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The Historical Roots and Pathways Forward

Peter D. Blair
George Mason University
Schar School of Policy and Government
Arlington, VA, USA
pblair2@gmu.edu

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Annals of Science and Technology Policy

Published, sold and distributed by:
now Publishers Inc.
PO Box 1024
Hanover, MA 02339
United States
Tel. +1-781-985-4510
www.nowpublishers.com
sales@nowpublishers.com

Outside North America:
now Publishers Inc.
PO Box 179
2600 AD Delft
The Netherlands
Tel. +31-6-51115274

The preferred citation for this publication is

P. D. Blair. *Toward More Effective Science and Technology Advice for Congress*. Annals of Science and Technology Policy, vol. 5, no. 2, pp. 91–246, 2021.

ISBN: 978-1-68083-803-9

Annals of Science and Technology Policy
Volume 5, Issue 2, 2021

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Annals of Science and Technology Policy, 2021, Volume 5, 4 issues. ISSN paper version 2475-1820. ISSN online version 2475-1812. Also available as a combined paper and online subscription.

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Toward More Effective Science and Technology Advice for Congress

Peter D. Blair[1]

[1] *George Mason University, Schar School of Policy and Government, Arlington, VA, USA; pblair2@gmu.edu*

ABSTRACT

Science and technology (S&T) assessment designed to effectively inform Congress must be both credible and suitable to congressional needs. To be unimpeachably credible, it should be widely accepted as (1) authoritative, (2) objective, and (3) independent. To be suitable and well-matched to congressional needs, the advice must be (4) relevant, (5) useful, and (6) timely. For S&T advice today, Congress draws on many sources for advice but it created four organizations over the last century and a half to provide itself with different types S&T advice: (1) the National Research Council, the operating arm of the National Academies of Sciences, Engineering and Medicine, (2) the Congressional Research Service, (3) the former Office of Technology Assessment, and (4) the Government Accountability Office. This monograph traces the historical roots of S&T advice for Congress and chronicles the creation and evolution of these four organizations over the past half century. Key characteristics for providing effective S&T advice for Congress are defined and then used to evaluate the relative strengths and weaknesses of these organizations today and to identify prospective organizational improvements in each to meet today's needs.

Peter D. Blair (2021), "Toward More Effective Science and Technology Advice for Congress", Annals of Science and Technology Policy: Vol. 5, No. 2, pp 91–246. DOI: 10.1561/110.00000022.

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Introduction: The Roots of Science Advice to American Government

Science and technology (S&T) developments over the past half-century, including transformational advances in medicine, information, communication, national security, energy, and many other areas have delivered extraordinary quality-of-life benefits. Many more prospects such as quantum computing, synthetic biology, and scores of others are developing apace as well. In reaping the benefits of these advancements, however, society must also cope with sobering challenges accompanying the scale, scope, and rapid pace of development for many of them.

Among the architects of American democracy, Thomas Jefferson believed firmly that an informed electorate and well-informed institutions of government were essential. He concluded "... whenever the people are well-informed, they can be trusted with their own government; that, whenever things get so far wrong as to attract their notice, they may be relied on to set them right" (Jefferson, 1789). Informing government about S&T issues is particularly challenging since such issues are often complex and can have substantial impact with outcomes uncertain. Government poorly informed about S&T is destined

to make inferior policy choices. Yet, today, it is difficult for policymakers and the public to keep pace with the frontiers of S&T and their implications.

Each branch of the US federal government has its own challenges in dealing with the expanding role of S&T in the decisions it makes.[1] This monograph focuses on the special challenges for the legislative branch. That is, how can the Congress acquire the most useful information and advice possible about the S&T dimensions of the issues it confronts and about which it must decide?

To compound the challenges, in the last several decades an information revolution has expanded dramatically the quantity of information available to the Congress. More information, however, is not necessarily better information and a key challenge today is how to gauge validity and usefulness of the daily flood of information, advice, and advocacy delivered to Congress. Because of its complexity, information about S&T is especially problematic. This monograph chronicles the evolution of organizations established to provide advice to Congress on issues related to S&T, assesses their relative effectiveness in providing advice in today's circumstances, and suggests a range of improvements that would increase effectiveness. All these organizations developed substantially in the wake of World War II and throughout the Cold War era, although the origins of several of them were much earlier. We begin with the roots of America's S&T infrastructure that led to creation of these organizations.

