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SCIENCE ADVICE TO THE PRESIDENT AND THE ROLE OF THE PRESIDENT'S COUNCIL OF ADVISORS ON SCIENCE AND TECHNOLOGY

Membership, Activities, and Impact in the Last Four Administrations

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August 2018

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Introduction

Dating back to World War II, presidents have employed scientists, engineers, and other professionals with technical backgrounds to provide counsel on policy issues with significant science and technology (S&T) components. Since 1976, White House S&T policymaking and advisory mechanisms have been managed by the Office of Science and Technology Policy (OSTP) (Lane, Evans, and Matthews 2016). OSTP is charged by statute to provide S&T data and analysis to the president “on areas of national concern” (P.L. 94-282). OSTP also coordinates federal S&T policy development and implementation, reports to Congress on S&T issues, and oversees the President’s Council of Advisors on Science and Technology (PCAST), an independent advisory committee (Shea and Sargent Jr. 2017).

Created in 1990, PCAST is composed of scientists, engineers, and industry leaders with diverse areas of expertise and backgrounds who are appointed by the president (E.O. 12700). The council is co-led by the assistant to the president for science and technology (also known as the president’s “science advisor,” who in most recent administrations has also served as director of OSTP)—the council’s only federal member—and up to two members from the private sector. According to its most recent charter, PCAST advises the president on “policy that affects science, technology, and innovation, as well as S&T information that is needed to inform public policy relating to the economy, energy, environment, public health, national and homeland security, and other topics” (E.O. 13539). Each president since President Bill Clinton, including President Donald Trump, has renewed the charter for PCAST or issued a new executive order to modify its operations.

PCAST responds to requests from the president, vice president, and the National Science and Technology Council (NSTC), a cabinet-level council chaired by the president that coordinates large-scale, interagency S&T programs. PCAST has only a few statutory responsibilities, allowing the president to tailor its membership and areas of study to best serve the administration’s policy agenda. PCAST’s proximity to the president, its high-profile membership, the science advisor’s role as its chair or co-chair (most external advisory committees do not include federal members as chairs), and the historical influence of its predecessor—the President’s Science Advisory Committee (PSAC)—make it unique among federal advisory bodies.

In this report, we review the membership, activities, and impact of PCAST in the past four presidential administrations: Presidents George H.W. Bush, Bill Clinton, George W. Bush, and Barack Obama. Despite the differences between each administration’s priorities and how they utilized the council, PCAST has consistently been effective in generating policy and advising the president. If PCAST is to continue to have an impact in future administrations, the White House should: carefully consider the number of members appointed, give special attention to the diversity of the council’s makeup (in terms of race, ethnicity, gender, experience, and areas of expertise), and adequately fund the council’s activities. Furthermore, considerations should be made to focus the number of topics PCAST addresses and increase the impact and dissemination of its work.

History of White House S&T Advisory Councils

Presidents have long considered S&T advice an important part of decision-making at the highest levels of government (Dupree 1986). The PCAST advisory mechanism dates back to President Harry S. Truman's creation of the Scientific Advisory Committee (SAC) in the Office of Defense Mobilization (ODM) (Blanpied 2010). ODM-SAC provided "independent advice on scientific matters" and established a channel between the S&T research community and the White House (Truman 1951). In response to Sputnik I and II, President Dwight D. Eisenhower elevated ODM-SAC to the President's Science Advisory Committee (PSAC) and appointed James Killian, then-president of the Massachusetts Institute of Technology (MIT), as the first full-time science advisor and PSAC co-chair (Eisenhower 1957). PSAC operated without a formal charter—such as a presidential directive, executive order, or legislative statute—from 1957 until its disbandment by President Richard Nixon in 1973.

PSAC's early activities focused on space and national security. It was primarily composed of scientists and engineers that had worked on either the Manhattan Project or in MIT's radar lab (Golden 1980). During the 1960s, PSAC expanded its responsibilities to include both "policy for science" studies—e.g., federal support for basic research—as well as additional "science for policy" reports—e.g., environmental studies (Wang 2008; Brooks and Cooper 1987). PSAC often served as a source of "technological skepticism" for the presidency, raising objections to federal S&T programs they believed were not technically viable or not in the national interest, as well as the larger implications of policies under consideration (Wang 2008). It was this skepticism, in part, that led to President Nixon disbanding PSAC, although tension had been building between the president and his scientists for some time (Blanpied 2010; Wang 2008; Stine 1986). At the end of his first term, President Nixon abolished the Office of Science and Technology (OST)—a predecessor to OSTP—and with it, PSAC. President Nixon's science advisor, Edward David Jr., stepped down in January 1973, and shortly thereafter, Nixon accepted the pro forma resignation of all PSAC members (Blanpied 2010; Wang 2008; Lyons 1973; Herken and Leone 2000). He transferred OST's civilian S&T responsibilities—advising the president and coordinating and evaluating federal S&T research programs—to the National Science Foundation (NSF), and its defense activities—assessing weapons needs and reviewing new weapons development programs—to the National Security Council (NSC) and the Department of Defense (DOD). He named Guyford Stever, then-director of NSF, as science advisor. Stever served as both NSF director and science advisor until Nixon's resignation in 1976, and later became the first director of OSTP under President Ford (Stever 2002; Nixon 1973).

After President Nixon's resignation, President Gerald Ford and Congress worked to establish a statutory national S&T policy, which resulted in the founding legislation for OSTP and its current mission statement, titled the "National Science and Technology Policy, Organization, and Priorities Act of 1976" (P.L. 94-282). This act authorized the creation of the President's Council on Science and Technology (PCST), an analog to PSAC that would serve at the pleasure of the president and conduct an extensive survey to analyze the "overall context of the federal science, engineering, and technology effort including missions, goals, personnel,

funding, organization, facilities, and activities” (P.L. 94-282). President Jimmy Carter chose not to renew PCST, accepting the pro forma resignation of its members at the start of his administration. His science advisor, Frank Press, operated with temporary, ad hoc committees to address specific issues, rather than with a standing advisory council (Carter 1977; Press 1981a; Press 1981b). President Ronald Reagan also chose not to reinstate the PSAC model. Instead, his first science advisor, George “Jay” Keyworth, created his own S&T advisory council, the White House Science Council, which advised Keyworth and helped resolve disputes between agencies (Keyworth 1988).

