New Pathways in U.S. Innovation Policy

Report to NEDO

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Abstract

TPI's May 2007 report to NEDO, *Innovation Policy Today in the United States: The Mainstream Consensus and Other Views*, summarized the mainstream consensus viewpoint on U.S. innovation policy that was then popular in Washington. This viewpoint was based on an October 2005 report, *Rising Above The Gathering Storm: Energizing and Employing America for a Brighter Economic Future.* The report called for more government funding for basic research in the physical sciences and engineering, more funding for science and engineering education, and tax credits for corporate research and development. These recommendations generally are non-controversial in the U.S., which helps account for their popularity. Both President Bush and the Democrat-controlled Congress endorsed the main recommendations in *Gathering Storm,* and their support led to the enactment of a new law based on the report, the America COMPETES Act (U.S. Public Law 110-69), signed by the President on August 9, 2007.

However, as TPI's 2007 report pointed out, there are good reasons to believe that the actions recommended by *Gathering Storm*, while valuable, are incomplete and not sufficient to ensure good American jobs and strong economic competitiveness in the new world economy. During the latter part of 2007 and into 2008, various American analysts have begun to suggest additional steps that are needed to update U.S. innovation policy for this new global era.

This paper, prepared for the Washington, DC, office of NEDO, summarizes these other ideas and how they might lead to new directions – new "pathways" – in U.S. innovation policy. In particular, this paper discusses the notion that the United States is becoming a "post-scientific society" in which conventional research and development, while still important, is not enough by itself to ensure U.S. economic success. The report then compares these ideas with the policy proposals made by the three leading presidential candidates and, finally, makes observations about the directions that U.S. innovation policy may take in 2009 and subsequent years.

Table of Contents

Preface

The Washington, D.C., office of Japan's New Energy and Industrial Technology Development Organization (NEDO) commissioned the study underlying this report. The study examines new directions in U.S. innovation policy. The authors have undertaken this study as independent consultants working together as the firm of Technology Policy International. The report and its findings are based on the authors' experience in government, the private sector, and academia. The opinions expressed in this report do not necessarily reflect the views of NEDO or the institutions with which the authors are affiliated.

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1. INTRODUCTION

1.1. Purpose of This Study

As Americans prepare to vote in November for a new President and Congress, the United States faces a number of major policy challenges. Science and technology – and government innovation policy – will play important roles in helping the U.S. cope with several of these challenges, particularly: (1) keeping America innovative and keeping Americans employed in today's very competitive global economy, (2) dealing with the twin problems of energy and climate change, (3) helping a diverse and ageing population, and (4) dealing with terrorism. Policy analysts and political leaders are asking if the U.S. has the right science, technology, and innovation policies to respond effectively to these problems.

From 2005 until now, the dominant viewpoint in America – what we call the "mainstream policy consensus" regarding innovation policy – has argued that the best way to meet these challenges is through additional federal funding for basic research; support for science, engineering, and mathematics education; and tax incentives for industrial research and development (R&D). This consensus view was presented in the *Gathering Storm* report prepared by the U.S. National Academies and released on October 12, 2005.[1] Technology Policy International summarized this consensus view and some alternative viewpoints

[1] Committee on Prospering in the Global Economy of the 21st Century, National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, Washington, DC: National Academies Press, October 12, 2005. PDF and printed versions of the report are available for sale from the National Academies at: http://books.nap.edu/catalog.php?record_id=11463.

in a May 2007 report for NEDO, entitled *Innovation Policy Today in the United States: The Mainstream Consensus and Other Viewpoints*.[2]

Gathering Storm proved very popular and became the rallying point for a wide range of organizations and leaders concerned about innovation in the United States. President Bush endorsed many, but not all, of its provisions in his "American Competitiveness Initiative" (ACI), which he announced in his January 2006 State of the Union speech. In 2007, leaders of the Democrat-controlled Congress also endorsed *Gathering Storm's* main recommendations, and the result was a bipartisan piece of legislation, the America COMPETES Act of 2007[3] (U.S. Public Law 110-69), signed into law by President Bush on August 9, 2007.

Even though *Gathering Storm's* assumptions and recommendations are popular, there are reasons to be skeptical about them. No one disagrees about the value of more basic research and science and engineering education, but are these steps, by themselves, enough to ensure U.S. economic strength and good American jobs in an increasingly competitive global economy, to deal effectively with energy problems and the threat of climate change, and to solve other problems facing the United States?

In the year since TPI submitted its May 2007 report to NEDO, innovation policy analysts in the United States have begun to offer alternative viewpoints about the challenges and opportunities that America faces in the new global economy and alternative suggestions about what policy steps would best help

[2] Technology Policy International, George R. Heaton, Jr., Christopher T. Hill, Patrick Windham, and David W. Cheney, *Innovation Policy Today in the United States: The Mainstream Consensus and Other Views*, a report to NEDO, May 2007. Online at: http://www.technopoli.net/InnovationPolicy2007.pdf.

[3] In this name, "COMPETES" is an acronym made up of the first letters of each word of the law's full name. The full name is the "America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act."

the United States. Together, these alternative viewpoints point towards possible new directions – new pathways – in U.S. innovation policy.

This May 2008 report to NEDO summarizes these new analyses and recommendations and discusses how they might affect future U.S. policies. That is, it attempts to summarize the climate of thinking and debate in the U.S. science and technology policy community today and to summarize new ideas about how best to promote U.S. innovation and deal with the challenges now facing America. This report is organized into four parts:

- The remainder of this chapter provides an updated summary of current U.S. innovation policy – the mainstream consensus built around *Gathering Storm* – and also summarizes the criticisms that have been made of that policy.
- Chapter 2 of this report examines several recent alternative analyses and proposals for U.S. innovation policy.
- Chapter 3 examines the positions that the three major U.S. presidential candidates have taken regarding science, technology, and innovation. In order to figure out whether U.S. innovation policy may change after the November 2008 election, we must examine not only what policy analysts are saying but also what the presidential candidates are saying.
- Finally, Chapter 4 discusses the major challenges now facing the United States and how, in response, U.S. policies for science, technology, and innovation might indeed change in 2009 and after. What might be the new directions – the new pathways – as America deals with the big problems it faces?

1.2. The Mainstream Policy Consensus Today

The America COMPETES Act is based on *Gathering Storm's* assumptions and recommendations, and so those assumptions and recommendations are now

official U.S. Government policy. This mainstream policy consensus has several main elements:

- It argues that U.S. scientific and technological leadership is a key element of American prosperity and jobs and important for dealing with major challenges, such as energy.

- It also argues that basic research in universities and government laboratories and the training of more PhD-level scientists and engineers are the most valuable ways to promote U.S. innovation and competitiveness, and therefore that more federal investments in basic research and science and engineering education will create good jobs. *Gathering Storm* also assumes that R&D tax credits for companies are also important to keeping corporate R&D and innovation within the United States.

- It argues that today increased federal support for basic research in the physical sciences, engineering, mathematics, and information sciences is particularly valuable to the U.S. economy. While *Gathering Storm* did not mention specific agencies (except the Defense Department), supporters of the report's recommendations have sought funding increases for the government's three principal physical sciences research agencies: the National Science Foundation (NSF), the Office of Science within the Department of Energy (DOE), and the laboratories of the National Institute of Standards and Technology (NIST).

