Final Report for Period: 05/2007 - 10/2007 **Submitted on:** 02/03/2008
Principal Investigator: Cozzens, Susan E. **Award ID:** 0631250
Organization: GA Tech Res Corp - GIT
Submitted By:

Title:
Workshop: Social Organization of Science and Science Policy; July 13-14, 2006; Arlington, VA

Project Participants

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Research Experience for Undergraduates

Organizational Partners

Other Collaborators or Contacts

None.

Activities and Findings

Research and Education Activities:

A workshop was held in July, 2006, to identify critical research issues for an NSF initiative in Science of Science Policy. A final report was prepared based on the workshop.

Findings: (See PDF version submitted by PI at the end of the report)

There are a wide variety of important topics that the initiative should explore. These are described in the workshop report, attached.

Training and Development:

The workshop raised interest in policy-relevant studies of science and technology among participants. It also provided experience for the graduate assistant in organizing a professional meeting and producing a volume of workshop papers.

Outreach Activities:

The workshop results were discussed at the Gordon Conference on Science and Technology Policy in August, 2006.

Journal Publications

Books or Other One-time Publications

Susan Cozzens, Priscilla Regan, Beth Rubin, "Social Organization of Science and Science Policy", (2008). Report, Posted on NSF web site
Bibliography: National Science Foundation, http://www.nsf.gov/sbe/scisip/ses_sosp_wksp_rpt.pdf

Web/Internet Site

URL(s):

http://www.tpac.gatech.edu/nsfworkshop/index.php

Description:

This site carries information on the workshop.

Other Specific Products

Product Type:

Final report

Product Description:

The final report for the workshop includes an executive summary, summary of discussions, and the workshop discussion papers.

Sharing Information:

This report is under review at the National Science Foundation. It will be published by NSF after review.

Contributions

Contributions within Discipline:

The workshop helped to raise interest in aspects of the social sciences that could contribute to science and innovation policy.

Contributions to Other Disciplines:

The social sciences can contribute to the whole science and engineering enterprise with research on the science of science and innovation policy.

Contributions to Human Resource Development:

Two graduate students were involved in the workshop, and several junior faculty members.

Contributions to Resources for Research and Education:

The workshop has made a contribution to an NSF initiative that will significantly build the intellectual base of the field.

Contributions Beyond Science and Engineering:

The workshop developed a research agenda that specifically recommended examining the wider outcomes of science and engineering. Building this consideration into policy-making can contribute significantly to the public welfare.

Categories for which nothing is reported:

Organizational Partners

Any Journal

Final Report

NSF Workshop on
Social Organization of Science and Science Policy

Prepared by:

Susan Cozzens

Priscilla Regan

Beth Rubin

ACKNOWLEDGMENTS

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We also thank the two student assistants for the workshop: John Parker from Arizona State University, who helped during the days of the workshop, and Sonia Gatchair, who provided pre-, during, and post-workshop assistance, including editing and summarizing. In addition, Chris Fehrenbach of the Ivan Allen College budget staff deserves special credit for extraordinary help with short-deadline arrangements.

Finally, we wish to thank the workshop participants for submitting reflective papers, and for contributing thoughtful comments and helpful recommendations during and after the workshop.

Table of Contents

EXECUTIVE SUMMARY

NSF Workshop on Social Organization of Science and Science Policy

On July 13-14, 2006, a workshop on the Social Organization of Science and Science Policy was held at the National Science Foundation (NSF) in Arlington, Virginia. The workshop was funded by an NSF grant from the Sociology and Science and Society Programs in the Directorate for Social, Behavioral and Economic Sciences (SBE).[1] The workshop was to provide guidance to the National Science Foundation as it launches a new focus on the Science of Science Policy. [2]

The participants in this workshop, who were drawn from across the research fields supported by the SBE Division of Social and Economic Sciences (SES), share a commitment to studying science, technology, engineering, and innovation as social processes and to working together across disciplines to understand the dynamics that conjoin science, technology, and society. The discussion asked, "How can those who study science as a social process do more to help science administrators and other participants in the policy making process understand the complex domain for which they are responsible? What new data or indicators might we develop? More generally, how can the social sciences and humanities provide better information and ideas to assist in shaping science, technology, and innovation policies intelligently?"

Science, engineering, and technology play a role in and are influenced by many policies, and they are in turn supported in order to contribute to a variety of desired societal outcomes. Workshop participants articulated a wide range of research questions about those interconnections. They identified the following areas as crucial components for a research agenda to inform and challenge current policy making with and for science, technology, engineering, and innovation. The questions illustrate but do not exhaust the range within each area.

1. **Innovation for well-being and social productivity.** Science, technology, and innovation (STI) policies aim not only to contribute to economic growth but also to make life better within nations and globally. Are those policies successful in these goals? When and how do they produce the outcomes policy makers project? Are their benefits distributed appropriately? Are they making a net contribution to generating decent work, high employment, economic competitiveness, and environmental sustainability? How might the connections between science, technology, and innovation policies and quality of life be enhanced?
2. **Social environments for innovation and creativity.** The institutional and organizational settings and social groups active in science, technology, and innovation have varied historically and across nations, and can change in response to changing conditions. What are the immediate and long-run implications of the different arrangements? What organizational, institutional, architectural,

[1] SES-0631250 to Susan Cozzens, Georgia Institute of Technology. The views expressed here are those of the workshop participants and do not necessarily represent those of the National Science Foundation.
[2] See the FY2007 NSF budget request, at http://www.nsf.gov/about/budget/fy2007/pdf/4-ResearchandRelatedActivities/6-SocialBehavioralandEconomicSciences/25-FY2007.pdf.

geographic, and social network and infrastructural conditions are most conducive to creativity and innovation that is socially and scientifically beneficial? What roles do disciplines and interdisciplinarity play? Who is included and excluded by current institutional, organizational and social arrangements? How do various ways of knowing contribute to creativity and problem solving for society? Why are some places successful at innovation while others fail? For example, which milieus set up creative tensions between competition and collaboration? Why are some innovations celebrated and promoted, while others are suppressed or ignored? How do innovators share data and knowledge and what are the opportunities and constraints of that process? How do established structures of status and hierarchy enhance or inhibit innovation and creativity and their translation into outputs?