In both the Carter and Reagan presidencies, OSTP’s staff was significantly reduced and key provisions of the 1976 legislation were not implemented, heightening tensions between Congress and the White House on federal S&T policy (Bromley 1994). PCST’s survey of federal science, engineering, and technology was not completed, nor were the annual S&T reports to Congress or the “five-year outlook” called for in Title II of the 1976 act. By 1987, the U.S. Government Accountability Office reported that “OSTP does not, in practice, have the authority or responsibility in the budget process that was intended in Public Law 94-282” (Blanpied 2010).

“Modern” PCAST

The modern era of PCAST began under President G.H.W. Bush and his science advisor D. Allan Bromley. Due in part to the ending of the Cold War, PCAST’s membership and focus broadened. With increased administrative structure inside the White House and the passage of the Federal Advisory Committee Act (FACA, discussed below), the operating environment for PCAST changed significantly from that of PSAC (Piore 1980; Halloran, Jr. 2015). Areas of interest shifted from predominately defense and space toward more domestic challenges such as competitiveness; environmental and energy policy; federal research and development (R&D) priority setting; and science, mathematics, engineering, and technology (STEM) education and workforce (Herken and Leone 2000; Bromley 1994; Wells Jr. and Moge 1990).

Since its creation in 1990, PCAST’s role, mission, and activities have largely been the same in each of the past four administrations. First, PCAST advises the president both directly and through the science advisor. The council’s membership, which does not have term limits, has always included distinguished professionals with diverse S&T perspectives and areas of expertise. PCAST has been organized into long-term panels or ad hoc working groups chaired by PCAST members that focus on specific policy issues and include other nongovernmental experts and stakeholders. PCAST’s primary products are reports and letters that are requested by the president or vice president, required in accordance with its role as two other statutory advisory committees (discussed below), or determined by the council to be of possible interest to the president and his policy agenda. Reports are typically written by subgroups and approved by PCAST as a whole. The council also has issued shorter letters addressing or reviewing S&T policies.

In each administration, PCAST met in plenary sessions in accordance FACA (P.L. 92-463; Ginsberg and Burgat 2016). Passed in 1972, FACA modified the operating conditions for PCAST from that of PSAC, requiring increased transparency of their activities (Press 1993). FACA requires all registered advisory committee meetings to be open to the public unless otherwise justified by the president, or an affiliated agency head, for national security reasons or for other issues requiring privacy, such as trade secrets or personal matters. However, many PCAST members have also reported meeting informally with the president and other senior government officials; these interactions fall outside of FACA's jurisdiction.

FACA reporting and administrative support for PCAST has shifted over the last four administrations. Under President G.H.W. Bush, administrative support and FACA reporting were provided by the White House Office of Administration. Under Presidents Clinton and G.W. Bush, as well as early in the Obama administration, OSTP performed both duties for PCAST. President Obama's 2011 executive order made the Department of Energy (DOE) responsible for the council's FACA reporting and administrative support, although OSTP maintained that it continued to perform these duties (Shea and Sargent Jr. 2017; E.O. 13596).

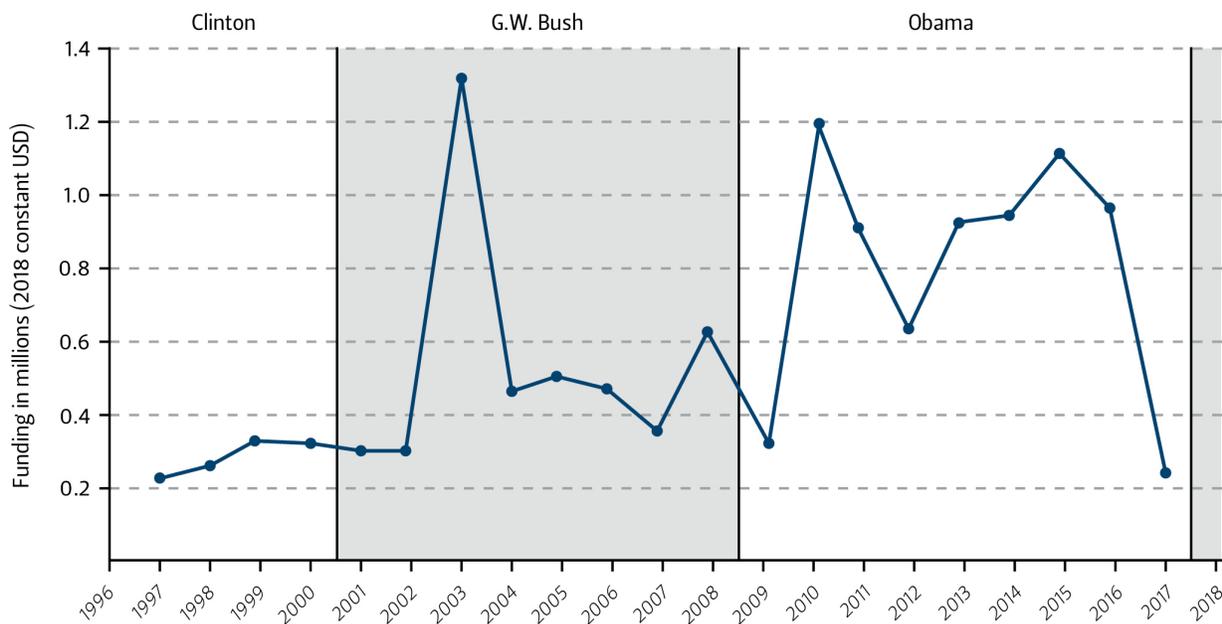
Since the G.W. Bush administration, PCAST's duties have also included the functions of two different statutory advisory panels. In 2004, PCAST was designated as the National Nanotechnology Advisory Panel (NNAP) in compliance with the 21st Century Nanotechnology Research and Development Act (P.L. 108-153; E.O. 13349). In this role, it reviews the National Nanotechnology Initiative (NNI) and makes recommendations to the president and NSTC. In 2005, PCAST was directed to assume the responsibilities of the President's Innovation and Technology Advisory Committee (PITAC), an independent advisory board for networking and information technology required by the High Performance Computing Act of 1991 (P.L. 102-194; E.O. 13385).