- *Gathering Storm* did call for one new R&D action beyond basic research: the creation of an Advanced Research Projects Agency – Energy (ARPA-E), modeled on the existing Defense Advanced Research Project Agency (DARPA). The America COMPETES Act authorized creation of that agency, but the agency has not yet been funded or established.

While the America COMPETES Act reflects the policy recommendations in *Gathering Storm,* the provisions of the new law are not identical to the report:

- First, the Act does indeed authorize more spending on R&D policy and science and engineering education. However, it does not

include several other specific provisions in *Gathering Storm:* increasingly research funding at the Department of Defense, changing U.S. immigration law, extending and expanding the research and experimentation (R&E) tax credit for companies, changing patent policy, and expanding broadband Internet access. Congress is discussing these other issues as it debates other possible laws.

- Second, the law contains several provisions that were not in either *Gathering Storm* or Mr. Bush's American Competitiveness Initiative. For example, it changed the existing Advanced Technology Program (ATP) into a new, slightly different Technology Investment Program (TIP). *Gathering Storm* did not endorse the ATP, and Mr. Bush opposed the ATP and has asked that the new TIP not receive funding. The new law also added several new science and mathematics programs, authorized the creation of a new President's Council on Innovation and Competitiveness (which has not yet been funded or established), and included provisions for two agencies not mentioned in the Bush ACI: NASA and the National Oceanic and Atmospheric Administration (NOAA). Table 1, below, compares the recommendations in *Gathering Storm* and the American Competitiveness Initiative with what Congress actually enacted in the new law.

- Third, and very important, the America COMPETES Act is what the U.S. Congress calls an "authorization law." This type of law creates or abolishes programs and "authorizes" funding – that is, gives legal permission to spend money up to certain levels. But authorization laws do not in fact provide actual money for government programs. Separate "appropriation laws" provide actual funding for agency activities.

- This third point is important because for the current U.S. federal fiscal year – FY 2008 – Congress and President Bush did not actually provide significantly more research or education money for NSF, DOE's Office of Science, or the NIST laboratories. Table 2 provides details on the actual appropriations. So far, the America COMPETES Act has not led to significantly greater federal funding for basic research and for science and engineering education.

TABLE 1. COMPARISON OF INNOVATION POLICY PROPOSALS

	GATHERING STORM	BUSH ACI	AMERICA COMPETES ACT
RESEARCH INVESTMENTS			
-General	Increase physical sciences basic research funding 10% per year for next 7 years	Double basic research funding in physical sciences over 10 years ($50B in new funds)	Creates Innovation Acceleration Research Program (8% of R&D to high-risk research)
-NSF		Double NSF research funding	Authorizes doubling of NSF budget
-DOE	Create ARPA-E	Double DOE Office of Science funding	Authorizes doubling of DOE Science Office, creates ARPA-E
-NIST		Double NIST labs funding	Authorizes doubling of NIST labs, changes ATP to TIP
-Other agencies	Increase research funding at DOD	No provision	NASA and NOAA provisions
EDUCATION/ WORKFORCE			
-Kindergarten-12th grade (K-12)	Scholarships for new math/science teachers	$380M for teacher training & materials	Several K-12 teacher and school provisions
-Undergraduates	25,000 new undergrad scholarships each year	No provision	No provision
-Graduate students	5,000 new fellowships each year	No provision	Expands existing NSF fellowship programs
-Worker training	No provision	Career Advancement Accounts	Not included in ACA
-Immigration	Extended visas for foreign students who receive US PhDs	Allow additional skilled immigrants	Not included in ACA
INCENTIVES FOR INNOVATION			
-R&E tax credit	Expand R&E credit and make permanent	Make R&E tax credit permanent	Not included in ACA
-Patent system	Modernize US patent system	No provision here	Not included in ACA
-Broadband access	Ensure affordable broadband access	No provision here	Not included in ACA
INNOVATION POLICY			
-Councils	No provision	No provision	Creates President's Innovation Council

TABLE 2. TOTAL R&D BY AGENCY

Source: American Association for the Advancement of Science

Congressional Action on R&D in the FY 2008 Budget (as of December 18, 2007)
(budget authority in millions of dollars)

			House-Senate Conference				
	FY 2007 Estimate	FY 2008 Request	FY 2008 CONF.	Chg. from Request Amount	Chg. from Request Percent	Chg. from FY 2007 Amount	Chg. from FY 2007 Percent
Defense (military) *	78,214	76,139	77,800	1,661	2.2%	-414	-0.5%
*("S&T" 6.1,6.2,6.3 + Medical) **	*14,008*	*10,906*	*13,036*	*2,130*	*19.5%*	*-972*	*-6.9%*
*(All Other DOD R&D) **	*64,205*	*65,233*	*64,764*	*-469*	*-0.7%*	*559*	*0.9%*
National Aeronautics & Space Admin.	11,806	12,594	12,476	-118	-0.9%	670	5.7%
Energy	8,732	9,234	9,376	142	1.5%	644	7.4%
(Office of Science)	*3,511*	*4,052*	*3,697*	*-355*	*-8.8%*	*186*	*5.3%*
(Energy R&D)	*1,522*	*1,386*	*1,873*	*487*	*35.1%*	*351*	*23.0%*
(Atomic Energy Defense R&D)	*3,699*	*3,796*	*3,806*	*10*	*0.3%*	*107*	*2.9%*
Health and Human Services	29,657	29,485	30,037	552	1.9%	380	1.3%
(National Institutes of Health)	*28,399*	*28,066*	*28,653*	*587*	*2.1%*	*254*	*0.9%*
(All Other HHS R&D)	*1,258*	*1,419*	*1,384*	*-35*	*-2.5%*	*126*	*10.0%*
National Science Foundation	4,482	4,856	4,530	-325	-6.7%	48	1.1%
Agriculture	2,256	2,009	2,301	292	14.6%	45	2.0%
Homeland Security	955	996	1,040	44	4.4%	86	9.0%
Interior	634	621	661	41	6.5%	27	4.2%
(U.S. Geological Survey)	*564*	*547*	*583*	*37*	*6.7%*	*19*	*3.4%*
Transportation	794	813	852	39	4.8%	58	7.3%
Environmental Protection Agency	561	540	542	3	0.5%	-18	-3.2%
Commerce	1,048	1,070	1,115	45	4.2%	68	6.5%
(NOAA)	*532*	*528*	*573*	*45*	*8.5%*	*41*	*7.6%*
(NIST)	*491*	*514*	*514*	*0*	*0.0%*	*23*	*4.7%*
Education	318	317	312	-5	-1.5%	-6	-1.8%
Agency for Int'l Development	223	223	242	19	8.5%	19	8.5%
Department of Veterans Affairs	851	822	891	69	8.4%	41	4.8%
Nuclear Regulatory Commission	74	77	74	-3	-4.1%	0	-0.2%
Smithsonian	175	183	175	-8	-4.4%	0	0.0%
All Other	288	299	290	-9	-3.0%	2	0.7%
TOTAL R&D	**141,067**	**140,278**	**142,715**	**2,438**	**1.7%**	**1,648**	**1.2%**
Defense R&D	82,209	80,110	81,762	1,651	2.1%	-447	-0.5%
Nondefense R&D	58,858	60,167	60,954	786	1.3%	2,096	3.6%
Nondefense R&D minus NASA	*47,051*	*47,574*	*48,478*	*904*	*1.9%*	*1,426*	*3.0%*
Basic Research	28,310	28,228	28,604	375	1.3%	293	1.0%
Applied Research	28,604	27,338	28,926	1,588	5.8%	322	1.1%
Total Research	56,915	55,567	57,530	1,963	3.5%	615	1.1%
Development	80,144	79,948	80,550	602	0.8%	406	0.5%
R&D Facilities and Capital Equipment	4,008	4,763	4,635	-127	-2.7%	628	15.7%
"FS&T"	61,821	61,370	63,074	1,704	2.8%	1,253	2.0%

AAAS estimates of R&D in FY 2008 appropriations bills. Includes conduct of R&D and R&D facilities.