3. **Political economy of science, technology, and innovation policy.** The development of science, technology, and innovation is a value-laden process that may be usefully informed by the creation of scientific indicators and models for S&T and their consequences, but never determined by them. Science, technology, and innovation policies are enacted in many places by many actors, well beyond national government decision making, for example, corporations, non-governmental organizations, multinational governing bodies, and other interest groups. What actors are involved? What influence do they have? How do they draw the boundaries around this domain of policy? Do they treat science, technology, and innovation as public goods or as private commodities? What processes of social action and decision making lead to the wisest, most widely acceptable results in science, technology, and innovation policies?

4. **Evidence and expertise in science-intensive decision making.** In science, technology, and innovation policies, as in other policy areas, evidence and expertise are just one source of inputs to a broader process of reasoning and logic. Who counts as an expert on issues of science, technology, and innovation policy? What constitutes evidence and evidence-based decision making in science-intensive policy areas? Do these factors differ from other policy areas and how do they change over time and in different contexts? What kinds of evidence, expertise, and models are actually used in science, technology, and innovation policy decisions? If evidence is not used, why? How are uncertainties and tacit assumptions in this knowledge base evaluated and factored into decision making? What is the empirical support for the major assumptions underlying science, technology, and innovation policies? Where that support is limited, what data and empirical approaches would shed more light on the policies? How can the use of knowledge and expertise by different types of actors, in various areas of policy, be made more accountable and transparent in democratic processes?

5. **Science, technology, innovation, and global change.** Economic, political and social relationships are changing at global level. What roles are science, technology, and innovation playing in those changes and vice versa? When different ways of knowing come into conflict in this process, how are the conflicts resolved? How are the structures and networks of science, technology, and innovation that extend across national boundaries changing options for national

governments and the citizens they serve? What national visions and goals move towards greater well-being for everyone in the emerging world order, and how can those visions and goals be implemented? How do science, technology, and innovation policies and policy-making processes differ between the United States, Europe, China, Japan, and other countries? What are the implications for national and international well-being of these differences?

To give the effort the breadth of vision, skill, and energy needed, those working directly on science, technology, and innovation policy issues should be joined by the wider science and technology studies community, other social scientists and humanists, and other scientists and engineers. Opportunities to involve civil society in the research agenda will be important. Comparative studies will be needed, and cross-national collaborations should be encouraged.

Workshop participants agreed that appropriate research approaches will be methodologically diverse, ranging from normative to descriptive studies and from discourse analysis, history, and ethnography to community-based research and quantitative approaches. New theoretical frameworks and methodologies are likely to be necessary. New sets of indicators should be developed, to reflect the broad range of processes and outcomes included in the research agenda. More open and machine readable access to grant records and affordable access to publication data would help the work, along with the generation of detailed case studies in policy making and outcomes.

A significantly expanded research effort in this area should be accompanied by community and capacity building efforts, including sharing of best practices, graduate training opportunities and program-building, data access and development, workshops, conferences, and public outreach. New forms of teamwork and collaboration should be explicitly encouraged, particularly those that involve mutual engagement across the social sciences, other sciences, and engineering. To be useful, the effort must also include interactions with policy audiences designed to include two-way communication of issues, information, and insights.

REPORT

A. Introduction

On July 13-14, 2006, a workshop on the Social Organization of Science and Science Policy was held at the National Science Foundation in Arlington, Virginia.[3] The workshop was originally planned by the Sociology and Science and Society Programs in response to a call from Dr. John Marburger, the U.S. President's Science Advisor, for a "social science of science policy" (more on this call in Section II below). These programs wanted to gather their grantee communities to review their past contributions to science policy discussions and suggest a future research agenda. The Science and Society program had co-sponsored an earlier workshop on a related theme, "Research Policy as an Agent of Change."[4]

As the NSF-wide response to Dr. Marburger's call evolved, the workshop became one of three in the Directorate for Social, Behavioral, and Economic Sciences held to provide advice on shaping a new funding program on the "science of science policy."[5] Over the course of the summer of 2006, each of the NSF divisions sponsored a workshop to help with this effort. The Division of Behavioral and Cognitive Sciences sponsored one on individual creativity.[6] The Division of Science Resources Statistics sponsored one on measurement of innovation, particularly at national level.[7] The Division of Social and Economic Sciences sponsored the one reported here to focus on team and organization-level innovation processes. The Executive Summary of this third workshop became one input to the prospectus for this effort, now renamed again the "Science of Science and Innovation Policy,"[8] and the program solicitation (NSF 07-547) for research proposals in this area.[9]

The participants in the workshop were drawn from across the fields supported in the Division of Social and Economic Sciences. Although there was a strong contingent of sociologists and science policy scholars, participants also came from backgrounds in political science, history of science, philosophy, science and technology studies, and economics. The group represented an unusual confluence of intellectual traditions; this mix was deliberate. The organizers felt that there was a much broader range of social

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[3] Funded by an NSF grant from the Sociology and Science and Society Programs, SES-0631250, to Susan Cozzens, Georgia Institute of Technology. The views expressed here are those of the workshop participants and do not necessarily represent those of the National Science Foundation.

[4] National Science Foundation, *Research Policy as an Agent of Change* (NSF 05-209): http://www.nsf.gov/pubs/2005/nsf05209/start.htm

[5] See the FY2007 NSF budget request, at http://www.nsf.gov/about/budget/fy2007/pdf/4-ResearchandRelatedActivities/6-SocialBehavioralandEconomicSciences/25-FY2007.pdf.

