UNLOCKING U.S. TECHNOLOGICAL COMPETITIVENESS

EVALUATING INITIAL SOLUTIONS TO PUBLIC-PRIVATE MISALIGNMENTS

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MARCH 2024

IST Institute for SECURITY + TECHNOLOGY

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Cover image a 3D illustration of a lipid nanoparticle siRNA antiviral delivery system

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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.

Acknowledgments

We are grateful to the members of the Biotechnology, Energy, and Quantum Working Groups for sharing their time and expertise. This work would not be possible without their invaluable insights.

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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 to accelerate American and likeminded technological strength. This is especially important in light of the People's Republic of China's (PRC's) focus on leading in emerging technology domains and utilizing the resulting technological capabilities to pursue its authoritarian interests at home and abroad. Ultimately, SBI aims to gain understanding, raise awareness, shape behavior, and deliver solutions to this set of strategic challenges.

Launched in 2023, this particular SBI effort is organized into separate working groups on three key technologies: *biotech*, *energy*, and *quantum*—each composed of public- and private-sector experts and stakeholders in those respective fields. Over the research period, each working group will convene three times, building and iterating from the previous work and generating concept papers after each round. The process will culminate in a capstone report and event.

The February 2024 report, Unlocking U.S. Technological Competitiveness: Public-Private Misalignments in Biotechnology, Energy, and Quantum Sectors summarized conclusions from the first round of working group discussions about the misalignments hindering innovation and proposed potential solutions, including options that would be useful across all three sectors. Those cross-cutting concepts were that the private sector would benefit from better access to government capital and government infrastructure (e.g., access to Department of Energy laboratories) and clarification of existing government innovation programs and how to leverage them.

Building on this work, the SBI team convened a second round of working group meetings to expand upon and further develop these concepts. Specifically, this round focused on examining potential ways to address the misalignments identified in the first round. These misalignments are to be expected; the last time the United States required intense collaboration between stakeholders from the U.S. government, private industry, and academia was at the height of the Cold War. Since then, financial, policy, and technological paradigms have changed. Unlike Cold War-era innovation, the private sector largely drives organic development of financial and technological capability, while the U.S. government has tended to take a back seat, particularly in technology domains.

However, as the first and second working group sessions highlighted and as stakeholder input and SBI research indicates, public policy tools exist to bridge certain misalignments between emerging technology companies and the policy apparatus. In order to unlock innovation, the U.S. government needs the ability to evaluate the existing tools and understand how they can be repurposed to better reflect the needs and trade-offs of the current technology development ecosystem. For example, across all working groups, the common thread from stakeholders regarding the accessibility of public capital is that U.S. government programs do not match up with the needs of different companies at different stages of maturity. There is a gap in financing vernacular, a lack of understanding of the startup technology development lifecycle, and a resulting set of problems with program implementation that lead to missed opportunities. Moreover, the tools that do exist are not paired with longer-term procurement or broader market access policies to ensure that companies developing in priority technology sectors will have a pathway to enduring competitiveness.

Biotech

In the second Biotech Working Group discussion, stakeholders explored specific aspects of the need for better access to government capital and shared biotech data, as well as how the latter might be enabled or constrained by existing U.S. policies. They also suggested specific considerations around the international biotech ecosystem, specifically how the U.S. government could host a repository of biotech data available to approved academic and private-sector researchers. Based on that additional input, the SBI team performed a "deep dive" on a way to operationalize such a solution. That work revealed that there are no policy limitations around the government establishing a data repository where privately-funded research could be uploaded and commoditized for others' commercial use. In short, such a data commoditization approach would not conflict with "open access" practices and could be a corollary to https://open.science.gov.

Energy

In the second Energy Working Group discussion, stakeholders analyzed financial tools and proposed a new concept for consideration: the opportunity for the U.S. government to incentivize energy innovation by establishing demand-side policies (e.g., mandating that a certain percentage of aviation fuel must be sustainable by a certain date). Participants also explored the complexities of divesting from Chinese supply chains given the technological superiority of certain Chinese technologies used to fabricate biomass and in gasification. Informed by this input, the SBI team performed a "deep dive" on how to operationalize the

idea of establishing demand-side energy policies. That work revealed that such demand-side tools are uncommon in the United States, but not impossible. For example, the Renewable Fuel Standard, which incorporates demand-side production mandates, has been effective in increasing the production and adoption of bioethanol in the United States. However, economic mandates, while effective in the European Union and Japan, generally seem to have only mixed support here.

Quantum

In the second Quantum Working Group discussion, stakeholders analyzed relevant financial tools and explored the need for a government-led effort to map the quantum ecosystem. Participants suggested limiting factors that hinder efforts to advance innovation in quantum, including differing or even conflicting agency-specific priorities, differing perspectives on quantum (e.g., the science of it vs. current market opportunities), and insufficient resources for the tasks at hand. Based on that additional input, the SBI team engaged in a "deep dive" on how to operationalize the technology mapping first identified in the first concept paper. That work revealed that, despite significant effort to already do this, different departments and agencies are still not yet unified in an approach or priority. Although there is potential for Congressional action to facilitate this, it would require careful positioning and coordination.

Next Steps

In the final set of working group discussions during the Spring of 2024, the SBI team will examine how to operationalize these concepts. For example, in the case of the Biotech Working Group's suggestion of a biotech data repository, the SBI team will explore who in the U.S. government might best host such a repository as well as propose a potential sequencing of policy steps to make that possible. After the third round of discussions, IST will conduct research on those findings and produce both a third concept paper—another working document that iteratively builds on this one—and a final report, which will lay out all of these findings and suggest specific actions that can be taken to improve U.S. and likeminded innovation in critical and emerging technology vis-à-vis China.

Introduction: Geostrategic Currents

Between the first and second sets of working group discussions, the PRC and U.S. governments took steps that added significant headwinds to the bilateral economic relationship.[1]

» **Less Foreign Investment in China.** In February, the CCP shared official reporting that indicated foreign direct investment (FDI) into the PRC for 2023 reached its lowest point since 1993. Specifically, 2023 FDI decreased by more than 80 percent from the previous year, which had in turn seen a 90 percent decrease from peak investment levels in 2021. Analysts explained the decline involved both the PRC's difficulty attracting new foreign capital—because of tensions with the West—and the outflow of existing foreign capital.

» **"Work Secret" Risks.** The National People's Congress, the PRC's highest legislative body, passed a revision to its Law on Guarding State Secrets to protect what the PRC government refers to as "work secrets," describing them as "any matters that are not technically state secrets but could nevertheless affect national security or the public interest if leaked."

» **White House Action.** President Joe Biden signed an Executive Order (E.O.) that, according to the Wall Street Journal, effectively limits sales of sensitive data to "China and other adversarial countries." The E.O. specifies the types of data involved (e.g., biometric) and describes its purpose as ensuring that countries like China cannot "develop AI capabilities and algorithms… to the detriment of United States national security." White House officials told the Wall Street Journal that the E.O. responds to concerns around data that might be considered anodyne (e.g., from smartwatches) but that collectively can be "weaponized."

» **Commerce Inquiry into Chinese Cars.** Pursuant to the E.O., the U.S. Department of Commerce (hereafter, "Commerce") announced the opening of an inquiry into PRC-produced "smart vehicles." Commerce Secretary Gina Raimondo stated in a press release, "we need to understand the extent of the technology in [PRC-manufactured] cars that can capture wide swaths of data or remotely disable or manipulate connected vehicles." Some analysts suggested that the move signaled potential and serious action against not just vehicles made in China, but those made by Chinese firms in third countries, like Mexico.