Until FY2014, PCAST had no direct appropriation; its staffing, report costs, and travel expenses were provided by OSTP, which has had an annual budget of between \$4 million and \$6 million since the Clinton administration (Shea and Sargent Jr. 2017). In 2011, in response to Congress sharply reducing the OSTP budget, President Obama amended the PCAST charter to switch its funding source to the DOE (E.O. 13596). Between FY2014 and FY2017, PCAST appeared as a specific line item in the DOE Office of Science's annual budget request to Congress (U.S. DOE 2017). However, OSTP maintained that it was responsible for managing PCAST (Shea and Sargent Jr. 2017). PCAST's budget has fluctuated significantly over time. Since 1997, it has ranged from between roughly \$200,000 and \$1.3 million, with an average of roughly \$600,000 over the years available (Figure 1) (Shea and Sargent Jr. 2017; Carnegie Commission 1997; U.S. General Services Administration 2018). In comparison, PSAC's annual budgets were approximately \$2 million (Beckler 1974). While President Trump has renewed the existing PCAST charter, the DOE eliminated appropriations for PCAST from its FY2018 and FY2019 budget requests, so it remains unclear how its operating costs will be covered if Trump decides

to appoint members to the council (U.S. DOE 2017; E.O. 13811). Further, 18 months into his administration, President Trump has not yet named a science advisor who would serve as PCAST’s co-chair, making the appointment of a PCAST appear unlikely.

Figure 1: Estimated PCAST Funding by Year

Funding for PCAST was inconsistent between administrations as well as within each administration. It ranged from \$200,000 to \$1.3 million, averaging roughly \$600,000 over the 20 years reviewed.



Note: Totals include salaries for federal employees; payments to consultants; reimbursement for travel for federal and non-federal members; staff and consultants; as well as general funds for printing, meetings, and other administrative costs.

Source: Data collected from U.S. General Services Administration’s FACA Database (facadatabase.gov).

The impact of PCAST’s informal advice to the president and other senior officials is challenging to track from the public record. However, PCAST reports and letters, which are its official mechanisms for advising the president, can be traced to budget items, new initiatives, and legislation, or as tools for informing policymakers on S&T. In addition, several qualitative and quantitative metrics have been proposed to assess the performance of OSTP and PCAST (Hart 2014; Krick 2015). PCAST can be evaluated through its success in eliminating proposals for scientific programs that are technically unfeasible or not in the public interest; its role in responding to national crises; and the uptake and longevity of its ideas of new for presidential science-, technology-, and innovation-related initiatives (Hart 2014).

Bromley believed increasing the S&T community's access to the president was PCAST's most important role:

PCAST, I think, is very important for one simple reason—and I illustrate it with what happened one afternoon in the middle of a meeting when President [G.H.W.] Bush very enthusiastically presented to PCAST his new idea on a particular topic. David Packard, who was sitting across the table, looked at him with some bewilderment and said, “Mr. President, that is the stupidest damn idea I ever heard.” And the President said, “Really?” It is vitally important that someone with David Packard's stature have direct access to the president. And it was important that Packard was prepared to spend time to get up to speed on key issues. (Abshire, Kirlin, and Solomon 2000)

Harold Shapiro, the second vice chairman of PCAST under President G.H.W. Bush, felt PCAST's role was to identify and encourage new S&T opportunities:

If our ideas are not distinguishable from others—if there are no PCAST fingerprints on a particular policy initiative—then it may mean that we've decided to help out somebody's good idea. But I would hope in other areas, we will have been able to come up with an idea that's better than what anybody can offer. (Mervis 1990)

PCAST's Impact in the Past Four Administrations

President George H.W. Bush

President G.H.W. Bush announced Bromley, a nuclear physicist from Yale University, as his science advisor on April 20, 1989. Bromley was confirmed as OSTP director on August 3, 1989 (Bush 1989; Congress.gov 2017). Bromley made clear his intention to encourage the president reestablish PCAST, and Bush issued its founding charter on January 19, 1990 (E.O. 12700; Beardsley 1989; Culliton 1989). PCAST consisted of “not more than 14 members” from the private sector with Bromley serving as chairman of PCAST in his capacity as director of OSTP (not by virtue of his second appointment as assistant to the president for science and technology, as it stands in the current executive order).

Twelve initial PCAST members, including vice chairman Bernadine Healy, a cardiologist and then-chair of the Cleveland Clinic Lerner Research Institute, were sworn in on February 2, 1990 (Bush 1990).¹ The council was noted for its diversity of S&T expertise in comparison to PSAC, which was largely made up of nuclear physicists (Mervis 1990). Its first meeting was held on February 3, 1990; President G.H.W. Bush hosted PCAST at Camp David alongside a group of his most senior aides (Bromley 1994; Library of Congress 2017; Goodwin 1990).

¹ Healy stepped down in 1991 to lead the National Institutes of Health (NIH) and was replaced as vice chairman by Harold Shapiro.

The February meeting was followed by strategic planning meetings to interface with OSTP's activities and decide topics for working groups. Early in the administration, PCAST met in plenary session on a nearly monthly basis, but trailed in regularity toward the end of the term, meeting 30 times in total in three years. When the president was in town, he reportedly attended PCAST meetings with some regularity and was receptive to the council's advice (Abshire, Kirlin, and Solomon 2000; Mervis 1990; Kelly et al. 2004; Reppert 1993).

Late in President G.H.W. Bush's term, PCAST was criticized by the press for holding many of its meetings in closed session (Reppert 1992). A lawsuit filed by the Bureau of National Affairs Inc. resulted in the public release of much of PCAST's materials, which were previously only distributed internally (Science 1993). This likely influenced the Clinton administration's operating principles toward a more transparent meeting schedule (Reppert 1993).

Bromley was strategic in his use of PCAST to mirror his—and presumably President G.H.W. Bush's—broad, crosscutting S&T priorities, which were implemented by the Federal Coordination Council for Science, Engineering, and Technology (FCCSET), a predecessor to NSTC.² These initiatives included high-performance computing and communication, STEM education, global change research, biotechnology, materials science and technology, and advanced manufacturing.

Three reports from the G.H.W. Bush administration proved to have lasting impact. The first, "Megaprojects in the Sciences," resulted in the establishment of the OECD Megascience Forum, later renamed the Global Science Forum (GSF) (PCAST 1992a). The GSF remains active more than 25 years later and has helped launch a number of multinational "big science" programs (Bond et al. 2008). The "High Performance Computing and Communications (HPCC) Panel Report" reviewed and made recommendations for HPCC, a presidential initiative coordinated by FCCSET, which led to the High Performance Computing Act of 1991. The 1991 legislation authorized a five-year program across 10 agencies in high-performance computing and related communication technologies and spurred the creation of the President's Innovation and Technology Advisory Committee (PITAC) (P.L. 102-194; PCAST 1992b). Finally, the Committee on Research-Intensive Universities report "Renewing the Promise: Research Intensive Universities and the Nation" was widely cited, including by several National Academies of

² FCCSET was a White House council, established as part of the 1976 legislation authorizing OSTP that served to coordinate federal science, engineering, and technology research budgets and activities. The council, chaired by the director of OSTP, consisted of members of 12 of the then 14 cabinet departments, as well as S&T-focused independent agencies, including the secretary or deputy secretary from the Department of Defense, the National Aeronautics and Space Administration, Department of Health, Education, and Welfare (now called Health and Human Services), and the National Science Foundation. In the Clinton administration, FCCSET was re-established under a new name—the National Science and Technology Council (NSTC). NSTC included the same agencies and cabinet departments, but was instead chaired by the president and explicitly included each cabinet's secretary and each agency's most senior position, rather than allowing surrogate representatives. Additionally, NSTC was broadened to include all S&T-focused multi-agency research programs beyond Bromley's six crosscutting initiatives.