[6] Workshop: Innovation and Discovery: The Scientific Basis of Individual and Team Innovation and Discovery, May 17-18, 2006. http://www.lrdc.pitt.edu/schunn/innov2006/talks/schedule.htm, accessed March 22, 2007.

[7] Workshop: Advancing Measures of Innovation: Knowledge Flows, Business Metrics, and Measurement Strategies, June 6–7, 2006. http://www.nsf.gov/statistics/workshop/innovation06/, accessed March 22, 2007.

[8] The prospectus was posted at http://www.nsf.gov/sbe/scisip/scisip_prospectus.pdf, accessed January 3, 2007.

[9] The solicitation can be found at: http://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf07547

scientists and humanists working on topics relevant to science and innovation policy than was reflected in usual gatherings under the policy label. They wanted to hear the voices of this broader group and include their insights in the formulation of the NSF initiative.

As the Executive Summary notes, the core questions motivating the discussion were of the following kinds: "How can those who study science as a social process do more to help science administrators and other participants in the policy making process understand the complex domain for which they are responsible? What new data or indicators might we develop? More generally, how can the social sciences and humanities provide better information and ideas to assist in shaping science, technology, and innovation policies intelligently?"

These questions posed challenges for the group that kept the two-day discussion lively and wide-ranging. Strands of discussion developed across the various presentations and captured and integrated the views of the participants better than the formal agenda. This report first summarizes the workshop sessions (Section B), then reports on those themes.

Three themes treated the relationship between the arena of science policy and the field of science policy research (Section C). First, there is the *opportunity* created by Dr. Marburger's call and the NSF initiative. The participating researchers did not assume that only the questions Dr. Marburger posed in his speeches should shape the research program. Instead, they articulated their own *visions* of what science policy is, informed by research on historical and contemporary policy processes in various policy domains. And there was considerable debate, reflecting a very wide range of views among workshop participants, on the best ways for research to have *impacts* in a policy arena.[10]

The bulk of the workshop discussion was devoted to articulating *research questions*, which fall into the categories outlined in the Executive Summary and used in Section D below. There was quick agreement that the *methodological approach* should be pluralistic since many methods used by social scientists and humanists would be useful in addressing the research agenda (Section E). Finally, the discussion returned again and again to what needed to be done to strengthen a sense of *community* in this research area and *educate a new generation* of researchers for impact in science policy deliberations (Section F). Section G summarizes the workshop conclusions, including general points made across the workshop papers (which appear in Appendix 3).

B. Workshop Sessions

For purposes of facilitating discussion, the workshop was organized into seven sessions. Because the topic of science policy is fundamentally interdisciplinary, dynamic and complex, ideas were often raised at several different sessions. However, to help readers understand the context of the discussions, brief highlights of the main points raised at each session are presented below.

[10] The workshop participants had the opportunity on the second day of the gathering to discuss these questions with Dr. David Lightfoot, the NSF Associate Director for Social and Behavioral Sciences, and with Dr. Kaye Husbands Fealing, the Senior Scientist coordinating the science of science policy initiative.

Session 1. Science Policy: Institutions and Issues

There was immediate consensus that the boundaries of the science policy community are dynamic and involve numerous interactions across the public and private sectors, and across disciplinary boundaries. The science policy sphere was described as “complex,” “decentralized,” “fragmented,” “networked,” and “pluralistic.” There was general agreement that working together across boundaries was important and would likely lead to more constructive activities. This should be encouraged both through policy decisions and through institutional arrangements. Reliance upon established institutional arrangements is likely to lead to somewhat predictable, perhaps conservative, agendas. Modifications to those institutional arrangements are likely to generate new agendas, unconventional models, and alternative framings of questions.

Session 2. Knowledge and Innovation Process

Workshop participants recognized the importance of better understanding where knowledge that shapes policy comes from and how it is granted legitimacy. A simple, linear model of how knowledge is incorporated in the innovation process was generally seen as outdated. It was also agreed that defining innovation in economic terms was too narrow and that “societal benefits,” “social productivity,” “quality of life,” and the “public good” needed to be incorporated in a re-conceptualization of that term. In this session, participants also brought up the importance of using both quantitative and qualitative research methods, the need to develop more inclusive and flexible databases and data structures, the significance of both “big” and “small” science, and the value of comparative research.

Session 3. The Institutions of U.S. Science

Much of this session focused on the relationship between the political process and the scientific communities. It was widely acknowledged that funding is important and that funding decisions are oftentimes motivated by political interests. Analysis of the claims that advocates use to support funding science would be beneficial. Case studies about the processes of science policy would be helpful in identifying actors, interests, biases, and institutions. Such studies would also point out where the existing system is not conducive to good science and where procedures for decision-making might be made fairer and more participatory. Studying the failures in science policy as well as the successes is essential to understanding the dynamics of the processes of science policy.

Session 4. Cultures, structures and networks of knowledge production in the conduct of research and inquiry

During this session workshop participants began to parse the environment of the science policy community. A number of important components were identified including the conservative tendency of disciplines and universities, and the ties between universities and industry. Participants also discussed how the context of scientific inquiry might be changed so that new ideas and patterns of interactions emerge. Geography and architecture could be designed to afford more transparency, flexibility, and interaction. Research schedules could allow more empty time for the possibility of insights and novelty.

Session 5. Social processes and the generation of data: elements, categories and indicators

The question of normative elements, the "ought's" and "should's" in science policy, mentioned in earlier sessions, received more attention here. Participants also recognized that data elements and standards were to some extent relative, often embodying some set of ethics or values. Analyses of crises and failures of knowledge are also likely to reveal inadequacies and limitations in existing data. It was also pointed out that the language of research and that of policy were not congruent and that the process and logic of translation was of critical importance. Developing the capacity for understanding the broader and contextualized nature of science policy is likely to extend beyond the training of researchers to involve the larger community.

