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The American Association for the Advancement of Science (AAAS) convened the AAAS Forum on Science and Technology Policy over two days on April 26-27, 2012 in Washington, D.C. The AAAS holds this annual forum every April or May. The forum, a gathering of the country's science and technology policy insiders, was first held in 1976 as the AAAS R&D Colloquium on Science and Technology Policy. The most recent meeting was the 37th. In addition to the Obama administration's policies (including the president's budget proposal), the forum covered topics such as higher education funding and training for skilled workers, the international standing of American science and technology, and economic growth and job creation. There were over 400 participants from universities, the federal government, non-profit organizations, private companies, overseas organizations and other institutions.

Overall, the fiscal 2013 budget proposal from the president is an austere one due, among other things, to the Budget Control Act that was passed last year. However, a slight expansion of science and technology-related budgets within the proposal showed the participants that the Obama administration places importance on science and technology. The participants also deepened their understanding on initiatives that the administration is promoting.

In addition to major shifts in financial assistance from the federal government, institutes of higher education are facing additional administrative difficulties due to cuts in assistance from state governments, and their outlook is not necessarily bright. However, university-affiliated speakers reported on future-oriented efforts under these circumstances, such as building new collaborative relationships with industry and government. There was also a widespread understanding of the importance of teaching in undergraduate education, especially at research universities.

Participants were also interested in the United States' international standing in science and technology as the BRIC countries have been experiencing rapid economic growth. Speakers shared their knowledge to promote understanding of science and technology in terms of economics, as well as labor, finance, public administration, the environment, energy and other perspectives.

Another topic of interest to the participants was the effect science and technology has on the economy and jobs. While many speakers expect science and technology to play a role in spurring economic growth, some pointed out that technological development does not necessarily benefit all people in terms of jobs. The result was that participants thought deeply as they reexamined their ideas about science and technology's relationship with society.

The forum took up diverse topics and individuals expressed various opinions. Even so, one could say that to many of the participants, this forum was an opportunity for them to inquire into what they should do to deal with the common problem of conducting scientific and technological research under tight budgets.

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U.S. Science and Technology Policy under Tight Budgets: Report on the 2012 AAAS Forum on Science and Technology Policy

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1 Introduction

The American Association for the Advancement of Science (AAAS) holds the AAAS Forum on Science and Technology Policy in Washington, D.C. every year in April or May.[1] The forum, a gathering of the country's science and technology policy insiders, was first held in 1976 as the AAAS R&D Colloquium on Science and Technology Policy. After that the meeting was renamed AAAS Colloquium on Science and Technology Policy, and again renamed current AAAS Forum on Science and Technology Policy. The 2012 meeting was the 37th one.

The 2012 forum was convened for two days on April 26th and 27th. The format began with a keynote address by the Assistant to the President for Science and Technology, followed by an analysis of the president's proposed budget and budget-related discussion. There were then breakout sessions on topics concerning the latest science and technology policies, as well as plenary sessions encompassing a wide range of topics on science and technology's relationship with the economy and society. According to material distributed at the forum, there were over 400 participants from universities, the federal government, non-profit organizations, private companies, overseas organizations and other institutions.

In the city of politics that is Washington, D.C., entities representing various industries organize numerous gatherings to promote their clients' interests and yield benefits for their industries. The initial purpose of the AAAS forum was to contribute to the formation of policy through responsible advocacy by the science and technology community. However, in recent years it has become more of a scene where

Table 1 : Forum Schedule

The schedule for the two-day forum is given below.

(Plenary Sessions)

- Budgetary And Policy Context For R&D in FY 2013
- The William D. Carey Lecture: An Audacity of Imagination
- Coping with Bleak Budgets
- International Trends: A Long-Term View of the Future and Science & Technology's Place In It
- Can the U.S. Innovate Its Way to Jobs and Economic Recovery?

(Breakout Sessions)

- How Voters Actually Think About Issues
- Start-up Tech Firms: Funding and Policy Challenges
- Why - and How - the Federal Budget Process Must Be Reformed
- When People are Research Subjects: Ethical and Policy Questions
- R&D Evaluation During Tight Budget Times
- Regulation and Communication of Risky Science: The Bird-Flu Papers as a Case Study

(Breakfast/Luncheon Speeches)

- Topics: STEM education (Apr. 26 luncheon), the NIH budget (Apr. 27 breakfast) and science and diplomacy (Apr. 27 luncheon)

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the broader science and technology community gathers to establish a shared understanding of budgets and a variety of other policy issues. In addition to the president's proposed budget, the subjects taken up by this year's forum included competitiveness; evaluations; international relations; science, technology, engineering and mathematics (STEM) education; and much more.

Public finances in the United States have come under particularly tough strain in recent years and forecasts concerning the federal budget for the 2013 fiscal year (October 2012 – September 2013) are grim. Accordingly, during forum meetings the members of the academic community were more concerned about asking themselves how they can raise the value of science and technology with limited funding from the federal government, rather than calling for budget increases. This sentiment was shared among the participants.

This paper provides a general overview of the forum by addressing issues such as the Obama administration's science and technology policies, research and education at universities and other subjects, with the current tight budget as a common underlying theme.

