Scientizing Science Policy: Implications for Science, Technology, and Innovation Policy and R&D Evaluation

Gouk Tae Kim

Dissertation submitted to the faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of

Doctor of Philosophy
In
Science and Technology Studies

Saul Halfon, Chair
Daniel Breslau
Stephen D. Nelson
Aaron D. Schroeder

July 12, 2012
Blacksburg, Virginia, USA

Keywords: science of science policy, government performance management reform, social contract of science, science and technology studies, R&D evaluation

Scientizing Science Policy: Implications for Science, Technology, and Innovation Policy and R&D Evaluation

Gouk Tae Kim

ABSTRACT

In this dissertation research, I try to deepen the understanding of the logic and history behind the science of science policy approaches and to substitute for this scientific evidence-based science policy model an evidence-critical and -informed model in which scientific and democratic claims are promoted simultaneously.

The science of science policy, or what I call the scientizing science policy (SSP) discourse, is a strategic response of science policy community members to the following two socio-political developments: the government performance management reform movement and a new social contract of science. These two developments have motivated the science policy community to construct new science R&D management strategies that make science R&D investment more effective and economically beneficial than before. Former Presidential Science Advisor John Marburger played an important role in articulating an SSP approach at the federal level that opened up a political space for the larger SSP discourse to emerge and take hold. Other heterogeneous science policy community actors, including science agency managers and academic researchers, have also engaged and played major roles in shaping the premises, strategies, and directions that make up the SSP discourse by articulating their own approaches to SSP.

The SSP discourse constitutes a series of strategies such as economizing and quantifying R&D investment decisions. In particular, to implement the ideas of performance reform and a new social contract of science in the field of science policy and management, the SSP community members have prioritized the development of data, models, and evidence related to federal R&D investment by funding studies on new scientific data, tools, and quantitative methods through the National Science Foundation (NSF) Science of Science and Innovation Policy (SciSIP) program. Interagency

collaboration organized and supported by the Office of Science and Technology Policy (OSTP) is another key feature promoted by the SSP community.

Through this research of the rise and development of the SSP discourse, I emphasize the following aspects that are relevant to both science policy practice and research community members. First, the SSP discourse demonstrates the influence of the performance reform movement on science, technology, and innovation policy and R&D management. Second, the SSP discourse has the strong potential to shift science policy makers' focus from planning and implementing to evaluating federal R&D programs. Third, the SSP discourse not only reflects, but also promotes the tendency of public policy makers, politicians, and the public to rely on scientific claims and evidence when they are engaged in discussions or policy decision making processes related to science and technology. Fourth, the SSP discourse alters the balance of authority and influence among science policy actors, including science agency managers, scientists, and executive branch offices in the decision making process on federal R&D priority and investment. Fifth, even though there are conflicts and disagreements among science policy community members on the visions and future of the NSF SciSIP program, the SSP discourse is valuable as a space in which heterogeneous science policy research and practice community members can interact, learn from each other, and collaborate to develop U.S. science, technology, and innovation policy.

I conclude by proposing an evidence-critical and -informed science policy in which the SSP discourse contributes to promoting democratic values in the science policy decision process. In particular, the evidence-critical and -informed model focuses on not only using scientific data and evidence when making federal R&D decisions, but also on promoting the democratic and deliberative process in monitoring R&D activities' performance and social outcomes. In this model, I view the public as a legitimate stakeholder for evaluating federal R&D investment. This evidence-informed model can be implemented under the SSP discourse if the new R&D data, models, and tools developed by the NSF SciSIP-funded research are coupled with a new government performance website in which the public can access information about federal R&D activities as well as provide feedback about R&D investments to science policy makers.

ACKNOWLEDGEMENTS

I want to express my deepest appreciation to my committee chair, Dr. Saul Halfon, and my three committee members, including Dr. Daniel Breslau, Dr. Stephen Nelson, and Dr. Aaron Schroeder, for their academic advice in producing my dissertation.

I thank Harvard Kennedy School STS fellow program director Dr. Sheila Jasanoff for offering me such a wonderful academic journey in her program to deepen my understanding of STS. I also appreciate for the NSF STS Program for providing a research grant to me for improving my dissertation research.

And I would like to special thank to my wife, Eun-Hee Kim, my son, Isaac Jae-Hyun Kim, and my parents for their great support of my study.

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

Chapter 1: Introduction

The former White House Office of Science and Technology Policy (OSTP) director, John H. Marburger, III, made two speeches in the early 2000s in which he addressed his vision of U.S. science policy. The first speech was made in 2002 in which Marburger proposed the "science-based science policy." In 2005, he made another speech at AAAS initiating the "science of science policy." In the latter speech, he called for the establishment of the new (social) science of science policy research community to support his science of science policy initiative.

In response to Marburger's call, OSTP formulated an inter-agency task group integrating 17 government science agencies in 2006 and produced the *Science of Science Policy Roadmap* in 2008. The National Science Foundation (NSF) established a new funding program, Science of Science and Innovation Policy (SciSIP), in 2007 to provide grants for social science of science policy research activities.

I use the term SSP (Scientizing Science Policy) discourse as a way to refer to Marburger's "science-based" and "science-of science policy" initiative. This research examines how the SSP discourse (1) is formed among the science policy community actors and (2) works to implement the visions of government performance reform in the science policy field. More specifically, there is a series of new science policy strategies designed to respond to the government performance management reform. Such new strategies are identified as economizing, mathematizing, and legalizing science policy and public R&D investment. These strategies have emerged and developed as one of the main science policy tools in the United States since Marburger's initiation of science-based and science-of science policy.

The focus of this research is the rise and development of the SSP discourse, which is analyzed using (1) a case analysis of the NSF SciSIP and OSTP, (2) the socio-cultural analysis of the U.S. science and science policy, (3) documentary analysis of Government Performance and Results Act (GPRA) and Government and Performance Results Act (PART), (4) a stakeholder analysis based on interview data, (5) a discourse analysis of the SSP and the politics of science, and (6) a comparative analysis with the SSP and the U.K./Europe's Science of Science Foundation.

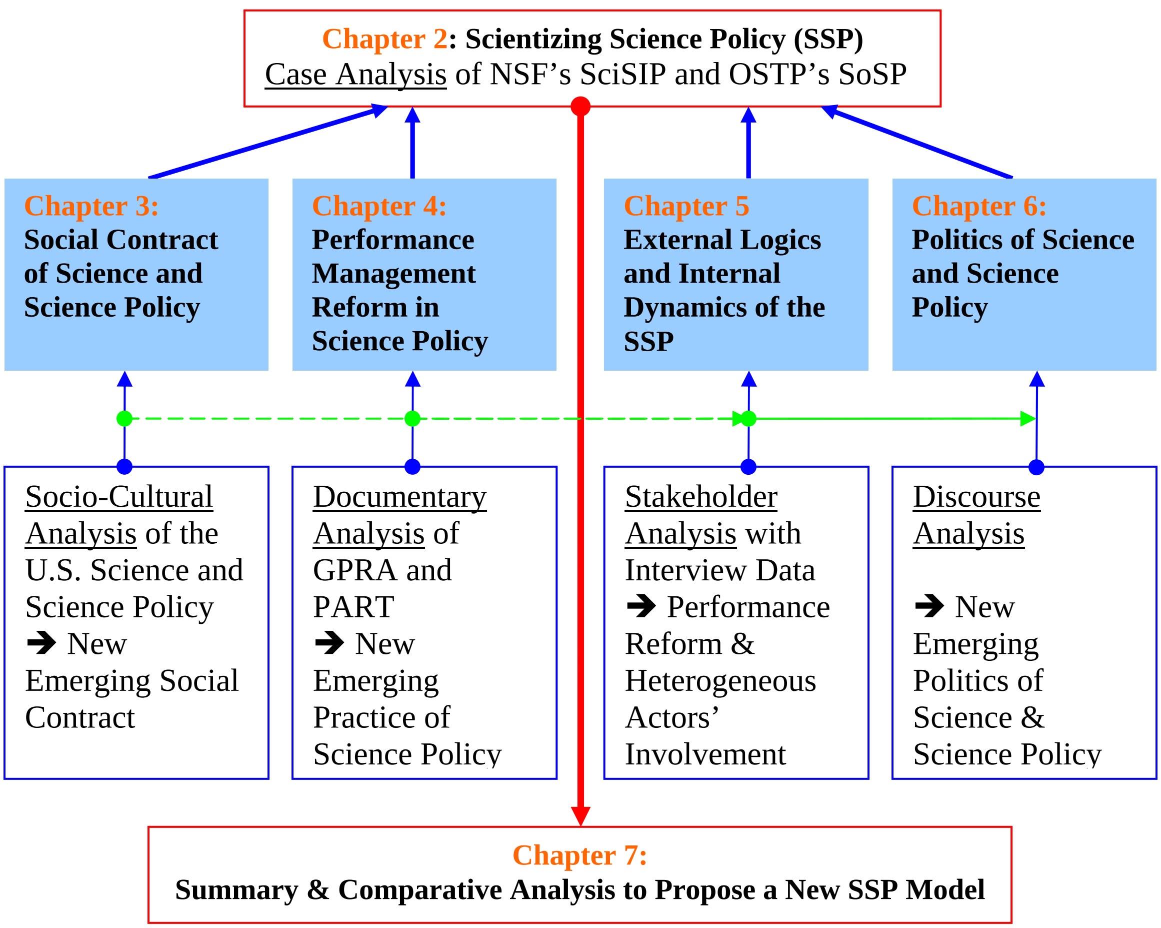


Figure 1-1. Structure of the Research

This analysis suggests that the SSP is (1) a reaction of science policy makers and practitioners to the call for establishing performance management reform practices in the science policy field, (2) a sign of changing the social contract of science that motivated the science policy community to construct new science policy tools and models supplementing the traditional science policy decision making mechanism such as the expert judgment system, and (3) an indicator showing the emphasis of science policy makers not only on using scientific claims and evidence to support science and technology policy decisions, but also on the evaluation of the federal R&D investments' outputs and outcomes.

More specifically, through the analysis in the chapters, I demonstrate that:

1. The rise and development of the SSP discourse is closely related to the government performance management movement that has taken hold during the G.W. Bush and Obama administrations. More specifically, the SSP is a strategic and historically specific response to the performance reform movement. The arrival of performance reform in science and science policy was delayed compared to other public policy fields due to the inherent characteristics of science and scientific research such as the difficulty of quantifying the results of science.
2. The SSP discourse represents changes in the social contract of science that has dominated U.S. science policy and politics since WWII. The SSP's emphasis on developing tools, models, and data for evaluating the outputs and outcomes of federal R&D investment is evidence to support this argument. The SSP discourse is also

likely to change the relationship and authority among science agencies, Congress, and the White House in governing science as well as the relationship between science agency managers and scientists. The former (changing relationship and authority among public policy community actors) is applicable to other public policy fields, whereas the latter (changing relationship among science policy community actors) is a unique aspect in science policy.

3. The SSP discourse supports the use of scientific claims and evidence by science policy makers, politicians, and the public in science policy discussion and decision making. This tendency is obvious when the SSP community members support studies on the scientific data, models, and tools for evaluating the R&D investment. The result is also a rebalancing of the authority and influence of science policy actors in the decision-making process on governing federal R&D priority and investment.

In this introductory chapter, along with the core research questions and methods, I provide a brief description of the SSP discourse as well as the analytical frameworks for examining the SSP.

1. Science of Science Policy Initiative

In his keynote speech at the 27th Annual AAAS (American Association for the Advancement of Science) Colloquium on Science and Technology Policy, 2002, Dr. Marburger described the concept of “science-based science policy,”[1] which calls for a science policy that is “based more on models and systematic research into what's needed and what's effective.”[2] At the AAAS Forum on Science and Technology Policy in 2005, he also called for a “new interdisciplinary field of quantitative science policy studies,” suggesting that “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.”[3]

One of the key assumptions of “science-based” or “science of science policy” derived from Marburger’s speeches is that science policy should be formulated based not only on an interdisciplinary approach to deepening an understanding of science, but also on systematic scientific research tools and methods, which should be emphasized as important criteria in deciding and assessing whether or not the scientific R&D program deserves support and funding. I examine how this new science policy discourse developed from 2002 as well as what implications this new science policy approach has had on Science, Technology, and Innovation (STI) policy practices because the term “science” in this new science policy discourse has the potential to be interpreted differently in various contexts.

---

[1] Audrey T. Leath, “Marburger Speaks at AAAS Colloquium,” American Institute of Physics, http://www.aip.org/fyi/2002/046.html

[2] Edward W. Lempinen, “Marburger Says Success Has Created Unexpected Challenges for U.S. S&T Research,” American Association for the Advancement of Science, http://www.aaas.org//news/releases/2006/1127marburger.shtml

[3] John Marburger, Speech at the *30th Annual AAAS Forum on Science and Technology Policy in Washington, D.C.*, American Association for the Advancement of Science (April 21, 2005), http://www.aaas.org/news/releases/2005/0421marburgerText.shtml

What is meant by scientific evidence-based science policy? What is the origin of this new science policy discourse and what distinguishes it from other science policy approaches? Can it be interpreted to formulate science policy strategies that emphasize the multi-directional socio-political aspects of science rather than the linear and traditional images of science? Does it draw imagery from the actual practices of modern science or rely on conventional images? Or does it simply focus on establishing quantitative science policy analysis toolkits and datasets?

My own initial confusion about this term "science-of" or "science-based" as well as the roles of science in shaping science policy, highlights the potentials and pitfalls that lie within this new science policy discourse, and motivates me to track the origin, the course of development, and the impact of this new science policy initiative on STI policy analysis and evaluation activities.

Marburger's call for science of science policy has been responded to by at least two institutions. The OSTP initiated the interagency task group on *Science of Science Policy* (SoSP), and the NSF launched a new SciSIP program. Science policy professionals and researchers from these two institutions have been announcing, circulating, and steering the discussion of this new science policy approach at major science and innovation policy conferences and meetings such as the AAAS Science and Technology Policy forum and the Atlanta Conference on Science and Innovation Policy.

As a SciSIP director, Julia Lane recognized in her presentation at the 34th annual AAAS Forum on Science and Technology Policy held on April 30, 2009, the interdisciplinary nature of the SciSIP program encourages efforts to identify emerging disciplines of research that might assist the scientific science policy community to develop rigorous scientific analytical policy tools. From this perspective, the scientific science policy discourse through NSF's SciSIP program and OSTP's SoSP has interests in not only identifying and constructing new science policy models and scientific infrastructures, but also in supporting any interdisciplinary research related to evaluating or analyzing the history, development, opportunities (taken or missed), choices, and challenges of the scientific science policy discourse itself.

Thus, in the following chapters, I examine the development of the OSTP's SoSP discourse along with the NSF's SciSIP program to gain in-depth knowledge of the "science-based" or "science-of science policy" discourse and science policy implications. I also examine the science policy and political environments and debates affecting the emergence of the "science of science policy" strategy.

2. Main Research Questions

The two central research goals are as follows:

The first research goal is to examine the implications of the SSP discourse as an indicator reflecting the change of the socio-political orders in U.S. science and science policy. To achieve this goal, I focus on how the social contract of science has changed since WWII. An analysis of how this change has not only affected the re-shaping of the science policy environment, but also motivated science policy makers in initiating the SSP discourse follows.

More detailed research questions to be answered for achieving the first research goal are shown in Table 1-1.

Table 1-1. Research Question Set 1

	Detail of Each Question
(1)	What does the social contract of science mean? How does it affect the culture of the U.S. science policy and politics?
(2)	What are the dominant elements of the social contract of science since WWII, and how does the change of these elements affect the emerging SSP discourse?
(3)	What are the political and historical backgrounds of key actors and the negotiation among them surrounding the development and the rise of the SSP discourse?
(4)	What were Marburger's main motivations in initiating the SSP movement?
(5)	Why do governments need a science-based or scientific approach to deal with the issues of science and technology policies and programs?
(6)	What concepts and socio-cultural understanding of modern science are possessed by those who are for or against scientific science policy?
(7)	How can the SSP discourse contribute to solving the impending issues science policy makers are confronting today, such as measuring the outcomes of federal R&D investment?
(8)	What would be the most prominent changes of science policy practices before and after the introduction of the SSP discourse?
(9)	Why is the SSP discourse supported by the Obama administration even though the political culture is different from that of the G.W Bush administration?
(10)	What does the future of the SSP look like? Will it become as influential as Vannevar Bush' *Science, the Endless Frontier*?

The second research goal is to demonstrate how the science policy community constructed the SSP discourse in response to the performance management reform movement. In order to achieve this goal, I examine not only the general development of the government performance regimes, but also the implementation of this movement's visions in science policy through the OSTP's SoSP and the NSF's SciSIP program. More detailed research questions to be answered in Chapters 3 and 4 for achieving the second research goal are shown in the Table 1-2.

Table 1-2. Research Question Set 2

	Detail of Each Question
(1)	What is the government performance reform movement in the U.S. and why does it matter in the study of the SSP discourse?
(2)	How does this reform movement change government management and policy practices?
(3)	What are the details of the performance reform Acts such as GPRA and PART?
(4)	How has the performance reform movement been changing the authority of public policy makers?
(5)	What kinds of impacts can be expected when the performance reform movement arrives in the field of science policy and management?
(6)	Why has there been a delay in adopting the performance reform visions in science policy?
(7)	What is the relationship between government performance reform and the SSP discourse?
(8)	How has the SSP discourse been interpreted and implemented in the science policy field under performance reform regimes?
(9)	What does the science-of or science-based science policy look like? Especially what does conducting science and innovation policy scientifically mean in improving science agencies' performance?
(10)	What are the roles and achievements of the OSTP's SoSP and NSF's SciSIP program in formulating and developing the SSP discourse?

By pursuing these two central research goals, I intend to improve the understanding of the socio-political and policy dynamics that reside inside and outside the discourse of the SSP, but also to explore the implications of this discourse on science and technology policy development.

