UNLOCKING U.S. TECHNOLOGICAL COMPETITIVENESS

PUBLIC-PRIVATE MISALIGNMENTS IN BIOTECHNOLOGY, ENERGY, AND QUANTUM SECTORS

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Unlocking U.S. Technological Competitiveness: Public-Private Misalignments in Biotechnology, Energy, and Quantum Sectors

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About the Institute for Security and Technology

As new technologies present humanity with unprecedented capabilities, they can also pose unimagined risks to global security. The Institute for Security and Technology's (IST) mission is to bridge gaps between technology and policy leaders to help solve these emerging security problems together. Uniquely situated on the West Coast with deep ties to Washington, DC, we have the access and relationships to unite the best experts, at the right time, using the most powerful mechanisms.

Our portfolio is organized across three analytical pillars: **Geopolitics of Technology**, anticipating the positive and negative security effects of emerging, disruptive technologies on the international balance of power, within states, and between governments and industries; **Innovation and Catastrophic Risk**, providing deep technical and analytical expertise on technology-derived existential threats to society; and **Future of Digital Security**, examining the systemic security risks of societal dependence on digital technologies.

IST aims to forge crucial connections across industry, civil society, and government to solve emerging security risks before they make deleterious real-world impact. By leveraging our expertise and engaging our networks, we offer a unique problem-solving approach with a proven track record.

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Executive Summary

The Strategic Balancing Initiative (SBI) at the Institute for Security and Technology (IST) works to overcome public-private misalignments in the technology development ecosystem. The aim is to accelerate American and likeminded economic success as a balance against authoritarian uses of technology, such as those exemplified by the People's Republic of China (PRC). SBI works to shift mindsets by connecting stakeholders siloed by the gaps between D.C. and Silicon Valley; shift behaviors to help public and private sector leadership align and collaborate; and identify technology applications of particular interest to policymakers and private sector leadership.

SBI endeavors to achieve these aims by convening public and private sector stakeholder Working Groups with representatives from the fields of biotechnology, energy, and quantum information sciences. These Working Groups examine critical misalignments between national security interests and technology industry incentives. Ultimately, SBI aims to shape understanding, raise awareness, impact behavior, and help develop potential solutions in consultation with cross-sectoral industry experts and national security policymakers to improve American competitiveness.

Through these closed-door discussions, SBI identified significant misalignments between the private and public sectors in relation to their geostrategic approaches to the PRC, as well as in how each sector considers related investment, business decisions, and financing. Although the overall socio-political climate in the United States with respect to the PRC seems to be shifting towards a more starkly bifurcated relationship, discrepancies remain in how public and private sector leaders see and manage PRC-related issues.

This initial SBI report summarizes key takeaways from Working Group discussions with stakeholders in the biotechnology, quantum, and energy industries, identifying the unique challenges that they face to improving U.S. competitiveness in each respective sector. For each, this report provides an Executive Summary, then expands in much greater detail on the core elements of the Working Groups findings to date. The report then engages in a 'deep dive' on a key concept from each industry that, if actioned, would improve innovation and could ultimately drive U.S. competitiveness. This report draws on in-depth research by the SBI team, interviews, and stakeholder input to propose potential solutions.

Geostrategic Currents

The current nature of the U.S.-China dynamic, in a strategic sense, transcends the public-private sector divide–with all stakeholders identifying the relationship as, at best, deeply contested and competitive. Despite this shared public-private understanding of the difficult bilateral relationship–and each side's concerted efforts to identify and dominate with the key relevant technologies–they continue to face struggles in working together. With this understanding, SBI intentionally structured convenings around questions of behaviors, identifying headwinds facing public and private actors and opportunities for improving alignment.

Biotechnology

Biotechnology Working Group participants, like those in the Energy and Quantum Working Groups, flagged issues around both access to government infrastructure and capital. Stakeholders explored the need for better data sharing amongst companies and other researchers, the need to protect some of that data (for security concerns related to dual-use technology), the importance and unintended consequences of recent legislation, and the complexity of biotech supply chains.

Based on this analysis, SBI engages in a 'deep dive' on the primacy of data in the biotech space, identifying the creation of a central data repository as one potential government contribution and noting that the federal government is uniquely positioned to undertake this effort given some of the challenges (e.g., the risks associated with dual-use technology).

Energy

Working Group participants from the energy sector identified the availability of infrastructure (or lack thereof), the impact of political uncertainty surrounding presidential and Congressional elections, the importance of supporting the entirety of the innovation ecosystem, and the asymmetry between technology companies' needs and the grants provided by the government to ostensibly meet these gaps as key challenges that they face in improving U.S. competitiveness in the energy sector.

Given the stakeholders' analysis of the literal experimental nature of some energy research (e.g., around fuels) and how it affects other cost structures, SBI's deep dive in this industry explores how the government aggregation and creation of data on such experiments would decrease the costs for insurance, giving companies more resources to dedicate to other causes.

Quantum

Quantum Working Group participants similarly noted that limitations around infrastructure and capital limit innovation, despite government commitments to help with both of those items. Stakeholders also flagged that the private sector lacks an understanding of extant innovation programs, when companies should try to use them, or how to do so. In addition, the variation in use cases, definitions, and timelines within the nascent but already sprawling quantum space complicates conversations and efforts to assist in quantum innovation and improve national competitiveness in a timely manner.

As a result of the uncertainties around how to understand and even talk about the quantum ecosystem as identified in our Working Group, SBI examines how the government could map the state of this technology and create definitions and standards that would align the public-private sector on how to empower innovation in the quantum space.

