementing IoT/I4.0 is costly, which may give large manufacturers an advantage over smaller ones who can't afford them, leading to decreased competition in the market.

Consequently, countries that have a large manufacturing industry, need a national strategy for IoT/I4.0 to enable using these technologies to spur economic growth, upskill or reskill affected workers, and support small and mid-size manufacturers so they do not fall behind.

The "need for government intervention" test

Successful development and adoption of a disruptive technology require several things:

- Research and development of the technology and its applications, both in academia and research institutions and by the industry.
- Infrastructure (e.g. computing, communications bandwidth, lab equipment).
- Proficient human capital, both with R&D, and with using the technology.
- Supporting regulations.
- Often – international collaboration agreements, as it is usually very hard or impossible for a single country to have the resources and capabilities to do everything alone.

These fall into several categories:

- Areas owned by governments (regulation, international G2G agreements).
- Areas governments should promote and fund, while collaborating with academia and the industry (infrastructure, basic research).
- Areas where governments can generally rely on the private sector (investments in start-ups), though they should strive to encourage investments in start-ups in their countries.
- Areas where government intervention may be needed (upskilling or reskilling), and therefore it should continuously assess if such a need arises.

The more a technology and its impact on the economy depend on areas where the government has a role, the higher the need for a national strategy for that technology.

Important Remarks

1. **There is a difference between a technology and an industry sector,** even if sometimes they are used interchangeably.
    a. AI is a technology, applicable to many industry sectors.
    b. Fintech is an industry sector, which uses technologies like AI, blockchain, etc.

    This paper deals with national strategies for technologies, not for sectors.

2. **A national strategy is not the only way a government can support a technology**. Governments can promote regulation, fund R&D, train human capital, and adopt technologies in public services even absent a national strategy for the specific technology. That is why it is important to define the criteria that justify a national strategy.
3. **While the criteria for defining which technologies justify a national strategy are universal, the conclusion may be different for different countries**. For example, countries with a significant manufacturing sector need an IoT/I4.0 strategy, and countries with little manufacturing may not need one.

Case Study – Quantum

The importance of AI is well-known, and dozens of countries have defined national AI strategies. A less known technology, which gets the attention of a growing number of governments is quantum. About 15 countries, including Israel, have defined or are in the process of defining a quantum strategy[1]. Let's examine quantum using the above-mentioned criteria.

As background, quantum technology deals with atomic and sub-atomic operations. It has broad applications in computing, sensing, communications, encryption, metrology, simulations, and advanced materials.

The "impact areas" test

- National security
    - Quantum computers, that are orders of magnitude faster than standard ones, can easily decrypt codes currently considered highly protected. This has huge implications on data protection and communications security, both military and civilian.
    - Conversely, quantum encryption can be "immune" to decryption by standard computers, giving a huge advantage to whoever has access to such encryption, whether governments or terror organizations, and putting those who don't in a big disadvantage.
- Public services – while quantum is still in its infancy, one can assume that ultra-fast computing can assist in areas like healthcare. In addition, quantum sensors, with

[1] https://thequantuminsider.com/2021/04/29/15-countries-with-national-quantum-initiatives/

sub-terrain vision, can help in construction and infrastructure layout, whose efficiency is currently limited by inability to see sub-terrain obstacles.

- Economic growth
    - Quantum computing can revolutionize big data analytics, enabling process optimizations in a variety of sectors.
    - Quantum simulation will dramatically shorten new product development. Pharma and chemicals are examples of industries that can benefit greatly from the ability to simulate atoms and molecules at a much larger scale than what is currently doable.
    - As mentioned above, quantum sensors with sub-terrain vision will reduce risk, shorten processes, and lower the cost of construction and infrastructure layout.
    - New advanced materials can potentially change current battery structures, helping products and industries that use batteries.
- Employment – there will be a need for training new capabilities for the "quantum world", which in parts is very different than the "standard one".
- Social and moral values
    - A dramatic change in encryption and decryption may impact privacy and data protection that are based on standard mechanisms.
    - Unequal access to quantum computing will provide those who have it an unfair advantage in areas like access to information, security trading, etc. where equality matters.

The "need for government intervention" test

Government involvement in quantum is required because the technology is still new and requires basic research, its development and adoption need large investments, and in spite of its potential, it's still unclear which sectors will adopt it and how. Existing national quantum strategies and initiatives address the following government-related items:

- Budget – some examples below:
    - France – President Macron announced in 2021 a quantum plan with a budget of 1.8B Euro[2].
    - India – $1.2B were assigned to the national quantum strategy in the 2021-2023 budget[3].
- Research – several governments have established new quantum research organizations, or funded new research programs in existing ones.
- Human capital – being disruptive, proficiency in standard computing may not apply to quantum computing. It requires new courses in the academia and elsewhere. In addition, many governments are concerned about brain drain to other countries with more attractive conditions for researchers and are developing key talent retention programs.