All figures are rounded to the nearest million. Changes calculated from unrounded figures.

FY 2007 figures have been adjusted to reflect supplementals enacted in Public Law 110-28.

FY 2008 figures exclude $2.9 billion in requested supplemental funds for DOD development.

These figures have been revised since the publication of *AAAS Report XXXII: R&D FY 2008.*

* - DOD appropriations are enacted. All other appropriations are 2008 omnibus bill appropriations.

December 18, 2007 - AAAS estimates of latest FY 2008 appropriations.

1.3. Criticisms of the Mainstream Consensus

Some policy analysts are skeptical about the assumptions and recommendations contained in *Gathering Storm*. They understand that *Gathering Storm* is a political document, containing non-controversial recommendations that both Republicans and Democrats can agree to. It is therefore a minimalist set of policy recommendations. Nearly everyone agrees that its recommendations – especially for more funding of basic research and science education – are important and valuable. And analysts do not want to criticize it publicly, because they do not want to be seen as opposing more federal support for basic research.

Nevertheless, some analysts privately believe that the report's assumptions and recommendations are not sufficient. That is, while they think more basic research and more science education are good things, they do not think that the report and the mainstream innovation policy consensus that has grown around it present a complete list of the things that the United States must do to stay innovative and competitive in today's global economy and deal effectively with other major national challenges. Some analysts do not think it even addresses the most important policy challenges, such as how to create good jobs for all American workers. And some skeptics privately worry that the analysis presented in the report will mislead policy-makers and the American public into thinking that the United States will succeed in innovation, create significant numbers of new jobs, and solve our energy problems if only we invest more in basic research and science education. Instead, the skeptics argue that today's challenges require more attention to the lessons learned about innovation in the 1980s and to the particular realities of 21st century life.

TPI's 2007 report to NEDO provided a detailed discussion of these points. Here, we will briefly summarize three of these points that seem important to analysts who are developing alternative viewpoints.

First, *Gathering Storm's* subtitle – *Energizing and Employing America for a Brighter Economic Future* – implies that investing more government money in existing types of physical sciences research and PhD training will create or preserve significant numbers of American jobs. But it does not seriously discuss several key topics:

- New industries based on university research, while important, employ relatively few Americans. In fact, most Americans now work in the service sector or in general manufacturing, and yet *Gathering Storm* does not discuss what kinds of R&D might be most helpful to these important parts of the economy.
- Related, what, if anything, can federal innovation policy do to help create and keep good jobs for American workers without college degrees? For example, can education and technical assistance programs help train new generations of skilled manufacturing workers?
- What answer should one give to American taxpayers who see American-based companies ask for more government support of research but then use many of the resulting technologies to create jobs overseas? In this era of offshoring, what economic benefits can the average American taxpayer expect to get from the research increases recommended by the authors of *Gathering Storm*?
- While the report implies that more physical sciences research might lead to valuable new energy technologies, it does not contain a systematic analysis of what R&D and other steps are needed for advances in energy, greenhouse gas reductions, and energy-related employment.

Second, the report largely ignores policy lessons that innovation analysts learned in the 1980s. In particular, the report implicitly endorses the old "linear

model" – the idea that if government invests in basic research then the rest of the innovation system will take care of itself. But innovation requires more than basic research. For example, companies often face a "valley of death" as they try to turn promising ideas into working technology. The report recognizes that special technology development funding might be needed in energy – hence the ARPA-E proposal – but ironically never asks whether non-energy areas of the economy might need similar help. In addition, the report acknowledges that tax incentives are probably important if we want to keep corporate R&D in the U.S., but it simply endorses an expansion of the existing R&E tax credit without analyzing how effective that credit actually is in today's new global economy.

Third, for a report that justifies increased government spending by arguing that it will help the U.S. be more competitive in the new world economy, *Rising Storm* says surprisingly little about how the world has changed in recent years and how U.S. science, technology, and innovation policies should adapt to these changes. In fact, the report does not seriously address several important questions:

- What are America's competitive strengths today relative to the rest of the world? High-tech start-ups certainly are an American strength and will continue to be. But what else will be strong in the U.S. as other countries become more competitive? For example, will the U.S. be stronger in creative products (e.g., iPods and Google) than in commodity products? Where will the U.S. be strong in services and general manufacturing? And what particular science, technology, and overall innovation policies will help America build and sustain these strengths?

- If regional high-tech clusters remain an advantage for the United States, what, if anything, should the federal government do to promote them? What is an appropriate federal role here?

- Is there really a shortage of U.S. scientists and engineers? *Gathering Storm* argues that the U.S. needs many more PhD's and therefore should increase graduate fellowships and extend visas for foreign-born scientists and engineers. But analysts such as Richard Freeman,[4] Ron Hira,[5] and B. Lindsay Lowell and Harold Salzman[6] argue that the U.S. does not in fact have a shortage.

- What factors – tax policy, the availability of skilled people, etc. – actually determine when companies keep R&D and high-tech manufacturing in the United States and when they send it to other countries?

- How can the U.S. best take advantage of the growing R&D capabilities of other countries? For example, should we try to duplicate what the Chinese do, or find ways to take advantage of their contributions to science and technology? If the latter, should U.S. policy help our scientists learn more about science in China and other countries?

- How should graduate education in science and engineering change so that U.S. PhD's are better prepared to succeed in global science and engineering? *Gathering Storm* implies that we should train more people in traditional ways. But if R&D and companies will continue to become more international, should graduate schools prepare students better for foreign cultures, working in teams, and design and supply-chain management?

The next chapter of this report discusses what other analysts are beginning to say about these questions and about overall U.S. innovation policy in this new global era.

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[4] Richard B. Freeman, "Does Globalization of the Scientific/Engineering Workforce Threaten U.S. Economic Leadership?" National Bureau of Economic Research Working Paper 11457, June 2005.

[5] See, for example, Ron Hira, "No, The Tech Skills Shortage Doesn't Exist," *InformationWeek,* January 12, 2008.

[6] B. Lowell Lindsay and Harold Salzman, *In the Eye of the Storm: Assessing the Evidence on Science and Engineering Education, Quality, and Workforce Demand*, Washington, DC: Urban Institute, 2007.