1 Prior to the publication of this report, the U.S. House of Representatives passed a bill that would require the Chinese owner of TikTok to sell the app within sixty days or ban the app in the United States. Given the structure of these reports, the third concept paper, set to investigate developments between the second and third working group meetings, will explore these TikTok developments.

Combined, these developments paint a picture of the dynamic between China and the United States as both more disconnected and more officially cautious of the other side. Such government actions will likely put greater pressure on the business environment, particularly in emerging technology sectors. Questions remain about the degree to which these geostrategic positions are shared across the public-private divide, and how businesses will be able to respond to these rapid developments.

Biotech

Stakeholder Analysis

The second SBI convening of the Biotech Working Group included more detailed discussions on topics elevated in the first session. Participants provided rich discussion on the importance of data, and specifically the challenges and opportunities in creating regimes for generating and potentially sharing relevant data for both research and commercial purposes. Further, the group underscored the importance of consistent public funding for each phase of the biotech lifecycle; biotechnology companies can grow to be quite capital intensive, both in the requirements for equipment, but also in navigating regulatory approvals.

At each stage, companies require different types of funding; funding for research, for example, requires a different level and duration than the funding required to support commercial activities and achieve scale. In order for U.S. biotech companies to compete on a global stage, participants noted that grants, loans and other forms of non-dilutive capital are required to de-risk efforts at each stage of a company's value chain. These interventions can shift the balance for a private investor when making a decision between investing in a pure software company where the associated risk is lower and a deep technology company where there is higher risk and a longer potential return horizon.

Finally, the stakeholders outlined some of the challenges and opportunities in international collaboration as economic and geostrategic factors shift the fundamental infrastructure of the bioeconomy. The below expands in much further detail upon each of these elements of the conversation.

DATA

Building out from previous discussions, stakeholders emphasized the need for researchers and entrepreneurs to have access to comprehensive data repositories (e.g., ones that include not just publicly funded research, but the research that other companies or labs are developing and are willing to share), which is essential for conducting analyses, developing insights, and advancing scientific knowledge. However, participants identified several risk factors that complicate the responsible and safe dissemination of biotechnology data, particularly on the commercial side. These risks include the potential conflict between data commoditization (i.e., turning data into a commodity which others can then pay to use) and the traditional U.S. approach to open science, as well as uncertainties surrounding property rights regimes and international standards for data sharing. Additionally, they noted risks of biological data misuse and abuse, such as privacy breaches or unintended consequences in research and development.

This culminated in a discussion of how the U.S. government is uniquely positioned to host a biotech data repository, with stakeholders proposing mechanisms for this, particularly the idea of data commoditization. A participant suggested a scenario in which a biotech company invests significant resources into collecting and analyzing genomic data to identify potential drug targets for a rare disease. The company might view this data as a valuable asset and seek to commoditize it by restricting access and thereafter monetizing it through licensing agreements. In this scenario, the U.S. government could incorporate this data into a repository, given accepted practices around such commoditized data. Other stakeholders agreed that this would offload the most concerning risks (i.e., around "dual use," meaning, technology with both civilian and military applications) to the U.S. government, which is most capable of mitigating those risks because of its unique ability to deconflict not only regulations across data types (e.g., patient data versus genomic sequencing), but also international concerns related to dual-use risks. Further augmenting its ability to mitigate these dual-use risks, the U.S. government has a monopoly on subject matter expertise as well as legal authorities.

Yet, some stakeholders noted that this approach would conflict with the traditional U.S. approach to open science, which emphasizes the free exchange of scientific knowledge for the greater benefit of society. Although this model, which incentivizes firms to both contribute and use data in the repository, may be workable, it raises questions about whether the U.S. government is willing to take steps that arguably run counter to policy principles (e.g., open and free data use). Stakeholders also noted how some researchers, particularly those in academia or smaller institutions, could face barriers to accessing the data necessary to validate findings, replicate experiments, or contribute to collaborative research efforts.

Additionally, uncertainties surrounding property rights regimes and international standards for data sharing might disrupt efforts to create this biotech data repository. Similarly, countries may have varying laws and regulations governing data ownership, privacy, and intellectual property rights that might complicate how multinational biotech entities could participate. In the absence of clear guidelines or agreements, disputes over data ownership and usage rights could arise, hindering cross-border collaborations and impeding scientific progress. Similarly, concerns about data security, privacy, and ethical considerations might arise when work crosses jurisdictions with differing legal frameworks and cultural norms (e.g., transatlantic collaboration that spans the U.S. and EU systems).

Stakeholders then talked through different models for data sharing and management that might offer insights into potential solutions. For instance, government-funded initiatives like the National Cancer Institute and the Genomic Data Commons, or the crowd-sourced Drug Target Commons, demonstrate successful efforts in data curation and community-driven data sharing.

However, challenges persist, including the capability constraints faced by the U.S. government, particularly in terms of data management. Participants recommended incentivizing data contribution and curation, establishing standardized protocols for data sharing, and fostering collaborations between academia, industry, and government agencies. While precedents exist, such as the National Institute on Aging's data sharing repositories, implementing scaled-up versions of these initiatives requires addressing logistical and funding challenges.

Overall, participants reached consensus on the importance of promoting data sharing and open science while ensuring robust measures for data security, privacy, and responsible use. They asserted that the U.S. government should take on the role of establishing such a biotech data repository, but highlighted that important policy questions would have to be resolved first. Perhaps most important is the question of whether the U.S. government would be willing to shift away from the traditional "open science" model in order to incentivize researchers to contribute to any such data repository.

ACCESS TO CAPITAL: CURRENT OPTIONS, CONSTRAINTS, AND ADDITIONAL NEEDS

The funding requirements for biotech startups share similarities with many other deep technology sectors. However, biotech startups face unique headwinds and unfavorable economics that make the current fundraising environment particularly complex. Stakeholders shared that the biotech funding landscape tightened significantly in 2023, with financing for biotech companies down by nearly half compared to 2021, and the Initial Public Offering (IPO) market experiencing a roughly 90 percent decrease in proceeds due to volatility and

uncertainty in 2022. Moreover, the 2023 collapse of Silicon Valley Bank deeply affected the industry, impacting small biotech companies that relied on the bank for longer duration financing in particular. Further, at the height of the COVID-19 pandemic and in its immediate aftermath, investors poured money into new drug discovery and therapeutic companies seeking to capitalize on global procurement trends. Public spending on vaccine and therapy development has since declined, and this tightening has cascaded through big pharmaceutical companies and consequently, the early-stage investment ecosystem as well.
While the funding environment for venture investors is rebalancing towards shorter-horizon and more mature products, the funding profile required for biotech remains consistent. As participants noted, biotech startups require significant capital, even at the earliest stages, to fund research and clinical trials and to traverse the regulatory hurdles. Further, development timelines are long: it can take 10 years or more to get a new drug to market and provide a liquidity event to investors.

Against this backdrop, stakeholders were keenly interested in the public resources available for innovators. They assessed the U.S. government's current resources, identified limitations associated with these opportunities, and suggested different types of products for specific departments and agencies to consider.