Sciences, Engineering, and Medicine (NASEM) studies (PCAST 1992c). Bromley saw this report as part of his legacy as science advisor and worked to draw attention to it within Congress and the Clinton administration (Anderson 1993). It was highlighted in a letter from President G.H.W. Bush to Congress on the future of federal S&T policy, and President Clinton's first science advisor was questioned about the report during his confirmation hearing (Bush 1993; Reppert 1993). Later, President Clinton's PCAST endorsed the report in a letter to the president on research universities (PCAST 1996).

President Bill Clinton

President Clinton named John "Jack" Gibbons, an atomic physicist and director of Congress's Office of Technology Assessment, as science advisor on December 24, 1992, before his inauguration (Horgan 1993; Mervis 1993). The Senate quickly confirmed Gibbons' nomination on January 28, 1993. However, PCAST appointments were delayed until fall of 1993, after much of the president's S&T policy agenda was laid out in two reports from OSTP: "Science in the National Interest" and "Technology for America's Economic Growth." However, PCAST did provide advice on the administration's broad S&T goals shortly after its first meeting (Clinton and Gore 1994; Clinton and Gore 1993; Goodwin 1995a; PCAST 1995).

In August 1993, Gibbons considered changing PCAST to the Science and Technology Advisory Committee (STAC) (Gibbons 1993). Nevertheless, Clinton ultimately re-chartered PCAST on November 23, 1993. It was similar to PCAST's charter under President G.H.W. Bush, but changed "Council" in its name to "Committee" (E.O. 12882). In addition, Gibbons served as co-chair in his capacity as assistant to the president for science and technology, whereas Bromley served as chairman in his capacity as director of OSTP.

Clinton's PCAST charter initially included up to 14 nonfederal members, one of whom served as co-chair, but later expanded to 19 members (E.O. 12907). The most significant change to PCAST's role stemmed from the creation of the NSTC; President Clinton mandated that PCAST review NSTC activities. Such reviews had proved to be a powerful mechanism for providing independent assessments and policy recommendations of Bromley's FCCSET initiatives prior to their launch, most notably the High Performance Computing and Communications initiative. President Clinton's PCAST followed this model to similar effect with PCAST's review and endorsement of the National Nanotechnology Initiative (NNI), discussed below.

President Clinton appointed 18 civilian members to PCAST on August 3, 1994, including naming John Young—former president and CEO of Hewlett-Packard—as the council's co-chair (Clinton 1994). The first PCAST meeting, held on October 25-26, 1994, was criticized by the S&T community and some of the participating PCAST members because the president did not attend and the agenda differed from their expectations (Goodwin 1995b; Federal Register 2017). Instead, the committee met privately with Vice President Al Gore and did not meet again until March 1995. President Clinton made clear early in his administration that he would rely on Vice President Gore to handle most S&T matters and did not meet with PCAST until its third meeting on July 11-12, 1995 (Goodwin 1995c; Broad

1992). While PCAST was active during the Clinton administration, meeting in plenary session three to five times per year, President Clinton only met with the group on three occasions, delegating Vice President Gore as PCAST's most senior point of contact in the White House (Rubinstein 2000). However, PCAST members reported that they met with President Clinton privately with some regularity (Sternberg 1996).

Gibbons stepped down as President Clinton's science advisor in April 1998 (Goodwin 1998; Lawler 1997). Neal Lane, a physicist who had served as director of the NSF since 1993, was confirmed as his replacement on July 31, 1998. PCAST's most notable accomplishment during this period was the launch of the NNI, which became a signature presidential S&T program at the end of President Clinton's administration. Lane worked alongside White House Chief of Staff John Podesta to increase the visibility of OSTP activities, including PCAST recommendations (Kelly et al. 2004).

President Clinton's PCAST focused more on short-term reviews and letters addressing specific issues rather than lengthy studies, which were prevalent in other modern PCASTs (Sternberg 1996; Mervis 1994). Of note is the "Report of the PCAST Panel on U.S.-Russian Cooperation to Protect, Control, and Account for Weapons-Usable Nuclear Materials," which resulted in a joint statement by President Clinton and Russian President Boris Yeltsin that expanded cooperation to secure and account for nuclear material, as well as a Presidential Decision Directive that outlined actions for specific agencies to aid this objective (Carnegie Commission 1997; PCAST 1994; Clinton 1995; Gibbons 1996; Wu 2001). In addition, the "PCAST energy studies" resulted in three high impact reports—"The U.S. Program of Fusion Energy R&D," "Federal Energy R&D for the Challenges of the 21st Century," and "Powerful Partnerships: The Federal Role in International Cooperation on Energy Innovation." These reports spurred several presidential initiatives, including the Climate Change Technology Initiative, the Nuclear Energy Research Initiative, and the International Clean Energy Initiative (Holdren and Baldwin 2001). The "Report to the President on the Use of Technology to Strengthen K-12 Education in the United States" led to the creation of the Interagency Education Initiative. This program, a collaboration between NSF, the Department of Education, and the National Institute of Child Health and Human Development at NIH, funded over 100 projects from 1999 to 2005, totaling \$223 million, and was revised several times to eventually become part of NSF's Fundamental Research in STEM Education program (PCAST 1997; Data Research and Development Center 2006). Finally, the "PCAST Review of the Proposed National Nanotechnology Initiative (NNI)," endorsed a draft report of the NSTC interagency working group on Nanoscience, Engineering, and Technology, titled "National Nanotechnology Initiative Leading to the Next Industrial Revolution" (PCAST 1999). The final NSTC report, which incorporated the PCAST recommendations, became a sustained presidential initiative. The NNI received initial funding in President Clinton's FY2001 budget, and continued to receive support under Presidents G.W. Bush, Obama, and Trump. Furthermore, the NNI was codified into law through the 21st Century Nanotechnology Research and Development Act, signed by President G.W. Bush in 2003 (P.L. 108-153).