2. Recent Proposals for New Directions in Innovation Policy

2.1. Overview

While policy discussions have yet to reach the level achieved during the "competitiveness crisis" of the late 1980s, recent months have witnessed a new outpouring of reports and studies on the state of U.S. innovation and on needs and opportunities for new directions in innovation policy. Some of these reports and studies are the work of single individuals or small groups of intellectuals and advocates; others are the product of special commissions, study panels and interest groups. All are intended in some way to influence the national debate on innovation policy.[7]

The forthcoming Presidential election in November 2008 is widely anticipated to lead to a substantial change in national directions in general, and advocates of new directions in innovation policy are adding their voices to calls for change in hopes of influencing the Presidential candidates and the President who ultimately takes office. Chapter 3 of this report discusses the positions *of* the major Presidential candidates on innovation and technology policy; this chapter discusses positions advocated by a number of parties, many of whom have written in order to advocate courses of action *to* the candidates.

In this chapter we summarize the main recommendations of several of the most significant recent studies and reports, in order to provide a sense for the

[7] In earlier work for JETRO and NEDO, TPI has discussed the role of both governmental and non-governmental interests in advocating for policy change in the U.S. system. See: George R. Heaton, Jr., Christopher T. Hill, and Patrick Windham with Tatsujiro Suzuki, "Policy Innovation: The Initiation and Formulation of new Science and Technology Policies in the U.S. During the 1980s," report to JETRO-New York and NEDO-Washington, March 2000. Executive Summary online in English at www.technopoli.net/2000execsum.pdf and in Japanese at www.technopoli.net/2000japanese.pdf.

directions that are being advocated for changes in U.S. innovation policy.[8] Following the summaries, we offer some general observations on main themes that cut across these studies, identifying, where we can, gaps in their coverage of what we believe to be promising policy alternatives.

2.2. Summaries of Recent Studies and Reports on Innovation Policy

In the following discussion, we provide a citation to each report, a few remarks on its origins, and a summary of its major recommendations. The reports are presented in alphabetical author by the last name of the first author, substituting the name of the sponsoring organization for the author if an author is not named.

The reader should be aware that the summaries that follow, especially the summaries of entire books, do not do justice to the richness of the original sources. Readers interested in the details of the policy recommendations listed below are encouraged to consult the original sources, which are given along with the citations.

1) Advisory Committee on Measuring Innovation in the 21st Century Economy, "Innovation Measurement: Tracking the State of Innovation in the American Economy," report to the U.S. Secretary of Commerce, January 2008, 36 pages.
www.innovationmetrics.gov/Innovation%20Measurement%2001-08.pdf

[8] Concern for innovation policy is not limited to the United States. For example, in March 2008, the U.K. Department for Innovation, Universities and Skills, in cooperation with the Chancellor of the Exchequer and the Secretary of State for Business Enterprise and Regulatory Reform, issued a report to Parliament entitled, *Innovation Nation*. This report advocates for, and promises, major changes in a variety of areas such as higher education, regulation, R&D funding, and government procurement to stimulate innovation and growth in the U.K. See: http://www.dius.gov.uk/docs/home/ScienceInnovation.pdf.

This committee was chartered to advise the Secretary of Commerce on ways to improve the measurement of innovation in firms in the United States. It made numerous recommendations, including improvements in collection of data on Total Factor Productivity (an indirect economy-wide measure of innovation), experimentation with new "satellite accounts" emphasizing intangibles and the service sector in the National Income and Product Accounts, and developments and improvements in various surveys that might facilitate innovation indicator construction.

2) Alliance for Science and Technology Research in America (ASTRA), "Riding the Rising Tide: A 21st Century Strategy for U.S. Competitiveness and Prosperity," December 2007, 76 pages. At: www.aboutastra.org/pdf/ASTRARisingTide121107.pdf

   ASTRA describes itself as

   > …a unique collaboration of interested organizations and individuals representing the physical and mathematical sciences and engineering. Founded in 2001, ASTRA is dedicated to promoting better understanding of the physical & mathematical sciences and engineering…. Members of ASTRA include leading industries, professional societies and associations, universities, and individual scientists and researchers.[9]

ASTRA's recent report proposed a fourteen-point innovation action program to strengthen U.S. innovation. Its major recommendations can be summarized as follows:

- R&D Enterprise
  - Balance defense/civilian share of Federal R&D portfolio
  - More Federal funds for physical sciences and engineering R&D

[9] Source: ASTRA web site: www.aboutastra.org/about/index.asp

  - Increasing inter-disciplinarity, collaboration, and new regions
  - Incentives to capture benefits of public R&D within the U.S.

- Innovation Workforce
  - Skills for innovation economy/non-rule based problem solving
  - Better career information in science and engineering
  - Broaden science and engineering education (to include cultural, communications, business topics)
  - Better attract top foreign students and STEM (science, technology, engineering, and mathematics) professionals

- Pro-Innovation Business Climate
  - Review U.S. regulations for impact on innovation
  - Develop innovation indicators and metrics to drive policy
  - Improve government analysis of U.S. and foreign innovation

3) Association of American Universities, "Science as a Solution: An Innovation Agenda for the Next President," March 2008, 7 pages.

The sixty-two members of the Association of American Universities (AAU) are generally the largest and most important research universities in the United States. It includes both large private institutions like Harvard, MIT and CalTech, as well as public institutions such as the University of Wisconsin and several of the University of California campuses. See www.aau.edu. In this statement, the AAU argues that U.S. research universities are key to producing both new ideas and the next generation of educated scientists, engineers and others who can contribute to innovation and the nation's economic and national security. They make a number of specific recommendations for action, including:

- Harness the nation's innovation matrix to help address major national and international challenges, such as:
  - Energy self-sufficiency
  - Environment and climate change

  - Twenty-first century life sciences
  - National and homeland security

- Expand and nurture U.S. talent in science, mathematics and engineering to create a workforce ready to meet the innovation challenges of the 21st century
  - Increase graduate fellowships and traineeships
  - Expand the DOD National Defense Education Program
  - Support young scientists
  - Enhance K-12 STEM education
  - Encourage the best students from around the world to study and live in the United States

- Reaffirm and strengthen the government-university partnership
  - Provide adequate resources for basic research
  - Support continued university technology transfer
  - Ensure that research decisions are based on scientific quality
  - Establish a new federal government advisory committee on the university-government partnership

- Elevate the role of science in White House policymaking
  - Raise the status of the President's Science Advisor
  - Respect and use the recommendations of scientific advisory committees
  - Enhance coordination of scientific research across the government

4) Robert Atkinson and Howard Wial, "Boosting Productivity, Innovation and Growth Through a National Innovation Foundation," report of the Information Technology and Innovation Foundation and the Brookings Institution, April 2008, 67 pages. Online at: http://www.itif.org/index.php?id=140.

Atkinson, the President of the Information Technology and Innovation Foundation, is a long-time participant in the national discussion about innovation policy, information technology policy, and related matters. For this study, he teamed with the Metropolitan Policy Program at the Brookings

Institution to propose the creation of a new government entity, a National Innovation Foundation. The proposal is not unlike proposals made throughout the 1980s for a National Technology Foundation or an Advanced Technology Foundation, both of which were considered but dropped from the comprehensive innovation agenda that became a part of the massive Omnibus Trade and Competitiveness Act of 1988. The proposed new Foundation would be part of the Department of Commerce, set up as an independent agency like NSF, or be set up as a government-related public corporation. The authors recommend that the Foundation carry out duties like the following:

- Catalyze industry-university research partnerships
- Expand regional innovation promotion
- Encourage technology adoption
- Support regional industry clusters
- Emphasize performance and accountability
- Champion innovation.