2 The Obama Administration's Science and Technology Policies

It is difficult to describe in one word the Obama administration's science and technology policies that began in 2009, but it helps to think of them by dividing them into two broad categories: pre-administration (i.e. Bush administration) policies that were initiated prior to Obama taking office and which are still in effect; and new policies with concepts and purposes that differ from those of the Bush administration's. The former includes a series of measures related to improving competitiveness, such as bolstering basic research.

The defining characteristics of the latter—the new policies began by the Obama administration—can be seen in the "Memorandum on Transparency and Open Government" released the day the president took office. The memo contains three key ideas demonstrating the Obama administration's objectives regarding public administration: "Government should be transparent"; "Government should be participatory"; "Government should be collaborative."[2] Of these, the idea that "government should be participatory" is an effort to improve public administration by sharing government information with the public so they can be involved in policy formation. A number of specific trials to raise policy effectiveness by encouraging citizen participation can be seen within the Obama administration's science and technology policies.

The science and technology policies which the Obama administration has been particularly focused on implementing include: policies that enhance economic effects such as job creation; life science research policies to support the government's healthcare reforms; policies related to the environment and sustainability, including the development of clean energy; and policies related to improving national security. A feature common to these policies is that they include experiments to try and vastly improve government effectiveness by recruiting the active participation of universities, private companies, and even the general public, within a comprehensive policy framework.

For example, while the departments of Commerce, Defense and Energy play a leading role in the Advanced Manufacturing Partnership promoted by the Obama administration, the program also contains parallel initiatives to be executed by universities and industry. In addition, at the same time that the federal government supports basic research and research that bridges the gap between basic research and commercialization, it is also presenting this support as part of its policies to encourage investment (such as tax credit) to promote collaboration between the public and private sectors, as well as its policies on education (including STEM fields). The administration is making clear that stakeholders other than just the federal government should also take appropriate action in response to these policies.

Another characteristic of the Obama administration's science and technology policies is that they are attempting to form initiatives that encompass diverse federal policy measures under a single concept. As an example, the Advanced Manufacturing Partnership is a single initiative that binds together different goals under the concept of "advanced manufacturing": the production capacity of the national security industry; the Materials Genome Initiative (a materials research and development initiative with a name making metaphorical use of the life science term "genome");

Table 2 : The Obama Administration's Science and Technology Policies

What follows is a summary of the Obama administration initiatives mentioned by Mr. Holdren, Assistant to the President for Science and Technology in his keynote address.

○ **Advanced Manufacturing Partnership**[3]

This project announced by President Obama in June, 2011 is intended to improve international competitiveness and create high-skilled manufacturing jobs through a partnership between industry, academia and the federal government. This initiative will invest in emerging technologies such as information technology, biotechnology and nanotechnology.

In his announcement, President Obama said the partnership will: 1) build domestic manufacturing capabilities in critical national security industries, 2) reduce the time to develop and deploy advanced materials, 3) invest in next-generation robotics and 4) develop innovative energy-efficient manufacturing processes. Some of the specific actions the president mentioned, which should involve all stakeholders—universities and private companies—include: new approaches at the Defense Advanced Research Projects Agency (DARPA); practical education programs and industry-academia partnerships at MIT and other higher education institutions; the advanced manufacturing technology consortia developed by the Department of Commerce; advanced software to American small and mid-sized manufacturers made available at no cost by Proctor & Gamble; training for next-generation manufacturing jobs through cooperation between universities and private companies; and Department of Defense investments in domestic manufacturing technology.

The partnership's conceptual background and proposals for specific measures were drafted by the President's Council of Advisors on Science and Technology (PCAST) and the President's Innovation and Technology Advisory Committee (PITAC) in the "Report to the President on Ensuring American Leadership in Advanced Manufacturing." The National Science and Technology Council (NSTC) compiled a concrete implementation plan for the federal government in February 2012 in "A National Strategic Plan for Advanced Manufacturing."

○ **Global Change**

The U.S. government is running the U.S. Global Change Research Program (USGCRP) to deal with the climate change and other global transformations.[4] Started up in 1989, this program to coordinate and integrate research, education and communication as well as to support policymaking, with the intended purpose of building a knowledge base providing information on changes to the climate and the Earth, is now run by 13 federal government departments and agencies. After budget cuts in the previous administration, the Obama administration has been increasing funding for the program. Under the president's proposed budget, the budget for the strategic plan covering FY 2012-2021 is composed of four parts: 1) scientific advances, 2) providing information for policymaking, 3) conducting sustained assessments and 4) communication and education.

○ **Big Data**[5]

The purpose of the Big Data Research and Development Initiative, established in March 2012, is to use the capabilities gained from the growth of information technology in new ways to make scientific discoveries, help the environment and improve research in the life sciences and medicine, education and national security. The initiative has three objectives: 1) Advance state-of-the-art core technologies needed to collect, store, preserve, manage, analyze, and share huge quantities of data; 2) Harness these technologies to accelerate the pace of discovery in science

and engineering, strengthen national security, and transform teaching and learning; 3) Expand the workforce needed to develop and use Big Data technologies.

Following the advice of PCAST, this initiative will establish the Senior Steering Group on Big Data in the Executive Office of the President, coordinate efforts throughout the government and execute programs in the NSF, NIH, Department of Defense, Department of Energy and the U.S. Geological Survey.

○ **Bioeconomy**[6]

This is a series of Obama administration efforts to enhance life science research as a driver of innovation and economic growth. The National Bioeconomy Blueprint announced in April 2012 lists the five following strategic imperatives.