Session 6. International Context

As is true in other realms, science today is embedded in a global economy and global community. Issues, concerns, methods, and scientific communities cross national borders and cultural contexts. Despite this, workshop participants recognized that concepts such as nation and country are still important in the development and implementation of science policy. Because it is important to understand different "ways of knowing" that emerge in the global environment, it is beneficial for scholars and scientists to seek opportunities to work outside their local realms. In this global environment, reconciling concerns about equality with those of competitiveness and concerns about peace with those of national security might be assumed into issues of science policy.

Session 7. How can the social sciences inform science policy?

Participants saw opportunities for social scientists to facilitate intellectual conversation and public reasoning about science policy. A broader social science perspective might reveal that science policy is more than the allocation of funds, but also involves the design of infrastructures, the collection of data, and the development of a legal system. Understanding the ways in which knowledge is provided and disseminated to citizens, industry, and government agencies is likely to reveal the biases in the operation of existing structures and possible areas for reform.

C. Discussion Themes

Opportunity for a policy audience

Dr. Marburger began his calls for a science of science policy in spring, 2005. In a speech at a AAAS forum,[11] he lamented the current state of science and technology (S&T) indicators:

> … the indicators are based on a data taxonomy that is nearly three decades old. Methods for defining data in both public and private sectors are not well adapted to how R&D is actually conducted today. … And the indicators are not linked to an overall interpretive framework that has been designed to inform policy.

[11] 30th Annual AAAS Forum on Science and Technology Policy in Washington, D.C., April 21, 2005. Text of Dr. Marburger's speech can be found at: http://www.aaas.org/news/releases/2005/0421marburgerText.shtml, accessed March 22, 2007.

Expressing his need for a better information base to inform the recommendations on budget and policies that his office makes to the President and Congress, Dr. Marburger described what he saw as the current state of the field:

> Much of the available literature on science policy is being produced piecemeal by scientists who are experts in their fields, but not necessarily in the methods and literature of the relevant social science disciplines needed to define appropriate data elements and create econometric models that can be useful to policy experts. I am suggesting that the nascent field of the social science of science policy needs to grow up, and quickly, to provide a basis for understanding the enormously complex dynamic of today's global, technology-based society.

Having identified this area of research as a branch of economics, Dr. Marburger then made a strong plea for the development of "econometric" models to assist in the policy process. "This is a task," he said, "for a new interdisciplinary field of quantitative science policy studies." The importance Dr. Marburger assigned to this effort was clear in his comments. He was not as worried about resources, he said, as about how to use them.

> I worry constantly that our tools for making wise decisions, and bringing along the American people and their elected representatives, are not yet sharp enough to manage the complexity of our evolving relationship with the awakening globe. I want to base advocacy on the best science we can muster to map our future in the world.

Dr. Marburger repeated and expanded on this call to action in several other gatherings. In November, 2005, at their invitation, Dr. Marburger again took up this theme in a talk to the Consortium of Social Science Associations (COSSA),[12] and in keynote addresses at the Atlanta Conference on Science and Technology Policy in May, 2006,[13] OECD's Global Science Forum international workshop on the science of science policy in July, 2006,[14] and another OECD event on the future agenda for science and technology indicators in Ottawa in September, 2006.[15]

Together, the talks provide a number of examples of the kinds of problems Dr. Marburger would like models to address:

- the likely futures of the technical workforce and its response to different possible stimuli
- the impact of globalization on technical work
- the sources and implications of high rates of production of technically trained personnel in China
- the impact of yet further revolutions in information technology on the work of scientists and engineers

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[12] COSSA Annual Meeting in Washington, DC. October 31, 2005. Text from Dr. Marburger's speech can be found at: http://www.tpac.gatech.edu/nsfworkshop/essays/MarburgerCOSSA_103105.doc, accessed March 22, 2007.
[13] Atlanta Conference on Science and Technology Policy 2006: US-EU Policies for Research and Innovation, May 18-20, 2006. http://www.spp.gatech.edu/conference2006/main.php, accessed March 22, 2007.
[14] http://www.oecd.org/dataoecd/42/63/37470200.pdf. Accessed January 5, 2007.
[15] http://www.oecd.org/dataoecd/48/14/37483994.pdf. Accessed January 5, 2007.

- the effect on federal programs of the inexorable proliferation of research centers, institutes, and laboratories
- the effect of huge fluctuations in state support for public universities
- the complex linkages between R&D investments and economic and other variables that lead to innovation, competitiveness, and societal benefits

Vision of science policy

The OSTP initiative created the opportunity for the workshop, but what science policy is, and what it is intended to do is much larger than what is embedded in the decisions on which OSTP might be asked to comment. Workshop participants shared a vision of science policy as concerning more than funding for frontier science and technology, competitiveness and the economy, and the actions of formal policymakers.

In addition to the scope of science policy, participants considered the relevant participants; here, too, they viewed government science policy makers as only a part of the large and complex web of actors that influences the development of science and engineering in a national context. This network includes government science policy makers, private firms (including both national and multi-national firms), social movements, media, non-governmental organizations, universities, other research institutions, and a wide range of government agencies, very few of which are concerned centrally with research and development. In addition, national science policy makers are increasingly acting in an international context set by the global operations of firms and research institutions as well as by the collaborative networks of non-governmental organizations and of science itself. The interactions and relationships among all these actors have evolved historically and are still evolving. Thus the whole web of relationships, not just the national science policymakers, are and must continue to be the focus of research in the social sciences.

The issues that arise in this network of actors go beyond funding for frontier science and technology, even though the funding questions tend to be front and center with national science policymakers. Funding allocations across broad fields have been relatively stable in U.S. R&D for a long time, with defense expenditures dominating the profile. It is therefore odd to focus U.S. policy research on the allocation issue, to the neglect of others. For example, some of the most important issues that affect contemporary life arise from existing technologies that are *not* used to their greatest capacity. Understanding these failures, as much as supporting innovation of cutting edge technologies, should be central to science and technology policy. Hurricane Katrina, for example, exemplifies the ways in which existing engineering knowledge and the capacity of the levees were the critical elements in the outcomes of a weather event.