Cross-Cutting Concepts

Through these Working Groups, SBI identified key concepts shared across sectors that limited their respective abilities to enhance U.S. competitiveness. Specifically, all Working Groups flagged the need for clarification of how the private sector can better utilize innovation programs, get greater access to capital, and get better access to infrastructure.

In terms of clarifying existing innovation programs, SBI examined the idea of how a "single stop shop" could be created for companies in the innovation space. For example, as FederalStudentAid.gov helps all students understand government resources, a similar venue would help the private sector identify and utilize extant opportunities.

On capital, SBI explores a combination of mechanisms for increasing available capital, including: loans or loan guarantees, Advanced Market Commitments, Milestone Payments, and connecting prototyping to procurement.

With respect to infrastructure access, the federal government would be able to significantly contribute to multiple economic sectors of the innovation economy by improving the opportunities and protocols for non-government employees to access and utilize government-sponsored infrastructure (e.g., Department of Energy national laboratories). Beyond questions of physical access, questions around intellectual property will also need to be clarified before companies feel comfortable investing time into efforts that might limit future profitability.

Looking Ahead

This is only the first of our reports in this initiative. We intend for future work to build on this and we look forward to gathering feedback about our analysis and these concepts as we continue to engage constructively in this work through multiple rounds of discussion and research.

Introduction: Geostrategic Currents

The SBI convenings have occurred in an increasingly divided geostrategic environment, with a significant percentage of analysts concluding that the global business climate has split into two camps: the United States and the PRC. Indeed, diplomatic relations between the two nations have become so tense that significant political focus is on simply avoiding a crisis. As foreign firms pull billions of dollars out of the PRC, SBI sees the discussion about the PRC solidifying in ways that make more private-sector leaders attentive to both their PRC exposure and how they could pursue other opportunities (e.g., for capital). For example, at the Roadmap to Quantum Value conference, a panel was asked how they saw things related to the PRC. Chad Rigetti, founder of Rigetti Computing and a significant leader in the quantum space, responded, “I don’t have my finger on the pulse of what is happening in the PRC, except that if you are building a company, you are either on the US-NATO-Western side, or the other.”

At the same time, other stakeholders continue to view U.S.-China relations in a positive light, or at least a complicated one. At the October 2023 IST online event Money Moves: Tech Investment and U.S.-China Relations, Craig Allen, President of the U.S.-China Business Council and former Ambassador, noted in his discussion with Michael Brown, partner at Shield Capital, and IST Senior Adjunct Advisor Pavneet Singh, how the PRC cannot be ignored by the business community. “China has about 18% of the world’s population…about 17% of world GDP…also 30% of global investment…and the talent in China is quite extraordinary. By some measurements, China has eight times as many STEM workers as the United States. They’re pumping them out at four times the rate of the United States. And I would say that Chinese companies are very, very innovative. We have to relieve ourselves of the fallacy that their successes are due to copying and espionage only. It’s doing the hard work and throwing an awful lot of resources at the talent and the technology and the companies to certainly rival the United States.” Allen’s statement echoes observations from other stakeholders and SBI Working Group members. Many emphasized that U.S. companies depend on goods produced in the PRC, goods passing through China for production steps that are uncommon or costly elsewhere (e.g., ethylene oxide sterilization), and a technical workforce educated in the PRC. For example, one company disclosed that 15% of their personnel are from China.

It is within this confluence of geopolitical currents that the U.S. and other governments seek to incentivize innovation in critical and emerging technologies. Specific U.S. legislative efforts include: the Inflation Reduction Act, the Infrastructure Investment and Jobs Act, and the CHIPS Act. The federal government thus directs departments and agencies to deploy funding and technical resources to industry to fund research and development, manufacturing, and scale-up of tech efforts. In addition, the U.S. Department of Defense (DoD) spends approximately $145 billion on research, development, test, and evaluation (RDT&E) and $170 billion on procurement as part of its yearly acquisition and procurement efforts; spending that, given the dual-use nature of emerging technologies, is relevant to incentivizing innovation.

However, many of the technologies prioritized by the United States, European Union, and other likeminded governments are considered “deep tech,” meaning they have high capital expenditure requirements, manufacturing needs, and raw materials inputs; a contrast to software-based efforts. Market forces for the two types of technologies also differ, as software-based efforts enable investors to earn a higher internal rate of return in software. Given these dynamics, U.S. investors and entrepreneurs have shifted focus towards software-based products and services. To try to supplement these market forces, and align the work of national labs and other public research and development enterprises with the work of the private sector, the U.S and other governments attempt to overcome these tensions by making financial and technical resources available. This can look like funding at different stages of a company’s lifecycle, connectivity to and with international markets, and the availability of public infrastructure.

As the U.S.-China relationship evolves and governments ostensibly accelerate efforts to incentivize technology innovation, this paper investigates misalignments identified by Working Group members in the energy, quantum, and biotechnology sectors and selects specific ideas that are particularly actionable–or at the very least, worthy of additional exploration in follow-on stakeholder discussions.

Biotech

Stakeholder Analysis

Participants in the Biotechnology Working Group run the gamut of private sector entrepreneurs, technologists, investors, and representatives from the Congressional and Executive branches of the U.S. government. From the industry perspective, biotechnology, like energy and quantum, has several rapidly evolving branches. The discussion included officials and experts from disciplines as diverse as computational biology, synthetic biology, drug discovery, pharmaceuticals, and medical devices. Biotechnology Working Group participants also represented companies at different stages of maturity, from startup to established entity.