5) Christopher T. Hill, "The Post-Scientific Society," *Issues in Science and Technology*, Fall 2007, pp. 78-84.

Hill is one of the co-authors of the present report. He wrote this paper for the popular magazine of the U.S. National Academies of Sciences, Engineering, and Medicine to explore some ideas about how the globalization of the scientific and technical workforce, combined with the widespread adoption of the concept sometimes known as "open innovation," is leading to a new kind of society in the United States that will increasingly depend on new scientific knowledge from abroad as the foundation for innovation and economic growth. His major recommendations for action can be summarized as follows:

- U.S. firms must be able to build profitable innovation on new R&D results from everywhere in the world

- Require a broadened education of scientists and engineers to include
  - Foreign languages and cultures
  - Study abroad programs
  - Business principles
  - Communications skills
  - Human behavior
  - Creative arts

- Professional science masters degrees should be encouraged

- Multidisciplinary, problem-oriented higher education should be the norm

- Re-emphasize integrative and creative subjects in K-12 education and lessen obsessive focus on reading and mathematics

- A new international institution to pay for and support basic research

- Flexible, strong intellectual property, emphasizing copyright

- NSF must provide leadership for new modes of R&D and S&E education

- Broaden scope of R&E tax credit beyond "experimentation"

- Avoid over-commitment to industrial "clusters" whose lifetime may be short.

6) John Kao, *Innovation Nation*, New York: Free Press, 2007.

Kao is successful innovator, academic and businessman whose new book offers a remarkably ambitious vision for a United States focused on becoming an "innovation nation." He offered his policy proposals in the spirit of initiating dialogue, not necessarily because he had given them careful consideration and taken into account all of the political realities and constraints that shape the

debates of policy outcomes. In other words, he has not attempted to be realistic as a policy specialist might be, but instead has sought to provoke and stimulate discussion. Prominent among his many recommendations for federal action are the following:

- Fund 20 innovation hubs at $1 billion each
  - Each focuses on one "wicked problem"
  - Public-private partnerships
  - Regional focus
  - Entrepreneurial expectations
  - Integrate K-12 education with business mentoring
  - Strong leadership for each hub is essential

- Appoint a National Innovation Advisor (to the President)

- Appoint a National Innovation Council
  - Report to the President
  - Conduct a national conversation
  - Fund innovation and coordinate other agencies

- Establish an Office of Innovation Assessment
  - Congressional agency
  - Serve as a national knowledge management office
  - Renew National Critical Technologies process.

7) Jeffrey T. Macher and David C. Mowery, editors, *Innovation in Global Industries: U.S. Firms Competing in a New World: Collected Studies*, Committee on Competitiveness and Workforce Needs of U.S. Industry, National Research Council, Washington, DC: The National Academies Press, 2008.

This report examines innovation, offshoring, and competitiveness in 10 US industries: personal computers, software, semiconductors, flat panel displays,

lighting, pharmaceuticals, biotechnology, logistics, venture capital, and financial services. The report reaches these conclusions, according to a summary from the National Academies Press:

> There is no doubt that overall there has been an acceleration in global sourcing of innovation and an emergence of new locations of research capacity and advanced technical skills, but the patterns are highly variable. Many industries and some firms in nearly all industries retain leading-edge capacity in the United States. However, the book concludes that is no reason for complacency about the future outlook.[10]

The report's main point about U.S. policy is the following:

> To preserve and expand employment in the functions and professions that benefit from the globalization of innovation, the United States must sustain the high levels of innovation performance that have supported the competitiveness of U.S. industry and have made the United States a major destination for R&D investment from foreign firms. Among other things, this goals means that support for the "R&D infrastructure" that decades of public and private investment have created must be strengthened.[11]

The report goes on to praise research universities, university-industry research collaborations, and public investments in "testbed" projects such as the ARPANET. It also recommends "more effective policies within the United States to address the legitimate concerns and needs of the domestic economic 'losers' from globalization."[12]

8) National Research Council, *Innovation Inducement Prizes at the National Science Foundation*, Committee on the Design of an NSF Innovation Prize, Washington DC: The National Academies Press, 2007, 59 pages.

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[10] National Academies Press statement, at: http://www.nap.edu/catalog.php?record_id=12112#description.
[11] Macher and Mowery, page 15.
[12] Macher and Mowery, page 18.

This study reflects the growing interest in the United States in using inducement prizes to encourage innovation. To create an incentive for a specific new innovation or for solving a problem, a sponsor of a prize offers a cash reward either to the first group that achieves the prize goal or to the group that achieves the highest score on some measure of innovation performance within a set period of time. Among the committee's recommendations are the following:

- NSF should experiment with a variety of prizes of different sizes, beginning with smaller prizes, and, as experience is gained, moving to much larger prizes
- NSF should take full responsibility for administering the prizes, but should cooperate with other agencies and with non-governmental groups in designing and publicizing prize opportunities
- The prize program should be carefully evaluated on a long-term basis.

9) Gregory Tassey, *The Technology Imperative*, Williston, VT: Edward Elgar, 2007.

Tassey has been on the economic analysis staff of the National Institute of Standards and Technology (NIST) for a number of years and is a frequent analyst and commentator on R&D and innovation policy. The views in the book are his personal views and are not intended to represent the opinions or policies of NIST. Tassey argues that the key to innovative success in the United States is vigorous investment in R&D in both the public and private sectors. He states a proposed new national goal for aggregate R&D intensity and recommends a number of actions to help reach that goal. His recommendations include the following:

- U.S. R&D intensity should be doubled to 5 percent of GDP
- R&E tax credit must be restructured and enlarged to a flat 10 percent rate

- R&D funding must be portfolio based and go beyond biotech and IT
- R&D funding must be technology-element based
- R&D efficiency must be increased
    - More technology clusters
    - Better timing over the technology life cycle.

10) Charles Weiss and William Bonvillian, "Stimulating U.S. Technological Innovation in Energy," unpublished manuscript, presentation to the Woodrow Wilson Center's "Tuesday Innovation Group,' November 29, 2007.

We include this paper because it reflects the shared perspectives of two long-time participants and observer of policy-making on innovation. Weiss is a professor at Georgetown University who served earlier in his career as science and technology advisor to the president of the World Bank, Robert McNamara. Bonvillian is the Washington representative of MIT who served earlier as legislative director for Senator Joseph Lieberman. The focus of their paper is on innovation in the field of energy, but the ideas are so broad that we include it here in our general review. Their principal observations and recommendations are as follows:

- Need to fill functional gaps in the present system of Federal support for energy innovation
    - Fund the energy-oriented Advanced Research Projects Agency, ARPA-E[13]
    - Create a Federal Energy Corporation to finance demonstration projects

[13] The America COMPETES Act of 2007 authorized the formation of an ARPA-Energy, but no funding has been made available in subsequent appropriations acts to implement the authorization. The failure to follow authorizations with appropriations that provide actual funding is not unusual in the American system.