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[2] https://sciencebusiness.net/network-updates/cnrs-frances-quantum-plan-will-make-country-key-player-quantum-technology

[3] https://www.psa.gov.in/technology-frontiers/quantum-technologies/346

- International collaborations – the large budgets needs of quantum development, and the scarcity of experts in the field, make international collaborations for resource leverage critical. At the same time, the implications of quantum on national security raise concerns about such collaborations. Governments play a key role in finding the balance between these, identifying potential partners, and funding collaborations.
- Sandboxes for experiments - due to the high costs of a quantum infrastructure, only tech giants can afford to build one themselves. Government support is needed to allow other researchers and organizations access to such infrastructure.
- Business environment – though investments in quantum-related start-ups in on the rise (see fig. 1), total number of world-wide investments in 2021 was only ~30. Investors are still deterred by lack of knowledge in the space, big uncertainty about when the technology can be commercialized, and the need for large investments. Governments may need to find ways to encourage investments in this area.

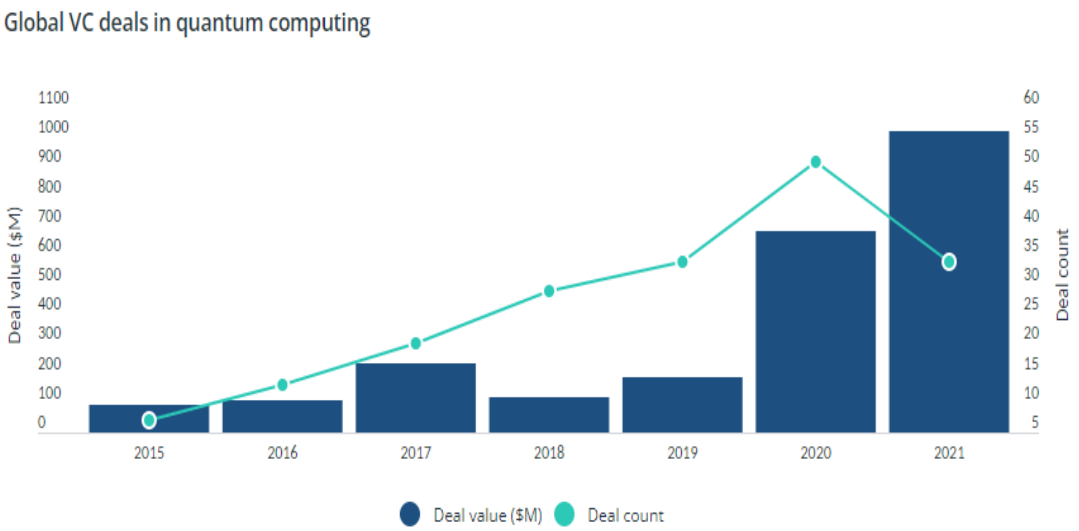

Fig.1 – Global VC deals in quantum computing. Source: Pitchbook, Sep 2021

Obstacles

If it's clear that certain technologies call for a national strategy, what is holding some governments back?

There are several causes for that.

Lack of a clear ownership

Let's compare India and Israel.

The Government of India established in 1999 the Office of the Principal Scientific Adviser (PSA), chartered to advise the Prime Minister and the cabinet in matters of Science and Technology. The PSA has responsibility over all key technologies. It currently addresses national strategies for AI,

quantum, semiconductors, smart manufacturing, future transportation, advanced communications technologies, and blockchain[4].

Israel, on the other hand, has several entities somewhat responsible for proposing the need for a national strategy for a particular technology. Among them - the National R&D Council (MOLMOP), the National Science Academy, the TELEM Forum, the National Economic Council, and the Israel Innovation Authority. However, none of them officially owns this topic, nor is there a process for discussing, recommending, and making decisions on it. Consequently, Israel only has a couple of national tech strategies, and both were defined quite late.

Defining a strategy is hard

A national strategy should be bold, yet achievable. It should define a country's vision, but take into account available resources. It often involves trade-offs and prioritization. It is always a challenge to define a good strategy, especially for a disruptive technology, whose full potential and implications are still unknown, and in which not every country has enough expertise. In addition, not every country can (or should) attempt to be a world leader in a given technology, but some are reluctant to openly admit it. Consequently, many governments tend to wait before taking on the challenge of defining a national strategy for a technology.

Lack of sufficient collaboration platforms

The race for innovation leadership is often between countries, and not just between companies. Disruptive technologies are major arenas in that competition. This prevents international collaborations in areas that countries view as critical for their national security, or for their global competitive position. However, there is no reason countries can't collaborate on big data regulations that balance economic benefits and privacy, on blockchain-related standards, or on best practices for using AI to improve access to justice. Yet, there are hardly any platforms for international collaboration on such matters.

Summary and Recommendations

Countries often need a national strategy for a disruptive technology to maximize its value for the country's security and prosperity, while avoiding its potential negative effects. To consistently identify such technologies in a timely manner and define national strategies, we recommended that:

1. Governments adopt the tests described in this paper to identify technologies for which they should define national strategies.
2. Governments have a clear definition of who owns identifying these technologies and defining strategies for them.
3. International organizations (e.g. OECD) develop platforms for international collaboration on elements of such strategies where collaboration is more important than competition.

[4] https://www.psa.gov.in/about-us