Participants were equally enthused and cautious about the biotechnology field. On the one hand, progress in emerging technology areas such as AI, materials, and compute, when coupled with biotech, offered tremendous opportunity for drug discoveries, novel therapeutics, and transformative devices to improve livelihood. However, amid post-pandemic concerns around supply chain security and resiliency, the potential peril associated with the ease of producing genetically modified viruses or other biological compounds, and the general uncertainty around the structure of global supply chains in light of increased U.S.-China tensions, the participants surfaced several issues in the economic and national security domains that merit greater scrutiny by policymakers.

DATA IS PARAMOUNT

Participants almost universally identified the availability and accessibility of data as key to unlocking technology progress and competitiveness of U.S. companies in biotechnology. Irrespective of the discipline, from device makers to synthetic biology companies, entrepreneurs are faced with the reality that medical data, toxicity data, and pharmaceutical data is often governed at the regulatory level by stringent policy guardrails.

» **Technical barriers**: At the technical level, data is stored in competing systems which prevent sharing. At the level of individual firms, there are often questions around intellectual property that prevent companies from 'open sourcing' valuable sources of data.

» **AI developments**: In light of the explosive growth of generative AI tools, biotechnologists' inability to acquire high volumes of domain-specific data to train large language models inhibits their ability to rapidly test hypotheses and augment innovative product developments.

While participants recognized the tensions preventing greater data sharing at each level, they offered several recommendations that are worthy of follow up. In order to improve the efficiency of data collection and data sharing, multiple stakeholders suggested that the U.S. government could partner with industry and academia to create frameworks that encourage greater federated learning. This approach would foster distributed data sharing models, something currently not possible given inadequate infrastructure. Further, the participants highlighted the need to start building common standards in data architectures so that when private firms develop according to industry standards, even if they offer different features, data can be shared anonymously and in a privacy- and security-compliant manner across systems. Finally, with respect to collaborating and sharing data with firms and institutions in Europe, stakeholders noted that policy and regulatory disparities between the U.S. and Europe are particularly acute.[1] Participants recommended that U.S. officials develop dedicated biotechnology policy dialogues under the existing data-sharing dialogues between the U.S. and Europe to ensure that firms are able to collaborate and share data and to prevent these dialogues from being stuck in silos.

UNINTENDED LEGISLATIVE CONSEQUENCES

Participants were generally very positive on the impact of the Inflation Reduction Act on the biotechnology industry. By lowering the costs of healthcare for small firms, increasing the R&D tax credit, and offering credits for pursuing clean energy solutions, the IRA provides avenues for biotechnology startups to exploit operational efficiencies and enhance their competitiveness. However, participants were also clear that the law is driving many unintended, potentially negative consequences onto venture-backed biotechnology startups, specifically those seeking to develop small-molecule based drugs.

As one participant noted, under the IRA small molecules could be subject to negotiated prices sooner after FDA approval compared to larger and more complex biologics. The period for negotiation would be around nine years for small molecules, compared to the 13 years generally required for biologics. Entrepreneurs and investors in particular are hyper focused on the financial significance of this shortened time period. In some cases, this discrepancy can lead to losses of hundreds of millions in potential revenue, making them far less attractive for investment when compared to biologics-focused startups. From a financial perspective, investors will find the path to the highest return; however, from an innovation and overall welfare perspective, small molecule-based drugs are still essential for reaching certain targets,

1 Stakeholders suggested that the only substantive regulatory regimes are the US, the EU, and the PRC – with many needing to remove themselves from the PRC, or at least reduce their exposure to it.

especially within cells, which biologics may struggle to reach. The full effects of the IRA are still unfolding, but this is one area where participants were clear that policy officials should examine reforms or amendments to ensure that the United States remains competitive in small-molecule based drugs.

COMPLEXITY OF SUPPLY CHAINS

Stakeholders observed that the pandemic, coupled with geopolitical tensions with the PRC and the upheaval caused by Russia's expanded invasion of Ukraine, spotlighted a serious pain point for the biotechnology industry in accessing secure and resilient supply chains. Drug development in particular is a highly fragmented process, with a strong reliance on raw materials, precursor materials, equipment, and testing from sources in Asia, Europe, and the United States.

- **Quality control**: Recent events increased regulatory scrutiny on quality control procedures. Small molecule compounds and cell therapies which involve intense chemical and biological processes are uniquely complex in their quality control measures to ensure the safety, efficacy, and quality of the final products.
- **Vaccine development**: The development of COVID-19 vaccines, especially mRNA vaccines, invited greater attention to novel technologies. These vaccines introduced new manufacturing and quality control challenges, and regulatory agencies are closely monitoring their development.

Investors and entrepreneurs commented that whereas in the past decade most biotech firms would rely on the PRC for raw materials and manufacturing, in particular companies such as Wuxi Biologics, since the pandemic, U.S. investors require that firms either have redundancy built into their supply chains or completely divest their roadmap of any PRC-based suppliers. As a result, companies have diversified to suppliers in Germany and India, in addition to new Contract Research Organizations (CRO) in the United States, a change that has made supply chains more resilient, but also more expensive.

FINANCIAL SUPPORT FOR THE BIOTECH INNOVATION ECOSYSTEM

Outside of the regulatory frameworks discussed above, the participants were quite supportive of the different forms of non-dilutive capital the government is offering to support R&D and prototyping in the biotech industry. Specifically, participants hailed the creation of the Advanced Research Projects Agency for Health (ARPA-H) and its launch of the Open Topic Broad Agency Announcement (BAA), which calls for cutting edge research and commercialization. This effort mirrors Department of Defense efforts and serves as a strong validator in the health space to private investors if a firm receives the non-dilutive funding from ARPA-H. Participants were encouraged by ARPA-H's willingness to leverage the Other Transaction Authority, which allows the federal agency expanded ability to negotiate with startups at commercial speeds and on commercial terms. They expressed a strong desire to see ARPA-H receive consistent funding and build out its portfolio of investment activity. In discussion of the BAA, some stakeholders expressed frustration with the difficulty of finding relevant programs, a frustration echoed by Quantum Working Group members about federal programs.