3. Analytical Frameworks to Investigate the SSP Discourse

In this section, I explain the main analytical frameworks that elucidate my research findings and argument in each chapter. I combine these analyses and elaborate my arguments: first, the government performance management reform movement through GPRA (Government Performance and Results Act) and PART (Program Assessment Rating Tool) has both implicit and explicit consequences for science and science policy through the rise and development of the SSP discourse; second, the SSP discourse reflects not only the changes in the social contract of science that has dominated U.S. science policy during past decades, but also the intention of Marburger and science policy community members to re-design the system governing science.

(1) New Social Contract of Science (Chapter 3)

There is little disagreement among science policy researchers that the Vannevar Bush's *Science, the Endless Frontier* report played a central role in the articulation and development of post-war U.S. science and technology policy. His vision of science and science policy was implemented in the establishment of several institutional settings, including the NSF (National Science Foundation), through which the federal government could play a major role in supporting scientific research, assuming this investment would yield benefits for society. This framework has shaped a social contract of science in the United States enabling federal support for science with a self-governing mechanism of science by scientists. I not only examine this social contract in governing scientists and scientific research over the last decades, but also analyze the changes in the social and political environments affecting the re-design of this contract.

Under the new social contract of science, the images of value-free, universal, and self-governing science have been replaced by value-laden, political, and social aspects of science, and the science policy community has begun to confront the demand to re-design policy approaches to deal with the new issues of modern science. For example, if self-governance and the peer-review process are the dominant mechanisms ensuring the quality of scientific research, then, under the new social contract of science, the government would put more focus on establishing a procedure to monitor the integrity of scientific research and to evaluate the effectiveness and outcomes of its investment in science. Through this examination, I point out that Marburger's initiation of science of science policy is a response to the demand for science policy makers to build a new system that measures and guides the social impacts of science instead of relying on the traditional mechanism developed under the old social contract of science.

(2) The Performance Management Reform Movement (Chapter 4-I)

Performance management reform began in the early 1990s. There is new legislation supporting this movement including GPRA and PART. These acts require government agencies to develop new tools for assessing their programs' performance, and the Obama administration has continued to support this movement by revising GPRA in 2011.

Multiple interviewees, including a science agency manager, indicated that support for SSP was motivated by the lack of experience among science policy practitioners in developing tools to meet the requirements of GPRA and PART. I analyze the details of this movement as well as the debates surrounding it before exploring the SSP under the performance reform movement.

The performance movement has reshaped the landscape of U.S. government management and policy practice. There are many studies on this movement in the public policy and management fields, but not in the field of science and science policy. So, I also examine these studies and discussions so I can adopt them into my analysis on the SSP under the performance reform movement in the next chapter.

(3) Performance Management Reform in Science Policy (Chapter 4-II)

There is little research on the impacts of the government performance reform movement on science and science policy compared to the studies on its implications for non-science policy fields. Since I argue that the SSP is another name for performance reform in science policy, my study on the SSP is likely to offer a way to understand how the performance-first idea can be implemented to change science policy practice in the United States.

However, performance management reform has arrived in the science policy field slowly compared to other fields of public policy, and the traditional government management system governing science has unique aspects that discourage the performance regimes from being directly implemented in science policy. Therefore, I also demonstrate how the performance reform movement changes science policy practice through the SSP as well as what kinds of unique changes are expected after incorporating the core values of performance reform into science policy. I also bring the discussion on the performance reform movement from Chapters 3 and 4 into the analysis of the SSP.

The performance reform movement does not represent the entire SSP, but it is one of the major elements affecting the initiation of the SSP, and thus the analysis in this chapter offers a way to deepen the understanding of the SSP discourse.

(4) Internal Dynamics of the SSP (Chapter 5)

In chapter 5, I use interview data to demonstrate that the SSP is the venue in which heterogeneous science policy community actors interact and are in conflict with each other based on their different visions of science, policy, and politics. In particular, the interview data shows that there is internal disagreement among SSP community members in terms of the meaning and the application of science to science policy. For example, many non-economic social scientists who engaged in the first stage of the SSP are no longer involved with the SSP and have remained critics of it. Even though there are some disagreements or debates among SSP community actors in terms of the meaning and the application of science to science policy, each of them regards the SSP as an opportunity to promote or implement their vision and research of science policy.

(5) Politics of Science & SSP (Chapter 6)

Politics of science provides an analytical framework to explain the rise and development of the SSP discourse. First, I discuss why this framework is useful for exploring the story of the SSP and its implications for U.S. science policy. The legacy of Vannevar Bush's proposal for creating the National Research Foundation is central to this argument.

Post-war science policy in the United States cannot be described without examining Vannevar Bush's report, *Science, the Endless Frontier*. However, there is little research that examines the political dynamics among science policy makers and politicians before and during the institutionalization of V. Bush's vision on science and science policy. Bush's initial proposal for establishing the independent NRF (National Research Foundation) was not welcomed by politicians and policy makers for various reasons, such as concern that civilians rather than the president's appointees would control the federal research money.

Michael Dennis argues that V. Bush's fear of control over peace-time scientific and technological research activities by military elites and scientists was one of the main motivations to produce the report, *Science, the Endless Frontier*.[4] In his report, V. Bush therefore proposed federal government support for basic scientific research through the National Research Foundation organized by non-military experts. His initial proposal became the subject of political debates, and the creation of the National Science Foundation (NSF) was made in a way against Bush's original intention.

In other words, understanding the politics of science between V. Bush's efforts to set up a new system of science policy for science and the post-war government's intentions to maintain its control over the science budget decision-making is important to analyze the birth of the post-war U.S. federal science support system. I intend to emphasize that analyzing the politics of science could also explain the rise and development of the SSP discourse. More specifically, I

[4] Michael A. Dennis, "Reconstructing Sociotechnical Order: Vannevar Bush and US Science Policy," in *States of Knowledge: The Co-production of Science and Social Order*, Sheila Jasanoff, ed. (London: Routledge, 2004), 225-253.

argue that the politics and power in science and science policy are important to understand the initiation, development, and future outlook of the SSP discourse by showing that the political and power struggle among scientists, government, and society is an ongoing and important backdrop of the SSP discourse.

Another case showing the need to understand the politics of science in order to examine science policy and discourse is Robert Merton's arguments about the normative structure of science.[5] His analysis of the four normative elements of science and scientists in the early 1940s was subjected to criticisms such as the over-simplification of scientific practices.[6] Merton describes the basic nature of science by pointing out four principles which include "universalism, communism, disinterestedness, and organized skepticism."[7] He called these four factors "the ethos of modern science," saying that the main object of science is to extend "certified knowledge."[8]

However, it would also be important to notice that the fear of U.S. scholars and scientists about the spillover of the Soviet Union's communism to the Western world became one of the main motivations to emphasize the normative characteristics of science and scientific research.[9] Thus Merton's analysis of scientific practice can be evaluated not only as a reflection of the

---

[5] Robert K. Merton and Norman W. Storer, *The Sociology of Science: Theoretical and Empirical Investigations* (Chicago: University of Chicago Press, 1973).

[6] Ibid.

[7] Ibid., 267-278.

[8] Ibid.

[9] Henry Etzkowitz, "The Commodification of Academic Research: Science and the Modern University" *Contemporary Sociology: A Journal of Reviews*, 40 (2011): 737-738.

reality of science, but also as the projection of images of science free from the involvement of state power and politics.

These two cases suggest that exploring the politics of science surrounding the rise and development of science policies and programs would also be useful for analyzing the SSP discourse instead of black boxing the process of initiating and developing science policy.

(6) Comparative Analysis (Chapter 7)

Comparative analysis of the U.S. SSP discourse and the U.K./Europe's Science of Science Foundation is presented. Comparing two cases across countries has limitations in coming up with results that are directly applicable to the study of the SSP discourse because each country has its own social, cultural, and political landscapes shaping unique science policy practices that are incommensurable. However, considering the SSP community actors' collaboration with European science policy researchers and practitioners to develop new tools and data supporting science policy, this comparative analysis has also the potential to benefit not only this research, but also the SSP community.

For example, Marburger gave a speech at the European Science Indicator (Blue Sky II) conference in 2006 in which he introduced his effort to develop the science of science policy initiative.[10] A congressional hearing on the NSF's SciSIP was initiated by the chairman of the science and technology subcommittee who learned about this NSF program from science policy actors in Europe. Early this year, the NSF's SciSIP program director presented the development

[10] John Marburger, "What Indicators for Science, Technology and Innovation Policies in the 21st Century?" Blue Sky II, Ottawa, Canada (September 25, 2006).

of the SciSIP at the science policy conference in Europe, and interviewees who are affiliated with the SSP said that SciSIP aims to establish data and models that are compatible with those of other countries. When the Science of Science Policy Roadmap was announced in 2008, global science policy community members attended the meeting, and, since then, Japan has tried to adopt and implement the SSP vision into the design of its science policy system. In other words, the SSP discourse is gaining attention globally because of its potential to be implemented across countries.

Moreover, the SSP in the United States and the Science of Science Foundation in the U.K. during the 1960s have similarities in terms of their goal of quantifying science policy tools to support science policy makers. Because the Science of Science Foundation has laid the foundation for the European Science Indicator research, which U.S. SSP community members have tried to adopt in U.S. science policy, the comparative analysis of these two science policy movements is beneficial to propose a new model of science policy that fixes the issues of the SSP.

4. Qualitative Research Methods and Interviews

This dissertation uses qualitative methods, including case studies of NSF's SciSIP program and OSTP's SoSP, to gather date for analysis. The case study is listed in the *Science of Science Policy Roadmap* as a scientific qualitative research method. Along with the case studies, one of the main methods to collect data on the SSP discourse is the qualitative ethnographic interview. In particular, I have tried to rely on qualitative ethnographic interviewing of science policy community members to understand the nature of their engagement in the rise and development of the scientific science policy discourse, as well as explain how the scientific science policy institutions such as NSF's SciSIP program is performing and developing. By combining "the purposes" of the research and "theoretical discourses," the qualitative ethnographical interview method has enabled me to capture the knowledge and understanding of the different visions of science policy actors in and out of scientific science policy discourse. [11]

(1) Qualitative Research Methods

Qualitative research methods seek to uncover "meaning rather than measuring" as well as "understanding why individuals and groups think and behave as they do."[12] Because of these characteristics, I chose qualitative research methods not only for explaining the meaning of the rise and development of the SSP discourse along with the science policy community actors' engagement in it, but also for analyzing and understanding its impacts inside and out of the science policy community and their research.

In a broader context, qualitative research methods have often been regarded as "non-rigorous, subjectively biased and, in general, unscientific,"[13] and the research interview using open-ended discussion is one of the qualitative methods under this criticism. However, Weiss

---

[11] Pamela Cawthorne, "Identity, Values and Method: Taking Interview Research Seriously in Political Economy" *Qualitative Research* 1 (2001): 65-90

[12] Sheila Keegan, *Qualitative Research: Good Decision Making Through Understanding People, Cultures and Markets* (London: Kogan, 2009), 11

[13] Pamela Cawthorne, "Identity, Values and Method: Taking Interview Research Seriously in Political Economy" *Qualitative Research* 1 (2001): 65-90.

points out that the criticism saying qualitative interviews are not an objective scientific method are not “unwarranted.”[14] Yet he contends that “much of the important work in the social sciences, work that has contributed in fundamental ways to our understanding of our society and ourselves, has been based on qualitative interview studies.”[15] It is known that the interview is “involved in up to 90% of social science investigations.”[16]

In particular, the ethnographic aspects of the interview I chose are useful to enable the researcher to situate him/herself into the context of the environmental, cultural, or institutional setting when conducting the interview. By doing so, the researcher is capable of acquiring and understanding the data and perspectives from the interviewees or actors located inside or the boarders of the specific socio-cultural and institutional background.

I also chose open-ended questionnaires for the interview. Because the qualitative interview methods allow “participants [to] discuss their experience of a situation created by the researcher,” open-ended (interview) questions enable the researcher to collect data on “each [interview] participant’s subjective experience and definitions.”[17] In other words, by using open-ended questionnaires, “participants are able to respond in their own terms, to take their own

[14] Robert Weiss, *Learning from Strangers, The Art and Method of Qualitative Interview Studies* (New York: The Free Press, 1994), 12.

[15] Ibid.

[16] James A. Holstein and Jaber F. Gubrium, *Inside Interviewing: New Lenses, New Concerns* (Thousand Oaks: Sage Publications, 2003), 3.; Charles L. Briggs, *Learning How to Ask: A Sociolingustic Appraisal of the Role of the Interview in Social Sicnece Research* (Cambridge: Cambridge University Press, 1986).

[17] Trudy A. Suchan and Cynthia A. Brewer, “Qualitative Methods for Research on Mapmaking and Map Use” *The Professional Geographer*, 52, Issue 1 (2000): 48.

direction in answering questions,"[18] which allow the researchers to collect ethnographic inside data on the institutions or the communities s/he researches.

Open-ended questionnaires in this research also prompted interviewees not only to answer the main two research questions, the rise and development of scientific science policy discourse as well as its impacts on science, technology and innovation policy and evaluation, but also to provide rich accountings of them. For example, I discovered that open and semi-structured interview questionnaires and discussion produced useful data and information that helped me answer the main research questions.

Interviews with actors who have been engaged in or affiliated with NSF SoSP or OSTP's SoSP directly and indirectly have also provided data and description of scientific science policy discourse that I might not get via other research methods. Weiss also points out that the qualitative interview studies have advantages in providing "descriptions of phenomena that could have been learned about in no other way."[19]

(2) Design and Goals of Research Interviews

As described above, qualitative research was conducted through interviews from which I collected information regarding the development of the SSP discourse.

First, interviews of science policy makers, researchers, and scientists who have affiliation with these two institutions as well as funding from NSF's SciSIP program were conducted.

---

[18] Ibid., 149.

[19] Robert S. Weiss, *Learning from Strangers, The Art and Method of Qualitative Interview Studies* (New York: The Free Press, 1994), 12.

Second, I also interviewed science policy researchers located outside the SSP discourse to find their views on the location of the SSP discourse in broader science policy perspectives, as well as to find any ongoing or future efforts of them to respond to SSP discourse.

By gathering perspectives from a range of both traditional science-policy scholars and social study of science scholars focusing on science policy, I have examined their views and interpretations of the development of SSP discourse. An overview of these interview groups is provided in Table 1-3. A total of 29 interview subjects including government officials initiating the SSP roadmap, science policy researchers, and research scientists affiliated with NSF's SciSIP were selected so as to examine the development of the SSP.

Table 1-3. Overview of Interview

	Three Groups of Interviewees
Group 1	Science policy researchers or scientists affiliated with or current/previous management-level in SoSP, OSTP and AAAS
Group 2	Science policy researchers or scientists who have participated in the process of formulating the SSP discourse
Group 3	Public policy researchers whose research interests include science and technology policy, but are located outside the SSP discourse

Face-to-face interviews were conducted using Patton's guideline for qualitative interviewing.[20] Table 1-4 shows sample questions that were used in the interviews.

[20] Michael Q. Patton, *Qualitative Research and Evaluation Methods* (Thousands Oaks, California: Sage Publications, 2002).

Table 1-4. Sample Interview Questions

	1. Academic Position / Professional Roles of the Interview Participants
1)	What motivated you to get into the science policy research field /SoSP/SciSIP program?
2)	How do your current research projects relate to science policy/SoSP/SciSIP program?
3)	If you are involved in SSP, could you explain your position/role in the program?
4)	To what extent do you think your research approach is involved in the SSP project?
	2. General Research Issues/Debates of Science and Innovation Policy and SSP
1)	Please provide your opinions about science and innovation policy/SSP in terms of analyzing and evaluating social impacts of science and innovation projects.
2)	What strong points do science and innovation policy formation and research in the U.S./SoSP have compared to those of other countries including the EU and Asia?
3)	What are the major differences between the SSP approach and other previous/current approaches to science and innovation policy?
4)	What are your perspectives on the major changes in the landscape of science and innovation policy /of your science research field before and after the SSP?
5)	What aspects of SSP would affect the research direction/contents/methods of science policy research and implementation?
6)	What elements do you think the SoSP/SciSIP project should have considered but didn't? Could you please describe them in more detail?

Through my research, I intend to show that qualitative research approaches are valuable for science of science policy research development. In particular, the interview method is not on the list of scientific research methods for the Science of Science Policy Roadmap. However, through my research interview project, I have acquired valuable data and information on the SSP discourse that I couldn't have gotten through quantitative methods. Moreover, using qualitative interviews as the main research method to study this quantitative-model-oriented science policy discourse, I contend that the combination of qualitative and quantitative methods is valuable for the SSP community to extend the scope of research as well as to develop systematic tools and data for science policy makers.

5. Benefits and Significance of the Research

This research has the potential not only to deepen the understanding of the SSP discourse, but also to promote the study of unresolved issues that the SSP is likely to exclude from science policy research and discussion under the performance reform regimes. More specifically, three key benefits this study will offer are the following:

First, this research which explains the rise and development of scientific science policy and its impacts on the future of science policy design and formation, will help science policy makers and practitioners in the United States and other countries understand how the vision and direction of science policy practices in modern society have been affected and will be changed by (1) the government performance reform movement and (2) the new social contract of science.

More specifically, this research provides the necessary understanding of and attention to (1) performance management reform in science policy, as well as (2) an emerging new social contract of science to national science policy makers so that they are capable of adjusting old science policy strategies and infrastructures and designing new ones to meet the criteria of both performance reform regimes and new social demands of science without diminishing the characteristics of modern science and scientific practices. This study's results are also applicable to not only the science, technology, and innovation policy field, but also other public policy areas where demonstrating the effectiveness of public policy programs and strategies scientifically is needed.

Second, I discuss the implications of the new SSP approach on the improvement of science policy research and practice such as developing new tools for evaluating the performance of science policy programs and for assessing the social impacts of R&D investment. Therefore, this study creates new opportunities and challenges for the science policy research and practice communities to deal with modern science policy issues by adopting, adjusting or rejecting the SSP discourse.