  - Set up a road-mapping think tank or other policy research institution or network

- Requires high-level (Presidential) leadership
- This effort would meet a national need and create a new wave of innovation.

2.3. Main Themes of Recent Studies and Reports on Innovation Policy

The reports and studies summarized above tend, on the whole, to reiterate recommendations and proposals made many times before. To some extent, this reflects the maturity of the field; most of the good ideas have been proposed, tried, and accepted or rejected. Of course, the fact that the ideas have been seen before does not mean that they are not worthy of renewed consideration, especially as circumstances bearing on the U.S. economy have changed over time.

The major themes that appear repeatedly in the works reviewed include the following:

- Renewed and expanded federal funding of R&D, especially but not only in the physical sciences
- Continued emphasis on partnerships for R&D among universities, industry and the federal government
- A focus on specific high-priority areas of national concern, such as energy, climate and the environment, life sciences, and national and homeland security
- New funding and support for advanced education for students majoring in science, technology, mathematics, and engineering (STEM)

- New approaches to STEM education that prepare graduates for success in a globalized economy
- Making the United States a more hospitable place for foreign students and professionals who wish to study, and especially, to make their homes here
- Supporting the development of new regional clusters, focused on specific sectors and technologies
- Increased support for R&D and innovation at the state level
- Improved mechanisms and programs for the collection and analysis of data on innovative performance
- Renewed emphasis on using scientific and technical information in government policymaking in general
- Experimentation with new modes of innovation support, including innovation inducement prizes
- New organizational structures to be responsible for innovation policy and programs in Congress and the executive branch.

Not all of the studies and reports agree on all these recommendations; in fact, one can notice a certain degree of dissension from some authors. For example, Hill is skeptical of efforts to substantially expand the number of STEM graduates and emphasizes the importance of globalization of the STEM curriculum. He is also skeptical of the industrial cluster concept as the basis for sound regional development policy.

There are a few new ideas in the studies and reports. Once again, Hill suggests the importance of establishing the principle of multi-national support for basic research, since the ability of any one nation to capture the benefits of fundamental scientific discoveries is lessened in the face of globalization. Atkinson and Wial propose the creation of a National Innovation Foundation to take responsibility for innovation support at the federal level. The National

Research Council recommended that NSF experiment with a program of innovation inducement prizes. None of these ideas is entirely new. For example, innovation inducement prizes were widely used in the 18th and 19th century and have been used a few times in the most recent century. Variations on the NIF theme were explored in the House of Representatives in the late 1960s through the mid-1980s. Hill's suggestion for collaborative international support of basic research was first made to a Congressional committee some two decades ago. On the other hand, these ideas have not yet taken root in the U.S. innovation policy debates, and each deserves and may get a new hearing after the 2008 elections.

3. SCIENCE, TECHNOLOGY, AND INNOVATION POLICY IN THE 2008 PRESIDENTIAL CAMPAIGN

3.1 . Science and Technology in U.S. Politics

Science and technology policy rarely takes on a high level of salience in U.S. national politics. Most of the issues that grab the attention of the American public – race, religion, economics, foreign affairs, gas prices, or health – are far removed from a direct connection with science and technology. And it is well demonstrated that very few science-related developments have attracted widespread public attention.[14] In Presidential election campaigns, science and technology tend to retreat even farther from center-stage, as the national and global problems that will affect the entire electorate come more to the fore. Thus far, the 2008 campaign has conformed to this pattern.

When science and technology do engage general attention, they tend to be seen as instruments to achieve a larger goal, rather than as a general good. This rationale was obvious in President Kennedy's call for a "Man on the Moon," or President Nixon's declaration of a "War on Cancer." It was perhaps more subtly made during the 1980s' discussion of "competitiveness," when policy-makers and the public began to recognize that the U.S. position in the world economy was highly dependent on the health of its science and technology enterprise. More recently still, President Bush has begun to emphasize the role of science and technology in solving the problems of energy and the environment as a

[14] The Pew Center for the People and the Press has been tracking this issue since 1986. Their data show that of the top 1000 news stories, very few had any apparent connection to science and technology, with one exception: the Challenger disaster in 1986. Most of the other stories where science was involved concerned natural disasters, and after that, health. See "Public Attentiveness for News Stories: 1986 – 2002 (Washington, D.C. 2003).

standard part of his public speaking.[15] But the extent to which new dollars flow and new focus proceeds from such rhetoric is not always clear.

In spite of the fact that science and technology policy is not a high-visibility area, it nevertheless always plays a role in Presidential campaigns. Every candidate of stature will have a "position" on science and technology policy, and members of the science and technology policy community routinely join the candidates' campaigns as advisors. It is worth noting that the science and technology policy community is comprised of highly educated, successful, and prominent individuals, who can be vocal and give advice across a wide range of issues. It is also worth noting that very few American politicians at any level have a technical background, and they thus must rely heavily on external advice in matters pertaining to science and technology. Lastly, while the science and technology community has never been organized around a single well-focused legislative agenda, there are nevertheless certain defined constituencies – notably, high-technology industry, universities, and major government laboratories – who have clear public policy goals and significant resources, financial and otherwise, with which to pursue them. Candidates thus court these constituencies as they would any other, with promises that appeal to their desires.

3.2 . An Overview of the 2008 Campaign

The 2008 U.S. Presidential campaign has been surprising in a number of important respects – above all, in the people who have emerged as leading candidates. On the Republican side, Senator John McCain effectively secured the

[15] See "Commencement Address at Greensburg High, Greensburg, Kansas, May 5, 2008, in which the President promised the rebuilding of tornado-devastated Greensburg according to "the highest environmental principles," and a talk that touted new energy technologies such as hydrogen to World Wide Systems, Inc. on May 2, 2008.

nomination at a relatively early stage, which is not unusual in the Republican Party. But McCain's success did depart from the norm in that he is much older than most other candidates, and in that he has advocated a set of policy positions that are hard to characterize according to ideology or party orthodoxy. In short, McCain is often described as a "maverick" – a description that he seems to enjoy and cultivate.

On the Democratic side, the emergence of Senators Hillary Clinton and Barack Obama as the leading candidates is unprecedented, since neither a woman nor an African-American has ever been a major party's Presidential nominee. Beyond this, the length, closeness, and shifting momentum in the Democratic race are unprecedented.

In the realm of science and technology policy, however, the campaign has held few, if any, surprises. Science and technology policy in general has not emerged as a major theme. Energy and climate change are surely the particular issues in which the role of science and technology is most often mentioned. While the individual candidates' positions are summarized below, one can say that as a group they have offered little that is new – either in terms of departures from their own established positions or from the current science and technology policy discussion in Washington.

Perhaps the most unusual issue that has come up in the campaign is the call for a "Science Debate" among the candidates.[16] A grassroots organization, "Science Debate 2008," has for some time been promoting the idea – and even scheduling dates and venues – that the candidates should meet to debate the role of science as well as a list of specific issues involving science and technology.