BALANCING INNOVATION WITH PROTECTION

Participants were quite sober on the risks associated with the dual-use nature of biotechnologies. The opportunities enabled by AI, automation, and advanced materials to discover new compounds, drugs, and vaccines can also potentially be used to fabricate novel biological or chemical weapons. Perhaps more concerning, this capability is not exclusively within the hands of the state and national security officials: anyone with access to compute, open source models, and materials can experiment with potentially dangerous cocktails. One participant, for example, stated that they were "very concerned our regulatory apparatus doesn't have the expertise or flexibility (in culture or statute) to contend with emergent concerns" related to these matters. While the group did not offer specific recommendations to mitigate downside risks, they were quite open that the risks around bioterrorism and other national security threats are difficult to assess, quantify, and mitigate while concurrently attempting to create more open, innovative data ecosystems. Further, there is not an accepted intellectual model for how to think about dual-use technologies. Participants were very open to collaborating with policymakers to ensure that the United States strikes the right balance between promoting innovation and protecting against catastrophic risk.

Deep Dive: Data Sharing as a Concept for Consideration

Given stakeholders' insights about the priority of and perils around data sharing, the federal government seems uniquely positioned to manage biotech data repositories, since some of the data types are quite different and come with different legal protections and overseers. For example, patient medical information would require different protections than genetic sequences that could be exploited by bad actors. Alternatively, the federal government can establish a framework for essential standards that should inform private sector collection and collaboration practices when it comes to biotech data.

OPPORTUNITY FOR GOVERNMENT CONTRIBUTION

The federal government would remove significant hurdles to biotechnology innovation by establishing a set of biotech data repositories. Such an initiative would require a combination of concerns to be addressed, including:

- **Information security**: Security protocols vary for the different types of data: both IT security and security questions around which types of people and entities, and in which locations, are allowed to access which types of data.
- **International complexities**: Different countries approach these data in different ways–including how data can be contributed, stored, and used–particularly those related to partnering with entities inside the European Union. Accordingly, these potential repositories should build on the EU-U.S. Data Privacy Framework.
- **Intellectual property**: Questions around IP regimes and overall incentives for entities to both contribute and use the data should be addressed. For example, it would be important to find the right balance of financial rewards so that companies are not discouraged from using the data that has been added to the repository.
- **Bioethics**: Beyond IP questions, there might be ethical concerns around both acceptable and encouraged cases for the data's usage and development.

Since these disparate concerns are each complicated and technical issues, it seems that the federal government might need to empower either an established entity (e.g., the White House's Office of Science and Technology Policy) or a bespoke one. Once empowered, such an agency could be tasked to begin negotiations with the European Union, et al., in developing the protocols and processes for developing such a set of repositories. Conversely, a legislative effort could be initiated that requires the executive branch to conduct such an integrated, long-term effort; this could be modeled after the Maritime SAFE Act and the mandate it created to fight illegal, unreported, and unregulated fishing.

Energy

Stakeholder Analysis

Participants in the SBI Energy Working Group included senior executives from industry, finance and advocacy organizations, as well as investors and policy advocates in new and clean energy companies. Industries represented included sustainable aviation fuels (SAF), carbon capture, solar, and nuclear. During Working Group discussions, participants addressed questions around geopolitical and financial risk, supply chain vulnerabilities, and access to infrastructure, capital, and contracts. During meetings of the Energy Working Group, SBI elicited suggested reforms to existing U.S. government offerings and proposals on new tools that companies would like to see the federal or state governments build out in order to improve U.S. competitiveness in the energy economy.

INFRASTRUCTURE

Almost universally, the stakeholders identified the availability of infrastructure, or lack thereof, in the United States as a major bottleneck to expanded startup technology activity. The infrastructure requirements for prototyping to scaling manufacturing processes in each sector of the energy economy, from carbon capture to solar and SAF, are non-trivial. For example, in the SAF sector entrepreneurs need access to feedstock processing equipment, such as biomass processing units, reaction vessels and reactors, and storage and distribution infrastructure such as storage tanks and emissions control systems, among other expensive equipment and materials. The industry is still nascent and has not benefited from the cost declines associated with higher volumes of production. Further complicating matters, the airline industry—the consumer of SAF products—operates on thin margins. As a result, airlines are reluctant to allocate or increase their spending on SAF over relatively cheaper petroleum options. In sum, high infrastructure costs prevent economies of scale in R&D and manufacturing. As in the case of SAF, the market-maker is not currently properly incentivized, at least financially, to buy at scale.

Historically, national labs conducted much of the foundational research in cutting-edge fields and provided intellectual property to industry for commercialization. Federal labs, leveraging tax-payer funded infrastructure, constituted the center of gravity for prototyping. Today, the paradigm has shifted. Much of the R&D and prototyping is occurring in the commercial sector, reliant on private sources of capital and commercial demand. However, amid stagnant market incentives—like those faced by SAF, carbon capture and nuclear, for example—the public sector needs to modernize their approaches, policies, rules, and resources in ways that provide de-risking tools and targeted interventions. As long as the federal government continues to “sponsor” this sort of infrastructure, the stakeholders suggested that they do so in a way that matches the current business environment.

