Appendix: Scientific Ethics (2005 -)

by Lloyd S. Etheredge[1]

[This appendix expands upon and documents a discussion in the author's letter of August 12, 2008 to Dr. James McCarthy, President of the American Association for the Advancement of Science.]

Two competing models might explain the behavior of the National Academy of Sciences and the National Science Board/NSF in the Gathering Storm/K-12 case (2005 -).[2] Either they are: a.) Scientific organizations that make honest, inadvertent mistakes; or b.) Acting as political/lobbying organizations. Their behavior in three areas (misleading people; favors to Exxon and others; and breakdowns of institutional responsibility) presents a strong *prima facie* case that model b is a better explanation.

I. Misleading People

A.) The Intentional Use of Untrustworthy Data

In October 2005 when Gathering Storm warned about "600,000 Chinese engineering graduates/year" the key players at the National Academy of Sciences already knew that the numbers were untrustworthy. John Marburger, the President's Science Adviser, had warned the planners of the pro-science lobbying initiative (in an editorial in Science on May 20, 2005 - attached) about "sharply differing opinions . . . regarding the numbers of degree holders produced in the United States and other countries, particularly China and India." The leaders of the National Academy featured the untrustworthy numbers at a national press conference, in their speeches and testimony to Congress, and reporters conveyed them to the American public (in-

cluding AAAS and National Academy members) in The New York Times and in hundreds of other stories, blogs, and speeches. [3] [4]

B.) The Intentional "Dumbing Down" of Scientific Analysis

In October 2005 the National Academy also knew that it had not done the scientific analysis needed for evidence-based policy recommendations**. I**n the same May 20, 2005 editorial Marburger had given his second early warning about this anticipated problem to the National Science Foundation (which had stewardship for economics, science education, manpower, and R&D statistics) and to the National Academy: They had not responsibly done their scientific homework (i.e., across several decades – LE) to integrate these different data into refined economic models that could make reliable policy recommendations for economic growth and competitiveness.

[Marburger's first warning was a news story in Science on April 29, 2005, three weeks earlier (enclosed). Science included his photograph and the caption: "U. S. science adviser John Marburger wants better econometric models of research trends." [The Science reporter (Jeffrey Mervis) also underscored the hard work that would be needed: "the sheer difficulty of coming up with a theoretical framework that takes into account enough of the important variables to generate useful results."][5]

- Marburger's May 20 editorial also diplomatically warned against "dumbing down" scientific advice – for example, replacing intelligent analysis by the crude "body counts" that were adopted: "[O]ptimal strategies for large mature economies such as that of the United States will doubtless (sic) differ from those for smaller or developing economies."

C.) The Intentional Withholding of Evidence

1.) The National Academy's Own Evidence. In its draft (2005) and final editions of Gathering Storm (2007) the National Academy made a bold claim: *"U.S. advantages in the marketplace and in science and technology have begun to erode. A comprehensive and coordinated federal effort [i.e., with 20 implementation steps] is urgently needed."* [6] But in 2007 – and even in 2005 - the National Academy of Sciences knew that it was putting its reputation behind a one-sided case and that it actually was withholding strong, disconfirming research evidence from Congress, the press, and the public. The Academy's own set of industry-level case studies (U. S. Industry in 2000: Studies in Competitive Performance) had documented that America's international competitiveness actually grew stronger beginning in the mid-1990s and the new China/India/South Korean/ Taiwan scare (that had appeared in the early 1990s) was going the way of the earlier Japan scare and the EU scare and the Russian scare.[7] In April 2006 (i.e., before the 2007 revision) the new results of its follow-up industry-level project were known at the National Academy: While finding that there was international competition and "no cause for complacency" the new research reconfirmed that many US industries and companies were highly adaptive and doing very well: "[D]espite the emergence of robust R&D and innovative capabilities in East, Southeast, and South Asia . . . [M]any industries and some firms within nearly all industries retain leading-edge capacity in the United States."[8] However this important news was not transmitted to Congress or published for two years.

[Similar problems of withholding evidence and "dumbing down" permeated the National Science Board/NSF K-12 testimony and plans. While improving K-12 science and mathematics education is a laudable goal, the National Science Foundation's lack of research progress across

several decades has been a national embarrassment. Thus, John Marburger said the K-12 strategic plan, pulled together quickly after Gathering Storm, was based on "efforts not yet proven effective." The National Science Board and NSF did not make such an honest disclosure. Their strategy was to use the scary, dumbed-down, limited homework, rhetorical flourishes of Augustine *et al*.: *"The danger exists that Americans may not know enough about science, technology, or mathematics to contribute significantly to, or fully benefit from, the knowledge-based economy that is already taking shape around us."* (There is not a single undergraduate policy analysis course in the country where this sentence, used to justify a cornucopia of well-intentioned spending, would receive a passing grade.)] [9]

2.) The National Academy's 52 Economists

The National Academy's elected members include 52 of the nation's most distinguished economists (as measured by their election to the National Academy). Yet they were not asked to participate, review, or agree to the National Academy's recommendations for the nation's economic growth and competitiveness. Why not? I suspect, in the comparison of model a and model b to which this appendix is addressed, that there was a political/lobbying logic to their exclusion.[10] For example (as John Marburger had warned) it already was recognized that their standards for data reliability and rigorous scientific analysis could not be met.

I suspect that economists also were shoved aside because they would be intellectually opposed to the one-sided "scare America about jobs" analysis and marketing plan. Gathering Storm – and Norman Augustine and Ralph Cicerone in their press briefings and testimony – built the National Academy's public case merely by citing examples of increasing globalization

and free trade - using a sales strategy of rhetorical horror and dumbed-down tribal paranoia rather than Economics 101 to think about the implications (excerpts from Norman Augustine's testimony are attached.) Thus (to economists) the fact that software engineers in India provide services to American companies (!), or that Latin American architectural firms are subcontractors in large architectural projects (!), is not a "Gathering Storm." Rather these are examples of growing free trade (that always is mutually beneficial) and of a division of labor based on comparative advantage, which also is good news for everyone. (American companies that make the better deals with companies in India benefit themselves, their stock holders, and their customers.)[11] Other examples used by Augustine *et al.* were just goofy: in the 21st century, the geographic fact that the next super particle accelerator is being built in a country that is not the USA is not inherently horrific. At least one of the urgent policy recommendations that Augustine *et al.* wanted to enact for their political coalition (the extraordinary 40% investment tax subsidies to Exxon *et al.*, discussed below) might have achieved a true academic rarity from the Academy's members: unanimous scientific agreement among 52 economists (although in opposition to the package that Augustine *et al.* wanted the Academy to endorse.)[12]

D.) Stonewalling

We expect drugs, when they are shown not to be safe and effective, to be withdrawn. By contrast, both the National Academy of Sciences and the National Science Board did not act according to model a. Instead, they stonewalled critics and organized a national lobbying campaign. The National Academy awarded a medal to Norman Augustine "for his contributions to the vitality of science" in 2006. It reconfirmed (2007) that the "urgent recommendations remain unchanged" and deployed its scientific prestige to discredit critics. [By now, the damage to the

reputations of these early dissenters may be partly restored – i.e., but thanks to a small number of journalists who pursued the story until national opinion leaders (e.g., Zakaria and Varmus) became publicly involved and the political momentum for funding fell apart in early 2008 – not because Cicerone, Augustine, Vest, Bement, Beering, *et al.* were honest and trustworthy scientific advisers.] [13]