For example, interdisciplinary and collaborative development of measures of the impact of federal science investments on society is being emphasized via the SSP discourse. Thus the new relations among science, politics, and society via the SSP approach creates whole new collaborative opportunities for interdisciplinary science policy community members who were not engaged in science policy research before. By examining these opportunities of SSP discourse, this research can map out the influences of SSP on science policy research activities.

In this context, throughout this research, I also demonstrate that the SSP discourse has the potential to play a role as a hybrid entity that is crossing boundaries of science and politics/society through which the two are co-produced. By doing so, this research can lead to further discussion on the implications of the SSP discourse on changing or re-shaping socio-democratic values and orders in the context of public policy and politics in the United States.

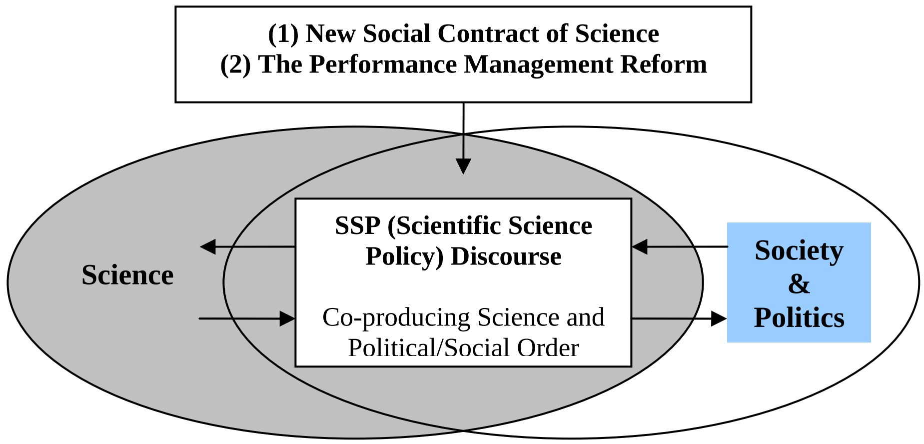


Figure 1-2. Proposed Model of the Scientizing Science Policy Approach

Third, in terms of the challenge to the SSP community, I also examine critiques of the SSP approach such as 1) scientifically objective evidence cannot be assumed or used as a magic pill to eradicate scientific controversies because evidence-based scientific assessment is not always right, and 2) scientific knowledge, consensus, and expert opinion are constructed and negotiated instead of being endowed by evidences.[21]

[21] H.M. Collins and Robert Evans, "The Third Wave of Science Studies: Studies of Expertise and Experience," *Social Studies of Science*, 32, no. 2 (2002): 235-296.

Chapter 2: Case Analysis: NSF's SciSIP and OSTP's SoSP

[O]bjectivity grew more important as a scientific ideal and also as a practical necessity….[P]rofessional social scientists finally based their claims to competence in social analysis on the authority conferred by scientific methods and attitudes. The value of objectivity was emphasized constantly in both training and professional practice, until it occupied a very special place in the professional ethos….[T]he tension between reform and knowledge reappeared as a conflict between advocacy and objectivity.

- Mary O. Furner (1975, 322-23)

In this chapter, I conduct a case analysis of the NSF SciSIP program as well as OSTP's SoSP initiative in order to collect data to support my arguments that the government performance reform regimes in science policy as we as the revised social contract between science and the state are closely related to the rise and development of the SSP. In addition, I examine the potential impacts of the SSP discourse on the federal evaluation of R&D to deepen the understanding of the scientific evidence based R&D evaluation that is being pursued by the SSP community.

1. Science Politics & the Empirical Evidence-Based Model

Two reports made by the National Research Council make recommendations to improve science policy toolkits and methods. The first is *Measuring the Science and Engineering Enterprise: Priorities for the Division of Science Resources Studies* (2000), and the other is *Measuring*

Research and Development Expenditures in the U.S. Economy (2004). These two reports highlight the need to evaluate R&D investment.

In his lecture on the science of science policy at the Brookhaven National Laboratory, Marburger stated that “[science] policy-making itself is a real-world activity that requires data and hypotheses that link the present with the future,” whereas “naturally hostile” science “advocacy,” which means “the practice of advancing arguments for certain actions without regard to the merits of competing activities” is dominating the science policy process.[22] He expressed his disappointment in the environment of science policy and politics, which urged him to state "whose side” he is on as well as his “science or political ideology" instead of “objectivity” with which scientists conduct their “professional work in science.”[23]

He admitted that advocacy is needed in the science policy process, but that it tends to “undermine the power of science.”[24] Thus he proposes “advice beyond advocacy,” aiming at “identifying and objectively analyzing options for action and presenting the result to decision makers.”[25] By doing so, he argues that the establishment of systematic approaches to setting science policy priorities, managing science policy problems and opportunities, and developing “action plans” of science policy is needed based on data and numbers.[26]

---

[22] John Marburger, “The Science of Science Policy” Pegram Lecture, Brookhaven National Laboratory (November 18, 2008)

[23] Ibid.; John Marburger, “Wanted: Better Benchmarks,” *Science*, 308, 1087 (2005).

[24] Ibid.

[25] Ibid.

[26] Ibid.

One of the negative examples of science policy advocacy he refers to is a “strong patriotic response in the science and engineering communities” after the September 11 terrorist attack, which resulted in “an immediate tightening of visas for students and visiting scientists, regulations on handling ‘select agents’ or substances of likely interest to terrorists, concern over the release even of non-classified research results that might assist terrorism, and the possible diversion of funds from existing science programs to new efforts related to homeland security.”[27]

He was doubtful about “the impact of security policies” on engineering and science workforce because there is “no reliable predictive model for workforce response to any particular driving force such as a change in policy affecting student visas.”[28] His role overseeing the development of Science and Engineering Indicators at the National Science Board also convinced him that, instead of “historical time-series data,” developing “empirically validated foundations for effective science policy” is needed.[29]

After Marburger’s AAAS speech on the science of science policy in 2005, the president of Georgia Tech, who was a member of President's Council of Advisors on Science and Technology (PCAST), introduced a public policy program at Georgia Tech. Later Cozzens, the director of the Science Policy Evaluation Center at Georgia Tech, was appointed as one of the co-chairs of the first science policy workshop in 2006. The establishment of the Interagency Task Group (ITG) by the National Science and Technology Council (NSTC) to produce the

---

[27] Ibid.

[28] Ibid.

[29] Ibid.

SoSP roadmap as well as the National Science Foundation's new SciSIP program also followed Marburger's 2005 speech.

(1) Marburger's Two Keynote Speeches on Scientizing Science Policy

Usually, Marburger's 2005 speech is regarded as the beginning of the science of science policy approach, but back in 2002, Marburger already stated the need to formulate scientific methods-based and systematic science policy and management throughout government agencies. In his keynote speech in 2002, Marburger described the concept of science-based science policy,[30] which means science policy needs to be implemented "based more on models and systematic research into what's needed and what's effective."[31]

More specifically, in his 2002 speech, he addressed the following six key principles of a new science policy: interagency, oversight, non-issue oriented, balancing, managing, and social science, which he intended to project into designing and implementing science policy during the Bush administration.[32] More details on these principles are listed below.

---

[30] Audrey T. Leath, "Marburger Speaks at AAAS Colloquium," American Institute of Physics, http://www.aip.org/fyi/2002/046.html

[31] Edward W. Lempinen, "Marburger Says Success Has Created Unexpected Challenges for U.S. S&T Research," American Association for the Advancement of Science, http://www.aaas.org//news/releases/2006/1127marburger.shtml

[32] John H. Marburger, "Science and Technology Policy After September 11" in *AAAS Science and Technology Policy Yearbook 2003*, Committee on Science, Engineering, and Public Policy, Albert H. Teich, Stephen D. Nelson, Stephen J. Lita, and Amanda E. Hunt, ed. (Washington, DC: American Association for the Advancement of Science, 2003), 5-13.

Table 2-1. Six Key Components of U.S. Science Policy after September 11

Main Theme	**Description**
(1) Interagency	Emphasizing "the interagency coordinating mechanism of the National Science and Technology Council (NSTC)" as well as interagency task groups' roles
(2) Oversight	Monitoring science activities across universities so as to reduce the possibility of them becoming sources for possible future terrorism
(3) Non-Issue Oriented	Science-based instead of particular social issue-based approach to science policy by protecting science's "intrinsic needs and process"
(4) Balance	Balancing federal science funding based on the improved understanding of how funding is working
(5) Management	Managing and evaluating basic science by "articulating criteria into the science evaluation process"
(6) Social Science	Systematic mobilization of social sciences to provide "structure and dimension to the discussion" of science policy and the war on terrorism

Source: John H. Marburger, "Science and Technology Policy After September 11" in *AAAS Science and Technology Policy Yearbook 2003,* ed. Albert H. Teich, Stephen D. Nelson, Stephen J. Lita, and Amanda E. Hunt, 5-13 (Washington, DC: Committee on Science, Engineering, and Public Policy, American Association for the Advancement of Science, 2003).

All six principles have been incorporated into the design and implementation of the Scientizing Science Policy (SSP) discourse. Evidence supporting this view includes the development of an SoSP roadmap via the Interagency Task Group organized and managed by

NSTC, the conducting of the STAR Metrics project to establish a real-time monitoring system of the activities and outcomes of R&D funding into universities, the shifting of scientists' roles from offering advice to science policy makers, NSF's SciSIP's funding for research on understanding the science and innovation process, development of quantitative evaluation toolkits and models to assess the outcomes of basic science activities, and the involvement of social scientists including economists leading the SciSIP program.

Among these six principles, in terms of updating and re-defining S&T policy data sources as well as examining how "qualitative and comparative" studies can contribute to deepening science policy debates, the engagement of social scientists in the science of science fields is particularly recommended.[33] The SSP discourse focuses on the involvement of social science fields to contribute to the development of science policy practice and research with the belief that social scientists represent a profound body of knowledge regarding the modern characteristics of science practices and knowledge, which would be useful in formulating and implementing science policy.

This would result in encouraging social scientists to be incorporated into SSP formulation or letting them access opportunities to respond to the call for establishing SSP approaches. Marburger even pointed out the need for social scientists' engagement in other policy fields, using the example of the contributions of social scientists from the anthropology fields to designing new anti-terrorism plans.

---

[33] Sally T. Hillsman, "Indicators for a New Social Science of Science Policy," *Footnotes* 33, no. 9 (December 2005), http://www2.asanet.org/footnotes/dec05/exec.html

Later, at the Science and Technology Forum of the American Association for the Advancement of Science (AAAS), April 21, 2005, Marburger stated "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."[34] During his speech, he emphasized the need to re-evaluate the framework that has been "used to evaluate S&T policies and assess their strength."[35] His call for creating a new "social science of science policy" during his 2005 keynote address on the examination of the "effectiveness of federal science and technology (S&T) expenditures" came from his complaints of the current discourse, which "prevents objective assessment of such government investment policies."[36]

One of the key assumptions of "science-based" and "science-of" science policy derived from Marburger's speech is that major science policy activities including federal R&D assessment should be formulated objectively and be based on scientific evidence, which should be emphasized as important criteria in deciding whether or not--as well as how much-- scientific research deserves support and funding.

(2) OSTP, Interagency Task Group, and the Science of Science Policy Roadmap

---

[34] American Association for the Advancement of Science, "Marburger Defends U.S. R&D Investment," http://www.aaas.org/news/releases/2005/0421marburgerText.shtml

[35] Ibid.

[36] Sally T. Hillsman, "Indicators for a New Social Science of Science Policy," *Footnotes* 33, no. 9 (December 2005), http://www2.asanet.org/footnotes/dec05/exec.html

OSTP's Science of Science Policy (SoSP) roadmap is one of the major guidelines shaping the scientizing science policy discourse. The National Science and Technology Council, which is chaired by the president and the director of the OSTP, has played a major role in formulating this roadmap through the coordination of interagency involvement. Broad federal science and technology agencies along with the NSF have already begun showing their interest in the new science of science policy approach, which has motivated their involvement into designing and discussing the roadmap. For example, the National Institute of Aging (NIA) has indicated its intention to support a science of science policy research because it would "promote well-informed, high-quality research policy making."[37]

Along with the launch of the NSF SciSIP program, the science of science policy Interagency Task Group (ITG) was created in 2006 by the National Science and Technology Council (NSTC) "to develop a coordinated Federal approach to the science of science policy to meet these challenges." [38]

There are 16 federal government agencies participating in this two-year project to produce the roadmap. These agencies are listed in Table 2-2.

---

[37] Irwin Feller and Paul C. Stern, ed. *A Strategy for Assessing Science, Behavioral and Social Research on Aging*, Committee on Assessing Behavioral and Social Science Research on Aging (Washington, D.C.: The National Academies Press). Available at http://www.ncbi.nlm.nih.gov/books/NBK26380/pdf

[38] Interagency Task Group, White House National Science and Technology Council, *The Science of Science Policy: A Federal Research Roadmap* (November 2008); OECD Global Science Forum (GSF), *Workshop on Science of Science Policy: Developing our Understanding of Public Investments in* Science (July 12, 2006). http://www.oecd.org/dataoecd/42/63/37470200.pdf

Table 2-2. List of ITG Member Agencies

Committee Chairs	Bill Valdez (Department of Energy) Julia Lane (National Science Foundation)
Participating Government Agencies	Department of Energy National Science Foundation Centers for Disease Control and Prevention Central Intelligence Agency Department of Commerce Department of Defense Environmental Protection Agency National Aeronautics & Space Administration National Institutes of Health National Institute for Standards & Technology National Oceanic & Atmospheric Administration Office of Management and Budget Office of Science and Technology Policy U.S. Department of Agriculture U.S. Geological Survey U.S. Department of Veterans Affairs

Source: Interagency Task Group, White House National Science and Technology Council, *The Science of Science Policy: A Federal Research Roadmap* (November 2008).

After two years of research, issued the report "The Science of Science Policy: A Federal Research Roadmap" in November 2008.[39] The roadmap has been used not only as the main

[39] Interagency Task Group, White House National Science and Technology Council, *The Science of Science Policy: A Federal Research Roadmap* (November 2008). http://www.whitehouse.gov/files/documents/ostp/NSTC%20Reports/39924_PDF%20Proof.pdf

guideline shaping the SoSP approach, but also as the criteria assessing the funding applications to the SciSIP program. For example, the roadmap lists the examples of the scientific research methods that are acceptable for the science of science policy research.

Table 2-3. Current and Potential Research Methods for SoSP

SoSP Research Methodologies		
Quantitative Analysis	Deterministic Models Econometrics Risk Modeling Options Modeling Cost Benefit	Cost Effectiveness Stochastic Models Agent Based System Dynamics
Qualitative Analysis	Case Studies Peer/Expert Review	Delphi Strategic/Logic
Visualization Tools	Network Analysis Visual Analytics	Science Mapping Scientometrics
Data Collection Tools	Survey Web Scraping	Administrative Data Data Mining

Source: Interagency Task Group, White House National Science and Technology Council, *The Science of Science Policy: A Federal Research Roadmap* (November 2008).

In this report, the science of science policy was defined as "an emerging field of interdisciplinary research, the goal of which is to provide a scientifically rigorous, quantitative basis from which policy makers and researchers can assess the impacts of the nation's scientific and engineering enterprise, improve their understanding of its dynamics, and assess the likely outcomes."[40] In short, the SoSP is designed to "make better R&D management decisions."[41]

Marburger states that a science of science policy (SoSP) has been developed in response to his challenge for a new science-based science policy approach that "will begin to address the need for better scientific theories and analytical tools for improving our understanding of the efficacy and impact of science and technology policy decisions."[42]

Irwin Feller and Susan Cozzens also point out that the Science of Science Policy initiative's main goal for designing systematic ways to allocate and invest the resources "to best effect" is familiar with Alvin Weinberg's "intrinsic and extrinsic criteria for scientific choice" in the 1960s.[43] There are also efforts by the government to develop empirical evidence and models for measuring and predicting scientific and technological innovation.

For example, Department of Commerce (DOC)'s *Measuring Innovation in the 21st Century Economy Advisory Committee* is focusing on "studying metrics on effectiveness of innovation in various businesses and sectors" as well as identifying data which can be used to "develop a broader measure of innovation's impact on the economy."[44]

---

[40] Ibid.

[41] Ibid.

[42] Ibid.

[43] Irwin Feller and Susan Cozzens, "It's about More Than Money," *Issues in Science and Technology* (summer 2008), http://www.issues.org/24.4/p_feller.html

[44] Francisco Moris, John Jankowski, and Pierre Perrolle, "Advancing Measures of Innovation in the United States," *The Journal of Technology Transfer* 33, no. 2 (2008):123-130

Based on the America COMPETES Act, *the President's Council on Innovation and Competitiveness* was established as well to conduct policy monitoring through not only ''developing a process for using metrics to assess the impact of existing and proposed policies and rules that affect innovation capabilities in the United States," but also "developing metrics for measuring the progress of the Federal government with respect to improving conditions for innovation, including through talent development, investment, and infrastructure development…"[45]

Even though there are all these previous and current endeavors for developing the measurement and prediction of scientific and technological innovation, still "no theory exists that can reliably predict which research activities are most likely to lead to scientific advances or to societal benefit."[46]

(3) NSF's Science of Science and Innovation Policy (SciSIP)

Since his initial call for developing science-based science policy in 2002, Dr. Marburger has played a leading role in steering research attention to science-based science policy within the science policy community. At the OECD (Organization for Economic Co-operation and

[45] Ibid.