[16] http://www.sciencedebate2008.com/www/index.php?id=8

Thus far, none of the candidates has warmed to this proposition; in fact, all ignored the invitation to debate at the Franklin Institute in Philadelphia during the Pennsylvania primary.[17] Perhaps the closest that the debate has gotten to reality is the discussion at the annual AAAS meeting in February between the "science advisors for Clinton and Obama (McCain declined to take part)."[18] Nevertheless, the organizers of Science Debate are still promoting dates, issues, and write-ins in the remaining few primary elections, and the list of prominent individuals and organizations who have signed on to the "invitation" to debate continues to grow.

3.3 . The Three Candidates' Positions

Each of the three candidates now running for President has put forth a detailed position statement on science and technology. In addition, each, having served in the Senate for some time, has a voting record with respect to many science and technology policy issues. The following table is an attempt to summarize these positions and these records, using a wide variety of sources. [19] Although the table is necessarily brief and general, this is also often true of positions taken during campaigns; and it is also true that they are subject to change. In the three paragraphs that follow the table, we offer an impressionistic sense of the background, tenor, and emphasis of each candidate's position.

Senator Clinton's views on the full range of science and technology issues are by far the most detailed and specific. This is undoubtedly in part a function of the overall tenor of her campaign, which has put forward detailed proposals

[17] http://cosmiclog.msnbc.msn.com/archive/2008/04/03/857647.aspx
[18] http://afp.google.com/article/ALeqM5g4Um08w453MSR2cfVIbz_saa6-Ng
[19] Compiled from a variety of campaign statements, new reports and summaries. The most complete site by far is the AAAS "Science and Technology in the 2008 Presidential Campaign." http://election2008.aaas.org/comparisons/ The site from Physics Today, "Campaign 2008 – Where do they stand on science" is also useful. http://blogs.physicstoday.org/politics08/.

on virtually all the issues; and in part a function of her advisors, who were central players in the development of White House science and technology policy during the Clinton-Gore Administration, and are therefore exceptionally familiar with the current Washington policy debate. Clinton portrays herself as a strong supporter of science in general – a claim that is substantiated by her endorsement of specific budget increases for the major scientific agencies of the government. But she has also made the issue of "scientific integrity" a major issue, vigorously attacking the Bush Administration on this point. As the campaign has unfolded, the Clinton emphasis has tended to shift toward economic issues such as trade and jobs, with the result that science and technology concerns have not played a large part.

Senator Obama's campaign is noteworthy for its emphasis on the general themes of change and unity across a wide range of the American polity. Neither his personal nor his political background is rooted in the world of science and technology. Consistent with this, his general approach has been to portray science and technology as tools to solve pressing national problems, and he has tended to avoid specific statements about particular policy areas. Obama's supporters and advisors appear to be drawn much more from the high-technology and venture capital communities – particularly the information technology sector – than from the Washington policy establishment.

Throughout his career, Senator McCain has been both a reasonable supporter of science and technology and an independent voice. His general philosophy emphasizes the workings of the free market rather than government intervention, either in terms of regulations or funding programs. This orientation leads him to support freer immigration, to support greater trade access for U.S. firms, and to oppose subsidies for ethanol and restrictions on stem

cell research. McCain's military background and support for continued involvement in Iraq make defense a top priority. On the issue of climate change, McCain was one of the first senators to recognize the need for action on CO_2 emissions, and he has been an advocate of market-based approaches, including cap-and-trade.

Comparison of Candidates' Views on Science and Technology Policy

	Clinton	*Obama*	*McCain*
Science Investment	$50 billion energy fund; increase basic research 50% in NSF, DOE, DOD in 10 years; more physical science, eng.; 8% set-aside for high-risk; innovation prizes; broadband support	Double basic research; increase physical science, engineering	Supports continued space exploration; vehemently opposes "earmarks" (special projects for individual members of Congress)
Competitiveness and Innovation	Science budget increases; permanent & more generous R&D tax credit; women & minorities in science; COMPETES Act	Improve STEM education; energy R&D; info tech; permanent R&D tax credit; improve H-1B visa; reform patents	Risk capital; entrepreneurship; light regulation; market access; skilled workers (H-1B); export energy technologies
STEM Education & Workforce	Part of competitiveness agenda; proposed in COMPETES Act; increase NSF teacher fellowships	Top national priority; public school STEM teacher fellowships	Supports increased immigration, including expanded H1-B visa program
Health	Stem cell and health R&D top priority; increase NIH by 50% in 5 years, 100% in 10	Rescind Bush stem cell policy; establish institute on comparative treatment	Supports stem cell research
Energy	$50 billion strategic energy fund; fuel efficiency regulation; building standards	Double energy R&D; increase fuel efficiency standards; biofuel support	Supports nuclear and biofuels; not ethanol
Climate Change	Cap & trade	First Senate bill with mandatory cuts in CO_2 emissions; market approaches	Cap & trade; international agreements
National & Homeland Security	Financial, infrastructure support for unstable countries; low-enriched fuel; international alliances	Pandemic prevention top priority; track spent nuclear material	Defense acquisition reform; fund defense only in regular appropriations process
"Science Advisor"	Thomas Kalil, Special Assistant to Chancellor, UC Berkeley	Alec Ross, Senior VP, One Economy Corporation	

3.4 . Science and Technology Policy in the Next Administration

Whichever of the current candidates reaches the White House in 2009, the national climate for science and technology policy over the next four years is likely to be more favorable than it has been under President Bush. All of the candidates have expressed strong support for science and technology, and all expressed a specificity and commitment that the Bush Administration has never shown. All can draw on support from members of the science and technology community to a degree that has not recently been the case.

This said, it is also true that none of the candidates has focused on science and technology policy with real fervor, as did, for example, Vice President Gore. None of the candidates has really articulated a vision that goes beyond the conventional wisdom that was discussed earlier in this report (see Chapter 1). And no matter who occupies the White House, severe constraints will limit the ability to make large changes. Most importantly the economic and fiscal situation – recession, high deficits, and very high fixed commitments to military and health/social security – makes any major budgetary increases for science and technology unlikely. Flat or slightly increasing budgets would probably be considered a positive development, in comparison to what might occur.

On the other hand, it would not be at all surprising to see new commitments in two related areas: energy and climate change. All of the candidates have long recognized the seriousness of these problems, and all have long expressed a strong desire to change the status quo.

4. NEW PATHWAYS IN U.S. INNOVATION POLICY

4.1. Overview

Earlier chapters of this report have discussed the current consensus in U.S. innovation policy and its limitations, the findings and recommendations of a number of recent reports and studies intended to influence the directions of U.S. innovation policy, and the views of the principal Presidential candidates on this subject. Here we add to this background a brief summary of the major forces that drive and motivate the innovation policy debate in the United States. We refer to these forces as "imperatives" – that is, they are important realities that cannot be ignored. We then discuss future directions that U.S. innovation policy is likely to follow, both in the near term—in roughly the first year of the next U.S. presidency—and in the longer term—in roughly the next two to five years.

4.2. Imperatives for U.S. Innovation Policy

During the past decade the overall environment for public policy-making toward innovation in the U.S. has changed as new problems have arisen and old ones have proven difficult to address or solve, and as new understanding of the innovation process itself has blossomed.