- In sum: Neither the National Academy nor the National Science Board have withdrawn their recommendations. They had called press conferences and written high-visibility "Trust us. We are the nation's best scientists. We speak with one voice. This is urgent and important" Reports. It is as if a group of physicians went beyond the evidence and told a patient that he/she suffered from the early stage of a threatening illness that required immediate and expensive treatment by themselves and their friends. And also misrepresented the treatment options, even if the diagnosis should prove correct. [14]

II. Favors to Exxon *et al.*

The National Academy of Sciences and the National Science Board operate with government charters. They are legally obligated to provide "unbiased and impartial scientific advice, both in fact and in appearance." In America, it is illegal for these government and quasi-government agencies, supported by taxpayers, to operate outside their authorized role and engage in lobbying and/or rally political movements or distort truth to influence public opinion. Even for self-perceived good causes. (And a good legal counsel normally would warn these institutions against crossing the line and engaging in sophistry about their true intent.) Thus, I think that

transparency and full disclosure will establish that "crossing the line" (to model b) was intentional.[15] For example:

A.) **Benefits for Coalition Supporters**

The Augustine Commission included the CEO's and other top current/former officials from Exxon and six other large corporations. They received a *quid pro quo* by the National Academy's endorsement for their agenda of a huge increase in tax credits/subsidies.[16] (I.e., bypassing its 52 economists, the National Academy's inner circle awarded Exxon *et al.* and their stockholders a huge, permanent doubling of an annual investment tax subsidy (credit), from 20% to 40%, and extra billions of dollars via expansion (inserted in Gathering Storm without discussion) of the expenditures covered. . . .[17]

Pushed further, the analysis shows that the voting majority of the (twenty members of the) Augustine Commission coalition had concurrent ties with large corporations that would receive large and immediate financial benefits if Gathering Storm was believed. In addition to the seven members who were identified as coming from the corporate world (Exxon, DuPont, Intel, Eli Lilly, Merck & Co, Lucent Technologies and Lockheed Martin) other Commissioners served concurrently as compensated Board members of beneficiaries – two members (Shirley Ann Jackson and Charles Vest) were on the Board of Directors of IBM in 2005. Anita K. Jones was elected to the Board of BBN in 2004. Concurrent with his chairmanship, Norman Augustine (a former CEO of Lockheed Martin) also apparently was a member of the Boards of Proctor and Gamble, Riggs National Bank, and Conoco-Phillips. Robert Gates was on the Boards of Fidelity Investments, Parker Drilling Company, and SAIC, among others. Most Commissioners

probably had stock holdings requiring legal disclosure. Thus, it appears that a voting majority had many conflicts of interest that were undisclosed, but should have been ethically and legally disclosed. [18] [19]

Corporate America has underwritten many earlier lobbying reports over the years to promote this tax handout. [*Caveat emptor*: not even Republican Congresses and Presidents have been persuaded!] [20] Yet America's leading scientists, via the National Academy, put their full credibility behind the claim that handouts to Exxon *et al.* are an "urgent priority." [21]

B.) **Killing Ideas Unwanted by Business**

The existence of a National Academy/corporate alliance also is suggested in missing tax alternatives that the Augustine Commission quietly killed. For example, while I disagree with the "Gathering Storm" forecasts and rationales, I think we are massively under-investing in scientific R&D and innovation, probably in all fields of science. But even if the Commission believed Gathering Storm, it would be a better recommendation to create an R&D tax on business income, to be paid by all US corporations above a certain size. The revenue would be earmarked, just as we earmark the gasoline tax for highway construction and maintenance. The rate for this tax could be adjusted to pay for whatever higher R&D expenditures we decide. Corporations also could have a substantial degree of control – they could reduce their federal R&D tax by any money that they use to fund public domain research at colleges and universities or contribute to science and technical education.[22]

C.) **Rationalizing Self-Interest: E.g., What Happened to the Liberal Arts?**

Probably, it is obvious that the National Academy of Sciences and National Science Board operated with a pro-scientific (i.e., physical science) bias.[23] By contrast - if we are open to the hypothesis that leadership is important for the innovation and competitiveness of US corporations - there is interesting scientific evidence from long-term studies of graduates of Harvard and several other schools that **liberal arts effectiveness** is the nation's most powerful educational investment. This is a measurable cluster of skills and sensibilities (e.g., analytical ability, empathy/emotional intelligence) to which many different undergraduate disciplines can contribute and that are nurtured by distinctive institutional cultures. But the National Academy of Sciences did not even mention this competing model, with different implications for national spending priorities to face the darkening future that it perceived.[24]

III. Breakdowns of Institutional Integrity

The National Academy of Sciences presents itself as a trustworthy institution. Its Reports are submitted with unanimity after a judicial-like internal review. National Academy members serve without compensation [i.e., although the income from the National Academy's scientific advice business is about $250 million/year – LE]. For Gathering Storm Ralph Cicerone, President of the National Academy of Sciences, invoked this full credibility of his organization (beginning with the signing of its enabling legislation by President Lincoln in 1863) when he appeared before Congress. And he assured Congress that the Augustine Commission's work to address the nation's future was the best that the National Academy could produce: twenty of twen-

ty-one people on his list of the ideal panel had accepted – Nobel Prize winners, captains of industry, distinguished university Presidents, and former holders of public office.[25] And "forty experts" had independently reviewed the work! And several Pantheons of distinguished scientists (attached) were guarantors of his organization's work and recommendations to the nation.[26] Across the Potomac River, at its Northern Virginia headquarters, the National Science Board (its members nominated by the President and approved by Congress to their positions of national trust) issued its K-12 Report with a unanimous vote.

Yet, as the Gathering Storm and K-12 reports unraveled a very different picture emerged of the organizational processes by which the Reports were crafted. And how the high-profile work of both organizations has become uninterpretable:

A.) A Mafia-like Code of Silence

Looking back at the failed lobbying strategy, the patterns of whistle-blowing suggest that inhibiting social pressures within our national science Establishment contributed to the silence and early façade of public unanimity after the Gathering Storm press conference. For example, although we now know that science Establishment experts and the senior officials crafting the cornucopia lobbying project (e.g., Cicerone, Vest, Augustine, Bement, and Beering) already knew by April 2005 that the "600,000 Chinese engineers" number was unreliable, the first observed public whistleblower (cited by Zakaria) was a young reporter ("The Numbers Guy" columnist) at the Wall Street Journal. And according to his column nobody in the US science Establishment had leaked the truth – he took the initiative to check their numbers, which felt wrong. Science reported that unreliable numbers in the Augustine Report were discovered in