[46] Committee on Assessing Behavioral and Social Science Research on Aging, Irwin Feller and Paul C. Stern, ed. *A Strategy for Assessing Science, Behavioral and Social Research on Aging* (Washington, D.C.: The National Academies Press). Available at http://www.ncbi.nlm.nih.gov/books/NBK26380/pdf; Irwin Feller and Susan Cozzens, "It's about More Than Money," *Issues in Science and Technology* (summer 2008), http://www.issues.org/24.4/p_feller.html

Development) in 2006 and the Atlanta Conference of Science and Innovation Policy,[47] Marburger addressed the need to establish a SoSP approach. NSF's Science of Science and Innovation Policy (SciSIP) was established in 2005 "in response to a call from John Marburger III… to study the science of science policy."[48]

SciSIP is a new NSF program that supports the design of analytical tools, explanatory models, and datasets for examining science and innovation practices.[49] In response to the SoSP roadmap initiated by Marburger's call for science-based science policy, SciSIP seeks to develop methodological tools and a scientific data infrastructure that science policy makers can use to answer science policy questions. In other words, launching the NSF SciSIP can be regarded as an effort of the science policy community to respond to a new demand for establishing a science-based and social science of science policy approach.

From this perspective, NSF's SciSIP is a crucial enactment of the scientific science policy approach that focuses on the practices of science at the micro level as opposed to traditional science and innovation policy approaches/analyses, which build on some

---

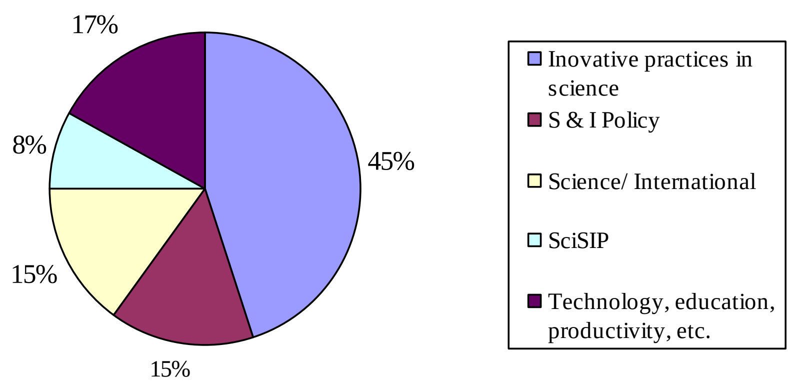
[47] Interagency Task Group, White House National Science and Technology Council, *The Science of Science Policy: A Federal Research Roadmap* (November 2008); OECD Global Science Forum (GSF), *Workshop on Science of Science Policy: Developing our Understanding of Public Investments in* Science (July 12, 2006). http://www.oecd.org/dataoecd/42/63/37470200.pdf

[48] National Science Foundation, *Science of Science and Innovation Policy Newsletter* 2, no. 1 (October 2009).

[49] Kathie L. Olsen, Neysa M. Call, Melissa A. Summers, and Ann B. Carlson, "The Evolution of Excellence: Policies, Paradigms, and Practices Shaping US Research and Development," *Technology in Society*, 30, Issues 3-4 (August-November 2008): 309-318. National Science Foundation, "Science of Science and Innovation Policy: Program Solicitation," (2008), http://www.nsf.gov/pubs/2008/nsf08520/nsf08520.htm/

normative/macro vision of science. A significant feature of this NSF program is that it seeks to improve STI policy practice and research by funding innovative practices in the basic science research and innovative research system or structure along with STI policy analysis.

For example, as shown in Figure 2-1, among forty-six SciSIP funded projects as of October 2008, approximately 45% of the projects have as their major research focus innovative practices or new ways of conducting collaboration in basic science research, approximately 15% focus on S&I policy, and the remaining projects focus on fields such as international perspectives of the S&I process. This analysis of the first solicitation of NSF SciSIP is important because it sets the basic direction of the following three funding phases of the SciSIP program.



Source: NSF SciSIP Program Funding Award Online Database, http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=501084

Figure 2-1. First Phase SciSIP Standard Grant Awarded Projects

More specifically, across the foci of SciSIP funded research, several sub-themes emerge, including open innovation systems, science networking practices, and collaboration models. In other words, micro-level innovative research practices in science are the most common focus, suggesting that it is a central emphasis within the SciSIP program.

Table 2-4. Examples for Each of the SciSIP Categories

Award #	Title	Category
0738164	"Developing the Science of Science and Innovation Policy: Profiles of Innovativeness and Gaps in the Idea Innovation Network"	SciSIP
0738058	"MOD: Stimulating Creative Insight - A Cohesive Model of Design Innovation Across Individuals, Groups and Computer Agents"	Innovative Practices in R&D
0738394	"TLS: Assessing the Impact of Science Policy on the Rate and Direction of Scientific Progress: Frontier Tools & Applications"	Science Policy
0830233	"DAT The Rise of International Co-Invention: A New Phase in the Globalization of R&D"	International
0830362	"(DAT) Impacts of Historically Black Institutions' Policies on Science and Engineering Education, Employment, Earnings and Innovation: A "Natural" Experiment"	Tech, Education & Productivity

Source: NSF SciSIP Program Funding Award Online Database, http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=501084

SciSIP research proposals are expected to develop the following three areas of focus:[50] First, developing "behavioral and analytical conceptualizations, discourses or models" to answer

[50] Dennis Hoffman and Kent Hill, "The Contribution of Universities to Regional Economies: A Report from Productivity and Prosperity Project (P3)," Center for Competitiveness and Prosperity Research (May 2009), http://wpcarey.asu.edu/seidman/Reports/P3/ContributionUniv_5-09.pdf

"SciSIP challenges" such as identifying "the relationship between broader participation and innovation or creativity";[51] Second, developing new methodologies not only "to analyze science and technology data," but also to "convey the information to a variety of audiences";[52] Third, creating, collecting, and analyzing "science and engineering data, metrics and indicators" especially on "knowledge generation and innovation in organizations."[53]

Among all this funded research, one of SciSIP's primary projects is *Science and Technology for America's Reinvestment: Measuring the Effect of Research on Innovation, Competitiveness and Science* (STAR METRICS) which is launched jointly by the OSTP, NSF, and National Institutes of Health (NIH) to assess the effectiveness of federal investment of science R&D.[54] It is one of the "first federal-university partnerships to develop a data infrastructure that documents the outcomes of science investments for the public,"[55] and based on the pilot study, the full- scale project began in March 2010.[56] SciSIP director Julia Lane explains that this project aims to construct a standardized empirical measurement infrastructure

[51] Ibid., 14.

[52] Ibid.

[53] Ibid.

[54] Julia Lane, "The Statement to the Congressional Hearing (Subcommittee on Research and Science Education, U.S. House of Representatives) on the Science of Science and Innovation Policy," (September 23, 2009), http://gop.science.house.gov/Media/hearings/research10/sept23/Lane.pdf

[55] Ibid.

[56] Ibid.

to evaluate all federal R&D funding recipients; the group's contributions to the four broad categories are the following:[57]

Table 2-5. Four Categories of the STAR Metrics

Category	Detail
Scientific knowledge	Publications and citations
Social outcomes	Health and environment
Economic growth	Patents, firm start ups and other measures
Workforce outcomes	Student mobility and employment

Source: The Statement of Julia Lane to the Congressional Hearing (Subcommittee on Research and Science Education, U.S. House of Representatives) on the Science of Science and Innovation Policy (September 23, 2009): 12.
http://gop.science.house.gov/Media/hearings/research10/sept23/Lane.pdf

One of the main actors initiating the SciSIP program in the NSF is Dr. Lightfoot, the former Assistant Director of NSF when Dr. Marburger made his 2005 AAAS speech, who assigned the budget to initiate the research on the science of science policy. At that time, the NSF was anxious about the plan making a new science policy program. More specifically, there was no immediate reaction from the sociology of science and technology field to Marburger's call for a science of science policy, and "many sociologists and other social scientists" stayed

[57] Ibid.

"curious and generally supportive of Marburger's potentially energizing proposal."[58] However, Lightfoot convinced the NSF that it should answer the call for creating a science policy relevant program to "establish the foundations for an evidence-based science of science policy."[59]

He emphasizes that the SoSP initiative's long term-goal is to "provide science policy makers with the same kinds of analyses and advice that economists now provide the Federal Reserve."[60] In order to achieve it, NSF's new SciSIP program will be conducting research on "the fundamental impact of cyberinfrastructure on scientific research and scientific culture."[61] Why does SciSIP need to focus on these two elements, cyber (digital) infrastructure and scientific culture? In this regard, he points out that "cyberinfrastructure has undermined disciplinary barriers, increased access to digital data, and created new mechanisms for sharing computational tools" which will result in improving and developing "the much cited bi–annual S&E Indicators."[62]

In terms of understanding "scientific culture - how different disciplines interact," Lightfoot explains that SciSIP will "create new opportunities and venues for interdisciplinary research" so that, instead of treating all sub-fields of science, from social science to chemistry, as

---

[58] Sally T. Hillsman, "Indicators for a New Social Science of Science Policy," *Footnotes* 33, no. 9 (December 2005), http://www2.asanet.org/footnotes/dec05/exec.html

[59] National Science Foundation, *FY 2007 Budget Request to Congress* (February 6, 2006), http://www.nsf.gov/about/budget/fy2007/pdf/fy2007.pdf

[60] David W. Lightfoot, "Social and Behavioral Scientists Building Cyberinstrastructure," *First Monday* 12, no. 6 (June 2007), http://firstmonday.org/htbin/cgiwrap/bin/ojs/index.php/fm/article/viewArticle/1907/1789

[61] Ibid.

[62] Ibid.

the “neutral” or look-a-like same entities, SciSIP via social and behavioral scientific research will bring individualized measuring and managing strategies and tools that will depend on the “specific domains” of science.[63]

In addition to the NSF FY 2003-2008 strategic plan to assess how well R&D investment was performing, in FY 2006, $2.60 million was requested for the division of SBE (Social, Behavioral, and Economic Sciences).[64] These funds would be used to “develop the data, tools, and knowledge needed to foster a new science of science policy” that aims at developing the metrics and policy tools to evaluate “returns received from past R&D investments and to forecast likely returns from future investments.”[65] As a specific plan, SBE has supported three workshops and “the broad interagency and interdisciplinary activities coordinated by the National Science and Technology Council,” as well as funded research via its new program SciSIP.

The first workshop on the “Social Organization of Science and Science Policy” was held in July 2006 to develop the science of science policy.[66] The workshop concluded that the research on scientific knowledge and the dynamics of science policy should be conducted in “political, economic, social, and historical” as well as cultural contexts.[67] Moreover, workshop participants concluded that the science of science policy discourse should encourage not only

---

[63] Ibid.

[64] Ibid.

[65] National Science Foundation, *FY 2007 Budget Request to Congress* (February 6, 2006), http://www.nsf.gov/about/budget/fy2007/pdf/fy2007.pdf

[66] Susan Cozzens, Priscilla Regan, and Beth Rubin, *Final Report: NSF Workshop on Social Organization of Science and Science Policy*, http://www.nsf.gov/sbe/scisip/ses_sosp_wksp_rpt.pdf

[67] Ibid.

public engagement and debate on science policy issues, but also on "disciplinary synergies" emphasizing the benefits from "multi-disciplinary (many disciplines), inter-disciplinary (integrative across disciplines), and trans-disciplinary (transcending disciplines)" dialogue and research across the fields of social sciences and the humanities along with the "systematic collaboration with scientists and engineers in developing new questions." [68]

In 2007, $6.8 million was allocated to start the SciSIP program, and in FY 2008, SBE increased funding for SciSIP to build a new dataset, models, and toolkits, with the specific goals to develop science and engineering indicators as well as data collection, identification of an innovation process and its socio-economic outcomes, and constructing a new interagency and interdisciplinary expert community. [69] Most recently, $14.25 million was requested for the program in the 2011 fiscal year

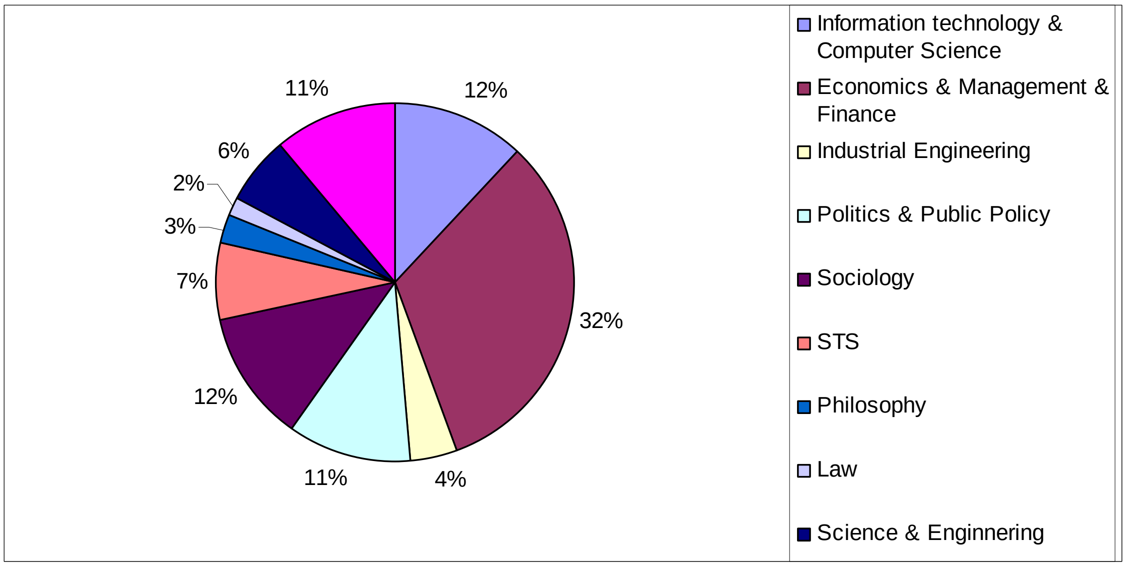
The first director of SciSIP, Kaye Husbands Fealing, and her successor, Julia Lane, are both economists, but their emphases were a little different. Kaye Husbands Fealing focused on drawing the outline of science of science policy as well as formulating a new interdisciplinary research community of science policy, whereas Julia Lane put more emphasis on building a bridge between the research community and science policy practitioners. The third SciSIP grantees workshop held in 2010 represented this shifting emphasis by allowing grantees to present their research results and then having science policy practitioners reply back with comments on each presentation.

---

[68] Ibid.

[69] National Science Foundation, *FY 2008 Budget Request to Congress* (February 5, 2007), http://www.nsf.gov/about/budget/fy2008/pdf/EntirePDF.pdf

As noticed above as well as in Marburger's speech, economics is the most dominant field of research whose actors participate in the SSP discourse via the NSF SciSIP. For example, as shown in the following figure, economics is the only field of research awarding one third of total SciSIP funding from 2007 to 2011. Sociology, law, and STS combined account for about 31%, which is the second largest portion of the NSF funding portfolio.

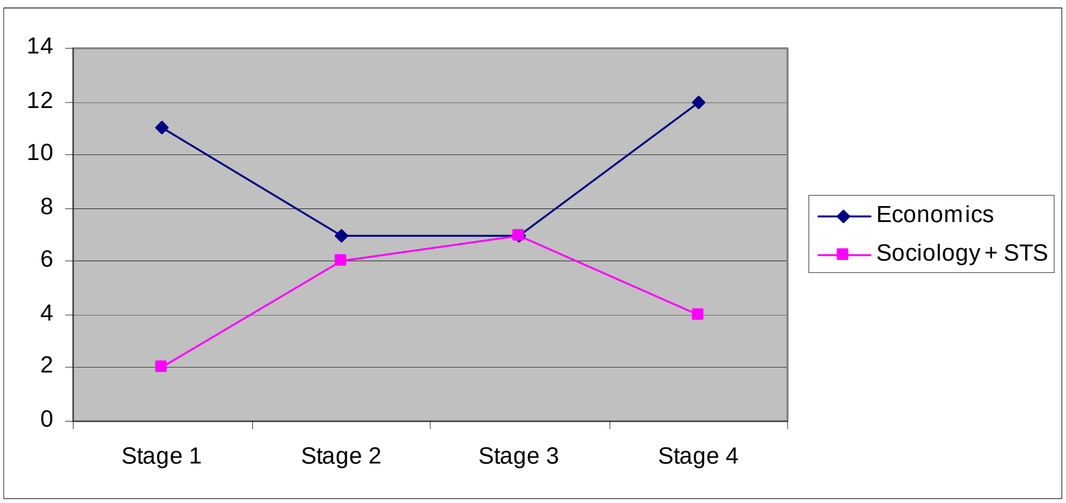


Source: NSF SciSIP Program Funding Award Online Database, http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=501084

Figure 2-2. NSF SciSIP's Four Solicitations 2007-2011 (by Discipline)

One of the interesting aspects shown in this figure is that STS accounts for 7% of the total funding, which is ranked third behind economics and sociology, which is tied with Information Technology and Computer Science. STS engagement in the SciSIP program is an interesting indicator not only because of the proportion of this field in the SciSIP portfolio, but also because the number of funded STS research projects has increased from 2007 (funding stage

1) to 2010 (funding stage 3), whereas the number of economics projects has declined. In funding stage 4, this trend has reversed, which coincides with the appointment of a new SciSIP co-director who is also a trained economist. The SSP community sees his appointment as a new sign of the emphasis on interdisciplinary research activities because his research emphasizes analyzing the effects of inter- and multidisciplinary research activities even though the actual trend shown in the following figure is not strongly supporting this hope.



Source: NSF SciSIP Program Funding Award Online Database, http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=501084

Figure 2-3. Number of SciSIP Funded Research (Economics and STS)

(4) Congressional Hearing on SciSIP

One of the main goals of the new scientizing science policy discourse is to improve the evaluation of science policy policies and programs. This means that the scientizing science policy discourse can create either new opportunities or challenges for the science policy community to assess and evaluate the impact of STI policies and programs, including the social impact of the deliberative science policy process. For example, the scientizing science policy discourse emphasizes the interdisciplinary and collaborative development of measures and indicators of the impact of federal science investments on society.