1.1 America's Strength: Relentless Adaptation and Innovation

In 1997, I argued: "The nature of government involvement in the nation's S&T enterprise is changing dramatically, and the effectiveness of that role will depend increasingly on a well-informed electorate" (Blair, 1997, p. 1). As most illustrative of the implications, I referred to a New York Times article in that year by German journalist Josef Joffe who, in the

[1] Neal *et al.* (2008) provide a useful overview of the evolution of US science policy and decision-making, particularly since the Cold War era.

fashion of Alexis de Tocqueville,[2] offered insightful observations about the uniqueness of the American technology innovation engine which continues today to drive the nation's massive S&T enterprise and to fuel economic growth.

Joffe's opening line was: "Something funny happened on the way down from the Cold War." He challenged a number of outspoken authors of the time, the so-called declinists, who argued that the post-Cold War United States was akin to Hapsburg Spain of the 16th and 17th centuries—arrogant, overreaching, and oblivious to the fact that military ambitions were outpacing the economic resources needed to support those ambitions.[3]

While the declinist view was then somewhat of a strawman, especially in retrospect, it was convenient for Joffe to construct a narrative recapping the bipolar US–Soviet struggle that dominated the technology development landscape of the period and the associated US approach to Cold War tensions. On the one hand, the US approach led to widespread perceptions around the world at the time, deserved or not, approaching big-brother imperialism. A high priority placed politically on defense technology superiority throughout the Cold War era contributed to those perceptions. To debunk the declinist view, Joffe recounted that Philip II of Spain and Louis XIV of France devoted three fourths of their nations' spending to the military, while Washington at the time of the debate (the late 1990s) devoted but 15 percent of federal spending (half of discretionary spending or 3 percent of the gross domestic product [GDP]) to defense. Such a level of spending is still arguably excessive as illustrated below, but nothing approaching that of the Hapsburgs.

Today, US defense spending is $649 billion annually (2019), which is more than that of the next seven countries combined—in descending order: China, Saudi Arabia, India, France, Russia, the U.K., and

[2] Joffe (1997) chronicled observations on America like those a century and a half earlier by Alexis Charles Henri Clérel, comte de Tocqueville, a well-known French aristocratic diplomat and historian, whose accounts as he traveled across the United States formed the basis of his two-volume work, *Democracy in America* (1835 and 1840), in which he observed the mid-19th century social and political forces transforming American life (de Tocqueville, 1840).

[3] Among the notable authors supporting the declinist view were Kennedy (1987), Mead (1987), and Calleo (1989).

Germany—but still only 3 percent of GDP, down from 9 percent during the Cold War.[4] With the end of the Cold War, the relative importance of defense technology-led innovation and deployment in fueling US economic growth faded and began to give way to a renaissance of US industrial innovation more broadly and a rapid assembly of global supply chains supporting a 21st century industrial infrastructure that is multilateral, vibrant, and fiercely competitive. Indeed, today the US economy vests its relative global strength much more in its overall massive scale ($20 trillion), its broad scope and diversity, and other features with far less dependence on the stimulus effect of defense spending. The declinist views noted earlier are much more salient today; key features of this transformation that impact and are impacted by the role of government are discussed in more detail later in this monograph.

The post-Cold War US economic transformation brought with it many challenges as well. Among them, the globalization of product supply chains, especially, continues to complicate the role of government(s) in many dimensions—international trade, domestic economic structural change, environmental impacts, employment, and others. Nonetheless, and despite the complications, Joffe and others consider the fruits of innovation to be among the most important sources of US global influence and competitiveness.[5] Joffe's key insight about the robust features of the US economy is not so much a consequence of the relative features of scale and diversity of the US economy compared to other nations, although those considerations alone are compelling today. Rather, returning to the declinist strawman comparison, Hapsburg Spain remained strong if it remained wealthy and its primary source of wealth was from the gold and silver plundered from Latin America. When that source

[4] A detailed accounting is provided in Stockholm International Peace Research Institute (2019).

[5] This recollection reprises Joffe's view expressed in Joffe (1997) and summarized in Blair (1997) but today Joffe is not alone in his optimism about the prospects of long-lasting US world influence. Nye (2015) and others suggest a broader array of sources of strength, such as cultural power, openness to immigration, broad-based economic resilience, a strong system of higher education, as well as innovation provide a basis for optimism while Joffe emphasizes especially the role of innovation.

dried up, the Hapsburg empire dimmed. Joffe argues that the principal source of America's wealth in the post-Cold War world was very different in that it was derived not from plundered resources but from industrial production fueled by, above all, "relentless adaptation and innovation."