2006, only after two Duke faculty members (from outside the national science Establishment) made a special trip to Asia.[27] Still later, it was not until 2008, when Harold Varmus became an effective whistleblower (on The Charlie Rose Show of 4/7/2008), that an opinion leader of our national scientific Establishment publicly cited research that undermined the K-12 cornucopia package.[28]

B.) The Uninterpretable "Meaning" of a National Academy Report

We cannot be certain, until there is full disclosure, why the National Academy and the National Science Board failed to fix the scientific unreliability of their initial national policy recommendations. But the organizations do not appear to have acted with (model a) collective integrity and responsibility. For example:

- The National Academy's Dream Team seems to have walked away from the Report after the draft was completed in 2005. (The 2007 final version only discusses meetings in August 2005). Instead they seem to respond to growing scientific criticism by distancing themselves: In the 2007 preface (attached) they hint that they might have acted too quickly in 2005: "[T]he time allotted to develop the report (10 weeks from the time of the committee's first gathering to report release) limited the ability of the committee to conduct an exhaustive analysis" and "The study and report was carried out with an unusual degree of urgency . . ."][29] They imply that, as individuals, they do not actually vouch for each policy recommendation: "It was not possible to assemble a committee of 20 members with direct expertise in each area."

- A closer reading of the 2007 Report's disclaimers leaves unclear which, **if any**, of their 20 urgent and costly recommendations the National Academy and the Augustine Commission

still believe are reliably supported. They say that "available information is only partly adequate for the committee's needs" and that ". . . definitive analyses on many issues are not possible given the uncertainties involved."[30] But – although they and the National Academy are recommending billions of dollars be spent for their ideas - they are not specific about the implication of these alarming disclaimers for each of their recommendations. The reviewers at the National Academy of Sciences did not require them to be specific about what they were trying to say. Viewed as model a scientific documents, neither Report is interpretable.

C. Ineffective Stewardship and Planning

Probably the most alarming discovery about organizational behavior is how irresponsible and historically negligent our national science Establishment has been, at least as it has acted through these specific institutions. Congress, in effect, scheduled their Final Exam. And, suddenly, Congress discovered – and rediscovered after eighteen months for a second chance - that nobody has been doing homework at the National Academy of Sciences and the National Science Board.[31] As Marburger warned in Science – and as whistleblowers and other scientists have informed Congress – there has been no responsible system for stewardship and rapid learning about key policy challenges. There are an abundance of Pantheons, advisory committees, and scientists who lend their names, yet an alarming lack of thinking and planning. Even the Dream Team members – and many are responsible for important institutions – seem to have been unprepared for their Final Exam question of evidence-based recommendations about what the nation should do next. And only after a focused period of intense work did they discover that the data systems were not there for evidence-based answers . . . and then (without taking steps to

design, list, or recommend the data systems for rapid learning in its top 20 recommendations) the Establishment's Dream Team walked away.[32] [33]

IV. Summary: Changing Organizational Models

In 1991, Donald Kennedy (the former Editor-in-Chief of Science) resigned as President of Stanford. The scandal (according to The New York Times) was "the discovery by auditors that the university had overcharged the Federal government for millions of dollars [possibly $200 million across the eleven years of Kennedy's Presidency] in indirect costs for research, with some of the improper spending used for cedar closets, antiques and fresh flowers in Mr. Kennedy's home."[34] Yet – for the current case, in 2008 – the important fact about the resignation is that Stanford's guiding institutional commitment in 1991 was to the reality and appearance of institutional integrity (i.e., even though Donald Kennedy's Administration had almost-successfully secured an additional $200 million on Stanford's behalf.) By contrast – looking across the behavior of the National Academy of Sciences, National Academy of Engineering, National Science Board, and NSF in the current case – nobody has resigned, although billions of dollars and poorly conceived plans for the future of the nation were being sold by unreliable numbers and distorting and withholding evidence, "dumbing down" standards for scientific judgments, etc. Once-trusted scientific advisers have been trying their best to mislead and steamroller Congress, the public, and a once-trusting press. Thus the question: *Why today – contrasting American institutions in 1991 and 2008 – has nobody at the top resigned?*

The difference between the two cases, I suspect, is that while Stanford was retaining the a.) "integrity" organizational model, the Washington-oriented institutions have shifted to the b.)

political/lobbying model. And the behavior of these senior officials in 2008, because their cornucopia lobbying was "pro-science," was institutionally forgivable given what these institutions had become.

It is worth emphasizing that, today, we are witnessing a (thankfully) failed effort to waste billions of dollars of resources in a good cause, make (urgent!) huge annual payments to Exxon *et al.* and their stockholders, restructure the national role of our universities, use large payments of federal scholarship funds to change the choice of undergraduate majors, launch poorly planned projects for our K-12 educational system, etc. But the failure of these schemes came, ultimately, via honest journalists and outsiders [35] – not from the self-governing systems of American science and institutions entrusted to give honest, unbiased, and reliable scientific advice.

Attached Documentation

John Marburger, "Wanted: Better Benchmarks," Science (May 20, 2005), p. 1087.

Jeffrey Mervis, "Marburger Asks Social Scientists for a Helping Hand in Interpreting ta," Science (April 29, 2005), p. 617.

Excerpt from Norman Augustine's Testimony to the Committee on Energy and Natural Resrouces, U. S. Senate (October 18, 2005).

"Preface and Acknowledgements" in Jeffrey T. Macher and David C. Mowry (Eds.), Innovation in Global Industries: U. S. Firms Competing in a New World. (Washington, DC: National Academies Press, 2008). Excerpt.

Pantheon/Guarantor Lists: the Augustine Commission, the Policy and Global Affairs Committee of the National Research Council, the National Research Council's Governing Council, the National Academy of Sciences Governing Council, the National Science Board, NSF's Advisory Committee on the Government Performance and Results Act.

Endnotes

[1] Lloyd Etheredge directs the Government Learning and International Scientific Networks projects at the Policy Sciences Center Inc. (a public foundation in New Haven, CT created by Harold Lasswell, Myres McDougal and their associates in 1948). URL: http://www.policyscience.net.

Two groups of organizations are discussed in this paper: a.) The National Academy group. The National Academy of Sciences and the National Academy of Engineering organized the Augustine Commission and its Report through the National Research Council (NRC), which is their institutional vehicle for conducting studies. Ralph Cicerone is President of the National Academy and Chairs the NRC; Charles Vest is President of the National Academy of Engineering, Vice-Chair of the NRC, and served on the Augustine Commission; b.) The National Science Foundation/National Science Board group. The National Science Foundation (Director – Arden Bement) is supervised by the National Science Board (Chair - Steven Beering) which issued the K-12 Report. The National Science Board's 24 members have full-time jobs outside of Washington: the NSF Director chairs their Executive Committee and NSF provided the staff and intellectual support.