The Congressional hearing on the NSF's SciSIP by the subcommittee on Research and Science Education of the Committee on Science and Technology, U.S. House of Representatives, was held on September 23, 2010, to hear testimony on the current progress status and the potential of the NSF's SciSIP program.[70] In Congress, the Science and Technology Committee oversees "non-defense and non-health related science research activities."[71] House Science and Technology Committee Chairman Bart Gordon has a special interest in SciSIP's STAR METRICS as well as the "potential values" and international collaboration of the SciSIP program with European institutions.[72]

Even though some of the main actors were left out, there were four witnesses, two from federal and non-federal institutions and two from funded research groups. In this hearing, subcommittee members asked the panel of witnesses two main questions, which included the program's contribution to (1) the measurement of the societal returns and outcomes of the federal science R&D, and (2) science policy education in higher education institutions. In other words,

[70] Vernon J. Ehlers, Opening Statement at the Congressional Hearing (Subcommittee on Research and Science Education, U.S. House of Representatives) on the Science of Science and Innovation Policy (September 23, 2009), http://gop.science.house.gov/Media/hearings/research10/sept23/ehlers.pdf

[71] Interview data

[72] Interview data

Congress' main interest in the scientizing science policy discourse is to advance the measurement of the implications of the scientific and technological innovation on society.

However, as one of the witnesses, Sarewitz, pointed out, measuring the outcomes of R&D investment instead of the outputs is still a difficult task to achieve. Moreover, to develop effective assessment tools to measure science fundings' societal outcomes, a new understanding of the relations among science, politics, and society is needed. Whether and how the scientizing science policy approach has created new research opportunities and challenges regarding the measurement of non-tangible societal outcomes of science investment and education is examined in the following section as well as in the subsequent chapters. For example, I point out that this issue leads to further discussion on the democratic process of the science policy expert judgment system as well as on the roles of the heterogeneous science and technology policy actors' engagement in the science policy process.

In the following subsection, I argue that, because the current SSP discourse has been dominated by R&D policy and evaluation researchers, it is important to explore the benefits of having new R&D evaluation toolkits, metrics, data, and models that are developed by social science researchers who are supported by or affiliated with the SSP discourse.

2. The SSP and the New Era of Evaluation of Federal R&D Investments

In this subsection, I examine the implications of the SSP discourse on the development of assessing federal science R&D investment. The evaluation of public policy and programs can be defined by the efforts to examine the value that public policies and programs can bring to society.

Because the improvement of evaluating scientific research and development (R&D) activities is one of the major components of the current stage of the SSP, exploring the development of scientific R&D assessment tools and models under the SSP discourse will be useful to understand the nature and visions of the SSP as well as to discuss the impacts of the discourse on evaluating federal science policies and programs. Based on this examination, I also provide alternative views of the SSP so as to eliminate shortcomings and maximize the advantages of the SSP.

(1) Needs for Developing a New Science Policy Evaluation Approach

Government agencies, including the ones running science and technology programs and laboratories, now face a task to improve legitimacy. Citizens are questioning the efficacy of these institutions and the intentions of public officials because they feel that the views of public officials are inconsistent with their own expectations on governing scientific and technological innovation. Government cutbacks, government deficits, and increased international economic competition escalate this crisis.

Therefore, practical responses are required for solving this problem. The science policy community in the United States, including government agencies, Congress, and science institutions, has proposed a series of reports and legislation to deal with the crisis described above, mainly focusing on improving the STI policy evaluation process as well as justifying R&D supports. The SSP discourse can be seen as one effort of science policy community actors and institutions to respond to this call for resolving the issue of legitimacy. For example, during the G.W. Bush administration, the federal government's share of academic R&D funding dropped “from 64% in FY 2005 to 60% in FY 2008.”[73] Moreover, based on the trends of federal R&D investment between 1976 and 2009, the amount increased until 2003, whereas the overall amount decreased or was flat during the G.W. Bush administration.[74]

In this situation, one interviewee points out that science and academic communities have tried to convince the federal government to increase its investment to them, whereas the government is now turning over the responsibility to the science community to answer why the federal government’s tax money should be spent on scientific activities.

New roles or responsibilities of scientists to prove the effectiveness of federal funding support for their research are emerging, whereas the government responsibility is to evaluate their justifications and make decisions based on them. If so, would establishing a so-called scientific or objective-evidence-based approach improve the legitimacy of government R&D funding decisions and the evaluation of social outcomes better than before?

From this perspective, I first argue that the SSP discourse needs to play a greater role in promoting the action of public officials and diverse stakeholders, including citizens, so they can enable each other and work together to promote the values of society in the process of science and technology policy, especially the evaluation process of publicly funded scientific and technological R&D activities. Otherwise, the SSP discourse would not fit with the basic purposes of public policy in terms of evaluating and promoting societal outcomes of policy decisions.

---

[73] Ronda Britt, “Federal Government is Largest Source of University R&D Funding in S&E: Share Drops in FY 2008,” *National Science Foundation Info Brief: Science Resources Statistics* (September 2009), http://www.nsf.gov/statistics/infbrief/nsf09318/nsf09318.pdf

[74] Proposal Exponent, “Resource 2. Federal R&D Funding: Quick Agency Profiles,” http://www.proposalexponent.com/federalprofiles.html

Second, I contend that greater effort by SSP community actors to examine and understand the social dynamics of the scientific knowledge process are needed for evaluating scientific R&D activities. More detail will be presented and discussed in the following.

(2) Evaluation of R&D Activities and the SSP

Scientific research and development (R&D) can be defined as "systematic, creative work" focusing on "enlarging knowledge" and comprising "activities exploring new applications for existing knowledge."[75] Evaluating the performance of R&D is not an easy task because "output measurement for R&D activities is not straight forward" and "not all R&D activities directly cause turnover (e.g. basic research) and not all output is traded on the market."[76]

Especially, during the G.W. Bush administration, the science community struggled to secure the limited resources from the federal government. In this situation, the assessment and forecast of R&D investment outcomes have become more important than before so that scientists and policy makers will also acquire useful data and information from this research to exercise the policy process by designing new policy strategies, institutions, and toolkits.

The current SSP approach's key actors commonly point out their frustration in finding little research done by the academic field that they could adopt for developing the SSP discourse.

[75] Hanna Fischer, "Turnover and Output Measurement for Scientific Research and Development Activities in Germany," 25th Vooburg Group Meeting, Vienna, Austria (September 20 to September 24, 2010): 2, http://voorburggroup.org/Documents/2010%20Vienna/Papers/2010%20-%2076.pdf

[76] Ibid., 10.

Bill Valdez describes this as one of the main motivations for developing the SSP approach.[77] He said that the preliminary research (literature review) conducted by his science program taskforce couldn't locate the research which would be useful for and mesh with the goals of the SSP discourse.[78]

However, multiple interviewees also made a counter argument that the SSP community is not just recognizing rich research achievements done by the current public policy and social science researchers on science and R&D evaluation. It would be true that the science and policy evaluation research community has a relatively short history of development, but as an emerging research discipline, several universities and research centers have established dedicated programs and departments for developing science, technology, and innovation policy and evaluation research. An Atlanta based STI policy conference and Arizona State University's nanotechnology research centers and programs are among them.

There also have been multiple research collaborations among the United States and the EU such as the PRIME conference. Moreover, these science and policy evaluation research communities and activities are rooted in interdisciplinary traditions combining economics, social studies/history/philosophy of science and technology. The interdisciplinary researchers who have contributed to these research communities have a common interest in science policy even though their main research disciplines are not public policy relevant. For example, STS is one of the fields contributing to this new emerging research field. STS has been putting its research emphasis on science and technology policy. Harvard, Cornell, RIT, and Virginia Tech each have

[77] Bill Valdez, in discussion with the author, October, 2010.

[78] Ibid.

their own STS-based research focus in science and technology policy. The NSF STS program supports research on science policy as well.

All these science policy research centers, programs, and institutions are not well coordinated with each other due to the lack of a single science policy practice and research control tower. Because U.S. science policy making is different from that of other countries, mainly in terms of its absence of a single federal department managing and directing the national science policy, dispersed efforts for developing science policy done by interdisciplinary research actors and institutions is inherent in the U.S. context.

In this situation, the SSP discourse is emerging as the one combining and steering these research efforts and channeling them into specific national goals. In particular, the SSP is one of the first and latest efforts of the science policy community to lead and develop a national science policy system similar to NIS (National Innovation System) in which the research and practice of science policy and R&D programs are connected and interact together within a single governmental agency. If it is so, then the implications of the SSP discourse on R&D evaluation can be defined in what follows.

(3) SciSIP Funded Research & the Possible Impacts of the SSP on R&D Evaluation

The SSP discourse is not the same as major government reform movements such as NPM (New Public Management), which has historically supported the idea that government should be run like a business in order to achieve effective external and natural changes in government. The main philosophy of NMP or reinventing government has meant that government should adopt practices and techniques, such as scientific management, performance-based contracting, strategic planning and Total Quality Management (TQM), that have been useful in the private sector.

Visions of the SSP discourse are that private toolkits and models can't be transferred directly and used to analyze and evaluate public sector scientific and technological innovation activities and investment mainly due to public values and interests of government-funded science and technology research. Therefore, the SSP actors who initiated the discourse have called for developing new approaches and techniques that can be used in the public sectors' R&D activity management and evaluation instead of contracting out or asking private sector R&D consulting companies and experts to conduct this task on behalf of government agencies.

Does this mean that preserving and promoting public values and ideas or public engagement related to science and technology policy were the main rationale and visions shared among the key actors of the SSP approach? The answer would be negative. Based on research interviews, the development of the SSP raises concerns by experts and the public on this question.

A total of 117 SciSIP research projects have been funded since 2008. The range of research is diverse, but the dominant field of research funded by the SciSIP program is economics. Based on an analysis of all the funded research activities' main focus, I found the following results. First, only 2.6% of total SciSIP funded research examines public input or interactions with the public in the science and technology process.[79] More specifically, three research projects are in this category, and the PIs of each project are from either sociology or

[79] NSF SciSIP Program Funding Award Online Database,

http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=501084 psychology.[80] All of them earned funding in 2010.[81] The following table shows these three research projects that focus on the relations between the public and the STI process. No other research in stage 1, 2, or 4 shows a similar research focus.

Table 2-6. SciSIP Research Projects on the Relations between the Public and STI Process

Discipline	Research Title	Research Focus
Psychology	Developing a Social-Cognitive, Multilevel, Empirically-Based Model of Public Engagement for the Shaping of Science and Innovation Policy	Promoting scientific understanding of and provides guidance for the design of successful public engagements in science and innovation policy
Sociology	Government Responses to Network Failures: The Case of the Manufacturing Extension Partnerships	Quantifying the relative importance of the factors contributing to the success of collaboration projects by developing and analyzing survey and interview-based indicators of public inputs to network production
Sociology / Education	The NIH Public Access Policy: Establishing a Basis for Assessing a Science Policy	Developing methods and instruments and measures for accurately assessing the value of the government's public access policy

Source: NSF SciSIP Program Funding Award Online Database, http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=501084

[80] Ibid.

[81] Ibid.

When describing SciSIP, it is known that the program has tried to provide the information of the SciSIP funded research results to the public. However, the SciSIP has little emphasis on promoting public engagement even though the SSP aims at improving the accountability of science and science policy, and public engagement is regarded as an optimal solution to achieve the goal of concreting accountability of government and policy.

I don't argue that the NSF SciSIP program should spread out its funding across fields or subjects, but considering the importance of public engagement in science policy or even R&D evaluation, funding so few research projects that examine public engagement provides room for criticism and to improvement. I will develop my arguments on these two aspects in the following subsections.

(4) Emphasis of Extrinsic Criteria & Large-Scale Data

The SSP discourse through NSF's SciSIP is designed to collect, analyze, and disseminate scientific research data as well as build a basis for informing and developing science and technology policy making. It is important to note that, even though it pursues interdisciplinary research activities, developing econometric models, data, and methods to create statistics is one of the main emphases of the program. In other words, there are diverse criteria for evaluating the scientific development, and, under the SSP discourse, the criteria associated with outputs or economic pay-off have gained more attention from SSP community actors.

The main actors of the SSP argue that small or missing data sets prevent science and technology policy makers from making informed decisions backed by scientific evidence or statistical data. Thus, they have emphasized building new economic models and toolkits that are especially designed to generate, manage, and process large-scale data with the belief that they will improve the efficiency and objective validity of science and technology policy decision making.

As with physics or other laboratory sciences, the SSP is calling for the need to have a new methodology for collecting and analyzing large-scale data for science and technology policy makers. The idea that only science policy decisions that are based on statistically valid models and large-scale data are empirically scientific is dominant in the SSP community.

(5) New Ways of Evaluating STI Policies and R&D Programs

David Lightfoot who participated in convincing the NSF to support Marburger's call for science of science policy describes his vision on this new science policy approach using the example of Nobel Prize winners and university performance.[82]

He points out that the number of Nobel Prize winners at a particular university could not be used to properly evaluate the performance of that university because, first, that university could hire more Nobel scholars from other universities or institutions by offering better financial and research opportunities, and second, Nobel scholars' achievements may have been based on her/his previous research experiences at other academic environments.[83] Therefore, the current number of Nobel scholars can be used as one criterion, but should not be used as the major criterion to assess the academic performance of a university. Instead, new tools and methods

[82] David Lightfoot, in discussion with the author, August, 2010.

[83] Ibid.

should be developed to track scholars' research paths and determine the common aspects that contributed to their research capacity to win the Nobel Prize.[84]

In other words, one of the initial goals of the SSP discourse was to conduct research to develop better science policy tools by increasing insight into the dynamics of modern science and scientists. Money is an important factor in supporting scientific achievements, but it should be regarded as one of many factors because many other unknown factors must have played critical roles in affecting the improvement of scientists' academic performance.

SSP's basic visions of scientific R&D evaluation research can also be described in the following; first, the SSP has intended to develop economic or statistical R&D evaluation models and toolkits that government can use to assess their R&D activities as well as to steer scientific institutions, including research universities. Second SSP has aimed at emphasizing the evaluation of long-term as well as the short-term aspects of science R&D investment. Third, it has tended to challenge the conventional science policy evaluation approaches or criteria related to public R&D investment. Fourth, it has tried to shift the focus of R&D evaluation from scientific knowledge production to diffusion, transfer, and networking. Fifth, it has expanded the focus of R&D evaluation from a macro-level to the micro-level activities and dynamics of science and scientists.

[84] Ibid.

Chapter 3: Reshaping the Social Contract of Science

This chapter, in an effort to answer the main research question about constructing scientific science policy discourse, explores developing historical perspectives on U.S. science policy. In order to examine the history and development of U.S. science policy, I explore the science policy initiatives, institutional activities, and legislation focusing on the federal government's support of basic R&D activities. The historical change and development of U.S. science policy, as well as the debates on the rationale and procedures of the government's sponsorship and control of basic science R&D are essential to understanding and analyzing the rise and development of the scientific science policy (SSP) discourse. In addition, I view U.S. science and technology policy history as a response to the social contract of science, and the rise of the SSP can be situated in this response.

By examining the history of U.S. science policy in connection with the change of the social contract of science, I argue that the relatively stable federal government's sponsorship of land grant universities and basic science research, assuming an optimistic expectation of research investment outputs, has shaped postwar science and technology practices,; whereas, the recent change of the social contract of science not only re-shaped U.S. science and technology policy strategies by promoting the gradual change of the discretion to control this sponsorship or selecting priorities of science funding, but also motivated science policy makers to initiate the SSP discourse.

1. Definition(s) of Science Policy, Technology Policy and Innovation Policy

The term, Science, Technology, and Innovation (STI) Policy, is used hereafter because science policy, technology policy, and innovation policy are interconnected. Barke points out the difficulty in separating science and technology policy by defining the term "science and technology policy" as "a governmental course of action intended to support, apply, or regulate scientific knowledge and technological innovation."[85]

During an interview with, Kaye Husbands Fealing, the first NSF SciSIP program officer, she points out that she created the name of the program, Science of Science and Innovation Policy, by combining "Innovation Policy" and "Science Policy" with the intention of connecting science, innovation, and engineering policies.[86] In other words, the integration of science, technology, and innovation policy is one of the main efforts of the SSP discourse to provide an in-depth view of government's activities regarding the entire scientific and technological innovation process instead of separating the terms even if in some specific fields science policy practice and approach would be different from those of technology or innovation policy.

2. History of the U.S. Science Policy

[85] Richard P. Barke, *Science, Technology, and Public Policy* (Washington, D.C.: CQ Press, 1986), 11-12.

[86] Kaye Husbands Fealing, in discussion with the author, August, 2010.

In this section, I describe the historical development of U.S. science policy as moving from bilateral to trilateral collaborations among universities, industries, and government[87] because, among many influences, this new trend shifted the emphasis of science policy R&D from spending to investment, which represents a new understanding of science by the actors in the SSP.

(1) Before World War I

Etzkowitz points out that U.S. science policy began with a "top-down" approach with perspectives that, first, "intellectual property rights as a mechanism of science, technology, and innovation policy" is "outlined" in the U.S. Constitution, and second, "following from the patent policy established in the Constitution," there are new emerging science policy initiatives and elements including "the establishment of agencies and support of scientific research in the earth sciences" to conduct "scientific investigation" of the land.[88]

Contrary to the origin of science policy initiated from the top down, the next stage of U.S. science policy emerged from the "bottom up," beginning from the early 19th century in response to the pressure from farmers "who were interested in applying science to improve farming."[89] An academic model was adopted as a mechanism for not only stimulating "scientific

[87] Henry Etzkowitz, "Science, Technology, and Innovation Policy in the US" in Namik K. Pak, Kostadinka Simeonova, and Ergun Türkcan, ed. *Strategies of the International Scientific Cooperation in South-East Europe*, (Amsterdam: IOS Press, 2000): 103-109, Proceedings of the NATO Advanced Research Workshop on Strategies of the International Scientific Cooperation in South-East Europe, Sofia, Bulgaria, October 28-31, 1998.

[88] Ibid., 103.