1. Support R&D investments that will provide the foundation for the future bioeconomy.
2. Facilitate the transition of bioinventions from research lab to market, including an increased focus on translational and regulatory sciences.
3. Develop and reform regulations to reduce barriers, increase the speed and predictability of regulatory processes, and reduce costs while protecting human and environmental health.
4. Update training programs and align academic institution incentives with student training for national workforce needs.
5. Identify and support opportunities for the development of public-private partnerships and precompetitive collaborations—where competitors pool resources, knowledge, and expertise to learn from successes and failures.

○ **STEM Education (see Figure 4 below)**

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next-generation robotics; higher energy efficiency production processes; and more. In addition to federal R&D support programs such as the many existing projects run by government departments and agencies, these concrete measures include the design of institutions intended to encourage R&D partnerships between universities—as well as between academia and private companies—and the support of small businesses for technological development by large companies

While the federal government has been spending money in this manner and taking measures to promote collaboration outside the scope of government (e.g. between universities and private companies), public finances in the U.S. are in a strenuous situation. In fact, expectations to the initiatives made by the universities and federal government can be understood as another aspect of the very tight fiscal 2013 budget and the difficulties to implement new projects through federal fiscal outlays.

At this year's forum, Assistant to the President for Science and Technology and Director of the White House Office of Science and Technology Policy John P. Holdren reported on the Obama administration's science and technology policies. At the opening of his speech, Holdren, while not touching on any specific figures in the president's Budget, indicated that the Obama administration's idea is not to cut investments in research. He also stated specific initiatives which the administration would promote, including "advanced manufacturing," "global change," "big data," "bioeconomy" and "STEM education" (see Table 2).

After explaining these initiatives, Holdren wrapped up his speech by stating that science and technology are a central part of the Obama administration's overall government policy.

After Holdren's address, he and moderator AAAS CEO Alan Leshner held a discussion that delved deeper into certain initiatives. They also took questions from the audience. There was a question from the floor on the Budget Control Act (addressed in more detail later in this paper) that passed last year and which will generally restrain the president's fiscal

2013 budget proposal. Holdren acknowledged that while science and technology-related budgets have increased more than other items in the discretionary spending budget, they are still in a difficult fiscal situation. The discussion also covered topics such as the significance of the federal government's promotion of international cooperation in science and technology, what the scientific community can do to contribute to public administration, and the federal government's efforts regarding STEM education. During Holdren's interaction with the audience as they asked him these questions, he gave many statements demonstrating the importance the Obama administration places on science and technology and shared the administration's ideas on the initiatives it is promoting, despite the tight restrictions within the president's budget proposal.

3 The Formulation of Science and Technology Policy under Fiscal Austerity

3-1 Forum Participants' Interest in the Federal Budget under the Obama Administration

The federal R&D budget during the preceding administration (Bush Administration) generally focused on defense, while a new development during the latter part of his second term in office with regards to budgeting for basic research was that larger budgets were granted to improve American competitiveness. In contrast, funding for defense-related development has experienced a steady decline during the Obama administration, while being relatively more generous in funding basic research. In addition, the American Recovery and Reinvestment Act of 2009, which was put into law in February 2009 as a response to the financial crisis that began with the collapse of Lehman Brothers, distributed large amounts of research funding: $10.4 billion to the NIH, $3 billion to the NSF, and $1.6 billion to Department of Energy's Office of Science.

Thereafter, as European countries fell into sovereign debt crises and attempted to maintain fiscal restraint, the U.S. took measures such as passing the Budget Control Act. The result was a drastic cut to the amount of discretionary spending in the president's fiscal 2013 budget proposal, with many projects forced to downsize. Yet despite these circumstances the R&D budget rose year-on-year by $2 billion (a 1.4% increase) to $140.8 billion, while funding for basic and applied research rose by 2.7% to $65.3 billion, receiving a generous slice of the budget for discretionary spending.[7] Seen as a possible sign that the Obama administration places importance on science and technology, the forum participants were visibly relieved and no one expressed hope that budgets could expand further.

That being said, the reality is that R&D is experiencing various problems such as cuts of state subsidies to universities and finding the money needed to pay for maintaining the expanded research level brought about by the American Recovery and Reinvestment Act. Furthermore, it was unable to make any predictions on the fiscal 2013 budget. The forum participats' interest turned to how they can improve R&D and yield better results during this time of strained public finances, during which the country as a whole cannot hope for greater support from the federal government.

3-2 The Fiscal 2013 Budget

3-2-1 Overview of the Proposed R&D Budget

AAAS Director of the R&D Budget Analysis Program Matthew Hourihan provided an overview of the proposed fiscal 2013 federal budget during the forum's session on Budgetary and Policy Context for R&D in FY 2013. Hourihan's description of the proposed budget as given in the president's Budget Message (see Table 3) largely followed a booklet handed out to participants entitled "AAAS Report XXXVII: Research and Development FY 2013."[8] He gave particular attention to explaining spending caps and across-the-board cuts, and he mentioned the possibility of a sequestration that would force budget cuts in the future.

Additionally, Lamar Smith, a Member of the U.S. House of Representatives, spoke on a number of legislative processes related to science and technology, though without discussing any particular budget items. More specifically, he explained that inadequate legislative procedures, such as the laws of intellectual property and cyber law, are detrimental. Concerning space, Representative Smith also expressed concern that the only manned spacecraft capable of entering Earth orbit and returning are operated by Russia. He further mentioned the need to spur American children's interest in science through American space activities.