Participants in the Working Group zeroed in on the issue of access to “energy infrastructure commons” as an area where the U.S. government can make a difference. Despite the presence of federally-funded resources at DOE labs such as the National Renewable Energy Laboratory (NREL), Sandia National Laboratories, and the Lawrence Livermore National Laboratory, which maintain much of the heavy infrastructure which could mitigate the capital expenditure challenges, Working Group participants highlighted the difficulties in accessing these resources. They identified both bureaucratic and cultural issues hindering collaboration and preventing efficient use of public resources to strengthen industry.

» **Bureaucratic issues**: The process of gaining access to national labs is riddled with hurdles. Safety training requirements are stringent, making it challenging for external companies, particularly those with immigrant employees or employees on green cards, to navigate the access procedures. Further, national labs tend to prioritize internal users over external ones. This preference limits the accessibility of the labs for outside companies, contributing to the challenges faced by solar startups, for example. Lastly, the overhead rates associated with utilizing national labs are often beyond what startups and even established firms can afford.

» **Cultural issues**: Stakeholders commented that national labs are everything that a startup is not. The emphasis on process, slow reaction times by career civil servants, and a general lack of agility at the labs directly contrast with operating procedures at startups, particularly given tight timelines from funders. Whereas startups are starved for capital and race to develop a prototype in order to raise additional funding, national labs are not measured on commercial or financial terms and thus are often not suited to support these companies.

Although national labs are sometimes considered part of the "hub" efforts—both formalized and not (e.g., Silicon Valley)—competing and overlapping government requirements at federal, state, and local levels can complicate a startup's ability to leverage these facilities.[2] For example, when state permitting requirements operate at a different speed and scale than businesses need for leveraging federal resources, businesses can get trapped between them.

Finally, from a funding and research stability perspective, national labs, including NREL, are heavily dependent on annual funding from the U.S. Department of Energy (DOE). The stability of this funding, including at times when government funding bills are subject to continuing resolutions or government shutdowns, and its impact on long-term research objectives, can be a challenge for startups seeking consistent support. Notably, even when policy experts are confident that national labs will continue to get funded during the political theater of negotiated budgets, the messy process can be seen in the business community as less certain, further aggravating concerns about the availability of this infrastructure.

2 Hubs include the 31 "tech hubs" that the current Biden administration has sponsored as well as unofficial hubs like Silicon Valley and Boston (thanks to schools like MIT); these locations often have hardware that is used by many–or, notionally used by many–but "sponsored" (as many in industry phrase it) by a single entity. For example, Illinois has a quantum hub in which FermiLab "sponsors" the hardware.

POLITICAL UNCERTAINTY

Beyond questions and concerns around when national labs would be funded and/or open, stakeholders expressed broader concerns about the political environment as it relates to Presidential elections and control of Congress. They expressed confidence in the ability of legislation to overcome barriers to innovation. For example, they noted that subsidies and tax credits in the Inflation Reduction Act can provide an exogenous shock to the frozen market structure described above, or the tax credits in the IRA can offset the price differential between petroleum and SAF for airlines. However, they remained concerned as to whether interventions such as the IRA will be enduring or subject to the whims of the political cycle. Several participants warned that if a Republican President and Republican-led Congress were in power, they may reverse or curtail many of the incentives for clean energy companies, for example.

INNOVATION ECOSYSTEM

Another important issue stakeholders surfaced is the importance of supporting the entirety of the innovation ecosystem, not just specific sectors. For example, in cases where these new technologies require specialty chemicals or other catalysts, the U.S. needs a robust domestic chemical industry to be able to quickly test and fabricate new chemical compounds. In the U.S., that ability is currently weak; by contrast, complementary industries in PRC, India, and Germany allow for rapid iteration, production at scale, and at reasonable costs.

In addition to funding aimed at the entire ecosystem, it is critical to understand how to plug startups into the ecosystem at the right scale and in sync with the appropriate upstream and downstream processes. Most new energy companies will be working with incumbent industries that will require their technology at a large scale, but unless startups are currently co-developing with a big corporation, they will not be able to align correctly with the entire supply chain. The U.S. government can provide incentives to large and small companies to work together, contributing to efforts to plug startups into the innovation ecosystem.

GRANTS AND CONTRACTS

Working group participants emphasized the asymmetry between the needs of technology companies when it comes to contracts and grants and the way that the government issues grants. While most of the participants welcomed federal financial interventions, they noted that transaction speeds and stipulations on how government funding can be used would benefit from known improvements.

- **Mapping funding**: Specifically, participants pointed to the need for public sector funding– whether grants, loans, or purchase contracts–to be mapped to the different stages of a technology company's life cycle and the need for it to be provided in ways that the company can then utilize to raise private capital. For example, while NASA has demonstrated a successful model by implementing a cost sharing and milestone-based program for private vendors, multiple stakeholders noted that DOE has been reluctant to apply a similar model despite having the necessary authorities to do so.

- **Milestone payments**: The use of milestone payments signals to investors that the company is delivering product and earning revenue. This method significantly boosts credibility of grants to private investors, who often discount grants or other forms of non-recurring engineering funding because they do not scale, are often bespoke, and are ultimately non-recurring.

