CHAPTER 2: CURRENT AND HISTORICAL US CAPABILITIES IN CRITICAL TECHNOLOGY ASSESSMENT

The sources and breadth of published science and technology (S&T) knowledge have expanded at unprecedented rates for the past half-century.[1] The institutions to support policymakers in light of this expansion have not kept up. Further, as S&T knowledge expands, of necessity it becomes ever more specialized, understood mostly by those working in narrow domains, who may have little contact with or knowledge of other domains. Policymakers need trusted sources of analysis, guidance, and insight with direct utility for issues they must address in a timely manner. There is much that critical technology assessment might do to clarify what makes some technologies more critical than others. Such information could assist policymakers in setting priorities, whether for R&D spending, foreign economic policies (trade and investment), taxation, public health, or economic development.

Context: Government Advisory Resources Past and Present

Compounding the challenges of rapid technical advances and specialization is the complex system of missions and activities across federal agencies and other actors.

Science and technology have been recognized as important to national security, the economy, and social well-being especially since the start of World War II, when the United States found itself technologically lagging behind Britain and Germany. The years following the war saw establishment of new S&T capabilities in the executive branch, legislative branch, and external sources. These included the Office of Naval Research (ONR; 1946), National Science Foundation (NSF; 1950), Air Force Office of Scientific Research (AFOSR; 1951), President's Science Advisory Committee (1957; later reconstituted as the President's Council of Advisors on Science and Technology, PCAST), and Advanced Research Projects Agency (ARPA, later DARPA; 1958). Other sources of advice and analytical expertise for the executive branch include the private RAND Corporation, the independent National Academies of Sciences, Engineering, and Medicine (NASEM; formerly the National Research Council), the federal National Science and Technology Council (NSTC) and Office of Science and Technology Policy (OSTP), and statistical agencies such as the Bureau of Economic Analysis (BEA) and Bureau of Labor Statistics (BLS). In the executive branch, dozens of agencies and subagencies have their own missions and often their own policy shops and considerable independence.

Congressional members and their staff are highly knowledgeable and talented, but do not necessarily have the numbers or depth and breadth in technical issues facing the US government, must less the US S&T enterprise as a whole. Congress can call on the Government Accountability Office (GAO), Congressional Budget Office (CBO), and Congressional Research Service (CRS) for studies touching on S&T, each with varying focuses and internal expertise. GAO, which reports to Congress and is charged with investigating "matters relating to the receipt, disbursement, and application of public funds," has published 30-plus "technology assessments" over the past 20-plus years; its products often reflect an accounting perspective given the agency's role, although with the creation of its Science, Technology Assessment, and Analytics (STAA) office, GAO has been conducting studies

1 The many publications of Derek J. de Solla Price, beginning in the early 1960s and culminating in *Little Science, Big Science…and Beyond* (Columbia University Press, 1986), mapped increases in the formal literature.

more closely based on S&T aspects of policy. CBO produces useful reports on R&D budgets and planning, and on regulatory measures and their costs, occasionally delving more deeply into S&T-related issues, while grounding its work in government finance. CRS provides meticulous reviews, focusing on legislative content, both enacted laws (and agency regulations based on them) and proposed legislation. From 1974 to 1995, Congress was also able to draw on the congressional Office of Technology Assessment (OTA). OTA's mandate included, but went well beyond, policy for S&T and it addressed the S&T components of wider policy issues.

Challenges and Limitations

Because multiple agencies and subagencies, with substantial R&D budgets and technical expertise, share responsibility for identifying and either supporting or regulating technologies, overlapping jurisdictions can create boundary issues, compounded by asymmetrical access to technical expertise. It is difficult to coordinate or harmonize among agencies with overlapping responsibilities and there is limited sharing of their terms, methods, data, and information, sometimes because of security restrictions. There is also limited capacity for monitoring what goes on among agencies and subagencies on almost any issue, much less monitoring and sorting through outside advice, developments, analysis, and opinion. All of this makes cross-agency coordination difficult and challenges policymakers and analysts in efforts to extract and synthesize useful guidance.

The Office of Science and Technology Policy (OSTP) is statutorily charged with advising the president on S&T, coordinating the implementation of S&T priorities across the federal government, and engaging with partners from academia, industry, civil society organizations, and other government bodies. Over the past several decades OSTP funding has ranged between $5 million (2021) and $10 million (1993), not including additional funding sourced from NSF (for the Science and Technology Policy Institute) and DOE (for PCAST). While OSTP is solely an advisory and coordinating body, it has at times enhanced its leverage by joining with the Office of Management and Budget (OMB), which, given its primary function of budget oversight, can influence agency actions through budgetary approvals.

Finally, data gathering and analytical capacity to support policymakers in science and technology (S&T) decision making may have been reduced in the past 3 decades, particularly in light of the increasing depth and breadth of S&T issues and growing amount and variety of data needed for effective decision making. For example, the Defense Logistics Agency for a period funded selected defense-relevant product and technology tracking by the US Census Bureau (information that is lacking in trade data, which is often by weight or dollars), but it is not clear that an alternative replaced that effort. As a result, a 2020 supply chain study, for example, was left to rely heavily on information from trade associations, news media, and nongovernment organizations with possible stakeholder agendas (USITC 2020).

Need and Opportunity for Overarching Independent Technical Analysis

Effective critical technology assessment demands deep knowledge of specific technologies that is difficult for anyone to acquire and keep up with other than direct participants. But the engineers and scientists who are engaged day-to-day in developing potentially critical technologies and who have the deepest knowledge may themselves have, or work for employers with, stakeholder interests. And unlike science, where results are regularly peer reviewed and published, understanding of new technology is particularly difficult because it requires (i) unpublished private sector knowledge retained in business firms (much of which is proprietary); (ii) a combination of scientific, economic, and market-related expertise; and (iii) tacit "know-how."

Organizations such as the National Academies of Sciences, Engineering, and Medicine can enlist national and international expertise. Their consensus reports, based on input from 12 to 18 committee members, typically take 2–3 years to produce. OTA had analytic capabilities and could tap deep reservoirs of knowledge about technology (including through short-term external contracts), but since its defunding in 1995 these capabilities have not been replicated elsewhere.

Finally, federally funded research and development centers (FFRDCs), such as RAND (which in the 1990s housed the government's Critical Technologies Institute), MITRE, SRI, and the Institute for Defense Analyses, as well as national labs can often play important roles in technology assessment.

In short, it is a significant and pervasive challenge for work on critical technology assessment to leverage the full set of data and the S&T expertise dispersed across the country in academia and industry, and to combine sophisticated analytics with knowledge that gets inside the "black box" of technology. The federal government, agencies, and policymakers are in deep need of clear evidence informed with technical depth and analyses that can be used to guide decisions about parsing R&D budgets, proffering industrial supports and subsidies as in the CHIPS and Science Act, developing and applying export controls, or evaluating potential risks to national security.