Joffe describe the US approach this way:

> If steel falters, let's do microchips; if the Japanese grab the camera market, Hollywood will flood the world with movies. Unlike the Hapsburgs, America's riches aren't dug from the ground, they roll out of labs, research outfits and universities. And that is an inexhaustible resource.
>
> (Joffe, 1997)

With the relative abundance of many domestic natural resources in the US, one could certainly quibble with Joffe's seeming dismissal of the US capacity for excavating riches. There are other contributing national advantages as well, such as a high average income, a large diverse population, a tradition of substantial capital investment, historically moderate unemployment, high consumer spending, and a relatively young population (IMF, 2019). Nonetheless, Joffe's central conclusion is that the most distinguishing feature of the US economy is its capacity for continuous innovation, i.e., to remain strong in the face of emerging competition from China and other global economic competitors, the US must retain the powerful advantage provided by its innovation engine.[6]

The American appreciation for innovation "and the supporting scaffolding of science and technology" (Joffe's phrase) as well as government's role in maintaining that scaffolding remain deeply embedded in the nation's history since the Cold War era. A longstanding but increasingly key question on the table today is the necessary or desirable degree of government's role in sustaining the US innovation engine.

A variety of forces shaped the role of government in today's massive US research, development, engineering, and technology commercialization

[6] Joffe revisited and refined the theme of the evolution of the American innovation engine in Joffe (2013). See also Rosenberg and Birdsell (1986).

infrastructure that evolved over the last century, and especially since the end of the Cold War. They include:

- The increased pace of knowledge creation and diffusion as already detailed.
- Globalization and integration of economies around the world.
- The changing structure of the US economy, especially the relative growth of the services, information, and high-tech sectors.
- The emergence of public as well as private research and development (R&D) investment strategies emerging largely since the end of the Cold War.

More prominent than ever today are the implications of the *pace* of technology developments over the last two decades that broadly shape essentially all aspects of human existence, which present both enormous benefits and complex challenges. Artificial intelligence, blockchain technology, the internet of things, quantum computing, autonomous vehicles, big data mining, hypersonic weapons, hydraulic fracturing, gene editing technology, and coping with a world-wide pandemic are but a few recent examples.

The pace of advancement and growth in scale of such developments and their implementation may vary, but many have the potential for transformative societal change.[7] Given such looming forces of change, how do we respond to Mr. Jefferson's admonition to include in the design of governmental institutions, especially the Congress, features to accommodate changes in technology or at least be aware of them in a decision environment increasingly complicated by S&T?

[7] A few authors are more pessimistic. For example, American technology entrepreneur and investor Peter Thiel has long held that Silicon Valley's leadership in high technology innovation and "breakthrough innovation" generally is slowing (as described in Simonite, 2014), albeit with at best anecdotal evidence.

1.2 The Roles of Government in the Nation's S&T Enterprise

Federal, state, and local governments are all involved increasingly in the nation's S&T enterprise in different ways.[8] At the highest level of abstraction, key among these government roles are:

- Carrying out research directly and sponsoring it in industry, academia, and elsewhere.
- Regulating the fruits of research through patents, copyrights, and antitrust law.
- Regulating key aspects of S&T-intensive industries such as health care, national security, energy, telecommunications, and transportation.
- Consuming the products of R&D and of technology in carrying out government missions.
- Sponsoring of research and otherwise influencing the education of scientists and engineers and the public about S&T.

Discussed later in this monograph are distinctions among the needs for S&T advice for the different branches of the federal government and their historical roots. For the moment and to generalize only slightly, until the 1970s in the US, the legislative branch essentially delegated most government authority over S&T issues to the executive branch. However, in the 1970s, with increased recognition of S&T's influence on major societal issues such as the environment, national security, and international economic competitiveness, Congress began to include S&T dimensions more explicitly and prominently across its agenda. A 2019 Harvard University study concluded that:

> Congress is driven to address S&T issues by several broad forces, including the pace of technological advancement, which creates new opportunities and concerns; catastrophic events, which cause Congress to react; national security,

[8] A useful summary is provided in Dupree (1986).