President George W. Bush

President G.W. Bush appointed E. Floyd Kvamme, a venture capitalist with a background in electrical engineering, as co-chair of PCAST on March 28, 2001 (Bush 2001a; Malakoff 2001). Breaking with tradition, Kvamme's appointment occurred three months before Bush's science advisor, John H. Marburger III, was nominated on June 25, 2001 (Bush 2001b). Marburger, a physicist and director of Brookhaven National Laboratory, was confirmed on October 23, 2001, but never received a dual-hatted appointment as assistant to the president for science and technology. His impact as science advisor with only the statutory "director of OSTP" title remains a subject of debate, but Marburger maintained that his title did not diminish his influence in the White House (Kramer 2008; Goldston 2008; Marburger III 2010; Matthews, Evans, and Lane 2017).

President G.W. Bush's PCAST executive order was issued on September 30, 2001, before Marburger was confirmed (E.O. 13226). As such, it states that "a federal government official designated by the president" will serve as co-chair in addition to the nonfederal member. The charter changed PCAST back to "Council" and increased its membership to 25. With these exceptions, President G.W. Bush's executive order contained provisions that were nearly identical to Clinton's: advise the president on S&T issues and review NSTC activities.

The first wave of PCAST members, 22 nominees in addition to Marburger and Kvamme as co-chairs, was announced on December 12, 2001 (Office of the Press Secretary 2001). The makeup, in terms of fields of expertise, was markedly different from its predecessors; the group contained only one active researcher, Charles Arntzen (Science 2001). However, two members—engineers Norman Augustine and Charles Vest—had served in the Clinton administration, and three had served on PCAST under President G.H.W. Bush—Ralph Gomory, Bernadine Healy, and Walter Massey. These five members remained on PCAST throughout both terms of the G.W. Bush administration. Marburger and Kvamme later wrote that "the role of technology in the economy was a strong factor in choosing members in that technological developments were increasingly impacting the performance of the economy as well as policy decisions in virtually every sector of government" (Marburger III and Kvamme 2008).

President G.W. Bush's PCAST first met on March 5, 2002, and focused on S&T's role in the "war on terror." The next two meetings also focused on this issue, resulting in the report, "Maximizing the Contribution of Science and Technology with the New Department of Homeland Security" (PCAST 2002). This aligned with the S&T policy priorities of the early Bush administration; by December 2004, 19 out of the 23 times Marburger testified before Congress involved issues related to terrorism and domestic security (Kelly et al. 2004). PCAST continued to meet semi-regularly over the course of President G.W. Bush's administration, for 20 total meetings.

When PITAC merged with PCAST on September 29, 2005, the executive order also expanded its membership to 45 (it reached 35 members at its peak) (P.L. 102-194). The next round of PCAST appointments occurred on February 27, 2006. The expanded PCAST included only one former member of PITAC, Daniel Reed (Sternstein 2005; Bush 2006;

NITRD 2017). The merger was panned by the S&T community, which believed it would further dilute the voice of S&T experts, especially academic researchers, in the White House (Nature 2005; UCS 2004).

President G.W. Bush, like President Clinton, rarely met with his PCAST in plenary session—only five times over eight years (Marburger III and Kvamme 2008). In addition, none of the council’s reports were formally requested by the president or vice president. Instead, many of the reports focused on the council’s stated priorities—industrial competitiveness and information technology—but they did not appear to garner attention from the president, vice president, or other senior administration officials. Additionally, President G.W. Bush’s PCAST had to complete two regular, congressionally mandated assessments of federal S&T programs as part of its two statutory advisory panel roles. One was the Networking and Information Technology Research and Development (NITRD) program, in accordance with the High Performance Computing Act of 1991 (P.L. 102-194). The other was a required assessment of the NNI (P.L. 108-153).

Several of PCAST’s reports during the G.W. Bush administration had traceable impact. The “Report on Maximizing the Contribution of Science and Technology with the New Department of Homeland Security (DHS)” recommended adding a DHS undersecretary for S&T, which the department created and still employs (PCAST 2002). The PCAST Education/Workforce subcommittee report “Sustaining the Nation’s Innovation Ecosystems: Maintaining the Strength of Our Science and Engineering Capabilities” served as a key reference for the NASEM *Rising Above the Gathering Storm* study (PCAST 2004; NASEM 2007). These two reports led to the American Competitiveness Initiative (ACI), announced during President G.W. Bush’s 2006 State of the Union address, and later the America Competes Act of 2007 (P.L. 110-69; Domestic Policy Council and OSTP 2006; Marburger III 2006).

President Barack Obama

President Obama announced John Holdren—a physicist who dedicated much of his career to energy and environmental policy—as his science advisor (with the title of assistant to the president for science and technology) and intended nominee for OSTP director on December 20, 2008 (Obama 2008a). In the same press release, President Obama announced that PCAST would have two additional co-chairs alongside Holdren—Eric Lander and Harold Varmus, also well-known members of the S&T community.³ President Obama declared that he would “work to remake PCAST into a vigorous external advisory council that will shape my thinking on scientific aspects of my policy priorities” (Obama 2008b; ChangeDotGov 2008; Kintisch and Mervis 2009).

Holdren was confirmed as OSTP director on March 19, 2009, and President Obama announced PCAST’s membership on April 27, 2009. PCAST’s charter was renewed on September 29, 2009 (E.O. 13511), and it was re-chartered with additional provisions a year

³ Varmus stepped down in July 2010 to serve as director of the National Cancer Institute at NIH. His position as third co-chair, alongside Holdren and Lander, was not filled. However, Bill Press and Maxine Savitz were appointed as vice chairs.

later on April 21, 2010 (E.O. 13539; Obama 2009). President Obama's PCAST charter (keeping it as a "Council") differed from previous orders in two ways: 1) there were two co-chairs in addition to the science advisor, and 2) Obama gave explicit permission for PCAST members to be granted security clearances. The administration later stated that "most" of its members had obtained security clearances (Shea and Sargent Jr. 2017). With the appropriate security clearances, members were allowed greater access to classified documents, increasing their ability to advise the president and other senior officials in the executive branch on matters of national security and foreign policy. Their clearances also helped clear the path for PCAST to convene in private sessions with the president on a regular basis while still meeting FACA requirements for transparency.

PCAST's first plenary meeting was held on August 6-7, 2009, and included presentations from representatives of various federal agencies and a discussion of future S&T priorities (Witze and Buchen 2009). By that time, PCAST had already convened a working group at President Obama's request in July 2009 and produced its first report, on the H1N1 (swine flu) threat (PCAST 2009). Several more strategy meetings and briefings with agency representatives followed in October 2009 and January 2010. The council then met regularly six times per year until the end of the Obama administration, totaling 46 plenary session meetings over eight years. Meetings included both an open portion—which was live streamed—as well as an hour of closed discussion with the president.