Working group participants, as well as the general entrepreneurial and investor community, are familiar with Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) grants, a set of programs that incentivize private-sector research and development in critical and emerging technologies. In addition to these grants, the National Institutes of Health (NIH), the Department of Health and Human Services (HHS), through entities such as the Advanced Research Projects Agency for Health (ARPA-H), and the DoD provide many opportunities for innovators to compete for awards that range anywhere from $275 thousand to $1.75 million or more. Generally speaking, the working group participants noted their appreciation of these award opportunities, but were sober in their analysis of the impact this type of funding could actually make. For small biotechnology companies trying to raise between $20 and $50 million in their initial rounds of funding (seed or Series A financing rounds), a $1.75 million government award would not be a material substitute, or even supplement, for private funding. Moreover, in practice, stakeholders commented that funding agencies such as the NIH are culturally more inclined to award grants to researchers, instead of entrepreneurs looking to mature science for commercialization purposes. By contrast, ARPA-H has a blended mandate, and its early track record indicates that it is receptive to supporting innovators in commercial industry.

Participants positively acknowledged the availability of loans and loan guarantees, specifically those that are being considered through DoD's Office of Strategic Capital (OSC) and those that

are currently available through the Export-Import Bank of the United States (EXIM) and the Small Business Administration (SBA). However, none of the investors or entrepreneurs in the group could point to the successful utilization of U.S. government loan facilities by an early stage biotech firm. Instead, they identified specific misalignments with loan products and early biotech companies. This insight highlights an unacceptable situation requiring urgent action, for which SBI will develop and publish specific recommendations in its final report.

As opposed to a grant or an exchange of equity for private investment, loans for an early stage biotech company are inherently risky at early stages (i.e., seed through Series C). With an untested product and no revenue, there is no ability to service the loan payments. As a result, private investors will not encourage a loan and most U.S. lenders will not accept the collateralization of intellectual property as a substitute for payment in the case of default. Loans could be valuable for a company that is graduating past its Series C stage, at which point it has proven its science, developed a product, and is scaling to achieve market capture. Finally, participants surfaced the potential for abuse of loan products. Referring to the Paycheck Protection Program (PPP) loans during the height of the COVID-19 pandemic, participants pointed out the moral hazard and opportunity for fraud when government money is made available in such large amounts with a lack of understanding of the counterparties.

Turning to recommendations, stakeholders highlighted that organizations such as HHS, NIH and others in the civilian human sciences could learn from reforms made to the U.S. Air Force's SBIR program. Through its innovation organization AFWERX, the Air Force modified its SBIR program to significantly increase award sizes by waiving certain caps internally and by developing incentive programs to either identify potential users within the government (i.e., the Tactical Funding Increase) or match private investors who invested alongside the SBIR award (i.e., Strategic Funding Increase). Through these mechanisms, awardees could receive upwards of $10 to $20 million in non-dilutive funding from the U.S. government, gain a credible customer, and catalyze private funding.

Finally, participants discussed the need for the U.S. government to create more transition pathways for the research and innovation that public dollars are sponsoring. For example, in contrast to the DoD's Defense Advanced Research Projects Agency (DARPA), for example, ARPA-H at HHS does not have a dedicated potential buyer of matured technologies emerging out of its technology pipeline. As such, ARPA-H has therefore established an office that describes its mission as, "help[ing] translate scientific and technological breakthroughs into real-word products and services."

INTERNATIONAL ENGAGEMENT

During the second Biotech Working Group discussion, participants provided thoughtful insight into how the private sector and public sector leadership are approaching the international ecosystem. This conversation built on the previous working group session's discussion of an overall reorientation of engagement with specific countries, such as China, due to supply chain security and quality control concerns over the development and utilization of precursor materials.

From the private sector perspective, firms are grappling with the question of how to invest in, or partner with, new countries that are attempting to develop organic biotechnology ecosystems. Those states sometimes face the same questions related to chokepoints, sovereignty, and data management, but they also face geostrategic decisions like deciding whether to pursue partnerships with Chinese or Western firms. Partner nations must decide the degree to which they want a centralized biotech ecosystem or a geographically dispersed one. Regardless of how dispersed an approach third countries pursue, choosing to partner with U.S. firms provides both redundancy in necessary infrastructure and the opportunity to reallocate individual investments to other priority elements of the value chain. However, as many of these nations are at the front end of developing their own infrastructure, full scale development and interoperability will take time. Aligning the U.S. and allied approach to innovation—a concept central to SBI's mission of accelerating technological competitiveness—will be explored further in the final report.

For the U.S. bioeconomy, there are several opportunities for international engagements to strengthen the biotechnology sector. Principal among them is the need to identify infrastructure that will enable the bioeconomy to flourish. While U.S. national goals clearly prioritize onshoring critical R&D and manufacturing capability, participants felt the United States may not be currently positioned to have competitive infrastructure in the coming years. With that in mind, the U.S. could consider prioritizing cooperation and collaboration with allies and partners that have strong biomanufacturing sectors.

Second, the U.S. may lack sufficient, trained members of the workforce necessary to support different sectors of the bioeconomy. Similar to issues with physical infrastructure, the United States could partner with countries that have comparative advantages in the different stages of biotechnologist education and training. The SBI final report will build on this insight to develop suggestions about how the United States and likeminded countries could collaborate on workforce development, such as through partnerships with universities.

Deep Dive: Biotech Data Repository

In response to the stakeholder suggestion of a U.S. government biotech data repository, this section explores the policy and possibilities around this idea. One important point of reference for this might be a corollary to the U.S. Patent and Trademark Office; rather than serving as a central repository for discoveries and writings, it could host biotech data. Specifically, researchers could upload their biotech-relevant data to this central database, where other researchers would be able to identify and use that data for a fee. Some stakeholders likened this proposal to the model implemented by the music platform application Spotify, which provides artists the ability to share their content and earn revenue for each distinct use by others. In the biotech context, the U.S. government would facilitate the storage and shareability of the biotechnology research and enable a revenue share feature for researchers and companies. This would allow biotech efforts to benefit from research that others have produced, but not yet found a way to commercialize.

RELEVANT POLICY POSITIONS

Given the stakeholder comments about data commoditization potentially being at odds with current U.S. government policies on "open access" and "open science," the SBI team researched the relevant policies and how any potential concept for consideration might fit into existing perceptions and lines of effort. Although these terms are often used interchangeably, their meanings are distinct. Open science is the broad idea of how science should be for everyone, invoking broad collaboration and knowledge sharing. Open access is a more narrow notion of scientific content being available either for free or with clear licensing that enables reuse. With respect to terminology, the Biden administration prefers the term "public access," not "open access." Notably, the term "open science" is sometimes used, including in the official government portal, where it is defined as "the principle and practice of making research products and processes available to all, while respecting diverse cultures, maintaining security and privacy, and fostering collaborations, reproducibility, and equity."[2] Despite two and a half decades of debate over this terminology, this policy of open science relates only to federally-funded research. For context, the U.S. government spends heavily on research; in 2022 alone, the total R&D funding across the U.S. government totaled roughly $177 billion.[3]

2 Last year, 2023, was officially the "Year of Open Science" which was "a multi-agency initiative across the U.S. government to spark change and inspire open science engagement through events and activities that will advance adoption of open, equitable, and secure science."

3 Historical Trends in Federal R&D; AAAS analyses of OMB and agency R&D budget data. Includes conduct of R&D and R&D facilities.

Historically, subscription-based journals published research, but, as noted in a Science 2022 article, both libraries and patient groups effectively lobbied the federal government to revise its access policies. As a result, the White House released a 2013 memo which mandated that "the direct results of federally funded scientific research are made available to and useful for the public, industry, and the scientific community." A 2022 White House memo reflected on the outcome of the 2013 policy, stating it "helped to reshape the landscape for data and research by sharing results freely and openly with the public and the scientific community."