> which drives demand for S&T research and development; and national economic competition, which, among other things, compels Congress to allocate funding to federal research and development. Other broad forces include pressure from the news media, lobbyists, and advocacy organizations, and American attitudes towards technology.
>
> Additionally, there are several localized forces that act on individual members of Congress. Members seek S&T information when constituents pressure them for information or to recommend they act on an issue, when committee work or floor legislation centers on an S&T topic, or when they are simply personally interested in an S&T topic.
>
> (Miesen *et al.*, 2019)

The Harvard study (discussed along with other recent studies in more detail in Section 6) captures much of, but by no means all of the context of an increasing role of S&T in the issues facing Congress. The rate of expansion of scale, scope, and complexity of such issues and their impact on the economy may be even more important. That is, S&T dimensions are becoming more significant throughout the agenda of Congress, including not only directly, such as in the prominent forces identified in the Harvard study, but also indirectly in that there are many issues where S&T may not be the dominant concerns but are often sufficiently significant that, if misunderstood, could lead to weak legislative and oversight decisions.

One current example of such issues is that Congress is considering the conditions under which the new fifth generation digital cellular network, known as 5G, will be deployed in the US. 5G will ultimately transform wireless data communications, enabling many new capabilities such as a greatly expanded industrial "internet of things," enterprise networking, and critical communication.[9] There are many complex impacts, however, accompanying deployment of 5G as well. As but one example of such issues, the portions of the electromagnetic spectrum planned for

[9] For example, 5G network technology supports up to a million devices per square kilometer, while the current 4G network can support only up to 100,000 devices per square kilometer.

use by various 5G proposals will be very near that of passive remote sensing technology used by weather and Earth observation satellites, particularly for measuring atmospheric water vapor concentrations. The likely interference caused by 5G deployment could be significant and impactful without effective controls. It is a complicated and very technical debate which Congress is poorly prepared to address independently, and its decisions could be very consequential. As currently proposed, 5G out-of-band emissions could produce a 30 percent reduction in weather forecast accuracy. Such a degradation in weather forecasting model performance would have failed to predict the track and thus the impact of Superstorm Sandy in 2012. (Jacobs, 2019.)

The weak and poorly organized federal response to the 2019 Coronavirus 19 (Covid-19) pandemic is another example. The pandemic precipitated global social and economic disruption, including the deepest global recession since the Great Depression. Without widely accepted authoritative information about the virus and an impartial analysis of it, widespread misinformation, conspiracy theories about the scale of the pandemic and its origin, and promotion of unproven methods of prevention, diagnosis, and treatment all became commonplace. The confusion continued late into 2020, complicating efforts to control the pandemic and mitigate its impacts. Among the most disturbing results is that the US, with but 4 percent of the world's population, represented 21 percent of the deaths worldwide associated with the pandemic throughout much of 2020.[10]

Finally, to compound these concerns, some features of the US political and economic systems, as worthy as they might be for other reasons, can also become weaknesses from the standpoint of productively addressing challenges presented by the increasing role of S&T in society, perhaps especially by Congress. Among the more important of such features are:

- *Short time horizon.* Both our political and economic systems focus on the short term—the next congressional election or the

[10]European Centre for Disease Prevention and Control (2020). Since January of 2020 and as of October 6, 2020, US deaths from Covid-19 were 7,458,550 compared with deaths worldwide of 35,523,518.

next quarter's earnings report. Often subordinated or neglected entirely are the long-term policy considerations, including those often associated with S&T.

- *Political-system inertia.* The US political system, operating under a very conservative constitution with many checks and balances, favors the status quo. Such a system requires consensus building that can be difficult in a large country with many competing values and interests.

- *Disagreement over the role of government.* The major political parties as well as other powerful constituencies disagree about the degree to which government should be activist in technology policy. The oscillation between activist policies in the 1970s, to a laissez-faire approach in the 1980s, to more moderate policies in the early 1990s, to a Republican revolution of the mid-1990s, to the current chaos, and so on, continues almost like a business cycle.

- *Poorly informed public.* As noted earlier, issues in S&T are often complex, and the public overall often has a weak knowledge base upon which to form views about policy choices.

- *Fractured political parties.* On many technology-related issues, rather than speaking with a single voice, regional or special interest concerns splinter the major political parties.

- *Government organization.* Congress distributes jurisdiction over S&T issues among many committees and subcommittees. Similarly, the Executive Branch diffuses authority for developing and implementing S&T-related development and policy across many departments and agencies.

These features and the dynamic context of S&T across the congressional agenda raise the sense of urgency for expanding Congress's capacity to deal with the S&T dimensions of the issues it faces. Developing or restoring that capacity is long overdue. The next section examines the historical roots of S&T advice to Congress.

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