[2] National Science Board, National Action Plan for Addressing the Critical Needs of the U.S. Science, Technology, Engineering and Mathematics Education System (October 30, 2007). (Washington, DC: National Science Foundation, 2007). Online at www.nsf.gov/nsb/stem/index.jsp. National

Academy of Sciences *et al*., Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future.(Washington, DC: 2007). Online at www.nap.edu. Final edition]. The "draft" 2005 edition is no longer available. (In 2005, Congress and the press were not told that the 2005 document was a draft. The testimony and arguments that shaped the legislation and public discussion are based on the 2005 edition.) The "Preface" to Gathering Storm (pp. ix – x) recounts the pre-history of the Augustine project, beginning in February 2005, that was a background to the expression of Dr. Marburger's views in April and May. While there was an invitation from Congress later, the initiatives came from the National Academy of Science and the National Academy of Engineering.

[3] Re the selling campaign of "hundreds of articles, books, and blogs, including a Fortune cover story, the Congressional Record, and speeches by technology titans like Bill Gates" see Fareed Zakaria, The Post-American World (NY: W. W. Norton, 2008), p. 187. See also Yudhijit Bhaitacharjee, "New Analysis Questions Push for More Degrees," Science (November 16, 2007), p. 1052: "*Academics, business leaders, and politicians have warned repeatedly* [italics added] that the United States risks losing its economic edge unless it produces more scientists and engineers. . . ." The story in The New York Times (October 13, 2005) was by William J. Broad, "Top Advisory Panel Warns of an Erosion of the U. S. Competitive Edge in Science." Online at www.nytimes.com.

Journalists may have assumed that the scary "600,000 Chinese engineers" number was reliable because it surfaced in July 2005 as part of a cover story in Fortune. As an historical footnote: There are grounds to suspect that the Fortune story was planted as part of a political strategy. (Fortune would not disclose a source to the Wall Street Journal). Re this aspect of the story see Gerald W. Bracey, "Heard the One About the 600,000 Chinese Engineers?" Washington Post (May 21, 2006), p. B3.

[4] John Marburger, "Wanted: Better Benchmarks," Science (May 20, 2005), p. 1087.

[5] Jeffrey Mervis, "Marburger Asks Social Scientists for a Helping Hand in Interpreting Data," Science (April 29, 2005), p. 617.

[6] "Free Executive Summary" online at http://www.nap.edu.

[7] The National Academy sponsored the conference in Washington and the research. The fact that the conclusions were reported on April 19, 2006 is mentioned in "Preface and Acknowledgements" (attached) in Jeffrey T. Macher and David C. Mowry (Eds.), Innovation in Global Industries: U. S. Firms Competing in a New World. (Washington, DC: National Academies Press, 2008), p. 10. The earlier study is U. S. Industry in 2000: Studies in Competitive Performance (Washington, DC: National Academy Press, 1999).

[8] Both studies underscored the importance of smart, innovative, and adaptive behavior by individuals and institutions, by contrast with the NSF/National Science Board K-12 crisis report that focused on such measures and goals as the comparative knowledge of scientific facts of fifth-grade students or mean differences in the ability to solve high school mathematics problems achieved in Asia by intense social pressure and six-day/week secondary schools.

[9] Marburger is cited in Donald Kennedy, "STEM – But No Stem," Science (August 24, 2007), p. 1009; "Danger exists . . ." in National Science Board, op. cit., p. 3. Granted, everybody should work harder and learn more at an earlier age. However, alarmist comparative data about eighth graders or fifteen year olds cannot be interpreted until the National Science Board specifies what, exactly, should be measured to evaluate "basic STEM literacy" or define its criteria like "contribute significantly to, or fully benefit from . . . ." We do not know if their well-intentioned national action plan is too much, too little, or aimed in the wrong direction, whether it could be improved, etc. Although the National Science Board declares that (p. 22) "The recommendations in this action plan are *essential* [italics added]. . ." they have

not defined and measured "basic STEM literacy" or tested their causal models, and they do not know, either.

[10] Under the Presidency of Bruce Alberts the National Academy revised its rules so that members do not have a right to review or comment upon draft reports in their fields, nor to have their dissenting views included in publications, and there is no institution-level mechanism to which they can appeal. This change partly reflects the growth of the National Research Council system to 300+ reports/year and the purely voluntary and uncompensated work of the scientists . In return for their uncompensated work, the study Directors and members are given the right to shape their own reports and to decide how to respond to the comments of reviewers. [Members who help to raise the money for a study (e.g., Vest, Augustine, and Cicerone – in an earlier case known to AAAS, Duncan Luce) also have a de facto standing to shape a report.] This reform also means that there is no longer a sense of, or mechanism for, collective responsibility by the National Academy. Within the National Academy it is Augustine's (and Vest's and Cicerone's) Report, although outsiders believe that a greater concurrence and imprimatur are implied.

[11] Although there always are legitimate worries about winners and losers and adjustments to change.

[12] The sharp-elbowed exclusion of economists is a tactic that can result in a definitive judgment (of model b behavior) in the academic world, in addition to Washington. The exclusion of economists probably was intellectually unfortunate for the country. They are likely to have insisted on a balanced analysis – the balance being on the positive side – and to emphasize the extraordinary *opportunities* that America has for global competition and to benefit from globalization. They might have urged a stronger and useful focus on global business opportunities by U.S. companies of all sizes. And also they might have endorsed a stronger (perhaps, better designed) package of pro-science and pro-R&D investments, with the sound logic that R&D (and innovation and adaptation, etc.) is America's comparative advantage.

[13] "Engineered Numbers?" Science (January 6, 2006), p. 21.

[14] An interesting student project would be to compare the use of CIA intelligence and evidence-distorting tactics that the Bush administration used to sell the US invasion of Iraq.

[15] Re working outside the authorized legal framework intentionally: Norman Augustine spoke candidly and enthusiastically about some of their political strategies and "Our biggest challenge is to sustain this coalition for the next 10 to 15 years." See Jeffrey Mervis, "Congress Passes Massive Measure to Support Research, Education," Science (August 10, 2007), p. 736. My perception is that passage of the America COMPETES bill was symbolic and that the funding support is not there because scientists are now seen as just another interest group.

[16] Usually, tax credits are an unreliable way to change behavior as corporations can simply declare "fiscal relief!" and reduce their own increase in expenditures. Also, capital markets are working well, interest rates are low, and we are not dealing with helping "infant industries" or startup companies. (I.e., subsidizing Exxon *et al*. and their stockholders to undertake investments that they should make in their own self-interest is a waste of money.) Politically, it is worth noting that in the summer of 2008 corporate lobbyists began to work on further ideas – using a National Academy conference in Washington – to gain scientific credibility for brand-name advertising as a qualifying investment tax credit activity (e.g., since Budweiser's advertising and support for sporting events can increase its competitive market share and its future income).

[17] Current law has been limited and awards the investment tax credit only for increases in R&D compared to a baseline period. It is designed as an incentive to increase R&D steadily. But Augustine et al. recommended that American taxpayers reimburse Exxon et al. at 40% for *all* that they spend. The recommendation was artfully phrased, without economic analysis: *"Finally the definition of applicable expenses*

used to calculate the tax credit should be expanded . . . The credit should be extended to companies that have consistently spent large amounts on research and development so that they will not be subject to the current de facto penalties for having previously invested in research and development," p. 197. Corporations also are recommended to receive 40% taxpayer subsidies for "defined benefits, retirement plans, healthcare plans, and so on" of employees engaged in research (ibid.). . . . Augustine *et al.* said that the total costs would be $10 billion/year: it will be interesting to see, via full disclosure, if the estimate for this package was made by methods that are scientifically reliable.