Table 3 : Highlights from the President's Fiscal 2013 Budget Proposal

The American Association for the Advancement of Science (AAAS) is providing information as needed on each fiscal year's R&D budgets based on information from documents released by the Executive Office of the President, federal departments and agencies, as well as from congressional deliberations. Below is a list of proposed budget highlights from "AAAS Report XXXVII, Research & Development FY 2013."*

- The proposed federal R&D portfolio in FY 2013 is $142.2 billion, an increase of 1.2 percent or $1.7 billion over FY 2012 levels.
- Total federal support of research (basic and applied) would increase 2.7 percent to $65.3 billion.
- Federal development spending, however, would decrease 1.7 percent to $74.1 billion.
- The three President's Plan for Science and Innovation agencies (NSF, NIST, DOE's Office of Science) would receive increases, but would fall well short of the doubling pace established in the America COMPETES Act.
- Clean energy is a clear R&D priority in the FY 2013 budget.
- The National Institutes of Health (NIH) would receive a flat R&D budget after a very modest increase last year
- DOD would receive flat funding for basic research, while virtually all other R&D accounts would decline.
- The U.S. Department of Agriculture's (USDA) R&D investment would decrease by 1.5%.

* All dollar amounts appearing in this report are figures compiled from materials provided not only by the Office of Management and Budget (OMB), but also by federal departments and agencies, which may differ somewhat from the figures released by the Executive Office of the President.

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3-2-2 The NIH Budget

American researchers of biology and medicine are extremely interested in the budget for the National Institutes of Health (NIH). NIH Deputy Director for Extramural Research Sally J. Rockey explained that while the NIH's fiscal 2013 budget would remain about the same as the previous year, she said that researchers should be grateful considering the austere times. She also explained that the NIH is considering ways to improve how grants are received in light of the effects of the American Recovery and Reinvestment Act and with researchers' perspectives in mind, as well as ways to improve the processes for distributing grants available as the NIH's actual grant budget declines. Rockey presented specific measures the NIH is considering for improving grant distribution steps such as: shrinking the sum distributed per grant; limiting the number of grants to each principal investigator; setting a limit to the sum each principal investigator can receive; and setting a limit to the salaries of principal investigators.

3-3 Fiscal Austerity and the Budget Process

Other than the aforementioned plenary session, there were two breakout sessions related to the budget: "Why – and How – the Federal Budget Process Must Be Reformed" and "R&D Evaluation During Tight Budget Times."

The U.S. budget process begins when the executive branch drafts a budget proposal in the summer of the year before the year in which the next fiscal year begins in October. As for the science and technology budget, the heads of the Office of Management and Budget (OMB) and the Office of Science and Technology Policy (OSTP) both sign a memorandum listing budget priorities, which are first sent to federal departments and agencies. These then work with the OMB and OSTP to draft budget proposals based on the guidelines in this memorandum. These are then compiled into the president's proposed budget in February of the following year and sent to Congress. Upon receiving the proposal, Congress makes budget resolutions that include revenues, expenditures, the fiscal balance and other information and sets limits.

After the House of Representatives and the Senate go through various revision processes and deliberations concerning the proposed appropriations measures, both houses consult each other to reconcile the measures and send them on to the president, who may sign them into law.

This is the usual budget formulation process, but during deliberations in Congress, it often happens that budget amounts are revised upward and language is added to the budget package due to the interests of members, the situation in their electoral districts and the like. In recent years, however, the government's fiscal problems and other circumstances have made it difficult to conduct smooth budget deliberations, and it has become normal for appropriations to remain unfinished by the start of the fiscal year on October 1. Interim budgets have caused problems such as the risk of a government shutdown, but there are concerns over even greater problems in the fiscal 2013 budget with government finances deteriorating with particular severity. The forum's session on "Why – and How – the Federal Budget Process Must Be Reformed" went beyond the context of the science and technology budget to consider the fundamental problems of the budget system.

Alice M. Rivlin, a Senior Fellow of Economic Studies at the Brookings Institution, pointed out that there are many defects in the legislative process, even with budgets for vital issues such as promoting entrepreneurship and creating innovation. She also pointed out that the cost of healthcare and social security is heavy due to an aging population, among other reasons, while politicians have been unable to find convergence on political issues through deliberations, thus creating a situation conducive to "polarization." In addition, because the process for adopting appropriations has become more complex than before, Rivlin also mentioned that improvements such as a simple and transparent process, or creating a two-year budget cycle with long-term revenue and expenditure forecasts, should be considered, even if they are difficult to implement.

Maya MacGuineas, President of the Committee for a Responsible Federal Budget and Director of the Fiscal Policy Program at the New America Foundation, stated that the "threats" faced by the federal budget require a nonpartisan response with a clear understanding of both the budget deficit and low interest rates in order to have a chance of confronting the "fiscal cliff."

Kenny Kraft, Director of Legislative Affairs – Appropriations at the Boeing Company, expressed hope that the political will to improve procedures relating to issues with both the appropriations process and the budget deficit will materialize. However, he expressed some sympathy for earmarks, a frequent subject of criticism by which members of Congress allocate budgets to certain items during the appropriations process.