Levels of funding also only partly shape the character and orientation of research institutions, including universities and government laboratories. These institutions are also shaped by intellectual property, safety regulations, immigration law, expectations of contributions to economic development, etc. Science policy should address not only how much funding is distributed to research communities but also the processes by which funding agencies allocate resources. Thus, the workshop raised a challenge to the current review processes and peer review system. Science policy should consider the site of knowledge production and role of knowledge networks, collaborations and complex distributions of effort that may challenge the relevance of the current system that is modeled on an independent, discipline-bound researcher model. Understanding the processes of generating and evaluating novel and innovative science and engineering enterprises within their organizational and political contexts should be a core concern of science policy.

Science policy sets directions for society at large, an idea captured in one participant's claim that "Innovation policy is the organized transformation of the world." The context and goals of science policy thus go well beyond the economic concepts that tend to dominate current discourse, including the concept of competitiveness. Even as embodied in public goals and reflected in agency research agendas, society wants much more from science than economic growth. The expectations extend to environmental and health protection, equality of opportunity, and a supportive environment for democratic governance. NSF's evaluation criteria include one called "broader social impacts," and the workshop participants were enthusiastic about using this established principle to examine all of what government does with and for science. Participants stressed the importance of "ought" and "should" questions, like "What kind of society are we trying to create?"

Impacts for the research in this field

This broad view of what science policy is also establishes quite an inclusive concept of what a policy-relevant science policy research agenda would consist of. This raised the question of correspondence between Dr. Marburger's call and the results such a research agenda was likely to produce.

Workshop participants were in agreement that this research agenda should not be geared to provide short-term answers to short-term questions. This is the role of policy analysts, who in the U.S. system are often located either inside government or in contract research organizations like SRI or the Science and Technology Policy Institute.[16]

Just as strongly, however, the workshop participants rejected the possibility that NSF should support an applied research program in this area, that is, one with a focused and negotiated agenda driven by policy needs determined by clearly-identified "users." Such agendas in other countries, for example, might include the "users" on panels that select projects and include direct "usefulness" as a selection criterion. Evaluating a program of research of this sort would involve asking whether key user questions received direct answers. Development of fundamental knowledge about the dynamics of science might be a by-product of such a research program, but not its primary goal.[17]

Where the workshop participants began to differ, however, was in the differentiation between two common concepts in science policy: "use-inspired basic research"[18] and "pure basic research." Both concepts imply the development of basic

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[16] Laredo's essay calls this "consultancy."

[17] Laredo's essay calls this "targeted research."

[18] A term introduced by Don Stokes in *Pasteur's Quadrant*, to call attention to the two dimensions of variation that are conflated in the traditional linear concepts of basic, applied, and development. Use-inspired basic research stands at the intersection between usefulness in solving practical problems and exploration of fundamental principles. Europeans would call it "strategic research." Laredo's essay refers to both of these as "long-term research."

understanding, through conceptual and methodological development and solid empirical research. But some workshop participants called for the research community to orient that knowledge to policy use by listening to policy audiences, paying particular attention to research that sheds light on the questions they face, whether classic or immediate, and challenging policy makers with new ways of seeing their problems. Others rejected this orientation towards policy questions and instead called on the field to develop its research agenda on its own terms.

Despite the debate over these two concepts, the group seemed to agree that the science policy research field should be strongly engaged both with the science and engineering research enterprise and with policy makers from the broad spectrum identified in Section III, from community to governmental. The science policy research community *should* have an impact, participants agreed, and it cannot have an impact if it is isolated in its own discourse. The key issue may then be autonomy. As long as it is understood that science policy research will raise its own issues, use its own concepts, and enlighten policy making rather than merely providing answers to its questions, the two concepts of basic research are not far apart from each other.

The relationship between research and policy, however, does raise organizational issues for the field. People who contribute to the research base for science policy now work in several different institutional locations including universities, government laboratories, think tanks, and statistical agencies. Some interact regularly with governmental policy makers and their staff; others interact regularly with civil society organizations and their staff; and still others interact with people in other parts of the policy network. Questions and knowledge from all these sources needs to be integrated to meet the challenges outlined by Dr. Marburger's call. The workshop participants did not make recommendations on how to do that, but agreed that the task needed attention under the NSF initiative.

D. Research questions

As we have pointed out, the workshop participants were an interdisciplinary group, but they envisioned an even more broadly interdisciplinary group of scholars as essential to extending knowledge in this field. In the next section of the report, we discuss the range of methods the group recommended, and in Section G we discuss their vision for an expansive research community. This section expands on the list of research topics the group recommended, as previewed in the Executive Summary.

The workshop participants saw science, engineering, and technology playing a role in and being influenced by many policies. In turn, they are supported in order to contribute to a variety of desired societal outcomes. The participants articulated a wide range of research questions about those interconnections. They identified the following areas as crucial components for a research agenda to inform and challenge current policy making with and for science, technology, engineering, and innovation. The questions illustrate but do not exhaust the range within each area. Examples come from the papers the workshop participants prepared ahead of the meeting, and which are included in this report as Appendix 4.