Since then, debates have raged around how to ensure public access to federally-funded research, including the 12-month embargo that academic publications had on data for research they published. The White House released another 2022 memo that ended the embargo and otherwise improved the "data sharing plans of the 2013 Memorandum." Although the memo functionally ended paywalls to government-funded research, it begged as-of-yet unanswered questions about how academic publishing will be funded, now that journals can no longer charge for data access.

Regardless, these policies paint a clear picture of the U.S. government's commitment to free access to data and analysis to federally funded research.[4] Importantly, these policies provide no guidance on what the U.S. government—or anyone—can or should do about non-government funded research.

OPPORTUNITY FOR GOVERNMENT CONTRIBUTION

Given this history of the U.S. government's commitment to providing access and data, a U.S. government-led effort to create a biotech data repository would not be at odds with "public access" mandates. Instead, this seems to present an opportunity for the U.S. government to take action: building on the Biden administration's history of modernizing the management of research data, the U.S. government could now create a commoditized data repository, to which privately funded research can be contributed and then utilized by others for a fee.

LEGISLATIVE CONSIDERATIONS

Congress has not produced relevant legislation in this space, despite serious efforts. Bipartisan bills were introduced (and reintroduced) in 2006, 2010, 2012, 2013, 2015, and 2017; none of them became law. Although Congress could notionally act here and now, the lack of a successful track record lends credence to the idea that attempting to operationalize this effort via legislation may not provide the most effective approach.

4 There are different rules for federal funds that are used for research with a national security application, including how the U.S. government could own or otherwise control the results of those efforts.

EXECUTIVE BRANCH OPTIONS

Given the aforementioned history of executive branch leadership in this space, officials within the Office of Science and Technology (OSTP) responsible for the 2022 update could pursue policy and operational clarity necessary for creating a biotech data repository. Specifically, just as free-to-use data is available at open.science.gov, this privately funded research could be available at something like "subscription.science.gov"—which, to be clear, does not yet exist. This approach would require that the U.S. government also clarify intellectual property aspects of this process. Meanwhile, concerns over individual privacy could be addressed in the initial collection and development of the data.

Energy

Stakeholder Analysis

NATIONAL POLICY TO STIMULATE DEMAND

Participants in the Energy Working Group highlighted the important role that regulatory policy can play in catalyzing the new energy economy. Namely, they pointed to the use of demand-side mandates (i.e., policies targeting consumption) to drive incentives in the new energy ecosystem. Until now, however, federal policy favors incentives such as tax credits or subsidies to increase production of clean energy alternatives. Through the Inflation Reduction Act (IRA) and other regulations, the U.S. government opts to enhance production through investments and tax credits. From a policy perspective, this may generate more clean energy options, while simultaneously creating more jobs domestically. Stakeholders pointed out that U.S. economic and energy policy historically gives preference to "carrots" (production) over "sticks" (caps and quotas), which is partially a function of the strong belief that the market will find the right solution absent state-directed mandates.

From the perspective of transforming the energy economy, however, the lack of a demand-side requirement may also slow, if not stunt, the overall conversion. In a salient example, stakeholders highlighted how new blending mandates related to sustainable aviation fuels (SAFs) enacted in European law serve as a forcing function to increase demand. In September of 2023, the European Parliament passed a law increasing targets for usage of SAFs in five-year increments (i.e., two percent of fuel must be sustainable by 2025 and 70 percent must

be sustainable by 2050). Japan seems likely to follow suit, targeting 10 percent SAF usage by 2030. By contrast, the United States relies on the now two-decades old Renewable Fuel Standard (RFS), originally instituted to stimulate bioethanol fuel consumption and production; the United States has since met the highest blending requirement called for in the RFS. Stakeholders now await a year-to-year decision by the Environmental Protection Agency (EPA) for new consumption targets.[5] Participants pointed out that the RFS is in need of an update with an ambitious framework for the next fifty years. Furthermore, across the United States, each state has a mix of incentives, each with different expiration dates. As a result, the United States operates with a patchwork system of production incentives with no clear market signal to investors and the financial ecosystem on where demand will come—or whether it will ever materialize.

The majority of participants in the Energy Working Group are either entrepreneurs or investors in the clean energy economy, and therefore leaned towards recommending the U.S. government set national quotas to stimulate consistent and predictable demand. Supporters cited three primary reasons for setting quotas:

- For large consumers such as airlines and other major industries, a quota would eliminate the prisoner's dilemma and encourage all firms to start altering their energy mix at the same time;
- Such mandates would align the United States with major consumers and producers in the EU and Japan, thus ensuring U.S. firms operate on a competitive playing field in global markets; and
- A requirement would provide certainty to financial markets and investors, thus smoothing out the business cycles and encouraging greater investment in these new markets.

It should be noted that the sole U.S. government participant in the working group supported tweaks to regulatory policy to include demand incentives. The official highlighted that the U.S. Department of Energy (DOE) reserved $1 billion of the $8 billion originally allocated for the Hydrogen Hubs program explicitly for policymakers to develop demand-side tools.

NECESSARY FINANCIAL TOOLS

Continuing initial discussions from the first Energy Working Group, participants elaborated on the importance of strategic financial tools for the energy economy. On insurance specifically, stakeholders identified specific constraints to the existing insurance products in the market.

5 It is important to note that the EPA's role here has been judicially limited: in 2022, the Supreme Court ruled "that neither the EPA nor any other agency may adopt rules that are transformational to the economy—unless Congress has specifically authorized such a rule to address a specific problem, like climate change."

Because the returns of energy transition investments are costlier and riskier, traditional counterparties such as bondholders are less likely to want to engage and as a result, insurance providers are reluctant to underwrite projects. Programs like DOE's Loan Program Office (LPO) play a critical role in assuming risk through loan products, but there remains a gap, especially for first-of-its-kind technology solutions that are deemed too risky even for LPO.

Participants indicated that in order to overcome this financial gap, entrepreneurs and startups are actively seeking relationships with deep-pocketed strategic partners, such as oil and gas majors, that are motivated by specific business or geostrategic reasons to take on these risks. International partnerships with foreign firms, including regional gas majors in markets like India, Malaysia, or Brazil, offer opportunities for global commercialization. These strategic partners often provide direct equity investments and take a partial ownership stake in the firm. Startups often allow regional majors to "own" the technology for their individual markets while maintaining ownership for commercialization in Europe and the United States. In this process, startups must balance the need for market access without relinquishing technology rights globally.

Participants highlighted that DOE has built the scaffolding for many riskier technologies to raise relevant financing at each stage of their growth. Through its newly created Office of Clean Energy Demonstration, SCALEUP at Advanced Research Projects Agency-Energy (ARPA-E), and the LPO, DOE is attempting to provide relevant funding for companies at different stages of maturity. In cases where a technology is eligible for commercial funding, but struggles to raise sufficient funds, the LPO can step in by offering a conditional commitment alongside existing debt providers. This commitment serves as an endorsement to the market, improving the likelihood that companies can raise additional debt or equity from the private sector. Additionally, DOE has established memoranda of understanding with other export credit agencies, such as the Export-Import Bank of Korea, to provide reinsurance tools, further enhancing the financial support ecosystem for innovative technologies.