This session's question and answer period involved an exchange of ideas covering a wide range of topics beyond the "federal budget process" such as measuring the effects of the budget, reforms to the political system, tax reform, as well as building trust between citizens, the executive branch and Congress.

3-4 The Budget Process and R&D Evaluations

Meanwhile, although the session on "R&D Evaluation During Tight Budget Times" was also about the budget, it covered how the academic community can respond to tight budgets through evaluations, unlike the aforementioned sessions addressing congressional issues.

Kaye Husbands Fealing, Senior Program Officer for the Committee on National Statistics at the National Research Council (NRC), cited an AAAS brief entitled "Potential Impacts of the House Budget on Federal R&D" (April 8, 2012)[9] as she discussed forecasts based on the President's proposed budget and Congress' budget resolutions and explained them within the context of evaluations and other aspects of policy formulation. More specifically, her presentation covered the subject within the contexts of: "Size" (How large should the federal research and development budget be? What is the optimal size of the scientific workforce, particularly in academia? Can research funds be spent in a way to refresh the research enterprise in a sustainable way?); "Options Portfolios" (Where should federal R&D dollars be put – into various fields, technologies, regions; intramural or extramural? What would constitute a "balance" between biological and physical sciences? How many people, possessing what kinds of skills are needed to achieve a robust STI system?); "Implementation" (What do we know about how to make applied research programs work? How and when can such programs be evaluated? What do we know about how to set up a successful demonstration program?);

"Impacts" (What are the employment impacts of federal R&D spending? What impact does federal R&D have on overall economic health, and over what time frame? What impacts are federal R&D programs having on entrepreneurial activities in science and engineering and on innovation?); and "Serendipity" (high-risk research, transformative research, etc.). Fealing also cited a number of evaluation tools and methods (network analysis, visual analytics, scientometric linkages, etc.), cautioning that they should be used accurately.

John L. King of the Resource, Environmental, and Science Policy Branch, Resource and Rural Economics Division, Economic Research Service, U.S. Department of Agriculture discussed two points under the subject of his presentation on "Research Evaluation when Times are Tight": 1) "Use the Process, Trust the Process" (i.e. research programs already have evaluation processes, and new processes should be introduced after a comparison of issues within current processes) and 2) "Make the strongest possible accurate analysis of research programs" (albeit evaluation paradigms do not apply equally to all programs and the best methods for making cuts may not be the best decisions for the research). However, King mentioned, among other things, that investing public funds in research may seem to take quite a long time to bring about benefits and that best practices may not necessarily apply in different fields.

Jerome Pischella, Science and Technology Counsellor for the Embassy of Canada in Washington, D.C. presented Canada's R&D policies. Although Canada enacted deep cuts in the fiscal 2013 budget due to a budget deficit, the innovation and science and technology budgets were spared. He also reported that R&D tax credit has been reduced, while the Canadian government has placed an emphasis on supporting entrepreneurial and business startup programs, as well as strengthening applied research at universities for joint research projects between industry and academia.

The Q&A session for the three aforementioned presentations included specific questions on the implementation of Star Metrics (a joint initiative between the federal government and universities to measure the results of investments in science and technology) and measuring the wide-ranging impact of other scientific research. While each speaker offered his or her own insights, the overall conclusion of these discussions was that policy decisions based on evaluations of scientific research need to be made very carefully and based on sufficient information on all the relevant circumstances, rather than going through simplified procedures.

4 Two Views on Higher Education: Finances and Human Resource Development

4-1 Funding Higher Education

The forum also had a session on budgets in terms of funding higher education entitled "Coping with Bleak Budgets," in which speakers with three different standpoints—a coalition of universities (the Association of American Universities), a university (the University of Oklahoma) and a state-level organization (the Texas Higher Education Coordinating Board)—reported on their responses to the tight federal budget.

According to Department of Education statistics, the United States has approximately 4,500 institutes of higher education, including two-year colleges, but there are not necessarily so many universities that place an emphasis on research. There are 61 members of the Association of American Universities, a group of institutes producing top-level research. According to the Department of Education's "Digest of Education Statistics," there are around 200 universities with research classified as either "very high" or "high." These universities receive a high share of their revenues as federal R&D money, accept capable students from around the world and conduct high-level research. These superior research universities are a symbol of the United States' competitive prowess.[10]

The federal budget has had a major effect on these research universities in recent years through the American Recovery and Reinvestment Act of 2009, which increased the federal government's spending. The act temporarily expanded the amount of research funds distributed through organizations such as the NIH and the NSF, upgraded facilities and equipment at universities and otherwise stimulated research by hiring new personnel. However, the federal budget then returned funding to previous levels, forcing universities that had enlarged the scope of their research to now face the difficult task of continuing the research while the federal government's budget is tight.

Grants given to research universities by state governments have also been subject to cuts. According

to data compiled from Department of Education statistics, the total sum obtained by the top 100 universities receiving the grant money from states has been declining since 2008.[11]

The effects of the fiscal problems are not confined to research universities, but are also having a major impact on many other institutes of higher education. Private universities have seen a significant drop in their financial resources since the collapse of Lehman Brothers. State universities have been receiving less state money due to the financial difficulties faced by state governments. As an example, a look at the budget for the University of Oklahoma, as reported during the session, shows that although the university's total operating budget has been rising, state spending dropped slightly in 2012, which when adjusted for inflation was actually a 2.2% drop year-on-year. Even in the nominal budget, the amount of money spent by the state per student dropped, which when adjusted for inflation was a 3.6% reduction.