1. **Innovation for well-being and social productivity.** Science, technology, and innovation (STI) policies aim not only to contribute to economic growth but also to

make life better within nations and globally, for example by exploring global climate change, fire management, human-ecosystem interactions, mental health, family stability, and personal well-being. How do scientific communities set their research agendas, given goals like these?

a. *Are those policies successful in these goals? When and how do they produce the outcomes policy-makers project? Are their benefits distributed appropriately?* Better measures of the effectiveness of research should go beyond return on investment concepts to be able to assess such goals as military supremacy, social connectivity, reduced child mortality, or a smaller gap between rich and poor. Successful research does not always lead to the positive outcomes policymakers expect; for example, excellent agricultural research may be done in a state with a declining agricultural economy.

b. *Are they making a net contribution to generating decent work, high employment, economic competitiveness, and environmental sustainability?* For example, can science policy help rehabilitate New Orleans's shattered research infrastructure and direct inquiry to resilient urban ecosystems?

c. *How might the connections between science, technology, and innovation policies and quality of life be enhanced?* Research in this field should contribute to identifying which fields will bear the most fruit.

2. Social environments for innovation and creativity. The institutional and organizational settings and social groups active in science, technology, and innovation have varied historically and across nations, and can change in response to changing conditions.

a. *What are the immediate and long-run implications of the different arrangements?* For example, is the traditional reliance on expert, peer-review procedures in many research management processes still effective? What are the alternatives? Universities are shifting from a public good knowledge/learning regime to an academic capitalist knowledge/learning regime. What are the implications?

b. *What organizational, institutional, architectural, geographic, and social network and infrastructural conditions are most conducive to socially and scientifically beneficial creativity and innovation?* What roles do disciplines and interdisciplinarity play? Where does engineering fit ?

c. *Who is included and excluded by current institutional, organizational and social arrangements? How do various ways of knowing contribute to creativity and problem solving for society?* For example, what is the role of patient groups formed on the Internet in producing medical knowledge? Many U.S. black and Hispanic students are excluded from science and engineering by the educational process, and the consequences stretch into community development.

d. *Why are some places successful at innovation while others fail? For example, which milieus set up creative tensions between competition and collaboration?* Current innovation processes are not linear, but involve co-evolution and co-production. Networks are the well-spring of innovation; but why do they establish themselves in some places rather than others?

e. *Why are some innovations celebrated and promoted, while others are suppressed or ignored?* For example, how is innovation rewarded in places that produce "gray knowledge," like government and industry laboratories?

f. *How do innovators share data and knowledge and what are the opportunities and constraints of that process?* For example, now that the information infrastructure allows scientists to share data freely, the potential for data abuse is greatly increased.

g. *How do established structures of status and hierarchy enhance or inhibit innovation and creativity and their translation into outputs?* Organizational context, intra-group structure, and individual relations may all influence creativity, but we lack empirical work to substantiate the claims made about them. Fundamentally conservative social institutions, like universities, nonetheless produce novelty.

3. Political economy of science, technology, and innovation policy. The development of science, technology, and innovation is a value-laden process. Science, technology, and innovation policies are enacted and implemented in many places by many actors, well beyond national government decision making, for example, corporations, non-governmental organizations, multinational governing bodies, and other interest groups.

a. *What actors are involved? What influence do they have? How do they draw the boundaries around this domain of policy? Do they treat science, technology, and innovation as public goods or as private commodities?* For example, knowledge creation, diffusion, and use involve scientific advisory bodies and regulatory agencies, standard-setting and professional bodies, courts, and legislatures. We need to know more about their roles in the various realms of STI policy. The political dimension of science policymaking must be taken into account.

b. *What processes of social action and decision making lead to the wisest, most widely acceptable results in science, technology, and innovation policies?* Social scientists need to challenge institutionalized science-think, by broadening the frame of reference and questioning myths and assumptions.

4. Evidence and expertise in science-intensive decision making. In science, technology, and innovation policies, as in other policy areas, evidence and expertise are just one source of inputs to a broader process of reasoning and logic.

a. *Who counts as an expert on issues of STI policy? What constitutes evidence and evidence-based decision making in science-intensive policy* *areas? Do these factors differ from other policy areas and how do they change over time and in different contexts?* We need more study of "public reasoning" and "reflexive government".

b. *What kinds of evidence, expertise, and models are actually used in science, technology, and innovation policy decisions? If evidence is not used, why? How are uncertainties and tacit assumptions in this knowledge base evaluated and factored into decision making?* For example, policy has yet to act on the results of global climate change research. The economic theory of "market failure," widely used as a rationale for science policy, does not provide guidance on resource allocation.

c. *What is the empirical support for the major assumptions underlying STI policies? Where that support is limited, what data and empirical approaches would shed more light on the policies?* Many scientists believe that allocating resources to research in areas that are scientifically interesting will maximize the social benefits from investment in science. This claim neither derives from theory nor has solid empirical support.

d. *How can the use of knowledge and expertise by different types of actors in various areas of policy be made more accountable and transparent in democratic processes?* Science policy needs to engage in dialogue with a range of American peoples and to benefit from "the intelligence of democracy." Social science research can contribute to the identification, analysis, and potential resolution of multiple, conflicting styles of reasoning.

5. Science, technology, innovation, and global change. Economic, political and social relationships are changing at global level. Historical studies have examined similar dynamics in the 17^{th} through 19^{th} centuries, and have much to contribute to examining this phenomenon now. The concepts of "country" and "nation state" are historically constructed and historically changing, even though most science policy is "national."

a. *What roles are science, technology, and innovation playing in those changes and vice versa?* For example, recent European science policy discussions have focused on where global firms do their R&D. Economic theories do not provide a rich enough understanding of global processes; we need social theories as well to understand the place of science and technology in the dynamics of global change.

b. *When different ways of knowing come into conflict in this process, how are the conflicts resolved?* For example, who owns indigenous knowledge and how can it be incorporated on an equal footing into contemporary innovation processes? What roles do actors outside government play in global processes?

c. *How are the structures and networks of science, technology, and innovation that extend across national boundaries changing options for national governments and the citizens they serve?* For example, will the global information infrastructure break down the first world/third world divide in science?

d. *What national visions and goals move towards greater well-being for everyone in the emerging world order, and how can those visions and goals be implemented?* Images of progress almost always include roles for science and technology institutions. The U.S. needs a new understanding of its place in the world order.

e. *How do STI policies and policy-making processes differ between the United States, Europe, China, Japan, and other countries? What are the implications for national and international well-being of these differences?* For example, government in the U.S. is traditionally indifferent to expertise in bureaucracies rather than outside government in civil society. How do S&T strategies differ in developing countries? Social scientists have an opportunity to apply what is known about the role of expertise in designing global governance institutions.