[89] Ibid., 104.

investigation” with “a practical end in mind,” but also “disseminating research” into agricultural sectors, which contributed to creating “feedback loops in innovation between research and innovation.”[90]

Establishing land grant universities through the Morrill Act was one of the main endeavors supporting this new model. Alic argues that one of the key aspects of “pre-war” science policy in the United States is its emphasis on the diffusion of scientific and technological knowledge via agricultural research.[91] In 1862, the Morrill Act was adopted to establish “land grant universities, which were dedicated to the support of agriculture and the mechanic arts.”[92] The first Morrill Act was adopted in 1862, and “expanded in 1890 with the passage of the second Morrill Act.”[93]

The first Morrill Act established 59 “land grant colleges in every state and territory and the District of Columbia,” and the 1890 Morrill Act, “which mandated access to African-Americans, gave rise to a set of historically black colleges located in southern states and known as the 1890 colleges.” These original colleges later grew to “full-fledged universities,” and the

[90] Ibid., 104.

[91] John A. Alic, “A Weakness in Diffusion: US Technology and Science Policy after World War II,” *Technology in Society* 30, issue 1 (January 2008): 17-29.

[92] Helen Lawton Smith, *Universities, Innovation and the Economy* (London: Routledge, 2006), 111.

[93] National Research Council - Board on Agriculture (BOA), *Colleges of Agriculture at the Land Grant Universities: Public Service and Public Policy* (Washington D.C.: National Academy Press, 1996), http://www.nap.edu/openbook.php?record_id=5133&page=1

land grant college of agriculture (LGCA) system "continued to have a unique relationship with the public and the federal government."[94]

The two Morrill Acts, along with "two subsequent pieces of land grant legislation, the 1887 Hatch Act and the 1914 Smith-Lever Act," allowed the LGCAs to conduct a "three-part mission of teaching, research, and extension."[95] By doing so, this land grant legislation "created a federal-state partnership in agricultural research and technology."[96] In 1996, the U.S. National Research Council's Committee on the Future of the Colleges of Agriculture in the Land Grant University System identified "four principal areas for change" within the LGCA system, including:[97]

1. *the need for greater relevance and accessibility through programs that embody an expanded view of the modern food and agricultural system and through the inclusion of a wider array of students, faculty, and clientele of diverse backgrounds and perspectives;*
2. *the need to remove historic barriers and, indeed, encourage research, teaching, and extension collaborations that cross disciplines, institutions, and states; to encourage faculty and student exchanges; and to make all programs in the system accessible to as*

[94] Ibid.

[95] Ibid.

[96] Ibid.

[97] Ibid.

wide a variety of stakeholders as possible, that is, there is a firm need to create a "new geography" that cannot be confined to a locality;

3. *the need for stronger linkages among the equally important functions of teaching, research, and extension as well as the need to reinvigorate the colleges' role as models of the land grant concept and philosophy; and finally,*
4. *the need for heightened accountability and quality through competitive processes for funding, guiding principles for the use of public (especially federal) resources, and more regular and critical evaluations of publicly funded programs.*

Lundvall and Borrás evaluate this land grant university system as "one of the most successful examples of innovation policy in the United States" because it was crucial "for training, research and development of new (agricultural) technologies and products," but also "for the rapid diffusion of new ideas among farmers."[98] Lundvall and Borrás continue their argument that "there have been few attempts to introduce similar diffusion oriented policies in relation to manufacturing and services" excepting the 1980s "Manufacturing Extension Partnership."[99]

Emerging non-government science policy institutions are another key characteristic of pre-WWI U.S. science policy. During the mid-19th century, two key science policy institutions were created including the American Association for the Advancement of Science (AAAS) and

[98] Bengt-Åke Lundvall and Susana Borrás, "Science, Technology and Innovation Policy," in *Innovation Handbook*, Jan Fagerberg, David C. Mowery, and Richard R. Nelson, ed. (Oxford: Oxford University Press, 2005), 599-631.

[99] Ibid.

the National Academy of Sciences (NAS). Crumpton and Teich explain the main roles of AAAS as its support of science as well as assisting the science community in collaborating with Congress and politicians over the 150 years since its establishment on September 20, 1848.[100] Crumpton and Teich also evaluate the 1863 establishment of the National Academy of Sciences (NAS) as an effort for investigating science-related subjects and providing advice about these scientific research activities to the government.[101] Steve Nelson also points out that during the pre-WWI period, there were federal efforts to conduct and support health-related research (forerunners of NIH), geology, geography, and ballistics, and after WWI, aeronautics.[102]

(2) Wartime and Post-War Science Policy

World War I (WWI) and World War II (WWII) shaped new connections between military and chemistry as well as military and physics respectively. In addition to these "bilateral relations between institutions," the linkage between "the universities and government" has emerged since the beginning of WWII through military technology development, and the Office of Scientific Research and Development (OSRD) was established for supporting this wartime military-

---

[100] Amy Crumpton and Albert H. Teich, "The Role of AAAS in U.S. Science Policy: The First 150 Years," in *AAAS Science and Technology Policy Yearbook 1999*, Committee on Science, Engineering, and Public Policy, (Washington, DC: American Association for the Advancement of Science, 1999), http://www.aaas.org/spp/yearbook/chap26.htm

[101] Ibid.

[102] Steve Nelson, Scientizing Science Policy Dissertation Review, AAAS, (2012).

scientific research collaboration.[103] This government-funded collaborative research system that was established during WWII was "more or less continued, both for military research and for basic research." [104]

In terms of postwar science policy, a new discourse to support government-sponsored basic science R&D activities was developed. Resnik describes the U.S. government support of scientific research noting that it "began to rise steadily during WWII" due to "a very influential rationale" developed by Vannevar Bush, who called for strong government investment for basic scientific research "on the grounds that basic research builds a general knowledge base that can be used by other sciences and applied disciplines, such as medicine, engineering, and agriculture."[105]

V. Bush also contended that government's support of basic research would "develop a scientifically trained labor force, which would play a role in applying scientific knowledge in the development of technology and solution to practical problems." [106] Because "science is a public good," sponsoring basic science needs to be done by government, whereas he also argued that "scientists should be self-regulating" and thus be free from "excessive government regulation

---

[103] Henry Etzkowitz, "Science, Technology, and Innovation Policy in the US" in Namik K. Pak, Kostadinka Simeonova, and Ergun Türkcan, ed. *Strategies of the International Scientific Cooperation in South-East Europe*, (Amsterdam: IOS Press, 2000): 104, Proceedings of the NATO Advanced Research Workshop on Strategies of the International Scientific Cooperation in South-East Europe, Sofia, Bulgaria, October 28-31, 1998.

[104] Ibid.

[105] David B. Resnik, *The Price of Truth: How Money Affects the Norms of Science*. Practical and professional ethics series. (Oxford: Oxford University Press, 2007), 170-186.

[106] Ibid.

and red tape."[107] More specifically, "peer-review" should be the process "to govern scientific funding decisions and research initiatives."[108]

Resnik points out that V. Bush's rationales, which are based on the "linear model of science," have had a "strong influence over government decisions concerning science" even if "different types of practical applications of science" have been selected." For example, during the Cold War, "strategic and military applications of science" were at the center of the "debate about science funding," whereas after the Cold War, policy emphasis was given to "the importance of funding science to promote economic growth and development and compete in the global economy."[109]

There is little disagreement on government support of basic science, and even if there have been and still are debates about government sponsorship of applied scientific research, including biomedical science and environmental science, Resnik argues that "there are good reasons for the government to invest in research on the safety, efficiency, and cost-effectiveness of drugs, medical devices, and biologics."[110]

Alic argues that "before WWII, most of the leaders of the U.S. armed forces had been indifferent or resistant to new technologies," whereas "the experience of war demonstrated the value of new [science and] technology." As a result, science policy after WWII changed by

[107] Ibid.

[108] Ibid.

[109] Ibid.

[110] Ibid.

reflecting this new attitude.[111] Alic also emphasizes that the Korean War, from 1950 to 1953, "led to fundamental changes in perceptions and attitudes toward R&D," and "the United States embarked on a fundamentally new approach to Cold War security strategy," which was "based on technology as a force multiplier."[112] In other words, the Korean War triggered "a fundamental shift in the U.S. approach to military technologies," and since then "defense spending heavily influenced the entire United States "national system of innovation."[113]

Marcus and Bix argue that "shortly before 1950, many American political leaders and others began to acknowledge that America's World War II success stemmed directly from its scientific and technological prowess," and the National Science Foundation (NSF) was created in 1950, which is "the first federal agency devoted entirely to the sponsorship and funding of scientific research."[114] Marcus and Bix evaluate the establishment of the NSF as "the beginning of the federal government's marriage to science and technology that has now spanned more than half a century."[115]

(3) Three Phases of Science Policy Development until the 1980s

[111] John A. Alic, "A Weakness in Diffusion: US Technology and Science Policy after World War II," *Technology in Society* 30, issue 1 (January 2008): 17-29.

[112] Ibid.

[113] Ibid.

[114] Alan I. Marcus and Amy S. Bix, *The Future is Now: Science and Technology Policy in America since 1950* (Amherst, N.Y: Humanity Books, 2007).

[115] Ibid.

Scientific and technological advancement has been regarded as one of the key factors in formulating and implementing public policy for economic and industrial development. In his book *The New Politics of Science*, Dickson describes the relations among science, technology, and economic (and military) development since the end of WWII, emphasizing that "advanced technology has become the key to both economic and military power," and during the same period of time, "science has become the key to advanced technology."[116]

He points out that optimistic views among political leaders on the contribution of scientific and technological development to industrializing America, winning international economic competition, and securing peace dominate the U.S.[117] As an example supporting this observation, Dickson refers to President Reagan's State of the Union Address in 1983 as "a hymn of praise to the cornucopia of technological promise" and evaluates the increased budget for basic research during the Reagan administration as an effort based on "this faith."[118] In 1983, the United States spent almost $86 billion on R&D, which is more than any other industrialized country in the world.[119]

Dickson further develops his analysis of a "new era in science policy, which started in the mid-1970s under President Gerald Ford, accelerated under President Jimmy Carter, and took off

[116] David Dickson, *The New Politics of Science* (Chicago: University of Chicago Press, 1993), 3.

[117] Ibid., 3.

[118] Ibid., 4.

[119] Ibid.

under President Ronald Reagan."[120] For developing this analysis, he begins with a brief characterization of U.S. science policy since WWII with three phases.

The first phase is the "the immediate postwar period," which was "a boom time for science, when political enthusiasm, grounded in the success of the Manhattan Project, spurred by the shock of the Russian Sputnik, and reaching its apogee during the Kennedy administration, provided scientists with both lavish financial support and high social status."[121] Marcus and Bixnot also mention that "the sense of success and optimism…was shattered on October 4, 1957, when the Soviet Union launched *Sputnik,* the world's first artificial satellite."[122]

The second phase, beginning during the mid-1960s, was "a stage of questioning and doubt, when more direct payoffs were asked of the scientific community."[123] The third phase of postwar science policy, between the late 1970s and early 1980s, was the time when "budgets are moving rapidly upwards and the dominant credo again follows Vannevar Bush's *Science: The Endless Frontier,* written in the wake of science's wartime successes and endorsed as the philosophy of the first phase, but harshly criticized in the second."[124]

Dickson also argues that, because "traditional economics seemed unable to provide an effective solution" to the economic crisis during the early 1980s, "politicians of both parties clutched eagerly at the mystical promise of high technology as a cure for the nation's ills," even if there were doubts about this optimistic view of and investment in science and technology

[120] Ibid., 5.

[121] Ibid., 5-6.

[122] Ibid.

[123] Ibid., 6.

[124] Ibid.

fields, which included the concern of "unequal distribution of the rewards that high technology offered." [125]

Dickson emphasizes that "the transformation in science policy has created a new agenda for the research community" and, instead of making "potential contributions to the government's major technological endeavors," especially during the "postwar decades," this transformation formulated the "principal trust" during the second stage of science policy to "make science directly relevant to social needs" such as developing a cure for diseases and new energy sources. [126]

However, during the third stage until the early 1980s, that focus shifted and "this time the contribution of science to the competitive strength of American industry and to military technology has risen to the top of the priority list" and "the extra funding" for basic science research in universities was "intended for this purpose" so as to help the United States achieve "world technological leadership." [127]

Etzkowitz also points out that new STI relationships and networks were emerged by adding industries "during the economic decline of the 1970s when international competition caused much of US industry, especially mid-level technology and consumer electronics industries, to decline." [128] Direct governmental supports for "technology development and

---

[125] Ibid., 12.

[126] Ibid., 17.

[127] Ibid., 17.

[128] Henry Etzkowitz, "Science, Technology, and Innovation Policy in the US" in Namik K. Pak, Kostadinka Simeonova, and Ergun Türkcan, ed. *Strategies of the International Scientific Cooperation in South-East Europe,*

research" to improve "industrial productivity" were proposed in response to the decline of U.S. economy's international competitiveness.[129] For this purpose, instead of "direct intervene with respect to industry," U.S. government focused on turning the federally funded research of universities into "intellectual property" by creating a new patent system and the legislations such as the Bayh–Dole Act for supporting this new movement.[130]

Dickson also describes the emerging new collaborations among science policy institutions in addition to the industries. He argues that the pattern of "political partnership" to control science and the science budget changed along with this shift. During the postwar decades, decisions on allocating science funds were made by "scientific, military, and corporate elites," whereas during the late 1960s and early 1970s, the type of decision process dominated by these three groups was challenged to "democratize science policy by opening up to a wide range of new inputs."[131] During the late 1970s and early 1980s, under the slogan of "social efficiency and international competition," the alliance of these "three groups" was re-established.[132]

In order to make intensive spending on R&D a belief that it would advance U.S. economic leadership, the following legislation was enacted: *Patent and Trademark Act (Bayh-Dole Act) 1980*, *Economic Recovery Tax 1981*, *Small Business Innovation Research Program (SBIR) 1982*, and the *National Cooperative Research Act*.

(Amsterdam: IOS Press, 2000): 104, Proceedings of the NATO Advanced Research Workshop on Strategies of the International Scientific Cooperation in South-East Europe, Sofia, Bulgaria, October 28-31, 1998.

[129] Ibid.

[130] Ibid., 105.

[131] David Dickson, *The New Politics of Science* (Chicago: University of Chicago Press, 1993).

[132] Ibid.

Among these legislations, the Bayh–Dole Act "made it easier for universities to patent their inventions, along with a sudden spurt in industry funding for university research," "the huge prior investment in life sciences research suddenly began to look commercially important," and "venture capital began to pour into biotechnology spin-offs from universities."[133]

This new science policy model incorporating industry into the STI mechanism and emphasizing intellectual properties, which was regarded as unusual compared to the post war mechanism since WWII, has resulted in shifting the "entire university system" toward strengthening the relations between university research and industrial application. Many of the new science and technology based industries were "coming out of the universities" since the 1980s, and "Stanford and Silicon Valley on the West Coast" are examples showing this new U.S. STI mechanism.[134]

(4) Developing the Triple-Helix System

Another new STI policy tradition in the United States is to improve local research institutions and universities, which emerged through "political pressures from below, this time from the universities themselves, which have been outside of the federal research funding system but

[133] Susan Cozzens, "Science Policy: Two Views from Two Decades," *Prometheus: Critical Studies in Innovation* 21, issue 4 (2003): 509-521.

[134] Henry Etzkowitz, "Science, Technology, and Innovation Policy in the US" in Namik K. Pak, Kostadinka Simeonova, and Ergun Türkcan, ed. *Strategies of the International Scientific Cooperation in South-East Europe*, (Amsterdam: IOS Press, 2000): 104-105, Proceedings of the NATO Advanced Research Workshop on Strategies of the International Scientific Cooperation in South-East Europe, Sofia, Bulgaria, October 28-31, 1998.

which want to build up and increase their (research) capabilities to compete."[135] Seeking research funding "from business sources" is another new mechanism of the US science system. [136]

Direct governmental support to "industrial R&D" was gradually established "in the later 80s" even if there was a series of political debates on it during the early 1990s.[137] Etzkowitz explains the ATP (Advanced Technology Program) as one example of this new mechanism, which collects data and discussions from both industry and universities regarding the fields of new "pre-competitive" technologies, and then, based on this list, stakeholders from each STI sector formulate the workshop to "discuss over issues in the field" and identify a "focused program." [138]

ATP is "one of three extramural programs at the National Institute of Standards and Technology (NIST)," to promote innovation "by stimulating companies to undertake high-risk, high-reward research and development projects."[139] The U.S. Congress created ATP as an effort to correct market failure, or "the lack of "beneficial technologies" for "society and national economy," caused by the companies' "under-investment" into the high-risk emerging technology fields. [140] Campbell *et al.* argue that ATP has fostered "the development and subsequent

[135] Ibid., 106.

[136] Ibid.

[137] Ibid., 106-107.

[138] Ibid., 107.

[139] Stephen Campbell, Stephanie Shipp, Tim Mulcahy, and Ted Allen, "Informing Public Policy on Science and Innovation: the Advanced Technology Program's Experience," *The Journal of Technology Transfer* 34, no. 3 (2009): 307.

[140] Ibid., 308.

commercialization of enabling technologies where the benefits to society are likely to exceed the perceived benefits to the innovating companies." [141]

Etzkowitz emphasizes that ATP's bottom-up based process operates "trilaterally" among university, industry, and government. [142] Through the ATP award process, ATP also stimulates the "consortia" between large and small companies; the commercialization of research results, even if original research is intended for military-use or non-market purpose; and companies' hiring university researchers. [143] Etzkowitz argues that "the consequences of this program were to move market-friendly companies to engage in longer-term research and research-oriented companies to reorient themselves toward the market."[144]

Through the analysis, Etzkowitz describes the origins and development of U.S. STI policy by emphasizing that, first, "the U.S. has one of the strongest science policies in the world incorporating inputs from outside of government," and moreover, "three institutional sectors" are "increasingly working together." [145] Etzkowitz focuses on the interconnections among these three sectors because these links have been not only formulating "a new innovation environment comprising universities, national laboratories, laboratories of large corporations and start up

---

[141] Ibid.