As for state-level spending on higher education, in Texas, for example, the amount of money for the Higher Education Coordinating Board, which provides assistance to students, had its budget drastically cut for fiscal 2011-2012. In addition, the financial statements of all the state's major universities show that the total sum of state grants is falling.

At the forum, Carrie Wolinetz, Associate Vice President for Federal Relations at the Association of American Universities, compared the budgets allocated to the NIH (mainly for human resources) during the period up until 2003 in which the allocations doubled, and the funds allocated by the American Recovery and Reinvestment Act. Her presentation gave particular attention to the issue of recent research following a temporary expansion of the budgets. She first discussed what is called a "Profzi scheme," which refers to the problem of faculty members who have received grants producing results only in the framework of their fields. Wolinetz also presented data including a breakdown of research funds, the ratios of American and foreign researchers, years until faculty receive tenured positions, the average age of principal investigators and the ages of those receiving regular R01 NIH research grants. She also provided an overview of NIH funding. Then, Wolinetz cited lessons learned from the results of the period during which allocations doubled: the problems of recent years were unavoidable; dealing with finances and the workforce appropriately was difficult; "advocacy fatigue."; and doubts over whether the American Recovery and Reinvestment Act will offer a second chance. She said that while budget increases have positive effects such as raising interest in medical research, there are problems with distributing budgets that focus on inducing economic effects. These problems include the difficulty of properly managing research execution.

Kelvin K. Droegemeier, a professor and Vice President for Research at the University of Oklahoma, gave a report from his own viewpoint. He said that the measures universities can take to deal with a tightening federal budget are: help faculty obtain competitive grants; pursue opportunities to obtain new R&D funding other than just from the NSF or NIH (e.g. the Department of Defense, the Department of Homeland Security, the intelligence community, etc.); provide research opportunities to undergraduate students as well as graduate; build linkages with industry; hope for research assistance from politicians (albeit difficult for individual universities).

Raymond Paredes, the Commissioner of Higher Education from Texas, reported on the problems related to higher education in his state. He explained that although the State of Texas has a diversity of higher education institutes including comprehensive universities, medical universities and community colleges, higher education funding has been on the decline, there are more college applicants and it has been difficult to find ways of dealing with higher tuition, especially for aspiring students from low-income families. However, he said that higher education on all levels needs to innovate, and to do this they need to switch to locally-tailored strategies, collaborate with industry and government (forming workforce pipelines, etc.), and introduce lean processes to spur productivity and streamline costs. He also talked about results-based financing for universities.

4-2 A University's Mission to Develop Human Resources (Especially for STEM Fields)

The White House Office of Science and Technology Policy and other parts of the federal government, as well as science academies and others within the science and technology community, are considering various topics and formulating measures relating to STEM (science, technology, engineering and mathematics) education. This applies to students from

Table 4 : Science, Technology, Engineering and Mathematics (STEM) Education

The most important topic in American science and technology policy as of late has been science, technology, engineering, and math (STEM) education. As mentioned in S. James Gates, Jr.'s presentation (see main body of this paper), the President's Council of Advisors on Science and Technology (PCAST), under the Executive Office of the President, released a report entitled "Prepare and Inspire: K-12 Education in Science, Technology, Engineering, and Math (STEM) for America's Future"[13] in September 2010, followed by "Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics"[14] in February 2012.

The latter of these two reports was created for the purpose of enriching education at two- and four-year institutes of higher education during the first two years of undergraduate schooling. The authors of the report were aware of this period's importance for life after completing an undergraduate degree program and for training highly skilled workers. The document sets a goal of adding a million people obtaining undergraduate degrees in science, technology, engineering and mathematics over 10 years through steps such as increasing the retention rate until graduation for students studying these subjects.

The actions to achieve the recommendations given by this report are listed below.

Recommendation 1: Catalyze widespread adoption of empirically validated teaching practices

Action 1-1: Establish discipline-focused programs funded by Federal research agencies, academic institutions, disciplinary societies, and foundations to train current and future faculty in evidence-based teaching practices.

Action 1-2: Create a "STEM Institutional Transformation Awards" competitive grants program at NSF.

Action 1-3: Request that the National Academies develop metrics to evaluate STEM education.

Recommendation 2: Advocate and provide support for replacing standard laboratory courses with discovery-based research courses.

Action 2-1: Expand the use of scientific research and engineering design courses in the first two years through an NSF program.

Action 2-2: Expand opportunities for student research and design in faculty research laboratories by reducing restrictions on Federal research funds and redefining a Department of Education program.

Recommendation 3: Launch a national experiment in postsecondary mathematics education to address the mathematics-preparation gap.

Action 3-1: Support a national experiment in mathematics undergraduate education at NSF, the Department of Labor, and the Department of Education.

Recommendation 4: Encourage partnerships among stakeholders to diversify pathways to STEM careers.

Action 4-1: Sponsor at the Department of Education summer STEM learning programs for high school students.

Action 4-2: Encourage pathways from 2- to 4-year institutions through an NSF program and expanded definition of a Department of Labor Program.

Action 4-3: Establish public-private partnerships to support successful STEM programs.