In addition to the form of the financial transaction, stakeholders also highlighted the legal structure of grants and contracts as another asymmetry. Many of the grants include language that is legally ambiguous. For example, one executive highlighted that NSF and DOE grants allowing for the purchase of necessary capital equipment are unclear or overly restrictive on how that equipment can be used outside the scope of the grant or in future scenarios. While the U.S. government is likely including such provisions to protect against fraud or abuse, there is a clear inefficiency in financing if grantees are unable to utilize the equipment for other purposes, and are instead forced to purchase a redundant piece of equipment due to the legal constraints of the grant. One solution would be to allow the grantee to transfer the equipment to a shared space, such as a university commons or an economic development organization, so it is available to many stakeholders and will not sit idly or otherwise be a highly inefficient use of taxpayer funds.

Deep Dive: Experimental Insurance as a Concept for Consideration

During the Working Group meetings, stakeholders flagged the steep price of insurance for new technology and pointed out how a lack of data on experimental materials, methodologies, and research results means that insurance companies lack the ability to narrowly quantify risk –driving up the price of insurance on specific but important aspects of technology innovation. For example, one company in the aviation sector faced difficulties in procuring insurance to offset risk for an effort that used a blend of hydrogen in aviation fuel. For more established practices, insurers could calculate risk "with a fair degree of accuracy," David Watkins, SVP, head of aviation at QBE notes. However, he says, "as long as the technology is applied to a novel purpose like flight, underwriters will approach it with caution."

In general, insurance is not a limiting factor in non-experimental parts of innovation business, where most elements of the business model are already covered by existing data and thus have access to established insurance products. Indeed, Kenneth Quinn, a partner at Clyde & Co. puts it, the insurance industry celebrates its ability to "play a very positive role in helping to provide cover for the introduction of new technology." For example, after significant research and development, insurance companies offered insurance products for the construction and installation of SAF infrastructure. Similarly, Munich Re's Plant Performance Insurance now offers services for specific aspects of work in biofuels, hydrogen production, and recycling.

Yet, experimentation–with associated uncertainty about outcomes–is central to innovation. If the risks associated with experimentation cannot be quantified, the business conducting those efforts, as well as its investors, must often carry that risk themselves. This lack of accessibility to insurance limits the funds available for investing in innovation and thus limits the pace and scope of U.S innovation overall.

OPPORTUNITY FOR GOVERNMENT CONTRIBUTION

With increased access to more data, insurance underwriters are better able to build out more risk evaluation metrics. We suggest considering a greater government role in enabling both the creation and sharing of this sort of data.[3] The government's role in this effort could include the facilitation of public information sharing activities, and support for the data collection and analysis necessary for the maturation of the sector's risk assessment.

In terms of sharing information, the government could create mechanisms for aggregating data, potentially modeled after entities like the Treasury Department's Climate-related Financial Risk Advisory Committee (CFRAC) or its Financial Stability Oversight Council. By creating a central location for tracking data, preferably in anonymized and aggregated ways that encourage companies to share information more freely, the government could help insurers better quantify risk, decreasing the cost of research and development for startups.

In order to facilitate the generation of useful data for underwriters, the government could broaden existing authorities and funding for efforts that perform this sort of analytical work. For example, the Department of Energy's Loan Program Office (LPO) already acts as a financial guarantee insurer, including under the Clean Energy Financing Program. As a result, the LPO retains an "in-house engineering and environmental team that leverages the DOE enterprise to assess and manage technical risk." Subject matter experts like those from the LPO can

3 Globally, governments have contributed to such efforts before. For example, The European Commission's Energy Efficiency Financial Institutions Group, created in 2013, produced an Underwriting Toolkit to "help financial institutions scale up the deployment of capital into energy efficiency," as well as launched Working Groups focused on topics like risk assessment.

serve as objective, third party risk analysts, easing reporting, quantification, and mitigation of experimental risk for private companies. For context, the Congressional Budget Office (CBO) "produces independent, nonpartisan, analysis of economic and budgetary issues to support the Congressional budget process;" by conducting their own research and analysis the CBO functions as a "neutral arbiter" and "nonpartisan scorekeeper that estimates the effects of legislation on the federal budget." If the LPO or a similar entity could likewise act as a trusted such source of information on experimental costs, it would allow for precise risk mitigation and thus better capital allocation. While such a government entity could conduct its own data generation, creation, and analysis, costs could vary based on proprietary factors specific to that company's line of work. Accordingly, there could be complexities associated with both generating usable data and getting companies to share their own information.

With this proposed government contribution, insurers would be better positioned to create access to capital through the shifting of risk. Insurers could do this internally, as well as by creating bonds that pass on some of the risk to the purchasers of the bonds, thus spreading the risk by bringing it into the financial market. A prominent example of these insurance-linked securities is catastrophe bonds ("cat bonds"), which can be issued by insurers, reinsurers, or catastrophe funds. These types of risk transfer would help offset the investment risk taken on by venture capitalists and the borrowing burden by the innovators.

By empowering insurers with data, this proposed government contribution would also help to set standards and norms of preconditions for insurance coverage. For example, the insurance provider DNV established technology standards for floating wind farms. Given the cascading effects of safety-related norm creation, facilitating cheaper and more accessible insurance would facilitate sector-wide improvements. In addition to norm-setting, the government could also take on a role in driving insurance standards more directly, as the Nuclear Regulatory Commission has done for Small Modular Reactors (SMRs).

Quantum

Stakeholder Analysis

The SBI Quantum Working Group included senior executives from quantum companies, companies pursuing quantum innovation (i.e. larger companies that are also working on quantum), and government officials leading work in quantum. SBI elicited suggested reforms to existing U.S. government offerings and proposals on new tools that companies would like to see the federal or state governments build out in order to improve U.S. competitiveness in quantum.