[142] Henry Etzkowitz, "Science, Technology, and Innovation Policy in the US" in Namik K. Pak, Kostadinka Simeonova, and Ergun Türkcan, ed. *Strategies of the International Scientific Cooperation in South-East Europe*, (Amsterdam: IOS Press, 2000): 107, Proceedings of the NATO Advanced Research Workshop on Strategies of the International Scientific Cooperation in South-East Europe, Sofia, Bulgaria, October 28-31, 1998.

[143] Ibid., 107-108.

[144] Ibid., 108.

[145] Ibid.

firms," but also acting "through various alliances and consortia, creating ties across the triad of helixes," instead of working "separately as in the old linear model."[146]

In other words, there has been a shift of STI policy emphasis from "bilateral government-industry and university-industry ties" to "trilateral relationships at the regional, national and multi-national levels," and this trend of an emerging "Triple Helix" system which is primarily based on the inter-linkages among "public, private, and academic" sectors in innovation process has developed to reshape U.S. science and technology policy.[147]

In terms of the collaborations among science policy institutions or actors, in his book *Science Policy and Politics*, Morin also examines science policy history from the early days of nationhood to the present and describes the principal actors such as the federal agencies, the president and Congress, the research universities, industry, scientists, and the public.[148] In first part of the book, he examines the history of science policy by dividing it into two periods, from 1787 to 1950 and from 1950 to the present.[149] He argues that a choice could have been made after WWII to concentrate federally supported research within government laboratories, or to procure research under contracts with rigid specifications, or to create a central authority with power over research, budgets and priorities, and that we have retained a loosely organized, undirected, pluralistic research system through all the vicissitudes of the past four decades.[150]

---

[146] Ibid.

[147] Etzkowitz, Henry, 2000, *Ibid.*

[148] Alexander J. Morin, *Science Policy and Politics* (Englewood Cliffs, NJ : Prentice-Hall, 1993).

[149] Ibid.

[150] Ibid.

In the second part, Morin provides analytic descriptions of the actors in the policy process.[151] The federal agencies have agendas, and bureaucrats preserve them. Presidents and congresses have claims to make and programs to pass. Universities become the actors with areas of influence and control to carve out for themselves and protect. Industries have corporate designs and ambitions.[152] The community of scientists can be part of each of the other areas and allied with the concerns as that particular group understands them, but is nonetheless united in its own professional and research aims as a scientific community.[153]

As an organized community it has its own stratagems, as well as internal disagreements that all too effectively paralyze it from time to time.[154] And, there is the public understanding of science in accordance with its own perceptions of need and that can be influential in the acceptance of programs of science and subject to manipulation and education in order to direct or contain that influence.[155]

Through the analyses of these communities, Morin argues the inevitability of some conflicts, the need for and limitations of compromise, and the reality of a political and programmatic environment in which science takes place. Morin's perspective is political, not in the sense of partisanship, but in the realization of possibilities at a given moment in time.[156] The

---

[151] Ibid.

[152] Ibid.

[153] Ibid.

[154] Ibid.

[155] Ibid.

[156] Ibid.

outcome must be political action, whether or not that action promotes or denies the interests of the scientific community. [157]

3. The Emerging New Social Contract of Science and Science Policy Culture

In this chapter, I view the history of U.S. science policy as an attempt of science policy makers and politicians to promote scientific research; the creation of land grant universities and the NSF would be examples to support this view. However, there have also been various attempts to construct a new science policy paradigm to manage scientific institutions and research. From this historical context, I argue that the recent development of the NSF's SciSIP and OSTP's SoSP demonstrates an emerging social contract of science that supplements or replaces the linear-model and Mertonian assumptions of science based on the old contract that originated from Vannevar Bush's *Science, The Endless Frontier* report.

(1) The New Social Contract of Science

Jasanoff notes two implicit principles of science policy proposed by "V. Bush and other architects of NSF" to construct the post-war social contract of science in the United States.[158] First, "the government would supply money and agenda-setting prerogatives to the research

[157] Ibid.

[158] Sheila Jasanoff, *Designs on Nature: Science and Democracy in Europe and the United States* (Princeton, N.J. : Princeton University Press, 2007), 225.

community," and second, "scientists would produce a steady flow of technically trained personnel and discoveries to advance the nation's health, prosperity, and welfare."[159] However, she also points out that this "tacit social contract between science and the state" that is based on "the ideal of an autonomous, value-free, and disinterested science" in the V. Bush era was reconsidered "in the 1980s" because this ideal didn't match the new social demands for "economically productive" science, which also provides the source for "medical, agricultural, and environmental innovation."[160]

One of the examples reflecting the altered social contract of science she examines is the "reform of NSF's peer review criteria" that asked grant applicants to identify "their broader implications for society."[161] Appraisal of scientific works by "fellow scientists" or the peer-review process is "a tradition that has been maintained since the establishment of modern science in the seventeenth century" based on "the principle of publishing or making the results of research available to the public."[162] This reform of NSF peer-review criteria asked scientists not only to identify the merits for their fields of research, but also to place "a greater emphasis on science's social utility."[163] The Bayh-Dole Act in 1980, which provided incentives to university scientists for their contribution to commercialization or technology transfer, is another sign

---

[159] Ibid.

[160] Ibid., 226-229

[161] Ibid., 229

[162] Fumihiko Satofuka, "Review: Science, Technology and Society in Postwar Japan," *Historia Scientiarum* 2, no. 3 (March 1993): 238.

[163] Sheila Jasanoff, *Designs on Nature: Science and Democracy in Europe and the United States* (Princeton, N.J. : Princeton University Press, 2007), 229

showing the change from the V. Bush era's social contract of science.[164] In particular, the Bayh-Dole Act is known as one of the "effective agents" of federal programs for increasing the "pay-off from R&D funding" that links "investment in research to economic growth."[165]

Demeritt examines the social contract for science using case studies of the U.S. and U.K. science policy. He argues that "the implicit social contract underwriting public support for science and academic research is changing."[166] The social contract for science he refers to originated from V. Bush's report, *Science, the Endless Frontier*, which "provided the blueprint for U.S. postwar policy on science and university research."[167] Under this contract, university and national laboratory scientists received "generous federal research funding and complete professional discretion about its allocation" because of the belief that "science research…constituted a public good in itself and ultimately paved the way for improvements in national security, human health, and economic performance."[168] Demeritt quotes Bijker's research and emphasizes that this belief has changed gradually because of doubts regarding the linear model of science and technology "implied by Bush's model."[169]

---

[164] Ibid., 235

[165] Douglas W. Jamison and Christina Jansen, "Technology Transfer and Economic Growth," *Journal of the Association of University Technology Managers* (2000): 23.

[166] David Demeritt, "The New Social Contract for Science: Accountability, Relevance, and Value in US and UK Science and Research Policy," *Antipode* 32, issue 3 (2000): 308.

[167] Ibid., 308.

[168] Ibid.

[169] Ibid.

Gibbons *et al*. examine the new aspects of technology transfer and argue that "the old view of a linear process…is displaced by a more interactive one."[170] In other words, the modern scientific process and its dynamics are much more complicated than this one-dimensional normative linear model. Alic argues that V. Bush's linear model, which is based on "let the market work" philosophy, "must appear absurd on its face to anyone with practical experience of innovation."[171] Alic states that "popular and political discussions, whether of medical practice or energy security, shift back and forth between innovation and research as if the two were synonymous." [172] He proposes that, in order to resolve this issue, U.S. science policy should put more focus on diffusion or delivery service of scientific and technological knowledge.

If the non-linear model matters in science policy, then it would mean that, instead of making policy decisions on funding basic science by assuming better societal outcome from it, the science policy and politics should also be actively engaged in the interactive innovation process or shaping new relationship with scientists and science institutions.

For example, Demeritt points out that the "cozy relationship between university scientists, society, and the state" that is based on V. Bush's "guiding principles of postwar U.S. science

[170] Michael Gibbons, Camille Limoges, Helga Nowotny, Simon Schwartzman, Peter Scott, and Martin Trow, *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies* (Thousands Oaks, California: SAGE Publications, 1994), 87,

[171] John A. Alic, "A Weakness in Diffusion: US Technology and Science Policy after World War II," *Technology in Society* 30, issue 1 (January 2008): 17-29.

[172] Ibid.

policy" has "begun to unravel." [173] Reduced discretionary government spending for science and the break down of "unquestioned allegiance" between the state and scientists after the Cold War demonstrate this change. It also resulted in separating science policy from "the ideas of academic autonomy championed in the U.S. by Bush and Merton."[174]

Merton noted in 1942 "four sets of institutional imperatives – universalism, communism, disinterestedness, organized skepticism" that constitute "the ethos of modern science."[175] For example, he states that "the virtual absence of fraud in the annals of science, which appears exceptional when compared with the record of other spheres of activity, has at times been attributed to the personal qualities of scientists" and the norm of "disinterestedness of science" is coming from this "unusual degree of moral integrity" of scientists.[176] However, most of his account of science has turned out not to be fitting with the practice of modern science, and the increasing scandal and fraud of science is one of the examples that demonstrates how the accountable and transparent images of science and scientists do not mesh with the reality of modern science.

Daston and Galison examine the history and the process of creating new images of science objectivity such as "value-free" science. One of the problems of objectivity in science, they pointed out, is that data or images that ensure scientific objectivity can be distorted.

---

[173] David Demeritt, "The New Social Contract for Science: Accountability, Relevance, and Value in US and UK Science and Research Policy," *Antipode* 32, issue 3 (2000): 309.

[174] Ibid.

[175] Merton, "Normative Structure of Science," in *The Sociology of Science: Theoretical and Empirical Investigations,* Robert K. Merton and Norman W. Storer (Chicago: University of Chicago Press, 1973), 270.

[176] Ibid., 275-276.

Moreover, even though one of the functions of mechanical objectivity in science is to "insulate science from the moral" aspects, some social value and intervention such as "scientific humility" and "morality" are still needed to correct the negative aspects of objectivity.

Instead of the ideas and consensus of public policy that governed science until the end of the Cold War, new social demands have emerged that ask "science, like other publicly funded services" to "be publicly accountable and prove its value for money."[177] Demeritt refers to the claim of Guston and Keniston that "the changed world of modern science and modern government means that it is imperative to search for and begin to define a new contract, or series of contracts, between institutions of democracy and the institutions of science" along with encouraging scientists to "justify its claim on public resources by demonstrating where and how it is relevant in solving public problems."[178] In other words, new social demands have emerged and attempted to shape a "new social contract for science"[179] that encouraged both science policy makers to reconstruct the science policy system in governing science and scientists to adjust their scientific research activities to be compatible with this new mode of science policy and culture. In this context, the next question is about what kinds of actual change in science and science policy can be expected under this new social contract of science.

Emerging new government management practices such as "strategic planning," "total quality management," and the conceptualization of academic science "in terms of research

---

[177] David Demeritt, "The New Social Contract for Science: Accountability, Relevance, and Value in US and UK Science and Research Policy," *Antipode* 32, issue 3 (2000): 309.

[178] Ibid.

[179] Ibid.

outputs" reflect this change, which aims at "improving the quality and efficiency of academic research" as well as "making academic research more directly responsive to broad public needs."[180] The triple-helix model that I examined above is another example through which the new social contract emphasizing research outputs or commercialization of scientific knowledge is emerging and playing a major role in reconstructing the relationships among science, government and society.[181]

Thus, the old social contract of science based on V. Bush's model of "a liberal policy for science" has been replaced by a new social contract in which science funding agencies want to know how much bang they are getting for their buck.[182] This new contract also promotes a consensus among science policy makers to develop "new managerial regimes of strategic government planning, performance and productivity assessment, and market discipline to maximize … success, efficiency, and accountability in the federal research enterprise."[183]

This new social contract of science has influenced science policy makers, including Marburger, to initiate the Science of Science Policy for rationalizing science R&D investment and making federal science policies and programs to be efficient and accountable.

(2) The Emerging New Science Policy Culture

---

[180] Ibid., 309-310.

[181] Ibid., 311.

[182] Ibid., 311-312.

[183] Ibid., 312.

The social contract for science examined above is also closely related to the discussion on the policy culture of the United States, which is the backdrop of science policy. Jasanoff has pointed out that, based on her cross-national comparison study, "particular historically and culturally relationships" shape the unique social expectations and contracts for science that affect the design of nation-specific science policies. [184]

For example, Ruscio discusses the role of a policy culture in shaping the "relationship between government and science."[185] He points out that "the policy culture of science has recently gone through one of those transformations," emphasizing that "a rough consensus that the scientific community was comprised of professionals who were most effective operating with a large degree of autonomy and self-regulation emerged following the establishment of the National Science Foundation and the rapid growth of federal funding for research"[186] was called into question.

The consensus-sharing science policy and research community that "has been accepted since the 1950s" can be described by Merton's contribution to "identifying the professional norms of scientists that would ensure that scientists would effectively regulate themselves"[187] And Ruscio emphasizes that Mertonian norms and characteristics of science, scientists, and scientific research, which have been influencing "the federal government became the primary

---

[184] Sheila Jasanoff, *Designs on Nature: Science and Democracy in Europe and the United States* (Princeton, N.J. : Princeton University Press, 2007), 245.

[185] Kenneth P. Ruscio, "Policy Cultures: The Case of Science Policy in the United States," *Science, Technology, & Human Values* 19, no. 2 (Spring, 1994): 205-222.

[186] Ibid.

[187] Ibid.

sponsor of academic scientific research, as budgets of both private and public research universities became heavily dependent on grants," are becoming "inadequate in changing political and economic circumstance."[188]

More specifically, he claims that the new policy culture is characterized by "three interrelated developments:" "science is no longer an individual enterprise but an organizational" one, "there is an increasing emphasis on cost-benefit terminology in debates over science policy," and "science policies are increasingly diverse, ranging from no-strings attached support to extensive regulation."[189] In order to examine these changes in science policy and the rise of a "new policy culture of science," the author looks into "pork-barrel science," and "university-industry relations."[190]

In order to discuss new science policy culture, the idea of "Post-Normal Science (PNS)" is useful. PNS is "a new conception of the management of complex science-related issues," focusing on "neglected" aspects of "traditional accounts of scientific practice" including "uncertainty, value loading, and a plurality of legitimate perspectives."[191] PNS regards these three elements as "integral to science," and furthermore "some leading economists are now calling for the inclusion of the political and social contexts into their analyses and models." [192]

---

[188] Ibid.

[189] Ibid.

[190] Ibid.

[191] International Society for Ecological Economics, Silvio Funtowicz, Jerry Ravetz, Robert Costanza (editor), "Post-Normal Science," Encyclopedia of Earth, http://www.eoearth.org/article/Post-Normal_Science

[192] Ibid.

The emphasis on reducing “complex phenomena to their simple, atomic elements” tends to “make effective use of a scientific methodology designed for controlled experimentation, abstract theory building, and full quantification,” this is “not best suited for the tasks of science-related policy today” which requires a more complex understanding of “the new problems and of appropriate methods for their solution.”[193] In other words, new science policy conditions and “the post-normal perspectives of science” show that the “classical economics approach” based on the “automatic mechanism” or the “hidden hand metaphor of Adam Smith” would not be proper for managing the multi-dimensional aspects of science and science policy issues.[194] In this context, PNS can provide new problem-solving strategies by extending the notion of “peer” to communities such as “citizens’ juries” and “consensus conferences” for the assessment of “the quality of policy proposals, including a scientific element.” This “evaluative function of extended communities” puts emphasis on local or “relevant traditional” knowledge, and lets the public no longer be recipients of science policy information “given by the experts” and at least allows them to “process, or create, their own extended facts.”[195]

(3) Beyond Science, the Endless Frontier

The application of Vannevar Bush’s view on science policy to the modern STI policy discourse has been criticized. Chubin and Hackett point out that V. Bush’s assertions that “scientific progress on a broad front results from the free play of free intellects, working on subjects of their

[193] Ibid.

[194] Ibid.

[195] Ibid.

own choice, in the manner dictated by their curiosity for the exploration of the unknown," as well as that science and technology research institutions such as universities were "uniquely qualified by tradition and by their special characteristics to carry on basic research …[because these institutions offer scientists]…an atmosphere which is relatively free from the adverse pressure of convention, prejudice, or commercial necessity… substantial degree of personal intellectual freedom" do not fit with the modern science and technology environment.[196]

They state that Bush's argument that "basic research is essential for practical gain" and that basic research must be "free, unconstrained by practical demands" has been crossing the pros and cons in various formats.[197] And they argue that "perhaps times have changed, or perhaps free intellects were never so freely at play in well-funded laboratories…[T]oday's free intellects do not play freely, but instead find themselves tethered to national goals for health, defense, economic competitiveness…"[198] Thus new science policy discourse is needed to reflect these changes in science practice and research. One of possible suggestions is to democratize science policy practice.

Sarewitz argues that "closer links among science, social goals, and democratic processes are essential to the future health of science and society."[199] He first emphasizes the need for "democratic control over technologies and institutions that profoundly influence daily life"

---

[196] Daryl E. Chubin and Edward J. Hackett, *Peerless Science: Peer Review and U.S. Science Policy* (Albany, NY: SUNY Press, 1990), 9-10.

[197] Ibid., 159.

[198] Ibid., 10.

[199] Daniel Sarewitz, "Social Change and Science Policy," *Issues in Science and Technology* (Summer 1997). http://www.issues.org/13.4/sarewi.htm

because the efforts to let the R&D community respond to “a social context that demands a more democratically responsive science and technology policy” have failed since WWII, mainly due to V. Bush’s argument that “scientific progress leads inevitably and automatically to social progress,” which has made “democratic input into the system” to control the direction and support of science “both unnecessary and counterproductive.”[200]

Sarewitz is somewhat skeptical about the role of “special interest groups” in influencing the democratization of science policy, and instead, proposes new science policies that “foster receptiveness to change within the R&D community” and provide incentives and rewards to institutions and research activities for their effort to offer public service or widen public engagement as a way to get rewarded for “a number of publications or patents.”[201]

As a consequence of this effort, Sarewitz emphasizes that “positive feedback between social needs and the research agenda would begin to evolve at a grassroots level.”[202] More broadly, because “the very success of modern science and technology - the capacity to transform every aspect of existence and every institution of society - brings R&D policy inextricably into the realm of democracy,” science policy makers and scientists need to “embrace this changing social context in a way that strengthens our R&D effort.”[203]

So the main challenge for science policy makers to go beyond V. Bush’s ideal image of science and science policy is to design new science policies and programs that are capable of

[200] Ibid.