E. Methods, measurement, and data

Workshop participants agreed that appropriate research approaches to address this agenda will be methodologically diverse, ranging from normative to descriptive studies and from discourse analysis, history, and ethnography to community-based research and quantitative approaches. This group placed less emphasis on models than on understanding of process, and less emphasis on measures than on empirical evidence understood more broadly.

Approaches from the humanities are crucial to this research effort. Many of the workshop contributions in general included consideration of values, ethics, and responsibility, and affirmed the importance of asking broad, framing questions about the directions policy processes are setting. Addressing these issues without contributions from philosophy is inconceivable. Likewise, many use history, and Maienschein's paper in particular provides several compelling examples of the insights to be derived for current policy issues from historical studies, another indispensable contributing field.

Several participants have done their research through participation in the phenomenon they are studying, like Star and Bowker's work in understanding computer-facilitated collaboration through their collaboration with scientists and involvement in projects. Miller also shared his experience in having an impact in a policy area through a long-term combination of research, collaboration, and consultancy. Frickel stressed the importance of connecting to community stakeholders in the policy process through action research, like that supported by the Environmental Justice research program at the National Institute of Environmental Health Sciences.[19] Comparative studies will be needed, and cross-national collaborations should be encouraged. Several workshop participants urged NSF to strengthen its processes for supporting such collaborations.

While not limiting itself to quantitative models, the group called for the development of new theoretical frameworks, methodologies, and indicators. For example,

[19] The Environmental Justice Research Program at the National Institute of Environmental Health Sciences: http://www.niehs.nih.gov/translat/envjust/envjust.htm, accessed on March 22, 2007.

Cozzens called for ways to think systematically about social as well as economic processes of globalization, including science and technology in that analysis. Rhoten called for pushing beyond patents in the measurement of innovation. Lucena's recommendation for an alternative science and engineering indicators volume to characterize the broader vision of science policy received enthusiastic endorsement from the group. In a related proposal, Sampat urged economists to focus more attention on developing measures of spillovers, rather than direct returns, on investment in various fields of science.

The pluralistic methodological range the group recommended pointed to the need for data and infrastructure that built qualitatively as well as quantitatively unclear. For example, archives of case studies could be very valuable in several of the recommended research areas. Collaborative tools to share experiences across the ethnographic and community-based projects could also be useful. More open and machine readable access to grant records and affordable access to publication data would help the work.

F. Community and capacity building

The workshop participants made a discovery as they moved through their discussion. Starting from a sense of the efforts in this field being scattered and weak, the group gradually realized that by drawing together the various strands of working they represented, there was already significant strength in the relevant scholarship.[20] Furthermore, their vision was to expand the community even further through collaboration with interested scientists and engineers. While the roots of the intellectual effort lie in many disciplines, the key to building a significant body of research knowledge was to work together, asking key general questions and integrating answers from a variety of perspectives. The observations earlier in this report about maintaining dialogue between researchers and policymakers applies to this integration activity as well.

A significantly expanded research effort in this area should be accompanied by community and capacity building efforts, including sharing of best practices, graduate training opportunities and program-building, data access and development, workshops, conferences, and public outreach. There was a feeling that a new generation of contributors to the field needed to be trained in the interdisciplinary and integrative modes the group was recommending. New forms of graduate training are necessary that prepare scholars to engage not only in interdisciplinary research, but also trans-disciplinary research. Where multi-disciplinary research encourages scholars from different disciplines to work together on common problems, interdisciplinary research encourages full collaboration (rather than, for instance parallel or sequential work) but rooted in home disciplines. Transdisciplinary science, however, emerges from a process in which collaborators from multiple disciplines (for example, social and natural sciences) develop shared conceptual frameworks that reflect the methods, theories and contributions of each discipline but creates a new synthesis. Creating such scholars

[20] Several noted that in Europe, the science studies and science policy communities have remained integrated, while in the U.S., they have largely diverged. This divide will need to be closed for the U.S. research effort to contribute maximally.

requires new kinds of graduate training; such programs would be, for instance, consistent with the sorts of integrative and innovative graduate education encouraged by NSF's Integrative Graduate Education and Research Traineeship Program (IGERT) grants. Insights from this research field should also be included in both formal and informal science education activities,

In addition to encouraging new forms of education NSF can play a major role in encouraging new forms of teamwork and collaboration, particularly those that involve mutual engagement across the social sciences, natural sciences, and engineering. New people need to do new things in new ways. Consistent with other NSF funding initiatives, such as *CYBERInfrastructure* and *Human Social Dynamics*, NSF funding initiatives can play a powerful role in creating funding incentives for truly interdisciplinary and transdisciplinary research. Transdisciplinary science faces considerable cultural, structural and organizational barriers. By creating such research opportunities and revamping the evaluation of these efforts, NSF sends a strong legitimating signal to relevant policy makers, research organizations and administrators and may topple some of these barriers. To support, strengthen and encourage interdisciplinary and transdisciplinary team science, NSF needs to reconsider and reconfigure the associated review processes and types of funding. For instance, this type of research often requires funding for longer-term start-up projects that make them appear high-risk. Creating these new intellectual networks will be aided by a renewed commitment on the part of funding agencies such as NSF to high risk, long-term research. The peer review process for interdisciplinary and transdisciplinary research must recognize and reward team, not just independent investigator, research projects. The SES research community can and should play an active role in helping NSF develop alternative formulations of multidisciplinary and transdisciplinary theories and models of science.