INFRASTRUCTURE

Like the energy Working Group stakeholders, participants in our quantum Working Group noted that limitations around access to government infrastructure posed a significant hurdle to innovation. Some of these limitations are bureaucratic, both for the individual (e.g., their nationalities) and the company (e.g., specific types of agreements were required). Meanwhile, some are cultural (e.g., timelines for public and private entities vary significantly). In addition to the aforementioned limitations, the quantum stakeholders flagged concerns around intellectual property when the companies and their employees do actually get to use government infrastructure.

ACCESS TO FINANCING

As in the case of the energy sector, access to financing and other contracting vehicles is another barrier to innovation in the quantum sector. Whereas the private sector must move more rapidly, government mechanisms do not move at the same pace. For example, one participant stated that “our VC doesn’t care about a 25 year technology plan” when deciding how or when to give the startup additional time for making progress.

DIFFERENCES AND DEFINITIONS

Stakeholders repeatedly noted that the wide scope of work that some consider part of “quantum,” as well as the degree of differences and incompatibility of definitions, often prove problematic. One stakeholder argued that “definitional challenges are pervasive,” and several Working Group participants agreed. Examples referenced included federal legislation, Executive Orders, and state-level programs, each of which use terminology that is inconsistent, accidentally exclusive (e.g., focusing on a narrower line of work that the framers had supposedly intended), or accidentally inclusive (e.g., not focused on a timeline that had supposedly been discussed because of misunderstandings on what counted as “near-term” quantum progress).

The nascent nature of quantum work aggravates these definitional concerns; creating differences of expert opinions on what can be done, how long things might take, or what the universe of use cases includes.

EXTANT INNOVATION PROGRAMS AND GOVERNMENT MECHANISMS

In discussing limitations to quantum innovation and potential opportunities for addressing them, multiple stakeholders flagged the complex, complicated, and evolving set of government innovation programs as being inaccessible, even to experts in government affairs, government relations, and public policy. For example, one stakeholder celebrated an innovation program in another country and lamented that the United States did not have a similar program, only for another person in the discussion to note that the foreign program was in fact a copy of an existing U.S. program, developed in partnership with Department of Energy quantum experts. This example underscores that the existing programs, at different levels of government and on different timelines, are difficult to identify, track, and utilize.

Deep Dive: Technology Mapping as a Concept for Consideration

Given the questions around defining quantum work, its timelines, and applications, there would be utility in a government-led effort to produce a standardized model for the quantum ecosystem.

For context, the U.S. government has already dedicated considerable effort to quantum. Examples include the 2018 National Quantum Initiative Act, the resulting National Quantum Initiative (and its contributions), the 2022 Quantum Computing Cybersecurity Preparedness Act, and the extensive work of the quantum information science team at the National Institute of Standards and Technology (NIST).

- **NIST**: The team is not just conducting independent work, but performing "the most fundamental quantum research in the world... in partnerships between NIST and top universities."
- **Air Force & Energy**: Both the U.S. Department of Energy and the Air Force have developed new infrastructure options for better collaborating with the private sector on quantum.[4]

4 In the Air Force's official announcement for the quantum facility, competition with PRC was cited as a key motivation: "As PRC invests heavily in quantum computing research, the AFRL [Air Force Research Laboratory] Information Directorate's work ensures that the U.S. pushes ahead on this critically important technology, the senators said, also noting that AFRL's projects are vital to ensuring the U.S. military maintains the technological edge over its adversaries"

OPPORTUNITY FOR GOVERNMENT CONTRIBUTION

The evolving nature of the quantum sector means both that a lot has changed since the 2018 law, and that significantly more work remains to be done, hence the growing support for additional legislation.

- **Extant Motivations**: The fact that some quantum technologies are "now here," including for the U.S. military, means that near-term consideration of definitions and standards would be useful beyond simple regulatory and research communities.
- **Identified Downsides**: Conversely, there has been market confusion over the state of quantum computing; for example, PayPal committed to quantum computing as a solution to fraud detection, only to later fire the team after realizing that quantum was not "a near-term business."

Accordingly, there would be value in producing and formalizing definitions, standards, and use cases. This idea is not new; international scientists have already worked to develop "Standard Quantum Technology Readiness Levels" and additional suggestions for facilitating industry-wide progress in quantum. Yet, such proposals have not been adopted as formal standards, similar to the Department of Justice's effort to define legal terms or the Government Accountability Office's detailed approach to standardizing Technology Readiness Levels.

Although the nascent nature of quantum technology complicates and limits the ability to develop a complete set of use cases, a government effort to map definitions, timelines, and standards could include approaches for already-identified use cases. Such cases include: AI and machine learning, design optimization (e.g., for better batteries), encryption and decryption, quantum sensing (both identified uses, estimated at contributing almost $1.5 billion in value by 2030, and those that are still only in "the laboratory"), grid and traffic optimization, financial modeling, weather forecasting and climate modeling, and drug discovery. For context, McKinsey estimates that quantum's "stake in pharmaceuticals, chemicals, automatic, and finance use cases could be up to nearly $700 billion."

By creating such a classification schema, the federal government can also be more clear in how or when it will provide different types of funding, whether grants for early-stage R&D or loans for manufacturing scale-up. Currently, government officials in the programmatic arms of big grant-making agencies are not as savvy on the needs or capabilities of companies developing different applications of quantum technology, and are therefore unable to offer differentiated tools according to the applicant's needs.

Conclusions

Cross-Cutting Issues

Across the Working Groups, three concepts emerged affecting each in significant ways: the need for clarification of existing innovation programs, the need for better access to capital, and the need for better access to government infrastructure.