However, if a technology is in the pre-pilot or pre-demonstration stage, DOE only offers grants or cost-sharing opportunities, funding which the working group participants suggested is insufficient. Participants underscored that for companies in this early development stage, DOE's offerings and pace are simply not enough to create a commercially viable product. Companies struggle to obtain even moderate amounts of funding and the timing is slow vis-à-vis commercial imperatives. Companies also face significant political uncertainty. For example, if companies are planning on bringing technology to market in a five-year time period, there is a strong likelihood that the United States will undergo political change, which introduces uncertainty as to whether the support or contract from DOE will remain available. Participants

indicated that venture capitalists react warily when startups indicate that they are relying exclusively on the DOE LPO loan for a first-of-its-kind technology.

Participants highlighted that the EU maintains a far more robust process for issuing substantial energy-related grants, which range from $100 million to $200 million for large-scale projects. Impressively, the EU has successfully executed 10 projects at this funding level, demonstrating a commitment to supporting initiatives even before the technology is considered loan-ready. This approach stands in contrast to the U.S. public sector, making the EU's grant system considerably more appealing for those seeking financial support for innovative energy technologies. This lack of strategic financial tools in the U.S. energy ecosystem identified by working group stakeholders presents an opportunity for SBI to provide recommendations in its final report on how to structure more large-scale policies in energy technology financing and ultimately strengthen U.S. and likeminded collaboration on innovation.

COMPLICATIONS WITH CHINA

In a revealing discussion, stakeholders highlighted a dilemma they face when balancing the benefits of the tax credits and other incentives in the Inflation Reduction Act (IRA) with the need to do some production and manufacturing in China. In one specific case, a participant noted that because China had built such a significant competitive advantage in coal and solar production, Chinese producers are able to quickly pivot and repurpose existing infrastructure and equipment to fabricate biomass, a critical input for bioenergy. According to one stakeholder, producing such a product in China costs almost 80 percent less than comparable production in the U.S. Gulf Coast.

Furthermore, China retains superior reactors and process integration in gasification technology. They have built one thousand gasification plants for methanol and hydrogen and far surpass competitors worldwide in design and optimization of supply chains. Entrepreneurs must now deliberate over the tradeoff between accessing incentives included in the IRA and a strategic desire to improve U.S. competitiveness with the very real commercial imperatives to pursue lower-cost, higher-quality technology solutions in China, which ultimately would disqualify them from U.S. incentives (e.g., the Clean Hydrogen Production Tax Credit, also known as the 45V credit). One participant opined that this strongly illustrates how the paradigm has shifted; where once the United States would take its most advanced research and development (R&D) and products to China for manufacturing at scale, the United States may now need to transfer technology from China in order to reverse engineer these significant gains in productivity. IST finds these insights about Chinese technology worthy of significant exploration; for the final report, the SBI team will include detailed information that contextualizes both this situation

and what the United States could do to help companies that feel compelled to leverage such Chinese opportunities.

Deep Dive: Demand-Side Mandates

POLICY CONTEXT

During the second Energy Working Group meeting, participants noted that there may be an opportunity for the U.S. government to create additional incentives that focus on demand-side mandates instead of just production incentives, a tool that our stakeholders suggested is commonly understood and used in the United States.

For context, production incentives are policy mechanisms like tax credits (e.g., the Renewable Electricity Production Tax Credit) and public funding of research and development. These "supply-side" tools reduce production costs, enabling political leadership to strategically catalyze job creation. Conversely, "demand-side" policy tools, such as rules about how much ethanol must be blended into gasoline, establish quotas on the amount of product that the market is allowed to pursue or must produce. While each of these types of tools has its detractors, the latter type seems less common in the U.S. energy sector. Yet, demand-side mandates provide unambiguous clarity for energy investors who are often assessing whether to invest in a company based on the potential revenue it can earn from a total addressable market, and for companies deciding whether to pursue a specific market or establish a new business line based on the revenue it can potentially earn.

Stakeholders initially raised this policy dynamic in the context of SAFs and the broader discussion of transition from hydrocarbons generally (e.g., as part of the Energy Earthshot Initiative) and with respect to recent legislation (e.g., the Inflation Reduction Act), as well as other existing incentives.

THE PROBLEM: LACK OF DEMAND MANDATES

In the working group discussion, participants collectively contended that current U.S. policy primarily prioritizes production-based incentives. While this is an important first step for shifting away from hydrocarbons to renewable energy or alternative solutions, working group participants generally agreed that it is important to consider demand-side incentives as well.

For example, some stakeholders flagged the 2021 U.S. Sustainable Aviation Fuel (SAF) Grand Challenge, which set targets for producing three billion gallons of SAF domestically by 2030,

and 35 billion gallons by 2050, but this challenge is functionally a supply-side production incentive with the goal of increasing production and use of SAF to three billion gallons per year by 2030. And according to a 2023 International Council on Clean Transportation white paper, the United States has enough SAF production potential to meet the grant challenge's 2030 goal, but not the 2050 target. These same experts call for a long-term price signal through a demand-focused mandate which will provide industry the incentives to invest in alternative sources of energy.

For additional context, the U.S. government and individual states provide production incentives in the SAF space. The IRA alone includes two tax credits to support SAF production (§§ 40B and 45Z). Similarly, California, Oregon, and Washington have clean fuel standards under which fuel producers are awarded credits.[6] Although these regulations are a good step in creating production incentives for SAFs, a March 2023 Government Accountability Office (GAO) report judged them insufficient. Thirteen of 43 stakeholders interviewed by GAO said that a mandate requiring airlines to use a certain volume of SAF "could also be an effective policy option to spur SAF production," noting that it could provide "a guaranteed demand signal to SAF producers and investors."

The United States has some demand-side mandates, such as the EPA's Renewable Fuel Standard, which sets biofuel blend mandates that award fuel producers credits for each gallon of qualifying biofuel produced. However, some notable groups have resisted demand-side mandates. For example, an International Air Transport Association (IATA) fact sheet on EU and U.S. SAF production policies states, "a mandate policy is not IATA's preferred option for advancing the commercial deployment of SAF… While a mandate does provide a clear demand signal which can be important for new production business cases, it rarely delivers the optimal economic outcome." For example, such a mandate can mean higher prices for consumers. The IATA is not alone in its opposition to policy tools which exert non-market forces on the demand side.[7]

OPPORTUNITY FOR GOVERNMENT SUPPORT

Given this absence of demand-side energy mandates in a U.S. context, SBI looked abroad for examples of countries that have enacted such policies. The second Energy Working Group discussed EU blending mandates, which create a clear demand signal for SAFs. Specifically,

6 These are complicated regulations that reward these credits and aviation fuel is an "opt-in" element, meaning that SAF producers can "stack" the credits earned for SAF with other incentive programs.

7 Additionally, sequencing of production versus demand mandates can also be critical. The GAO report notes that production incentives should come before such mandates. Fortunately, if the U.S. were to legislate such mandates, they would benefit from the already existing production incentives, as noted above.

participants mentioned that these types of signals create predictability in the private sector in terms of market size and timelines, which help the private sector to fundraise and make business decisions. As an example of demand-side policy, in October 2023, the EU passed a revised directive establishing blending mandates for SAFs, adding to earlier legislation like the 2018 Renewable Energy Directive. The EU SAF regulation "sets out annual SAF mandate shares" to be achieved by 2030 and 2035. According to the Research Institutes of Sweden, these demand-side tools "have been effective in encouraging high-performance biofuels."

Passage of such mandates in the U.S. context would have downstream effects on industry, including job creation. Indeed, in the EU case, EU Commissioner for Transport Adina Valean noted that the SAF market will create more than 200,000 additional jobs in the renewables sector. Hydrogen Europe's Mobility Policy Director Darko Levicar noted that binding mandates create "long-term certainty" for fuel suppliers to establish a European supply chain for cleaner fuels. Notably, demand-side incentives in the United States—unless coupled with import restrictions—would not guarantee domestic job creation as the supplies could otherwise be imported.