G. Summary and conclusions

The workshop papers reflected many of the points made above. They pointed out that

1. Research is needed on the political, economic, social, and historical contexts and processes that underlie knowledge production and science policy. Research at multiple levels employing multiple methods is ideal.
2. Greater understanding of the development and dynamics of science policy agendas is needed.
3. The range of values that infuse science policy must be acknowledged and understood.
4. The effectiveness of more flexible, responsive funding structures that can accommodate fast-paced changes in science and technology, as well as in organizational research configurations, should be considered.
5. The science policy research field should be global in its scope, community, and research. Understanding what makes us similar and what makes us different must incorporate knowledge of culture and place.

6. The science policy community should encourage and enable public debate, acknowledging the importance of public participation in science policy along with the availability of data and information, the variety of credible ways of knowing, and the emergence of a variety of stakeholders.
7. The collection, categorization and availability of data must be improved.
8. The science policy research field should be multi-disciplinary (many disciplines), inter-disciplinary (integrative across disciplines), and trans-disciplinary (transcending disciplines). Accomplishing these goals requires fostering the development of productive intellectual and disciplinary synergies and identifying barriers and incentives.

In summary, the workshop participants were enthusiastic about meeting the challenges presented by the NSF initiative. They saw significant contributions coming from many fields of the social sciences and from the areas of the humanities that devote themselves to examining science and technology in context, and they urged stronger and more systematic collaboration with scientists and engineers in developing new questions, methods, and insights. They embraced the opportunity to open a dialogue with science policymakers, and are ready to bring a new generation of researchers into the field. The workshop offered its best wishes, as well as its advice, to the NSF staff who would continue to nurture the effort.

APPENDIX 1: WORKSHOP PARTICIPANTS

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Kamau Bobb [not able to attend, but contributed paper]
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APPENDIX 2: WORKSHOP AGENDA

NSF Workshop on
The Social Organization of Science and Science Policy
July 13-14, 2006

The workshop will explore the social science foundations of science policy in the context of today's complex, global, and technologically-mediated society. Understanding the fundamental social processes involved in the structure and organization of science policy are crucial for maximizing the ability of science policy to enhance scientific development and innovation. This understanding requires more than an examination of economic inputs, outputs and the rational deployment of economic resources towards scientific goals; these criteria are necessary but not sufficient. In order to fully understand the formulation, acceptance, dissemination, and impacts of science policy, we also need to understand its *social organization* and the political, economic, and sociological context within which science policy and science succeed or flounder.

The goal of the workshop is to identify central research questions through dialogue among an interdisciplinary group of scholars from the social sciences that are working on aspects of science policy. Workshop participants will examine areas of convergence across arenas of inquiry, identify gaps in research and knowledge, and specify the most promising issues and areas most ripe for systematic and rigorous inquiry. The workshop will examine the relations among the social organization of science, policy knowledge networks and innovation and productivity. The workshop will also explore existing theories, methods and measures to determine which require further development or testing. Finally the workshop will discuss the critical next steps regarding research funding, development of data resources, and education and training. Workshop recommendations will be published in a report and posted on the Web.

THURSDAY, July 13, 2006

8:30 Welcome, Background, Introductions and Workshop Objectives
Wanda Ward, Deputy Assistant Director, Directorate for Social, Behavioral, and Economic Sciences
Edward Hackett, Division Director, Social and Economic Sciences

9:00-10:30 Session 1: Science Policy: Institutions and Issues
Chair: Felice Levine

- What is science policy? What role does it play in national life?
- Is U.S. science policy distinctive in content or process?
- How do differences in organizational, cultural, economic, social, political, informational and resource environments affect the development and implementation of science policy?

Dave Guston
Jane Maienschein

Irwin Feller
Philippe Laredo

10:45-12:15 Session 2: Knowledge and Innovation Processes
Chair: Jane Maienschein

- What do science studies offer to the understanding of innovation?
- What do we know about how science policies affect the practice and content of science?

Scott Frickel
Geof Bowker
Diana Rhoten

1:15-2:45 Session 3: The Institutions of U.S. Science
Chair: Irwin Feller

- Are the major institutions that do research in transition? If yes, from what to what?
- What factors are challenging those institutions? What role does policy play in those challenges?
- Are the trends particular to the U.S. or more general? Why?

Sheila Slaughter
Dan Sarewitz

3:00-4:15 Session 4: Cultures, structures and networks of knowledge production in the conduct of research and inquiry
Chair: Tom Gieryn

- What organizational factors affect the conduct of research? i.e., what factors enhance or inhibit trust? Shared meanings? Opportunities among scientists across disciplines?
- What roles do competition and collaboration play in the conduct of research?
- What ever happened to disciplines and specialties? Are these concepts still relevant?
- What makes careers in science worth earning, having, and keeping?

Jason Owen-Smith
Kamau Bobb
Cheryl Leggon

4:30 – 5:30 Observations from Designated Commentator Tom Gieryn, followed by general discussion

FRIDAY, July 14, 2006

8:30-9:30 Session 5: Social processes and the generation of data: elements, categories and indicators
Chair: Geof Bowker

- What are some of the different ways in which we produce, share and disseminate knowledge and data?
- What are some of the ethical challenges of these relationships?
  Leigh Star
  Rosalyn Berne

9:30–10:30 Session 6: International Context
Chair: Philippe Laredo

- How are changes at the global level likely to affect U.S. research?
  Juan Lucena
  Susan Cozzens

10:45-12:00 Session 7: How can the social sciences inform science policy?
Chair: Dan Sarewitz

- What are the most fruitful ways for social science to inform policy making in general and science policy in particular?
  Ned Woodhouse
  Clark Miller
  Bhaven Sampat

1:00-2:30 Session 7: Taking Stock and Setting an Agenda
Discussion Leaders: Beth Rubin, Patricia White, Priscilla Regan and Fred Kronz, NSF
Discussion among all participants

Concluding Remarks