President Obama's PCAST was the most active in the modern era in terms of publications, producing 36. Many of these were long, detailed reports, similar to NASEM studies. PCAST also had the necessary infrastructure and resources—including two full-time staff—to respond quickly to new policy challenges, as evidenced by the H1N1 paper. Furthermore, PCAST maintained the responsibilities of PITAC and NNAP to carry out periodic assessments of NITRD and NNI; seven of the total publications produced were assessments. Due in part to its direct engagement with the president, PCAST was successful in influencing public policy decisions. For instance, the "Report to the President on Accelerating the Pace of Change in Energy Technologies through an Integrated Federal Energy Policy" led to the DOE's Quadrennial Energy Review series, which focuses on U.S. energy infrastructure (PCAST 2010; U.S. DOE 2015; Lee and Predith 2017). PCAST's "Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth" led to a new Federal Communications Commission (FCC) rule to establish an "innovation band" that increased the capacity of the federal internet broadband spectrum based on a sharing strategy outlined in the report (PCAST 2012; FCC 2015). The report "Combating Antibiotic Resistant Bacteria" led to an executive order of the same name and later the National Action Plan for Combating Antibiotic-Resistant Bacteria, which responds directly to PCAST's recommendations (E.O. 13676; PCAST 2014; White House 2015). PCAST's "Report on Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature-Comparison Methods" prompted an immediate response from the forensic science community, including statements from the FBI and Attorney General Loretta Lynch. However, the report's long-term impact in generating reform in forensic practices and their use in the court system is yet to be determined (PCAST 2016; Shniderman 2017). Finally, the report "Aging America and Hearing Loss: Imperative of Improved Hearing

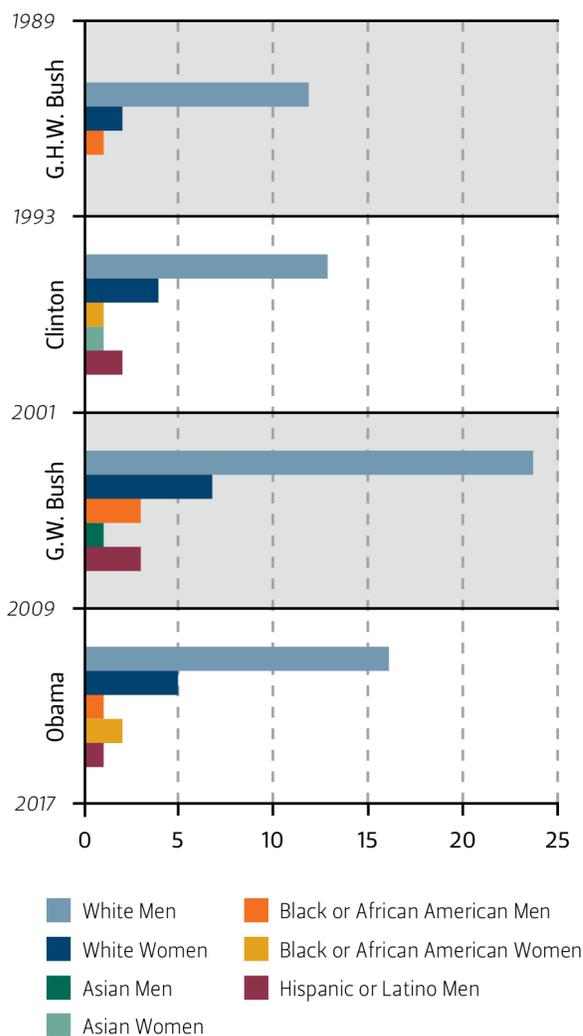
Technologies” prompted a new Food and Drug Administration (FDA) regulation to increase the accessibility of hearing aids (PCAST 2015; FDA 2016).

President Donald Trump

President Trump renewed charters for 32 committees, including PCAST, on September 29, 2017 (E.O. 13811). However, as of July 2018, he has yet to appoint a science advisor and director of OSTP, or to name any individuals to PCAST. OSTP is currently led by Michael Kratsios, the deputy U.S. chief technology officer and deputy assistant to the president, who has a background in political science and previously worked in venture capital. Ted Wackler, a holdover from the Obama administration, serves as the deputy chief of staff and assistant director of OSTP. However, his role is less visible than that of Kratsios, who represents the administration at international scientific meetings and other public forums. OSTP’s priorities so far have largely focused on STEM education and technology policy, including information technology, innovation, and artificial intelligence. It seems unlikely that President Trump will follow the model of his predecessors and appoint a PCAST. While NSTC has continued to be active in coordinating federal interagency S&T programs, it remains unclear if President Trump has a mechanism for requesting S&T advice from the academic or industrial sectors. For this reason, the Trump administration’s S&T policy and advisory structures are not included in this report.

Figure 2: Demographic Diversity of PCAST Members by Administration

The total number of PCAST members varied depending on the length of the administration and turnover within PCAST, with President George H.W. Bush’s administration only appointing 14 members (serving only one term) and President George W. Bush appointing 38 members (over two terms). Under Presidents Bill Clinton, George W. Bush and Barack Obama, PCAST included an increasingly diverse group of experts (non-white males), but overall the PCAST make-up is predominately white males.



Note: Race and ethnicity appear as defined by the U.S. Census Bureau.

Source: Authors’ own work based on collected data from public records.