Other countries worldwide are developing their own demand-side mandates. In May 2023, the Japanese government introduced a proposed regulation mandating that 10 percent of aviation fuel for international flights using Japanese airports be sustainable. The amendment is expected to be enacted by March 2024. Additionally, Japan's Ministry of Land, Infrastructure, Transport and Tourism (MLIT) estimates that Japan could have the capacity to produce about 1.9 billion gallons of SAF annually by 2030. Until this development, Japan's decarbonization policies have utilized mechanisms like subsidies; this is the first shift to a demand-side, "EU-like" policy. Australia in September 2023 released a green paper that suggested proposing blending mandates, noting such a mandate "would create a new demand signal for SAF production, although global demand for SAF is already high." In some ways, these developments on a global scale signal a shift in approach to the energy sector.

Arguably, the use of SAF in high-consumption, high-polluting industries such as shipping and aviation would be a good place to start with demand-side mandates; the scale of the need would create private-sector clarity and the environmental impact would be significant. Additionally, there are historical precedents in the United States, such as the RFS and mandates for reductions in carbon intensity of the fuel supply on fuel providers, such as California's Low Carbon Fuel Standard. Such a SAF mandate could parallel the introduction of blending requirements in ethanol, which is reported to have produced hundreds of thousands of jobs and tens of billions in Gross Domestic Product (GDP). The Renewable Fuel Standard effort began at lower percentages and increased through shifts in blending requirements and legislation. Through the signing of the Energy Policy Act in 2005, the RFS first specified the amount of

biofuel blended into the fuel supply and then transformed the precursor ethanol tax exemption into a tax credit. Following the development of the California Low Carbon Fuel Standard in 2010 and subsequent greenhouse gas reductions, which proved the impact of ethanol and the policy, in 2011 the EPA approved a blend of ethanol in gasoline. In 2011, as a result of tax credits and tariff expirations, U.S. ethanol became a net export. In 2018, ethanol production reached 16.1 billion gallons. That same year, according to the Renewable Fuels Association (RFA), more than 200 ethanol plants around the United States supported approximately 350,000 jobs and added $40 billion to the country's GDP.

With SAF currently benefiting from supply-side incentives, some stakeholders see current SAF policy as equivalent to early-days ethanol policy.[8] Policymakers could consider developing a clear mandate for demand, possibly by amending existing legislation like the RFS (e.g., switching from an opt-in to direct recognition), or through new legislation that specifically creates SAF mandates. An ideal scenario would include a mixture of incentives at the state and federal level, since the International Civil Aviation Organization finds that such "stacking" is the most effective. Accordingly, in SBI's final report, IST intends to propose specific ways to operationalize demand-side mandates.

Quantum

Stakeholder Analysis

The second convening of the Quantum Working Group occurred against the backdrop of significant concern from stakeholders regarding the National Quantum Initiative Act (NQIA) reauthorization. Passed in 2018, the NQIA provided administrative guidance for departments and agencies to focus R&D dollars on quantum technology development, created the National Quantum Coordination Office within the Executive Office of the President, and established a mandate to build out an agenda for economic and technological competitiveness over the subsequent five years. These concerns generated a fruitful discussion on the pain points in the

8 Even though the development of ethanol policy can serve as a good blueprint for the development of SAF policy from production into demand mandates, ethanol policy is not without its own warnings. Environmentally, scientists note that ethanol production is the main reason for the "dead zone" in the Gulf of Mexico due to the increase in corn cultivation, which uses fertilizer harmful to aquatic life. Additionally, a study in Science warned that U.S. biofuel policy could encourage farmers to plow into land set aside for conservation, in turn increasing carbon dioxide, a pattern observed in 2008, 2009, 2011, and 2012, and supported by a study from 2013 in the Proceedings of the National Academy of Sciences. As such, SBI recommends that regulation be created in conjunction with scientists and advisors who can help shape SAF feedstock, land use, and other environmental impact such as waste, to ensure that the policy results in greenhouse gas reduction and not greater environmental harm.

current public sector approach to supporting the quantum ecosystem and provided participants with an opportunity to highlight specific recommendations that could strengthen the legislation. Participants identified overlapping concerns around three key topic areas and concluded the U.S. government should:

- Take a holistic view of the state of the U.S. quantum industrial base and develop a sophisticated analysis of its various strengths and weaknesses;
- Make targeted financial or technical interventions in different industry sectors and within these sectors, for companies at different stages of maturity; and
- Develop a more deliberate approach to international partnerships, to include information exchange, industrial collaboration, and rules governing fundraising.

QUANTUM ECOSYSTEM MAPPING

Building off of topics raised in the first Quantum Working Group discussion, stakeholders asserted that the U.S. government currently lacks a holistic view of the entire quantum value chain. Such a holistic view would include an understanding of the different technologies and applications possible with quantum technology and, importantly, the various dependencies quantum companies have when it comes to input materials, infrastructure, downstream partnerships, or use-cases. Participants highlighted that at least three key factors contribute to this lack of a holistic view.

- **Misaligned expertise.** Personnel across government that are charged with managing quantum portfolios at the DoD, DOE, OSTP, and National Science Foundation (NSF) are often academics, and therefore professionally trained in the early stages of the technology readiness scale. While such knowledge and training is very important for the government to possess, when companies that are attempting to commercialize certain applications discuss their needs with these offices, government experts are not equipped to offer solutions or recommendations that are relevant to the challenges.
- **Differing perspectives on quantum.** Stakeholders pointed out that government offices often have fundamentally different points of view on quantum, even for the same set of technologies. While some of this can be expected—for instance, the DoD is contemplating the development and use of quantum technologies in a national security context while DOE might be exploring use cases to improve materials discovery for clean energy—the lack of connective tissue between these offices and programs creates confusion for vendors and adds costly complexity for companies that are seeking grant funding or contracts in order to build a product that will ultimately be sold in the commercial markets.
- **Insufficient resourcing.** Finally, from an infrastructure point of view, participants pointed out that many of the U.S. government's offerings, such as the recently launched "Quantum Garage" are necessary, but not sufficient. These offerings are reflective of the broader

underlying approach best captured by one participant, who described how the labs are reaching out to industry through Requests for Information (RFIs) and then responding to specific requests on what those companies want. However, no single department or agency is looking at the entire value chain to understand gaps within the industrial base and then providing facilities to close them. As an example, quantum computing public infrastructure does not currently offer differentiated products to support development of methodologies such as annealing (i.e., the development of components such as gate circuits) or superconducting qubits.

TARGETED FINANCIAL INTERVENTIONS

Since most of the U.S. government's expertise focuses on the early stages of the quantum industrial base, the types of funding tools that different departments and agencies possess are often not relevant to more mature companies' product roadmaps. Further, as one participant pointed out, senior leaders at the DoD are not as savvy to the nuances of the fundraising environment for a startup in the quantum sector, which leads to a significant disconnect between available public funding and start-up needs. Additionally, current government-sponsored non-dilutive funding pathways are too small; for example, the average Small Business Innovation Research funding opportunity tops out at roughly $1.75 million over the course of two years. While there are ways to augment this amount, those practices are the exception and not the norm.