Action 4-4: Improve data provided by the Department of Education and the Bureau of Labor Statistics to STEM students, parents, and the greater community on STEM disciplines and the labor market.

Recommendation 5: Create a Presidential Council on STEM Education with leadership from the academic and business communities to provide strategic leadership for transformative and sustainable change in STEM undergraduate education.

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kindergarten through university, but many forum participants were particularly interested in STEM education for undergraduate students.

As mentioned earlier in this report, it is said that the significance of top-level research is that the graduate schools placing an emphasis on research represent the excellence of American scientific research. Research universities plan for excellence by channeling most research funding to their graduate schools and recruiting exemplary students from around the world. On the other hand, it is also said that they do not necessarily apply this sort of planning to undergraduate education. Since many overseas students skilled in science and engineering fields enroll at American universities after completing undergraduate programs, there are not necessarily so many foreign students in these universities' undergraduate programs. In addition, although circumstances vary by university, research universities tend to treat undergraduate education as separate from their graduate schools' research, while undergraduate students focus on passing their classes to complete their degree programs. Thus, some point out that it is vital for these sorts of research universities to make efforts to enhance their undergraduate programs and to educate a highly skilled U.S. labor force.

Furthermore, higher education institutes other than research universities have less opportunities to win grants. This and other factors make it even more difficult to arouse more interest in research in their undergraduate schools. In addition to ideas appearing in reports by the President's Council of Advisors on Science and Technology (PCAST), the NRC, an organization comprising the country's National Academies, is also considering ways to improve undergraduate education through the introduction of research elements in their programs.[12]

Many forum participants mentioned the importance of STEM education in general. S. James Gates, Jr., a professor at the University of Maryland, College Park and PCAST member, mainly spoke about the White House's efforts.

Professor Gates referred to two PCAST reports (see Table 4) as he presented the views of PCAST and the Obama administration's STEM education-related efforts. He mentioned concrete measures such as offering undergraduate students research opportunities and showing them a variety of pathways, as well as a proposal for establishing a Presidential Council on STEM Education.

5 A Global View of U.S. Science and Technology

Many people, including those in the American science and technology community, are talking about the rise of the BRIC countries and worries over the United States falling behind them. A typical example they give is the Augustine report put out by a national academy. There were multiple sessions at the forum to discuss the United States' competitive position.

During the session entitled "International Trends: A Long-Term View of the Future and Science & Technology's Place in It," James Andrew Lewis, Director and Senior Fellow of the Technology and Public Policy Program at the Center for Strategic and International Studies (CSIS), mainly talked about America's position in terms of economic competitiveness. His comparison of the current situation in the U.S. with Europe and the BRICs covered many aspects: workforce (highly skilled workers, unemployment, immigration, demographics), budget deficits, corruption, policymaking processes, protecting intellectual property, domestic environmental problems and more. The general result of his comparison was that physical indicators show the U.S. has, at the least, adequate capabilities. In addition, Lewis said that the government's defense R&D has been, for the long-term, at the heart of existing industry, and that he expects federal policy, rather than private-sector entrepreneurship, to play more of a role in this sort of R&D.

As described above, Lewis' lecture covered a wide range of topics beyond science and technology, but a number of important questions on science and technology innovation came from the floor. In his responses he said that while American universities remain at as high a level as ever, issues remain such as pipelines of human resources. Lewis also expressed his opinions on issues concerning industrial growth in each field, such as growth in information technology, the lack of clarity over returns on biotechnology investments and the politicization of energy issues.

During the session "Budgetary and Policy Context for R&D in FY 2013," Foreign Policy magazine CEO and Editor-at-Large David Rothkopf gave a lecture entitled "The Global Economic and Political Picture." Today, the world's states, power structures and the

like, which have functioned well until now, are facing an assortment of issues including the environment, energy and labor and are in a period of transition that is pushing them to change. Furthermore, Rothkopf said that resolving these issues is made even harder because developed countries are looking inward due to their fiscal problems, while developing countries are doing the same due to domestic social problems.

Concerning educational and labor problems, he also stated that the segment of the American population that has not completed high school is a burden on society and spoke on the importance of technology education and lifelong learning. On the other hand, he also said that the level of higher education leads the world, as it always has.

In addition to issues posed by technology, markets, labor and the like that transcend borders, questions from the floor after Rothkopf's speech also queried problems arising from global austerity.

Regarding science and technology policy from a global standpoint, there was a lecture on the relationship between science and diplomacy. Science and Technology Adviser to the Secretary of State E. William Colglazier's science-related advice to the Department of State, based on his vast personal experience with international science and technology, is to consider whether to formulate policy that helps American science and technology connect somehow to prosperity in other countries while simultaneously benefiting the U.S. in some way. After stating that the research targeted by this support should focus on basic research and pre-competitive research, he did say that this sort of support might go to countries that compete with the U.S., but such countries would also be the market of U.S. products. He added that universities, academic societies and other non-governmental organizations, in addition to the government, would likely play a role in such initiatives. Furthermore, Colglazier stated that a general historical view of the government's international scientific activities reveals that they have had an influence on innovation, education, intellectual property and more. He also mentioned the academic community's importance to these activities.