[18] I cannot complete and confirm an analysis via the Internet. Nor can this be done directly: The National Academy changed its rules under Bruce Alberts and does not permit access to conflict of interest filings by the public. It also remains unclear whether Norman Augustine and other members filed the legally required conflict of interest forms concerning stock owned in companies that would receive immediate and substantial benefits if Gathering Storm was believed.

The ethical reasons to disclose all conflicts of interest are: a.) to serve as a deterrent and b.) to support informed consent. If a consumer/user of the Augustine Report saw a written disclosure of the extent of corporate ties, and estimates of the immediate payments to the corporations represented on the Commission, he/she would be alerted to ask skeptical questions about the scientific foundation for the National Academy's work. However the National Academy has, by now, developed remarkable sophistry (a "right to privacy," etc.) about these issues, and it has ethical exceptions for individuals who are formal officers or employees of organizations and who have alleged legal and ethical obligations to present or defend viewpoints. Etc. My point is not that the National Academy violated its own ethics, conflict of interest, and public disclosure rules but that (model b) it did not do so.

[19] Nor did Ralph Cicerone (President of the National Academy of Sciences) and Charles Vest (President of the National Academy of Engineering), the senior officials with legal liability, disclose the annual

donations and income to their National Research Council [about $65 million/year from private and non-federal sources in 2007, although complete and audited information has not been provided to Congress in recent years] by the corporations and lobbying groups whose members served on the Augustine Commission and the working group that slipped-in the Gathering Storm tax give-away. See "Revenue Applied to 2007" in Report to Congress, 2007 (Washington, DC: National Academy Press, 2007) online at http://nationalacademies.org/annualreport.

[20] Gathering Storm also says that it is urgent for the US rate to double from 20% to 40% "to be competitive" with other nations. However this bold claim was never submitted for rigorous scientific review by independent economists. [One of the obvious omissions in the Commission's "to be competitive" sound-bite justification is the scientific requirement to control for the lower capital gains tax in America, which already provides special competitive advantages for investment capital raised by the sale of stock.] The Commission's charts of tax subsidies in different countries should be viewed with caution: One of the "outsmart government" strategies of large national corporations and multinationals is to secure tax advantages in one jurisdiction and then to lobby in other jurisdictions to receive the same benefits "to be competitive."

I think that the one-sided scientific analysis in the public statements, Congressional testimony, Executive Summaries and competitive inclusion in the list of urgent 20 recommendations are *prima facie* evidence of fraudulent intent, judged by the expectations of impartial and reliable scientific analysis. This appears to be model b behavior: In the perspective of model a the ethics of the Dream Team and the National Academy are astonishing: it is as if scientific advisers, before Hurricane Katrina, recommended unreliable construction for the levees and also used their scientific credibility to recommend their friends to do unnecessary work at inflated prices.

[21] Re the perceived likelihood that corporate executives were using a competitiveness initiative for self-interested lobbying for a permanent tax credit see the White House staff perspective discussed in Jeffrey Mervis, "How the Competitiveness Initiative Came About," Science (February 17, 2006), p. 929.

[22] This mechanism also allows corporations to think about and fund university research in new or adjacent fields that might benefit them, but which they could not justify as current corporate R&D expenses.

[23] There are indications that Gathering Storm is an end-run by Charles Vest and Norman Augustine to boost funds for engineering, just as Harold Varmus doubled the NIH budget. (Engineering R&D is recommended to double compared to biomedical research.) Augustine et al. create winners and losers across the sciences – including the social sciences (that are not mentioned.)

[24] David G. Winter, David C. McClelland, and Abigail J. Stewart, A New Case for the Liberal Arts (San Francisco: Jossey-Bass, 1981).

[25] Testimony of Ralph J. Cicerone before the Committee on Energy and Natural Resources. U. S. Senate (October 18, 2005). Online at http://www7.nationalacademies.org/ocga.

[26] In addition to the membership of the Augustine Commission, I enclose the Pantheons from the NRC Committee on Science, Engineering and Public Policy, which was responsible for the Commission's work, the National Research Council Governing Council, the Governing Council of the National Academy, the National Science Board (its Consultants were members, whose term has expired, who served during the K-12 pseudo-plan period), and NSF's Government Performance and Results Act Committee (responsible for overseeing national strategic planning for rapid learning and results).

[27] "Engineered Numbers?" Science (January 6, 2006), p. 21.

[28] It is somewhat chilling to consider why the 52 economists and other excluded social scientists who have been elected to the National Academy did not protest in public. Earlier, in the Luce Commission case (discussed in background filings for government investigators, online at www.policyscience.net) supporters of the late Donald Campbell pressed strongly for continued support of "honest broker" evidence-based public policy research that would test Republican policy assumptions as Democratic policy assumptions had been tested in the Great Society. (As current AAAS officers know, there was an unsuccessful off-the-record meeting of the Carnegie Commission on Science, Technology and Government, organized by the former AAAS President David Hamburg, to underscore the case for scientific integrity and support for these civic learning investments.) In consequence, the National Academy under three Presidents has sustained the derailment of the (unwanted) Campbell tradition, apparently because of the perceived potential for evidence-based public policy ("policies as experiments") research programs to anger Republican zealots and endanger the national science budget. A memory of the fate of Campbell *et al.* may have influenced the recent silence.

[29] Gathering Storm, "Executive Summary," p. 2. The claim about being too rushed – for example, being unable to hold public hearings or receive public comment about a national plan or do thoughtful analysis – is unpersuasive. The National Academy initiated and helped to design the invitation for the study and surely Congress gave it all of the time that it requested.

[30] Ibid.

[31] By contrast, NIH, NASA, FDA and the Institute of Medicine do use their advisory committees for serious long-range planning and they develop data systems that help to monitor, discuss, and improve their effectiveness. Thus, Congress has vivid examples of scientific agencies and organizations who have sustained model a behavior.

[32] Under David Lightfoot, NSF's Assistant Director for social sciences, there is a new "science of science policy" initiative to fund research centers. However, the level of funding suggests that this is not a serious and high priority. And since all of the major macroeconomic forecasting models have been eroding for more than a decade and need fresh and innovative thinking and better data systems to include the vast economic changes in the world - which the NSB/NSF system has not been willing to fund – the NSB/NSF system probably needs to be rethought and reorganized.

[33] In consequence of failing to recommend new data systems – i.e., and one reason that model b institutions should be redesigned – there have been lost opportunities. The Institute of Medicine (IOM), for example, has pioneered an extraordinary new rapid learning healthcare system [and received overwhelming bipartisan support in Congress] based on 100 million patient records with genomic data (etc.) A similar research strategy would be straightforward to improve science and mathematics education – beginning, for example, with online pools of quiz and test items that teachers and students could use to develop large N databases, compare results, refine diagnostic capabilities to understand what is working (or not) with different students and explore the match of best practices to different students. Students themselves, with appropriate privacy guarantees, could use the system to supply further research data about themselves and, in return, receive feedback and suggestions for supplemental Web-based teaching approaches (etc.) that would make learning easier and faster. (They also could become more active learners, and they might become interested in research.) Nationally (and internationally) NSF still operates (in 2008) with such extraordinary, continuing data loss.]