All is not lost, however. Participants were complimentary of the recent creation of DoD's Office of Strategic Capital (OSC) and the partnership between DoD and SBA to create the Small Business Investment Company Critical Technologies Initiative. Participants said initiatives like these, which give the government the ability to partner with private investors in a more robust way to explicitly tackle the underserved components of the quantum value chain and other deep technologies, are exactly what is needed. However, participants noted that OSC funding, while authorized, remains subject to the appropriation process, a complicated Congressional effort that officially occurs every year. In a similar light, participants were bullish on the potential of the EXIM's Make More in America Initiative and China and Transformational Exports Program (CTEP). In theory, EXIM, which can offer large low-interest loans and loan guarantees for critical technologies looking to scale up, has the potential to bolster the industrial base in areas where traditional venture capital is not currently investing. However, EXIM, a historically risk-averse entity, struggles to navigate the nuances of technology company finances and determine whether they fit the bank's risk profile.

Ultimately, stakeholders recommended that the U.S. government develop a more credible national strategy that accounts not only for basic R&D in quantum, but also Commerce programs and the industrial policy elements of the DoD, among others, to ensure that the government can

design technical and financial interventions that are relevant to the industrial base we seek as a nation.

COHERENT INTERNATIONAL STRATEGY

In a wide-ranging discussion on the current levels of international engagement on quantum technology, stakeholders remained unconvinced that current efforts are strategic in nature and that recent deliverables are meaningfully progressing U.S. competitiveness. From the work of the State Department's Special Envoy for Critical and Emerging Technology to the various dialogues the U.S. government currently engages in, stakeholders reported that officials are seemingly hyper-focused on producing tactical deliverables, rather than working towards achieving broader, long-term goals. Rather than solving pain points around integrating necessary supply chains or synchronizing computing standards and architectures, announcements and deliverables seem to working group participants to be driven by Presidential engagements or other high-level visits and not the needs of the private sector.

In addition, U.S. departments and agencies need to better spell out where and how startup technology companies can raise money from foreign sources. Some guidance emerged from the 2018 reform of the Committee on Foreign Investment in the United States (CFIUS), but it fails to clarify some of the more pressing questions that fall outside of CFIUS' scope. For example, many of the quantum companies who need to raise large amounts of money from strategic investors turn to sovereign wealth funds in regions such as the Middle East and Asia. Participants flagged uncertainty around the current and future risks to attaining U.S. government contracts if they take money from such investors today, despite the fact that it is the only money currently available to them. Further, in exchange for funds, many of these strategic investors request a local presence and joint ownership of intellectual property. Participants asked whether this kind of request might be acceptable to the U.S. government, either now or in the future. Companies would like to understand the operating boundaries from the perspective of the U.S. government on these issues. These insights give SBI the opportunity to explore U.S. and likeminded collaboration on incentivizing critical and emerging technology—including laying out a framework that clarifies where companies can seek capital without being concerned about jeopardizing opportunities with the U.S. government. The SBI final report, expected this summer, will describe this in detail.

NATIONAL STRATEGY

In the context of Congress' reauthorization of the NQIA, reauthorization participants urged the U.S. government to clearly articulate a strategy for maturing quantum research and importantly, for developing commercial quantum products and applications. In order to do so, the U.S.

government would need to engage more commercially focused officials in the assessment of the industrial base, include more financially-savvy officials in designing non-dilutive capital tools, and develop an understanding of when and how to intervene in the ecosystem to close gaps without picking winners. These assessments are precisely the type of insight that demonstrate the need for additional efforts to close this gap—and why SBI will be developing specific recommendations in our third concept paper and final report.

Participants emphasized the need to centralize quantum coordination, augmenting the National Quantum Coordination Office, potentially with a Presidentially-appointed czar who has the mandate to shape budgets and coordinate higher technology readiness level (TRL) quantum activities. Further, Congress should be explicit in the authorization and appropriation of budgets to ensure that different offices are directed to work on specific TRLs.

Deep Dive: How Technology Mapping Can Clarify Long-Term, Strategic Position

In the second Quantum Working Group discussion, stakeholders built on the prior discussion with respect to the importance of creating clear definitions and a coherent quantum policy.

The 2018 NQIA attempted to set out a national direction for quantum policy, under which departments and agencies have created their own quantum centers and programs. However, work still remains to clarify definitions and national policies. For example, stakeholders report that Congressional approval of its pending reauthorization will be critical to setting out a clear plan for the United States' leadership in the field, as well as continuing the work in progress since 2018. Significantly, participants noted that the Quantum Information Science (QIS) centers established by the NQIA tend to focus on specific architectures. In their experiences across the DoD, DOE, and NSF, they note a lack of a cohesive quantum strategy, despite the existence of OSTP's National Quantum Coordination Office (NQCO)—an office intended to handle strategic alignment, but limited by its narrow approach. Specifically, Quantum Working Group participants asserted that the NQCO prioritizes DOE activities over those of other departments and agencies and fails to provide sufficiently strong direction for the development of companies and efforts at different stages of maturity.

THE GAP IN NATIONAL QUANTUM GOVERNANCE: NO EXISTING CENTER OF GRAVITY

In addition to OSTP's NQCO and its explicit goal of coordinating across NQIA programs, a number of other federal and state programs are also developing their own quantum activities and environments. Beyond the five national QIS research centers, DOE's Office of Science includes quantum information science efforts, such as DOE-focused applications in support of fundamental science underpinning quantum computing, simulation, communication, and sensing. In addition, the DoD includes quantum in its microelectronics initiatives, such as its Microelectronics Commons hubs, which include quantum as a priority technology area. Similarly, the U.S. Army's Combat Capabilities Development Command (DEVCOM) Army Research Laboratory's research priorities include photonics, electronics, and quantum sciences. Two of the Economic Development Administration's 31 designated Tech Hubs focus on quantum leadership. Relatedly, EXIM's China and Transformational Exports Program (CTEP), prioritize quantum as a critical sector. These are just a few examples of the disparate quantum initiatives throughout the U.S. government.

Department of State-led efforts, such as Quantum Foundry at UC Santa Barbara, which is funded through an NSF Q-AMASE-i initiative award, drive progress in the quantum ecosystem—largely, according to our stakeholders and research, without strong strategic direction that contemplates all stages and activities in the quantum ecosystem. Although one of the purposes of the NQIA was "[i]mproving the interagency planning and coordination of federal research and development of quantum information science and technology," working group members consistently report that this goal is not being met.

AN OPPORTUNITY FOR IMPROVEMENT

As noted in the first concept paper, this is not a problem that industry alone can solve; the government, given its unique ability to create standards, align budgets, formalize priorities, and align technical approaches, also needs to step in. Government involvement primarily occurs in one of two ways: executive branch action or Congressional action. These pathways for improving national quantum governance are explored in the following sections.

THE POTENTIAL FOR EXECUTIVE BRANCH ACTION

There have already been multiple presidential actions related to quantum. Examples include the 2022 E.O. on Enhancing the National Quantum Initiative Advisory Committee, the National Security Memorandum on Promoting United States Leadership in Quantum Computing While

Mitigating Risks to Vulnerable Cryptographic Systems, and 2023 E.O. on Addressing United States Investments in Certain National Security Technologies and Products in Countries of Concern. Yet, both SBI research and comments from stakeholders reveal a need for something more.