6 Expectations and Issues Concerning the Social Benefits of Science and Technology

Many forum presenters spoke of expectations that science and technology will be enormously beneficial for society. At the same time, the wide-ranging themes of the forum included deeper inquiries into the relationship science and technology have with society. Such sessions were "Regulation and Communication of Risky Science: The Bird-Flu Papers as a Case Study," which covered papers on the H5N1 bird influenza virus that generated much interest in 2011 and 2012, and "When People are Research Subjects: Ethical and Policy Questions," which was about research ethics.

Meanwhile, there were other sessions that inquired about science and technology's relationship with society in terms of the economic growth brought about by science and technology and what significance and value they have to people.

Jeff Bingaman, a senator from New Mexico and Chairman of the Committee on Energy and Natural Resources, spoke in strong favor of science and technology's benefits in his talk entitled "An Audacity of Imagination." Citing the example of how the exploitation of shale gas has been made feasible despite the difficulty involved, he gave four goals for national energy policy: 1) research leadership, 2) diverse domestic energy resources, 3) promotion of efficient energy usage and 4) reducing adverse environmental impacts. Senator Bingaman said that gaining the consent of the American people is needed to accomplish these goals, after which he expects that science and technology, guided by the proper policies, will lead to social and economic benefits.

Meanwhile the session "Can the U.S. Innovate its Way to Jobs and Economic Recovery?" took up both positive and negative aspects of science and technology's effects on society and the economy, giving equal attention to both with respect to employment. Going beyond the standard question of how much investing in R&D raises employment indicators, the session inquired into whether science and technology truly enrich people as they transform the character of the labor force.

Andrew P. McAfee, Associate Director and Principal Research Scientist at the Center for Digital Business,

Sloan School of Management, Massachusetts Institute of Technology, showed data such as inbalanced productivity, jobs and skills. Then, after talking about how technologies like Google Street View and Google Translate have created new possibilities for tasks that humans once did with their own hands, eyes or minds, McAfee said that he expects these sorts of developments to continue.

In contrast to McAfee, Harvard University Professor of Economics Richard B. Freeman expressed a negative view in response to the question of whether technology can enrich people through job creation. Explaining his reasoning, he cited as examples the fact that this enrichment does not affect all people, and that when one considers individual manufacturing sectors, technology does not necessarily create jobs in all of them. Thus, Freeman stated that powerful policy means are needed to resolve these kinds of problems. He added that technological development will display this sort of thinking in disaster response and the proposal and formulation of highly transparent regulatory policies.

Speaking from the perspective of a researcher specializing in communication and culture, Georgetown University Adjunct Professor Michael R. Nelson explained the good and bad technology does for people on five levels: 1) individual, 2) team, 3) company, 4) ecosystem and 5) nation. Concerning the individual level, regardless of any expectations over a cross-field innovation, we still think of things in a field-centric way (academic journals published for each field, funding systems with certain fields as their basis, etc.). Although the team level is thought to be the one with the greatest potential because of Wikis, Skype and other creations made by people with diverse interests and specialties, the teaching at American business schools has not adapted to this situation. As for the company level, companies are in fact a great source of innovation, but there are regulations that currently impede them. Technology produced on the ecosystem level, such as websites created by a few people but used by many, is seen as a model for much innovation and companies are also aware of this merit, but intellectual property rights can impede its growth. On the national level, while there are innovative initiatives such as the America COMPETES Act, many measures are still thought up in old-fashioned ways and the regulatory structure still holds back innovation. Furthermore, Nelson said that if we set comprehensive future goals that develop information technology to scale up the manufacture of a large volume of highly diverse products, while focusing on communities, then we can create work based on sharing, volunteerism and other non-traditional values.

7 Conclusion

The preceding chapters have reported and described in a certain amount of detail the views of the author on the 2012 AAAS Forum. As has already been stated a number of times in this paper, the participants were most interested in how to sustain scientific and technological research under tight budgets. However, the forum also covered many other topics such as economic growth and jobs, university management, undergraduate education and America's international standing. While at first glance these may seem largely unrelated, the author believes that each of these displays a facet of major changes related to science and technology enterprise that are now happening throughout American society. These changes could portend a scenario characterized by a series of negative events in which tight budgets weaken scientific and technological research and hurt employment through slower economic growth, deteriorated university finances reduce the quality of undergraduate education, labor productivity falls and America's international standing drops.

However, the impression the author received from the forum's coverage of these various matters is that participants expressed a desire to create a scenario characterized by a series of positive events in spite of tight budgets: improved education and research at universities, training skilled workers, and using fundamental knowledge to develop industries. What is needed to make this scenario a reality is for all stakeholders to take part and establish the foundation for basic research, training skilled workers and the like, in order to develop manufacturing and other industries for economic growth. Universities, government and companies will all have to address issues together rather than separately. In addition, rather than just relying on recruiting foreign students to exploit their superior skills in their educational programs, universities (research universities in particular) need to devote more effort to educating American citizens, especially in undergraduate

programs, to improve Americans' skills and create jobs and economic benefits.

The impression the author received from joining the forum is that it was an opportunity for the participants to share the recognition that in order to achieve this positive scenario, state and local governments, universities, companies and the general public, not just the federal government, all need to make efforts.

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Profile

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The subject of Professor Endo's research is science policy in the United States. While at his prior position at the Japan Society for the Promotion of Science, he created the U.S. Science Policy website in 2000 to share policy trends. At the Tokyo Institute of Technology, Endo's research has expanded to include the relationship between science and society, as well as higher education.

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