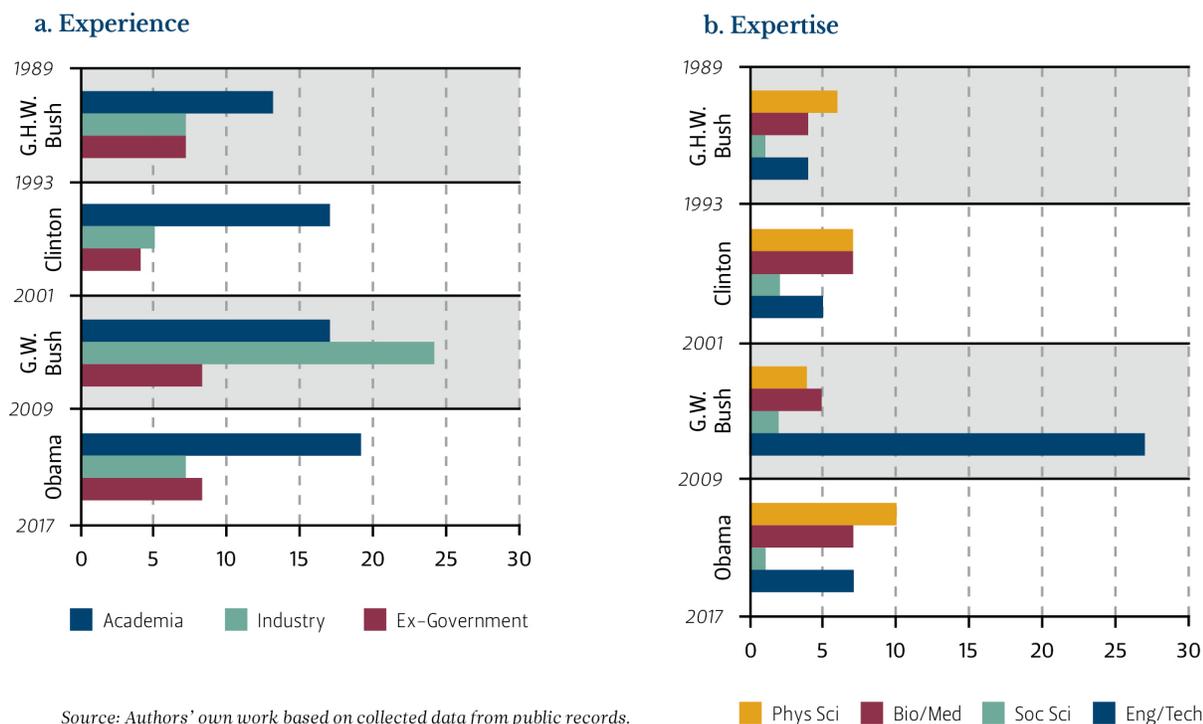
Discussion

Both PSAC and PCAST influenced a great number of policies and programmatic decisions during their tenures. PSAC’s success can be attributed to three observations: 1) S&T was a clear part of the national policy agenda, especially on matters of national security; 2) advice was given confidentially; and 3) PSAC stayed out of budget negotiations (Lane 2008). With the passage of FACA in 1972, PCAST’s role shifted toward domestic issues during the George H.W. Bush and Clinton administrations. However, after the September 11 terrorist attacks, PCAST again became involved in defense and foreign policy issues.

The total number of PCAST members has varied depending on the length of the administration and turnover within PCAST. The G.H.W. Bush administration only appointed 15 members (over only one term) and President G.W. Bush appointed 38 members (over two terms). While the variations in size did not seem to impact PCAST’s productivity, Marburger noted that the large PCAST under President G.W. Bush was hard to manage effectively and suggested a smaller council of between 20 and 25 members in the future (Marburger III and Kvamme 2008).

Figure 3: Experience and Expertise of PCAST Members

The expertise and previous experience of PCAST members varied among administrations. (a) PCAST experts came with various experiences in academia, industry, and/or government. [Some members were counted in more than one category.] (b) Member expertise has varied by field. [Phys Sci includes physics, chemistry, astronomy, and environmental sciences; Bio/Med includes biology and medicine; Soc Sci includes economics, psychology, education, and law; Eng/Tech captures engineering, computer sciences, math, and technology.]



PCAST’s membership throughout the last four administrations was markedly more diverse than its predecessor PSAC. However, its composition has nevertheless been dominated by white males (Figure 2). Each subsequent administration has increased gender and ethnic diversity, although there is still much room for improvement. For instance, while seven Hispanic men have participated since 1990, no Hispanic woman has.

PCAST members have largely been from academia (Figure 3a). Most often, they had expertise in the physical sciences, engineering, and biological sciences (Figure 3b). President G.W. Bush’s PCAST was an outlier in this regard; a larger fraction of its members came from industry with an engineering or technology background, in line with the administration’s stated mission for the council to focus on economic development. In contrast, under Presidents Clinton and Obama, PCAST included the largest cohorts from biosciences and medicine. PCAST’s expertise often reflected the priorities of the president and his administration. However, diversity of expertise on PCAST is vitally important especially given the range of issues—including crises—PCAST is likely to address. In addition, the social, behavioral, and economic sciences have not been well represented in PCAST membership.

In all four administrations, PCAST focused primarily on issues related to research and innovation (Figure 4). PCAST also conducted a range of other studies in which members served as panel chairs. Notable exceptions include an absence of publications on energy and the environment during the G.H.W. Bush administration and an absence of publications on education during the G.W.

Figure 4: PCAST Publications by Category for Each Administration

Priorities within each administration were similar regarding the use of PCAST. The largest category of publications—both lengthy detailed reports and shorter letters—related to research and innovation.



Note: Several reports were in multiple areas and were counted more than once.

Source: Authors’ own work based on collected data from public records.

Bush administration. President Obama’s PCAST also had a larger portion of their publications focus on health and medicine than the other administrations, but less focus on defense and security issues.

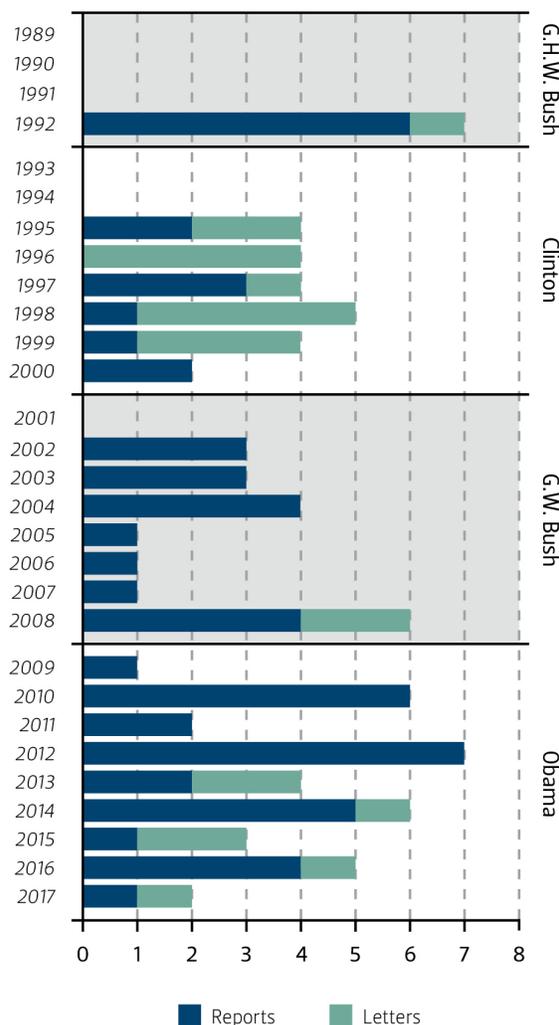
President Obama’s PCAST was also notable in its quick rise to action, releasing its first report in July 2009—no other administration in this study published a report within its first year (Figure 5). This was likely due to President Obama’s early focus on S&T as part of his campaign to “restore science to its rightful place,” and the leadership of Holdren, a seasoned government advisor with a clear vision as co-chair of PCAST. Furthermore, President Obama’s PCAST was the most productive in terms of publications—36, compared to Presidents G.H.W. Bush (7), Clinton (23), and G.W. Bush (18)—as well as in its regularity and total number of meetings (Table 1). President G.H.W. Bush’s PCAST was the outlier with the fewest reports, arguably because he only served one term, all of which were released at the end of the administration. However, his PCAST met more frequently than all other administrations, and members also stated that much of their impact on policy decisions occurred during informal meetings with the president (Reppert 1993).