The major "imperatives" with which innovation policy must be concerned include some of the toughest challenges faced by the United States. They include:

- Globalization

The opening of much of the world to relatively free and open trade in natural resources, human capital, investment, goods, services, and knowledge

has substantially reduced the relative importance of the United States in the world economy. New strategies and new policies are needed to ensure that America can maintain its standard of living and its relatively great independence and influence on others, in part through new approaches to making and benefitting from innovation both at home and in collaboration with others.

- Environmental sustainability and climate change

Many of the old assumptions about the carrying capacity of the Earth and about the scale and scope of humanity's impact on that capacity have proven to be false. The modern world economy was constructed without much regard to whether it could be sustained in its current form. Now we know that human activity is responsible for large and growing negative impacts on climate, for the loss of biodiversity, for exhaustion of seemingly renewable resources, etc. New technologies are needed to enable us to continue to survive and thrive in the numbers and with the intensity of our current life.

- Massive demographic changes

Although not to the same degree as Japan, the United States is experiencing a substantial shift in the age structure of its population, with relatively fewer children being born and many more people living to an advanced age. Unlike Japan, the United States is experiencing very substantial immigration of new residents from all over the world who are rapidly changing the racial, ethnic and cultural mix of our already eclectic society. Consumer tastes and preferences are changing as well. These new demographics are leading to demands for new kinds of technologies to serve,

on the one hand, the very old and disabled, and, on the other hand, the diverse newcomers to America.

- The threat of non-state terror as an instrument of warfare

The attacks of September 11, 2001, while by no means the first terrorist incidents in the U.S., were the most dramatic expression of a new determination by non-state actors to launch symbolic and disabling attacks on key elements of American society. Since that date, efforts have been made to mobilize technological innovations in detecting, tracking, preventing, disabling, ameliorating and otherwise addressing the manifestations of terrorist activity aimed at the United States.

- Other imperatives

The imperatives listed above only scratch the surface of a long list of problems and challenges that American ingenuity and innovation are being called on to address. We might easily add to the list such matters as the threat of new epidemic diseases, the concomitant decline in the effectiveness of traditional antibiotic therapies, the rise of obesity, the growth in inequality, Internet-enabled disintermediation in many sectors of society, and the decline of interest in science, engineering, mathematics, and other careers of importance to innovation.

4.3. Expectations for Near-Term Innovation Policy Pathways

In the next year or two, which will encompass the first year of the new President elected in November 2008, certain developments in innovation policy seem more likely than others. Some important pathways – that is, policy

directions – will be followed regardless of which candidate wins; others will depend on which candidate and party wins.[20]

In the category of likely pathways that are independent of who wins the election, we would expect the following:

- Major expansion of incentives for development of technologies to address climate change, energy conservation, and environmental sustainability
- A reversal of President Bush's ban on use of Federal funds to create and use new human embryonic stem cell lines for research
- Improvements to the integrity and openness of the use of scientific expertise in general public policymaking ("science advice")
- Restored U.S. funding for its share of the International Thermonuclear Experimental Reactor (ITER) project
- Continued severe limits on Federal spending for R&D, as a result of a determination to address Federal budget deficits

If a Democrat (Clinton or Obama) is elected President, in addition to the above, we would expect that during his or her first or second year in office the following kinds of initiatives would be taken:

- More funding for the programs and agencies favored in the American COMPETES Act of 2007; namely, engineering and physical sciences in NSF, DOE, and NIST
- Establishment and initial operation of ARPA-E (Advanced Research Projects Agency-Energy) as authorized in the COMPETES Act
- Greater funding for the new Technology Investment Program in NIST

[20] As of this writing, Senator McCain is the presumptive nominee of the Republican Party, needing only the formalities of the national convention in September to become the formal nominee. The race for the Democratic nomination between Senators Clinton and Obama continues, but Senator Obama appears overwhelmingly likely to be their nominee.

- A reassessment of the wisdom and management of the Moon-Mars exploration initiative of the Bush Administration

It is less clear to us what might happen to innovation policy during the first year or two of a McCain administration. Senator McCain is known to prefer "market based" approaches to the climate change program, but he has actively supported a relatively modest cap and trade proposal that includes free distribution of emissions permits to existing emitters, at least at first. He is known to be opposed in general to Federal funding of research and innovation programs designed to assist industry, such as the now-defunct Advanced Technology Program in NIST. While his campaign materials pay some attention to innovation policy, as summarized in Chapter 3, they do not provide strong insights into any new directions he might take.

4.4. Longer-Term Innovation Policy Pathways

The innovation policy pathways that are likely to be taken in the near term do not fully address the imperatives for public policy we discussed earlier in this section. We have identified at least two related sets of more profound changes in the direction of innovation policy that may occur over the somewhat longer term—say, two to five years.

First, responding to the challenge of globalization of science, research, innovation, and industry will require a substantial enhancement of America's innovation policies. Using the framework of the "Post-Scientific Society" discussed in Chapter 2 of this report, a number of important new pathways will be explored. These include:

- Internationalization of some part of the funding base for fundamental science, perhaps through experimentation with a new international

organization we might refer to conceptually as a "World Science Foundation (WFS)." A WFS would receive funds from the governments of leading industrial nations to support R&D involving collaborations among researchers in academia, government laboratories, and other non-profit entities who are located in different member countries.

- Major qualitative changes in the nature of science, mathematics, and engineering education at the undergraduate and graduate levels. Students will be required to learn about other cultures and languages through intensive study, foreign language training, and study-abroad programs. They will also pay much greater attention to studies in business, public affairs, communications, and the arts to prepare them for leading roles as entrepreneurs and leaders in technology-based industries.

- Re-opening America's partially-shut doors to welcome a new generation of college and university students from abroad who will be permitted to establish permanent residency in the United States upon graduation from an approved program of study, without the extended and often-frustrating time of probationary visits, Green Cards, and H-1B visas.

- A change in attitudes and practices in industry and elsewhere that will emphasize learning from and exploiting new ideas from other countries and cultures, regardless of their points of origin.

Second, to help organize and focus American efforts to enhance the spirit of entrepreneurship, to provide leadership for the kinds of transformations envisioned above, and to provide incentives for making and using innovations for both economic growth and environmental sustainability, we anticipate a renewed interest in creating a new agency or unit of the Federal government that will be devoted to encouraging innovation in all segments of society, including but not limited to private industry. One of the unfortunate aspects of the America COMPETES Act of 2007 was that it ended the authorization for the Technology Administration in the Department of Commerce. The Technology Administration was created by the 1988 Omnibus Trade and Competitiveness Act at a time when the United States was most anxious about losing its lead in

technology-based industries to Japan. Today's challenges to America's leadership in innovation are every bit as profound as were those from Japan at that time, but we are left without a coordinating body and a focus for innovation. Atkinson's National Innovation Foundation, discussed above, is one possible approach to re-establishing such an entity. Others will be explored and, we expect, some sort of new government innovation agency will emerge from the national debate as it matures under a new Presidential administration.

In summary, the United States faces new global realities and new policy challenges. While the current mainstream consensus on innovation policy owes more to the policy ideas of the past than to an analysis of what changes are now needed, and while the current Presidential candidates have fairly conventional views on science, technology, and innovation policy, we believe that, in time, American innovation policies will change in an attempt to respond effectively to these new realities and challenges.