Re IOM: It also has organized a series of extraordinary conferences (under-reported in Science) to assess the relative strengths of randomized clinical trials and very large N databases. For example JoAnn Manson's review of different results from randomized clinical trials and large N field observations concerning hormone replacement therapy for women. See http://www.iom.edu and the Roundtable on Evi-

dence-Based Medicine, and also http://www.iom.edu/CMS/3718.aspx. Similar serious issues need to be worked through for science education research.

[34] Jane Gross, "Stanford Chief Quits Amid Furor on Use of Federal Money," The New York Times, June 30, 1991. Online at www.nytimes.com.

[35] Also, a debt to the late Richard Feynman. He resigned from the National Academy and warned that it was preoccupied with awarding and managing a scientific status hierarchy - i.e., who was distinguished enough to be elected? – rather than science. The National Academy system was not intended by Congress as a status-creating institution for top-down rule.

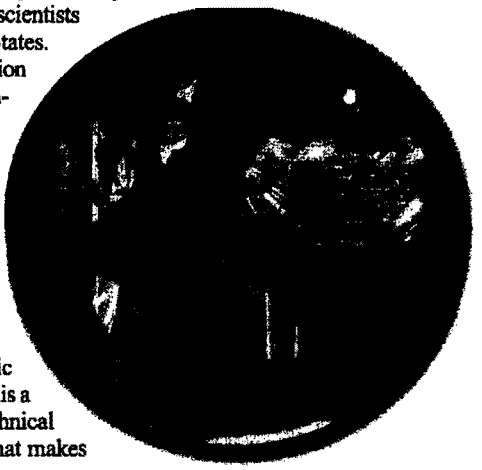
Today, the National Academy and National Science Board/NSF models also may be dysfunctional because too much money is affected by their recommendations. They also wield extraordinary power behind closed doors (for example, in the case of NSF and the National Science Board, to shape budgets and the future of entire disciplines) and may inhibit legitimate and needed criticism.

Wanted: Better Benchmarks

How much should a nation spend on science? What kind of science? How much from private versus public sectors? Does demand for funding by potential science performers imply a shortage of funding or a surfeit of performers? These and related science policy questions tend to be asked and answered today in a highly visible advocacy context that makes assumptions that are deserving of closer scrutiny. A new "science of science policy" is emerging, and it may offer more compelling guidance for policy decisions and for more credible advocacy.

All developed and many developing nations today have accepted the need to support technical education and research as keys to future economic strength. Studies from the 1990s show that U.S. investment in R&D development led to greater economic productivity, and that information technology, in particular, has been a major factor in sustaining U.S. productivity growth. The question is not whether R&D investments are important, but what investment strategies are most effective in the rapidly changing global environment for science. Here, ideas diverge.

Take the issue of the technical workforce. Sharply differing opinions exist regarding the production of U.S. scientists to meet possible impending shortages.* The differences turn on the interpretation of "benchmark" data regarding the numbers of degree holders produced in the United States and other countries, particularly China and India. In the latter countries, the rates of growth in the numbers of scientists are high, although actual numbers are small relative to those in the United States. Advocates for increased production of U.S. scientists point to our low graduation rates, whereas critics emphasize limited short-term job opportunities for graduates and postdocs. Resolution of this issue requires a broader understanding of socioeconomic factors in a number of nations that would allow us to attach probabilities to different future scenarios. Optimal strategies for large mature economies such as that of the United States will doubtless differ from those for smaller or developing economies. Here, as elsewhere in policy debates, the benchmarks do not speak for themselves.



The data we choose to collect do say something about the framework in which we understand the relations among science, government, and society. Our customary reliance on historical trends in national data, however, creates an inertia that causes data categories to lag far behind changes in the dynamic socioeconomic framework, now evolving internationally. We know that there is a complex linkage between workforce issues and other economic variables. Technical workforces in different countries are increasingly interdependent in a way that makes single-country data unreliable for workforce forecasts.

Globalization and changing modes of science that have blurred disciplinary distinctions have undermined the value of traditional science and engineering data and their conventional interpretations. The old budget categories of basic and applied R&D, still tracked by the U.S. Office of Management and Budget, do not come close to capturing information about the highly interdisciplinary activities thought to fuel innovation. A 1995 U.S. National Research Council (NRC) committee chaired by Frank Press took a step toward data reform when it introduced the combined category of "federal science and technology," declaring that "the linear sequential view of innovation is simplistic and misleading." More attention, however, is needed to definitions and models that suit current needs of policy. A recent report from the NRC Committee on National Statistics found that "the structure of . . . data collection is tied to models of R&D performance that are increasingly unrepresentative of the whole of the R&D enterprise." Further, "It would be desirable to devise, test and, if possible, implement survey tools that more directly measure the economic output of R&D in terms of short-term and long-term innovation."†

Relating R&D to innovation in any but a general way is a tall order, but not a hopeless one. We need econometric models that encompass enough variables in a sufficient number of countries to produce reasonable simulations of the effect of specific policy choices. This need won't be satisfied by a few grants or workshops, but demands the attention of a specialist scholarly community. As more economists and social scientists turn to these issues, the effectiveness of science policy will grow, and of science advocacy too.

John H. Marburger III

John H. Marburger III is director of the Office of Science and Technology Policy, Executive Office of the President of the United States, In Washington, DC.

*D. Kennedy, J. Austin, K. Urquhart, C. Taylor, *Science* **303**, 1105 (2004). †*Measuring Research and Development Expenditures in the U.S. Economy*, L. D. Brown, T. J. Plewes, M. A. Gerstein, Eds. (National Academies Press, Washington, DC, 2005).

10.1126/science.1114801

CREDIT: DIGITAL VISION AND L. CREVELING/SCIENCE

Science 29 April 2005
308, p. 617

SCIENCE POLICY

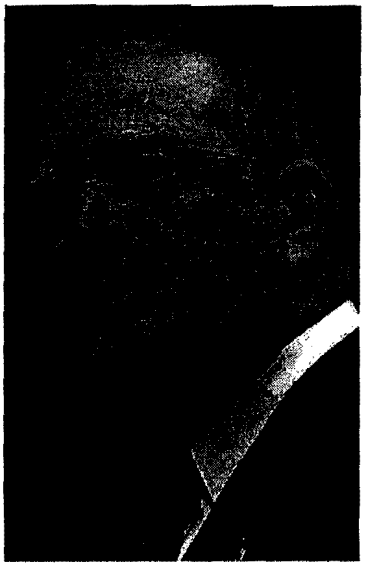
Marburger Asks Social Scientists for A Helping Hand in Interpreting Data

Will the growing number of engineers graduating from Chinese universities be a boon or bane to the United States and the rest of the world?