While a higher level of productivity allowed President Obama’s PCAST to respond to a broader range of topics, it received criticism for lacking a clear focus that made priority-setting challenging, especially when pushing initiatives to the Office of Management and Budget and Congress. William Wells Jr., a former OSTP chief of staff, argued that “PCAST should not be all over the map. It

has to focus on a half-dozen or so issues, period, if it is going to help the president. And early in an administration, OSTP and PCAST have to agree on what those half-dozen key issues are going to be” (Abshire, Kirlin, and Solomon 2000). Members of both the Clinton

Figure 5: PCAST Publications for Each Administration, by Year

Each administration’s PCAST produced a combination of lengthy detailed reports on a science policy issue and shorter letters in support of a STEM program or initiative.



Note: Each box represents publications the administration produced.

Source: Authors’ own work based on collected data from public records.

and G.W. Bush administrations’ PCASTs cited increased follow-up and a closer working relationship with Congress and agency representatives as key steps toward increasing the overall impact of PCAST in their exit memos (Wu 2001; Marburger III and Kvamme 2008).

Each PCAST worked to align itself, to an extent, with its administration’s overarching priorities: the G.H.W. Bush administration’s FCCSET initiatives, the Clinton administration’s dedication to NSTC reviews and short-term studies, homeland security and economic competitiveness under President G.W. Bush, and President Obama’s broad spectrum of S&T topics. PCAST was also deliberate in its work to meet each president’s stated policy goals—most reports were framed in terms of administration priorities or statements made by the president. As an independent advisory body, there was always tension over how closely PCAST’s advice, at least its public statements, should track the president’s policy decisions (e.g., his annual budget request to Congress). Murray Gell-Mann, the only living member to have served on both PSAC and PCAST, believed that a president “probably does better having a committee that is frankly in some degree of sympathy with the administration, and can therefore help the administration in what it needs” (Gell-Mann 2016).

Table 1. In-person, Full Council Meetings in Each Administration

	G.H.W. Bush	Clinton	G.W. Bush	Obama
Only Open Session	6	20	20	0
Only Closed Session	11	0	0	1
Both Open and Closed Sessions	13	1	0	45
Total	30	21	20	46

Note: Totals include all meeting records in the Federal Register, excluding teleconferences.

Source: Authors’ own work based on collected data (Library of Congress 2017; Federal Register 2017).

While reviewing the membership, activities, and publications of PCAST allows us to examine the council’s public record, it does not give the full impact of its effectiveness, nor does it help ascertain the full range of possible recommendations for best practices since many meetings (or portions of meetings) were private. Additional work including interviews with former PCAST members, PCAST staffers, and White House members—especially those in OSTP who worked with PCAST and were involved in preparing its reports—would elucidate in more detail the impact of PCAST’s activities, choices of focus areas, types of work products, diversity, and other relevant aspects, as well as identify issues and additional best practices that are not captured by public documents.

Policy Recommendations⁴

Membership

- The president should quickly appoint a science advisor, ideally before or shortly after the inauguration, to serve as PCAST's co-chair, help identify potential PCAST nominees, and establish PCAST as a resource for the administration.
- Special attention should be given to the diversity of the council's makeup, in particular the ethnic and gender composition of its membership.
- The expertise of PCAST's members should reflect the administration's strategic S&T policy goals, but still include a full range of S&T areas including physical sciences, biological sciences, engineering and technology, and social sciences, as well as backgrounds in academia, industry, and government.
- Council membership should be kept to a manageable number, less than 25 members, to be effective.
- Members should be given appropriate security clearance to allow them to undertake studies requiring access to classified information, as well as to allow them to meet privately with the president on confidential matters relating to national security and foreign policy.

Activities

- The president should empower PCAST by requesting information, analysis, and studies and by meeting regularly with its members. Direct engagement with the president will help PCAST align its studies and reports with the administration's highest S&T priorities while maintaining its flexibility to alert the president to new opportunities for initiatives, potential problems, developing crises, and other timely information.
- PCAST should conduct both in-depth analysis for longer reports as well as shorter-term letters and studies on timely policy matters.
- PCAST should optimize its funding and expertise resources to ensure that public reports are well disseminated and that PCAST members can help support recommendations within the White House and to Congress as appropriate.
- PCAST should continue its practice of reviewing NSTC activities to guide new and existing federal S&T initiatives and programs, and ensure PCAST recommendations are implemented across agencies and research disciplines.
- PCAST should offer advice on strategies and budget goals for S&T programs, particularly R&D funding, but avoid advocating on behalf of the president's budget request or other active legislation to Congress.

⁴ These recommendations are based on both our data collection and analysis as well as from existing literature. Several recommendations were also recommended in other publications: Abshire, Kirlin, and Solomon 2000; Wu 2001; Marburger III and Kvamme 2008; Bond et al. 2008; Meserve and Solomon 2008; and Lane, Evans, and Matthews 2016.

Funding

- The annual OSTP budget should include a line item for PCAST operations as the most visible and sustainable funding strategy for the council.
- OSTP should allocate, and Congress should provide, sufficient funds for PCAST including at least two full-time OSTP employees to support PCAST activities, expenses for a minimum of six plenary sessions per year, and publication costs.

Appendices

Appendices containing information on PCAST publications and membership from 1990-2017 are available at: <https://bit.ly/2npBGdb>

Acknowledgements

This report was funded by grant NSF SBE SMA-1735682. The authors would like to acknowledge the contributions of Rice University students Katherine Bartos, Brittany Lai, Loah Stevens, and Rafael Treviño.

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