CLARIFICATION OF EXISTING INNOVATION PROGRAMS

Given the diverse, expansive, and technical nature of many innovation programs (e.g., government initiatives help companies innovate and grow, like the Commerce Department's "Tech Hubs" program, which exists to "supercharge a critical technology ecosystem")–and how they have been created and are now managed in disparate offices and ways–there would be cross-sector utility in the development of a resource or set of resources that facilitates startup identification and utilization of extant federal programs. Above all, it is crucial that private-sector individuals and entities can easily use the information as a "one stop shop" for leveraging these programs.

Such an effort could be undertaken by the federal government itself, like how the government created and maintains FederalStudentAid.gov to help all students understand how they can utilize existing programs. Yet, unlike some of the other concepts identified in this first round of discussion, this is not an effort that has to be done by the federal government itself; it could be performed by a non-profit or other independent entity that was committed to identifying, centralizing, and updating the information.

Ideally, state-level programs, or at least of some of the key states in these economic sectors, could also be similarly clarified and centralized. Given the international nature of emerging technology, and the companies making progress in it, some content within the "one stop shop" on other countries' programs might be particularly helpful. Of note, the role of third-countries is to be explored more directly in following iterations of this work.

ACCESS TO CAPITAL

While access to capital is a perennial issue for entrepreneurs, access to capital is at a premium for executives in emerging technology areas of quantum, advanced energy, and biotechnology.

This is in light of three proximate factors. First, the higher risk associated with each stage in the development of these technologies–from R&D and prototyping to manufacturing at scale–provides a less appealing investment opportunity for private investors relative to consumer or enterprise software opportunities. Second and relatedly, since novel applications in these sectors often do not have immediate use-cases in the commercial market, there is not a strong demand signal driving investors to support technology maturation. Third, in the current geostrategic environment, U.S. policymakers have instituted several technology investment restrictions preventing patient capital investments from foreign sources, namely PRC, thus drying up a potential alternative source of patient capital investment.

The SBI team identified some prominent cross-cutting issues in the financing space that could accelerate development of U.S. technology companies in these sectors. These include:

- **Loans or Loan Guarantees**. The United States has a robust loan and loan guarantee program for various private industries. These financial tools provide valuable sources of low-cost capital for companies seeking to scale operations in fields as diverse as aerospace and agriculture. However, for technologies such as quantum or biotechnology, where there is not a track record of commercial operations or a well-understood project finance model for financing, U.S. government agencies such as the Small Business Administration (SBA) and Export-Import Bank are reluctant or even unable (due to Congressional constraints) to underwrite loans or loan guarantees. Stakeholders in the quantum, biotech, and energy industries are more than willing to work with public officials to develop new frameworks to clearly articulate risks and unlock these meaningful supplies of capital, but the government needs to provide mechanisms for this collaboration.
- **Advanced Market Commitments (AMC)**. The U.S. government can utilize an AMC in these fields to jumpstart technology development and provide a positive market signal in advance of a robust commercial market development. NASA was particularly successful in utilizing AMCs in creating Commercial Orbital Transportation Services (COTS) and Commercial Resupply Services, effectively enabling the United States to launch cost-effective rockets–a capability the U.S. did not have organically and for which it was historically reliant on Russia. This program gave way to companies such as SpaceX, making efficient use of taxpayer dollars and serving as a credible source of initial demand that invited subsequent private investment.
- **Milestone Payments as Part of Contracts**. Stakeholders in these three technology areas also identified the importance of milestone-based payments as critical to more effectively catalyzing private investment. The more that public investments can be structured to resemble how private companies do business—namely in providing recurring revenue opportunities such as through milestone payments—the clearer the signal will be to the private investment community that emerging technology areas have a viable path in the

government market. This signal increases private sector willingness to take the risk on the longer-term development of commercial markets.

» **Connect Prototyping to Procurement**. A related concern with government engagements is the current "valley of death" between achieving a successful prototype and a long-term procurement opportunity. This concern is most relevant in the Department of Defense, where various offices utilize research and development money to fund prototypes that leverage emerging technology capability, but do not have a plan for transitioning successful capabilities into multiyear procurement opportunities. For vendors at the frontier of technology development in quantum, biotech, or energy, the prospect of waiting 18-24 months after the completion of the prototype for the DoD to align budgets, gain congressional approval, and allocate program dollars for procurement is a frustrating experience. In fact, it is often a death knell and prevents untold numbers of entrepreneurs from ever pursuing such markets. Stakeholders emphasized that before launching the prototyping opportunity, the DoD should align the research dollars with procurement dollars for a more seamless transition (an already widely known and broadly debated set of challenges).

INFRASTRUCTURE ACCESS

The federal government would be able to significantly contribute to multiple economic sectors of the innovation economy by improving the opportunities and protocols for non-government employees to access and utilize government-sponsored infrastructure (e.g., Department of Energy national laboratories). This could require the creation of new physical buildings not located on classified properties so that people without security clearances can get on and into the facilities. It could also be addressed by updating facility access procedures. Regardless of the process to access these facilities, the nature of use will likely depend on how the government can develop an appropriate approach to intellectual property of work utilizing such infrastructure. As noted above, there are additional cultural hurdles that need to be addressed as well, but those could potentially be addressed in the steps that address these other concerns.

Looking Ahead

This first extensive SBI research publication lays out both the framing of the overall work and the progress of the Working Groups so far. Future work–including additional rounds of Working Group discussions and in-person sessions–will build on what has been laid out here. Feedback, both on what is included here and new concepts for consideration, would be welcome and incorporated into future convenings, research, and products.

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