John Marburger would like to tell his boss, President George W. Bush, how that trend might affect the U.S. technical workforce and the country's economy—or even how long it's likely to persist. But the president's science adviser says he'd be flying by the seat of his pants. "I won't take a position on whether it's good or bad based on the data," says Marburger, "because we don't have adequate models."

Last week Marburger challenged the scientific community to help him find answers to a host of questions like these that puzzle science policymakers. "I am suggesting that the nascent field of the social science of science policy needs to grow up, and quickly," Marburger told a Washington, D.C., gathering sponsored by AAAS (which publishes *Science*). Economists have applied "behavioristic" tools successfully in other fields, says Marburger, pointing to analyses of how changes in retirement patterns might affect Social Security. He urged scientists to incorporate "the methods and literature of the relevant social science disciplines" to explore trends such as the community's "voracious appetite" for federal research funding, the "huge fluctuations" in state support for public universities, and the continuing advances in information technology.

Marburger's call to statistical arms was generally welcomed by policy analysts, who agreed that their field hadn't made much progress on the big questions confronting decision makers. "We operate with blinders on," says Daniel Sarewitz of Arizona State University in Tempe, a former congressional staffer who studies the interplay of science and society. "Rather than simply tracking the growth in industrial R&D, for example, we also need to look at how that affects public sector investment. The set of assumptions that goes into S&T policy is unbelievably oversimplified."



Supermodel. U.S. science adviser John Marburger wants better econometric models of research trends.

That lack of rigor, speculates Harvard economist Joshua Lerner, part of a group studying U.S. innovation policy, could be a result of the limited interaction between the disciplines. "A lot of science policy has an amateur-hour flavor to it because it's done by scientists who aren't familiar with the principles of the social sciences," he says. "But it's also our fault. We economists haven't communicated as well with other disciplines as we should."

Another factor is the sheer difficulty of coming up with a theoretical framework that takes into account enough of the important variables to generate useful results. "Such a model has proved to be elusive," says Rolf Lehming, who oversees the National Science Foundation's biennial volume: *Science and Engineering Indicators*. Previous efforts to nurture such a community of scholars were abandoned, notes Mary Ellen Mogee, a science policy analyst at SRI International in Arlington, Virginia, including the 1995 elimination of the congressional Office of Technology Assessment.

Marburger says that he believes a new effort can be mounted at minimal cost. "We're not talking about a lot of money; ... funding is not a rate-limiting factor in this equation." But others see a federal role as crucial. Connie Citro, who directs the National Academies' Committee on National Statistics, says that "there needs to be at least a signal [from the federal government] that proposals would be welcome." Sarewitz admits that a plea for federal support is self-serving, but he adds, "that's what drives academics in any field."

–JEFFREY MERVIS

Rising Above The Gathering Storm:
Energizing and Employing America for a Brighter Economic Future [Excerpts]

Statement of

Norman R. Augustine
Retired Chairman and Chief Executive Officer
Lockheed Martin Corporation

And

Chair, Committee on Prospering in the Global Economy of the 21st Century
Committee on Science, Engineering, and Public Policy
Division on Policy and Global Affairs
The National Academies

before the

Committee on Science
U.S. House of Representatives

October 20, 2005

Mr. Chairman and members of the Committee.

Thank you for this opportunity to appear before you on behalf of the National Academies' Committee on Prospering in the Global Economy of the 21st Century. As you know, our effort was sponsored by the National Academy of Sciences, National Academy of Engineering and Institute of Medicine (collectively known as the National Academies). The National Academies were chartered by Congress in 1863 to advise the government on matters of science and technology.

The Academies were requested by Senator Alexander and Senator Jeff Bingaman, members of the Senate Committee on Energy and Natural Resources to conduct an assessment of America's ability to compete and prosper in the 21st century—and to propose appropriate actions to enhance the likelihood of success in that endeavor. This request was endorsed by Representatives Sherwood Boehlert and Bart Gordon of the House Committee on Science.

To respond to that request the Academies assembled twenty individuals with diverse backgrounds, including university presidents, CEOs, Nobel Laureates and former presidential appointees. The result of our committee's work was examined by over forty highly qualified reviewers who were also designated by the Academies. In undertaking our assignment we considered the results of a number of prior studies which were conducted on various aspects of America's future prosperity. We also gathered sixty subject-matter experts with whom we consulted for a weekend here in Washington and who provided recommendations related to their fields of specialty.[. . . .]

• U.S. companies each morning receive software that was written in India overnight in time to be tested in the U.S. and returned to India for further production that same evening—making the 24-hour workday a practicality.

• Back-offices of U.S. firms operate in such places as Costa Rica, Ireland and Switzerland.

• Drawings for American architectural firms are produced in Brazil.

• U.S. firm's call centers are based in India—where employees are now being taught to speak with a mid-western accent.

• U.S. hospitals have x-rays and CAT scans read by radiologists in Australia and India.

• At some McDonald's drive-in windows orders are transmitted to a processing center a thousand miles away (currently in the U.S.), where they are processed and returned to the worker who actually prepares the order.

• Accounting firms in the U.S. have clients tax returns prepared by experts in India.

• Visitors to an office not far from the White House are greeted by a receptionist on a flat screen display who controls access to the building and arranges contacts—she is in Pakistan.

• Surgeons sit on the opposite side of the operating room and control robots which perform the procedures. It is not a huge leap of imagination to have highly-specialized, world-class surgeons located not just across the operating room but across the ocean. [. . .]

• In 1997 China had fewer than fifty research centers managed by multinational corporations. By 2004 there were over six-hundred.

• Two years from now, for the first time, the most capable high-energy particle accelerator on earth will reside outside the United States. [. . .]

• In 2003 foreign students earned 59% of the engineering doctorates awarded in U.S. universities.

[. . . .]

http://www7.nationalacademies.org/ocga/testimony/Gathering_Storm_Energizing_and_Employing_America2.asp

From Jeffrey T. Macher and David C. Mowry (Eds.), **Innovation in Global Industries: U.S. Firms Competing in a New World (Collected Studies)**. Washington, DC: National Academies Press, 2008), pp. ix – xi.

Preface and Acknowledgments

In 1999 the National Academies' Board on Science, Technology, and Economic Policy (STEP) released a series of industry studies analyzing the sources of competitive resurgence from the 1980s to the 1990s of many U.S.-based firms in a variety of manufacturing and service sectors. These studies, published under the title *U.S. Industry in 2000: Studies in Competitive Performance*, included steel, chemicals, metal working, trucking, grocery retailing, retail banking, computing, semiconductors, hard disk drives, apparel, pharmaceuticals, and biotechnology.

The general picture of stronger performance in the mid-to-late 1990s than in the early 1990s was attributed to a variety of factors including heavy investment in applications of information technology, supportive public policies, openness to innovation, and changes in supplier and customer relationships. Vigorous foreign competition forced cost-cutting changes in manufacturing processes, organization, and strategy but then receded, making the performance of U.S. industries look even better. As none of these favorable conditions could be assumed to be permanent, the collected studies persuasively made the point that U.S. industries' superior performance is not guaranteed to continue.