SBI suggests an effort modeled after the recent work on AI. In October 2023, President Biden issued an E.O. on Safe, Secure, and Trustworthy Artificial Intelligence, which initiated a set of activities related to the use, regulation, and management of AI. Structurally, activities on AI—like quantum—are being pursued across the U.S. government. The 2023 E.O. instructed the National Institute of Standards and Technology (NIST) to "drive the tools and methods that all participants need to understand the safety, trustworthiness, and effectiveness of AI models," as well as initiating "a pilot for a National AI Research Resource (NAIRR), a compute and data infrastructure to support AI research." Generally speaking, a broad-ranging E.O. that initiates a range of activities related to quantum could be a good way for the U.S. government to clarify direction and ownership of quantum governance.

Further, an E.O. could lay out a strategic approach that ties together disparate programs, preferably with guidance on how to collaborate internationally on quantum. In our Quantum Working Group discussion, participants emphasized the importance of working with allies, highlighting supply chain reliance on other countries for component parts. As such, an E.O. could be helpful in establishing direction for the international component of quantum. It could also be modeled after AI.gov, which the executive branch is using as a repository and jumping off point to convey White House and U.S. government activities in AI.

Within this context, a quantum governance E.O. that centers supply chain resilience, focuses on technology leadership (especially vis-à-vis competition with China), and articulates the need to create a robust, democratic, quantum-allied cluster of nations, could align with this mandate. Yet, such an E.O. could be undone by a successor's pen stroke and thus is not as durable as legislation.[9] Accordingly, this paper now turns to examining the role Congressional action could play in defining the U.S. government's holistic approach to quantum.

THE POTENTIAL FOR CONGRESSIONAL ACTION

Many experts on quantum have noted how the CHIPS and Science Act—a landmark law that appropriated $53 billion and authorized $280 billion in spending to boost domestic research and manufacturing of semiconductors—lays out the kind of approach that would benefit

9 Similarly, the White House could create and empower a "czar" for quantum – something that multiple working group participants suggested. Such a senior official could have the mandate to shape budgets and coordination in higher TRL quantum activities. Yet, like the other steps suggested in this subsection, though, it could be instantly undone by a successive administration which wanted to take a different approach to quantum.

quantum. Yet, that statue did not simply come to fruition as the result of a single or simple process that worked to produce a specific result.[10] Importantly, exogenous conditions aligned to make the CHIPS Act possible. First, supply chain bottlenecks and dependencies created delays in critical manufacturing sectors, like automobiles, during the COVID-19 pandemic. Second, increasing bipartisan concern around the "China threat" acted, in effect, as a bridge between the Democrat and Republican caucuses. These conditions suggest that such a standalone bill for quantum, while not impossible, would require a lot of groundwork in both chambers of Congress, as well as the alignment of external factors, such as the designation of quantum as an immediate economic imperative or pressing national security threat.

Rather than trying to pass a stand-alone bill like the CHIPS Act, the quantum effort could instead be tied to well-known, high-profile issues through an amendment to existing work. For example, quantum intersects with critical minerals: the rare-earth element ytterbium is used in some trapped ion architectures. Legislation could capitalize on the Department of Commerce's existing focus on rare earth element supply chain security. Quantum also intersects with semiconductor development: the CHIPS Act in fact calls out quantum and certain foci, like the DoD's Microelectronics Commons, flag quantum capabilities as a priority.

Regardless of the process that could produce such quantum legislation, there would need to be intense coordination across departments and agencies for there to be any potential quantum legislation that would aim to provide the sort of holistic approach recommended in this paper. In the case of semiconductors for example, NSF grants related to semiconductor workforce development must align with workforce growth priorities the CHIPs Program Office outlines in their funding calls. In a similar way, DOE's existing work in quantum, including NQIA, as well as existing lower-TRL-level research, should be paralleled by any added funding this quantum legislation creates for supporting the domestic quantum industry.

10 CHIPS was originally two separate bipartisan bills. The Endless Frontier Act was designed to focus on high-tech research science for national security, and the CHIPS for America Act was focused on bringing back manufacturing to compete with China. The different texts were rolled into the United States Innovation and Competition Act of 2021 (USICA), which temporarily took on other names before eventually becoming law.

Conclusion

The second round of working group sessions reinforced SBI's understanding of the challenges faced by the private and public sectors in communicating and connecting on each other's needs and offerings as put forth in the initial working group sessions. These misalignments are to be expected; the last time the United States required intense collaboration between stakeholders from the U.S. government, private industry, and academia was at the height of the Cold War. Since then, financial, policy, and technological paradigms have changed. Unlike Cold War-era innovation, the private sector largely drives organic development of financial and technological capability, while the U.S. government has tended to take a back seat, particularly in technology domains.

However, as the first and second working group sessions highlighted, the U.S. government is—and will continue to be—an indispensable partner in cutting-edge, deep technologies of national security importance that require non-trivial capital expenses and the need for nuanced regulatory interventions over a long term horizon. Stakeholder input and SBI research indicates that public policy tools exist to bridge certain misalignments between emerging technology companies and the policy apparatus. Now, in order to unlock innovation, the U.S. government needs the ability to evaluate the existing tools and understand how they can be repurposed to better reflect the needs and trade-offs of the current technology development ecosystem.

Particularly when addressing the capital needs, the U.S. government has ample resources, whether through federally funded research and development grants and contracts, or through instruments such as loans or loan guarantees, to adequately support specific technology sectors without picking winners. However, departments and agencies are not currently oriented to do so effectively. In Biotech, Energy, and Quantum, three representative deep tech sectors where global leadership is up for grabs, the common thread from stakeholders regarding the accessibility of public capital is that U.S. government programs do not match up with the needs of different companies at different stages of maturity. There is a gap in financing vernacular, a lack of understanding of the venture-backed technology development lifecycle, and a resulting set of problems with program implementation that lead to missed opportunities. Moreover, the tools that do exist are not paired with longer-term procurement or broader market access policies to ensure that companies developing in priority technology sectors will have a pathway to enduring competitiveness.

On the policy and regulatory front, companies in each of these sectors highlighted that the regulatory and policy environment is silent on the trade-offs that real businesses have to make, thus compounding uncertainty. Whether unclear on the design of federal incentive programs or uncertain about the deliberations of investment screening committees, companies that are making decisions on where to build supply chains or where to obtain patient capital lack clarity on U.S. policy. In addition, companies in these sectors would benefit tremendously from some of the day-to-day work of the U.S. government if it were organized to deliver against some of the big gaps in their sectors. For example, the U.S. government could leverage existing industry and analysis offices at Commerce or DoD to map out value chains and identify financing and supplier gaps in key technology sectors. In SBI's forthcoming final report, IST will explain more about how to operationalize this concept and ways the SBI team might help bring it to fruition.

Efforts like these would provide tremendous benefit to entrepreneurs and investors while only requiring a relatively light U.S. government lift, given that these offices are already equipped to perform these analyses. More ambitiously, the government could design and establish more novel tools, such as data repositories for private sector research, in effect obviating the need for new companies to invest significantly in research that has already been conducted by a peer and instead offering an opportunity for monetization and sharing of critical results.

Next Steps

In the final set of working group discussions during the Spring of 2024, the SBI team will dive deeper into questions on how to operationalize these ideas. Specifically, SBI aims to drill down into the unique development stages of venture-backed technology companies in these three critical sectors. Through the third sessions, SBI will develop a strong understanding of the type of public capital most suitable at each stage of product and company development specific to each sector, whether grants and investments or loans and procurement. SBI will work to develop a nuanced understanding of what type of money is required, when it is required, and what it is required for. SBI will then collaborate with government colleagues to see how existing offerings match up to those needs. Lastly, where legal or policy constraints simply do not allow for alignment, SBI will work to provide recommendations to private stakeholders on how to adapt in order to access public resources.

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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