In late 2005 the STEP Board decided to reprise the study, focusing on the acceleration in global sourcing of innovation and emergence of new locations of research capacity, new sources of skilled technical workers, and the implications of these developments for U.S. businesses and workforce. Although the current study involves several of the same industries—in particular, semiconductors, personal computing, financial services, pharmaceuticals, and biotechnology—the overall selection shifted markedly toward technology-intensive producing, supporting, or using sectors to include software, flat panel displays, solid state lighting, logistics, and venture capital finance. The group of industries examined does not represent

a carefully selected sample representative of the economy as a whole. Rather, it reflects a decision to again capitalize on the work of university-based multidisciplinary research teams studying economic performance and technological change at the industry level. Most of these groups were formed and supported under the Industry Centers Program of the Alfred P. Sloan Foundation.

To help integrate this work, the Board again asked **David C. Mowery**, Professor at the Haas School of Business at the University of California at Berkeley, to develop a general framework for analyzing changes in the structure of innovation over the past 10 to 15 years. Mowery in turn recruited **Jeffrey T. Macher**, Associate Professor, McDonough School of Business, Georgetown University, to assist in this effort and co-edit the resulting volume. The chapters in this volume were drafted independently by individual authors, and their findings and any policy recommendations do not represent a consensus among all of the contributors to the volume. They also do not necessarily represent the opinions and views of the Committee on Competitiveness and Workforce Needs of U.S. Industry, the STEP Board, the National Academies, or the sponsoring organizations.

In the course of their work, the editors and chapter authors participated in two public workshops in Washington, D.C. The first, on April 19, 2006, reviewed their preliminary findings with industry representatives and other analysts including **Irving Wladawsky-Berger**, IBM Corporation; **Jack Gill**, Vanguard Ventures and Harvard Medical School; **Richard S. Golaszewski**, GRA, Inc.; **Jeffrey D. Tew**, General Motors; **Jerome H. Grossman**, LionGate Corporation and Harvard University; **Gordon W. Day**, Optoelectronic Industry Development Association; **Timothy J. Sturgeon**, Massachusetts Institute of Technology; **Charles W. Wade**, Technology Forecasters, Inc.; **Richard B. Freeman**, Harvard University; **Nancy Hauge**, K12; **Harold Salzman**, the Urban Institute; and **Navi Radjou**, Forrester Research, Inc.

A year later a second workshop was held, on April 20, 2007, to try to anticipate trends over the next several years in three broad sectors encompassing most of the industries being studied—information and computing technology, biopharmaceuticals, and finance. Speakers in addition to committee members and authors included **Undersecretary Robert C. Cresanti**, Commerce Department's Technology Administration; **Barry Jaruzelski**, Booz Allen Hamilton; **Robert D. Atkinson**, Information Technology and Innovation Foundation; **Alex Soojung-Kim Pang**, Institute for the Future; **Bhaskar Chakravorti**, McKinsey and Company; **David Moschella**, Leading Edge Forum; **Michael E. Fawkes**, Hewlett-Packard Company; **Anna D. Barker**, National Cancer Institute; **Thomas R. Cech**, Howard Hughes Medical Institute; **Joseph Jasinski**, Health Care Life Science, IBM; **Andy Lee**, Pfizer Inc.; **T. L. Stebbins**, Canaccord Adams, Inc.; **Karen G. Mills**, Solera Capital; and **Alex J. Pollock**, American Enterprise Institute.

As the editors state in their summary introduction to this collection, despite the emergence of robust R&D and innovative capabilities in East, Southeast, and

South Asia, and concerted efforts to develop them in other parts of the world, patterns of innovation are highly variable across industries and across firms within industries. Many industries and some firms within nearly all industries retain leading-edge capacity in the United States. The flat panel display sector, in which innovative activity for the most part has followed production abroad, is not as yet the norm. This is no reason for complacency about the outlook for the future, however. Empirically-based analyses such as those in this volume are inevitably backward-looking. Even recently issued patents generally represent filings two to five years back and R&D investments considerably earlier. Although not pessimistic overall, our authors compellingly document the rapidity of contemporary industrial change and shifts in competitive advantage. For that reason alone, innovation deserves more sustained public policy attention than it has been receiving.

The STEP Board is grateful to the authors, the editors, and the workshop participants as well as to the sponsors of this activity—**the Alfred P. Sloan Foundation**, the **U.S. Department of Education**, and the **Technology Administration of the U.S. Department of Commerce**.

This collection has been reviewed in draft from by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Academies' Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making the published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process.

We wish to thank the following individuals for their review of this report: **Suma Athreye**, Brunel University; **MaryAnn Feldman**, University of Toronto; **Jeffrey Furman**, Boston University; **Bronwyn Hall**, University of California at Berkeley; **Megan MacGarvie**, Boston University; **Deepak Somaya**, University of Maryland; **Jerry Thursby**, Emory University; and **Philip Webre**, Congressional Budget Office.

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the content of the report, nor did they see the final draft of the report before its release. Responsibility for the final content of this report rests entirely with the individual authors.

David T. Morgenthaler, *Chair*
Stephen A. Merrill, *Study Director*

India, or dozens of other nations whose economies are growing. This has been aptly referred to as "the Death of Distance."

CHARGE TO THE COMMITTEE

The National Academies was asked by Senator Lamar Alexander and Senator Jeff Bingaman of the Committee on Energy and Natural Resources, with endorsement by Representative Sherwood Boehlert and Representative Bart Gordon of the House Committee on Science, to respond to the following questions:

What are the top 10 actions, in priority order, that federal policymakers could take to enhance the science and technology enterprise so that the United States can successfully compete, prosper, and be secure in the global community of the 21st century? What strategy, with several concrete steps, could be used to implement each of those actions?

The National Academies created the Committee on Prospering in the Global Economy of the 21st Century to respond to this request. The charge constitutes a challenge both daunting and exhilarating: to recommend to the nation specific steps that can best strengthen the quality of life in America—our prosperity, our health, and our security. The committee has been cautious in its analysis of information. The available information is only partly adequate for the committee's needs. In addition, the time allotted to develop the report (10 weeks from the time of the committee's first gathering to report release) limited the ability of the committee to conduct an exhaustive analysis. Even if unlimited time were available, definitive analyses on many issues are not possible given the uncertainties involved.[2]

This report reflects the consensus views and judgment of the committee members. Although the committee consists of leaders in academe, industry, and government—including several current and former industry chief executive officers, university presidents, researchers (including three Nobel prize winners), and former presidential appointees—the array of topics and policies covered is so broad that it was not possible to assemble a committee of 20 members with direct expertise in each relevant area. Because of those limitations, the committee has relied heavily on the judgment of many experts in the study's focus groups, additional consultations via e-mail and telephone with other experts, and an unusually large panel of reviewers.

[2] Since the prepublication version of the report was released in October, certain changes have been made to correct editorial and factual errors, add relevant examples and indicators, and ensure consistency among sections of the report. Although modifications have been made to the text, the recommendations remain unchanged, except for a few corrections, which have been footnoted.