[201] Ibid.

[202] Ibid.

[203] Ibid.

responding to a new social contract for science and science policy culture considering the characteristics of science in post-modern society.

In terms of designing new science policies, Fuller uses the term, "New Deal for Science Policy." [204] He uses this term to describe the new form of science policy in the 21st century: to "extend scientific peerage, not simply by recruiting more scientists, but by ensuring that science's full constituency was represented on governing boards and policy forums." [205] In other words, the New Deal for Science Policy Fuller refers to is not closer to the 20th century's old fashioned New Deal, but to the 21st century's network- and knowledge-based policy discourse, ensuring an extended or wide range of community, including public, involvement. [206]

Saul Halfon points out that, in the history of U.S. science and technology policy, the federal government's policy decisions about allocating funds for science R&D activities have been made based on combining "expert opinions and political considerations,"[207] whereas, under the revised social contract of science, this conventional practice of science policy doesn't provide adequate tools and models to govern the federally funded scientific research and programs. And I argue that Marburger addressed this issue by initiating the Science of Science Policy aimed at not only developing new science policy models and toolkits, but also creating equilibrium among experts (scientists), politicians, and science policy managers and decision makers. The emerging revised social contract between science and the state has begun to demand the establishment of a

[204] Steve Fuller, "The Secularization of Science and a New Deal for Science Policy," *Futures* 29, issue 6 (August 1997): 483-503.

[205] Ibid.

[206] Ibid.

[207] Saul Halfon, "Preliminary Examination Note," (2008), Virginia Tech.

new science policy system for securing accountable and efficient use of government sponsorship for science, and the SSP discourse is designed precisely to serve this purpose. Greater detail of the development of the SSP discourse is examined in the following section.

(4) SciSIP and SoSP: New Science Policy Tools for the Revised Social Contract between Science and the State

In this subsection, I view Marburger's initiation of the SSP discourse as an effort to re-design new science policy tools and a system that matches the revised social contract between science and the state. In order to support this argument, I trace the emergence and history of what I call the scientizing science policy (SSP) discourse, as enacted through the Office of Science and Technology Policy's (OSTP) Science of Science Policy (SoSP) and the National Science Foundation's (NSF) Science of Science and Innovation Policy (SciSIP) program.

One of the significant features of this NSF program is that it seeks to improve science policy practice and research by funding innovative practices in the science research/innovative research system along with science policy analysis research. In response to the SoSP (Science of Science Policy) roadmap that was developed to formulate the basic elements and visions of science-of and science-based science policy, SciSIP seeks to develop methodological tools, models and scientific data infrastructures that science policy makers can use to answer science policy questions. In other words, launching the NSF SciSIP can be regarded as an effort of the science-based science policy community to respond to a new demand of establishing a science-based science policy approach.

NSF's SciSIP is a crucial enactment of the scientific science policy approach that focuses on the practices of science at the micro level as opposed to traditional science and innovation policy approaches/analyses, which build on some normative/macro vision of science. A significant feature of this NSF program is that it seeks to improve S&I policy practice and research by funding innovative practices in the basic science research/innovative research system or structure along with S&I policy analysis.

Along with the launch of the NSF SciSIP program, the science of science policy Interagency Task Group (ITG) was created in 2006 by the National Science and Technology Council "to develop a coordinated Federal approach to the science of science policy to meet these challenges." [208] SoSP ITG published "The Science of Science Policy: A Federal Research Roadmap" in November 2008, emphasizing the need to improve science policy toolkits. In this roadmap for science of science policy, Marburger states that a science of science policy (SoSP) has been developed in response to his challenge for a new science-based science policy approach that "will begin to address the need for better scientific theories and analytical tools for improving our understanding of the efficacy and impact of science and technology policy decisions."[209]

---

[208] Interagency Task Group, White House National Science and Technology Council, *The Science of Science Policy: A Federal Research Roadmap* (November 2008); OECD Global Science Forum (GSF), *Workshop on Science of Science Policy: Developing our Understanding of Public Investments in* Science (July 12, 2006). http://www.oecd.org/dataoecd/42/63/37470200.pdf

[209] Interagency Task Group, White House National Science and Technology Council, *The Science of Science Policy: A Federal Research Roadmap* (November 2008). http://www.whitehouse.gov/files/documents/ostp/NSTC%20Reports/39924_PDF%20Proof.pdf

NSF's SciSIP program has teamed with the Office of Science and Technology Policy (OSTP) to support science, technology, and innovation (STI) policy makers to establish new STI policy initiatives as well as to objectively evaluate government funding on STI projects. In terms of describing the socio-political circumstances surrounding the emerging scientific science policy discourse, there are arguments that the construction of the SSP discourse is a response of the government to the scientific community's criticism of science policy, especially the increasing influence of politics on science or scientists activities, with the goal of imposing limitations on the influence of science advocate groups on science policy. It can be also claimed that the SoSP was initiated to improve the resource allocation process by decreasing the conflicts among science policy experts, especially between science policy advocates and technocrats, or limiting the democratic process of science policy.

However, by examining the social contract of science and its implication for science policy in the United States, I dismiss these claims and instead point out that the change of the social contract of science has affected the emergence of new policy goals and values that are imbedded in the core of the SSP discourse.

Chapter 4: The Government Performance Management Reform Movement in Science Policy

In this chapter, I examine the history of the government performance management reform movement and related legislation, such as the Government Performance and Results Act (GPRA) and the Program Assessment Rating Tool (PART), to demonstrate how these government-wide efforts to improve performance of agencies have affected the rise and development of the SSP discourse, or more specifically, the performance-first idea in science policy.

1. SSP, the Arrival of the Government Performance Reform Movement in Science and Science Policy

Through the interview and discourse analysis of the SSP initiative, I found that the rise and development of the SSP discourse are closely related to the government performance management movement during the G.W. Bush and Obama administrations. As Moynihan notes, both presidents seem to agree on the need to use performance management tools, but at the same time, they have different perspectives on managing performance in the government.[210]

However, there is little research on the impact of performance management in science and science agencies compared to the research on the impact of GPRA and PART in the general public policy landscape. Therefore, based on my research findings, I show that the SSP discourse

[210] Donald Moynihan, "The Politics Measurement Makes: Performance Management in the Obama Era," *The Forum* 7, issue 4 (January 2010).

can be used as an indicator showing this missed analysis, the impact of performance management in science and science policy.

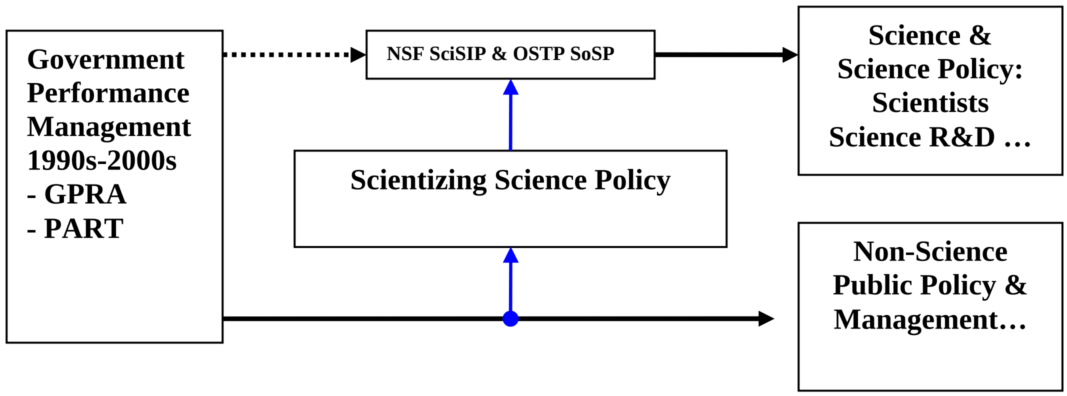


Figure 4-1. Performance Management and the SSP Discourse

In this context, previous and current research on performance management would be a useful resource to develop my analysis on the SSP discourse. At the same time, my research on the SSP would benefit the research communities of public policy and administration to examine how government performance management regimes affect science, scientists, and the science policy community. I show that the research on government performance reform is applicable to my analysis and arguments because the SSP discourse originates from and meshes with the goals of performance management efforts in terms of evaluating performance and providing evidence to show the effectiveness of government programs.

More specifically, in the following subsection, I begin examining the discussion on the movement of government performance management reform, including GPRA and PART, to confirm and support my research findings including the potential of the SSP discourse to change the relationship among heterogeneous science policy actors and the re-design of the shared responsibilities of the science policy system that meshes with the pluralistic American political culture. I also argue that the SSP discourse is an indicator of the impact of this performance management movement on science and science policy.

2. Government Performance Management, GPRA and PART

The ideas that "performance systems can improve performance" and "performance metrics" can increase the effectiveness of government programs are the core of government performance management.[211] Performance management has its origin from "Total Quality Management and strategic planning" in the 1980s, but the performance-based government management approach was started in 1993 "when the Government Performance and Results Act (GPRA) was passed."[212] GPRA requires federal agencies to "prepare performance plans delineating objectives and indicators that address the outcomes of their programs."[213] Since then new initiatives such as PART have emerged to influence "(policy) decision making in a systematic way."[214]

Martin also points out that "accountability has become a major issue," and thus "in 1993, Congress passed the *Results and Performance Act*, which requires federal agencies to establish

---

[211] Ibid.

[212] Ibid.

[213] Paul L. Posner, "Accountability Challenges of Third-Party Government," in *The Tools of Government, A Guide to the New Governance*, Salamon, Lester M., ed. (New York: Oxford University Press, 2002), 541.

[214] Donald Moynihan, "The Politics Measurement Makes: Performance Management in the Obama Era," *The Forum* 7, issue 4 (January 2010).

strategic planning and performance measurement," which "requires the establishment of performance goals and performance indicators to assess output, service level, and outcome."[215]

In terms of developing and institutionalizing the idea of performance management, G.W. Bush and the Obama administration have played key roles in identifying "performance as the central organizing theme for their management initiatives" because both presidents "have said that results and performance management are important to their respective administrations."[216]

In particular, G.W. Bush, who is the "first MBA president" framed "the central role of performance in his governing philosophy" in that, first, "government should be results-oriented – guided not by the process but guided by performance," and second, "scarce federal resources should be allocated to program that deliver results."[217] To achieve this governing philosophy, the Office of Management and Budget (OMB) began using "Program Assessment Rating Tool (PART)" from 2002, which is designed to "assess federal programs."[218]

The general assumption of OMB's PART is similar to GPRA, introducing "some form of performance budgeting at the Federal level."[219] The main goal of PART is to "move budgeting to

---

[215] Ben R. Martin, "The Use of Multiple Indicators in the Assessment of Basic Research," *Scientometrics* 36, no. 3 (1996), 343-362.

[216] Donald Moynihan, "The Politics Measurement Makes: Performance Management in the Obama Era," *The Forum* 7, issue 4 (January 2010).

[217] Ibid.; U.S. Office of Management and Budget, *The President's Management Agenda*. (Washington, D.C.: Government Printing Office, 2001).

[218] Ibid.

[219] Donald Moynihan, "What Do We Talk About When We Talk About Performance? Dialogue Theory and Performance Budgeting," *Journal of Public Administration Research and Theory* 16, issue 2 (2006) 151.

a point where politicians fund more effective programs and reduce or reorganize the less effective program."[220] By adopting this goal statement, the science agencies need to identify the effective science and technology programs by the use of PART rating tools.

During the current administration, Obama seems to regard performance as the way to project "his image as a pragmatist" and emphasizes that "programs should be judged on whether they work."[221] OMB also uses "performance information" as an important source of their operation, and Obama appointed a "Chief Performance Officer" as "the OMB Deputy Director for Management" for over-sighting the "government-wide performance apparatus."[222]Moynihan argues that these performance initiatives show the White House's "preference for data."[223] Obama signed the new legislation, "Government Performance and Results Modernization Act of 2010" in January 2011 for expanding the GPRA of 1993.[224] In the following subsection, I examine the details of the government performance management reform legislation.

(1) GPRA of 1993

The GPRA is a law "passed by Congress in 1993 (Public Law 103-62) to improve stewardship in the Federal Government by linking resources and management decisions with program

[220] Ibid., 152.

[221] Donald Moynihan, "What Do We Talk About When We Talk About Performance? Dialogue Theory and Performance Budgeting," *Journal of Public Administration Research and Theory* 16, issue 2 (2006).

[222] Ibid.

[223] Ibid.

[224] Office of Program Evaluation and Performance, "Performance," National Institutes of Health, http://dpcpsi.nih.gov/opep/performance.aspx

performance."[225] In particular, the GPRA was designed to achieve the following six goals, which are shown in Table 4-1.[226]

Table 4-1. Six Goals of the GPRA of 1993

	Goal of the GPRA
1	Improving "the confidence of the American people in the capability of the Federal Government, by ***systematically holding Federal agencies accountable*** for achieving program results";
2	Initiating "***program performance reform*** with a series of pilot projects in setting program goals, ***measuring program performance*** against those goals, and reporting publicly on their progress";
3	Improving "Federal ***program effectiveness and public accountability*** by promoting a new focus on results, service quality, and customer satisfaction";
4	Helping "Federal managers improve service delivery, by requiring that they plan for meeting program objectives and by providing them with ***information about program results*** and service quality";
5	Improving "congressional decisionmaking by providing more ***objective information*** on achieving statutory objectives, and on the relative effectiveness and efficiency of Federal programs and spending";
6	Improving "internal ***management of the Federal Government***."

Source: Office of Management and Budget, "Government Performance Results Act of 1993," The White House. [227]

[225] National Institutes of Health, "GPRA and PART, NIH Systemic Assessments," http://sourcebook.od.nih.gov/SD%20Orientation/GPRA%20.pdf

[226] Office of Management and Budget, "Government Performance Results Act of 1993," The White House, http://www.whitehouse.gov/omb/mgmt-gpra/gplaw2m#h6; http://www.orau.gov/pbm/links/PL103_62.pdf

[227] Ibid.

In particular, introducing performance management reform and promoting the systematic evaluation of government programs' effectiveness, based on these six goals, are the main emphases of the Act. It also requires agencies to produce an "Annual Performance Plan (APP)" in which the six elements shown in Table 4-2 should be addressed. [228]

Table 4-2. Six Elements of the Annual Performance Plan (APP)

	Element of APP
1	Establishment of "performance goals to define the level of performance to be achieved by a program activity";
2	Demonstration of "(performance) goals in an ***objective, quantifiable, and measurable form*** unless authorized to be in an alternative form under subsection" ;
3	Brief description of "the operational processes, skills and technology, and the human, capital, information, or other resources required to meet the performance goals";
4	Establishment of "***performance indicators to be used in measuring or assessing the relevant outputs***, service levels, and outcomes of each program activity";
5	Submission of "a basis for comparing actual program results with the established performance goals";
6	Description of "the means to be used to verify and validate measured values."

Source: Office of Management and Budget, "Government Performance Results Act of 1993," The White House. [229]

As the requirements of the APP indicate, agencies should not only set the performance goals in an "objective, quantifiable and measurable form," but also develop "performance

[228] Ibid.

[229] Ibid.

indicators" to evaluate the outputs and outcomes of the program's performance.[230] In other words, non-quantifiable or non-measurable goals would not be acceptable, and moreover each agency should invest in the development of performance indicators to assess their activities.

It is important to note that these GPRA requirements have presented challenges to science agencies that are conducting their own R&D investment and programs because their R&D outputs and outcomes tend to be intangible or non-quantifiable and long-term aspects.

GPRA offers an exception and allows the agency to use an "alternative form" if "it is not feasible to express the performance goals for a particular program activity in an objective, quantifiable, and measurable form."[231] Some agencies, including the NSF, have tried to convince the OMB to grant the use of alternative forms to set performance goals. However, even when using the alternative form, "the program activity's performance" should meet "the criteria of the description."[232]

For example, the National Institute of Health (NIH) prepares and "submits a performance plan to the Department of Health and Human Services (HHS) and to the Office of Management and Budget (OMB) in June and September, respectively," every year.[233] In order to plan and assess performance, the NIH implements the following activities in "five functional areas" including: Scientific Research Outcomes, Communication and Transfer of Results (CTR), Capacity Building and Research Resources (CBRR), Strategic Management of Human Capital (SMHC), and Program

---

[230] Ibid.

[231] Ibid.

[232] Ibid.

[233] National Institutes of Health, "GPRA and PART, NIH Systemic Assessments," http://sourcebook.od.nih.gov/SD%20Orientation/GPRA%20.pdf

Oversight and Improvement (POI).[234] NIH performance reports present "a story of scientific discovery, including the background… rationale for the goal, planned implementation strategies, baseline data, summary of performance, targets and target adjustment to enhance goal achievement, and other highlights."[235]

(2) The President's Management Agenda (PMA) of 2001 and the OMB's Program Assessment Rating Tool (PART)

As "one of five government-wide management initiatives" during the G.W. Bush administration, the Budget and Performance Integration Initiative "builds on the Government Performance and Results Act of 1993 (GPRA)" so as to "identify program goals and performance measures, and link them to the budget process."[236] One of the major influences of this initiative along with the GPRA is to conduct "explicit assessments of program performance" from the president's FY 2003 Budget.[237] More specifically, the President's Management Agenda (PMA) of 2001 called for the development of the Budget and Performance Integration Initiative.

The PMA outlines "fourteen areas of improvements" focusing on "performance and results."[238] In other words, this agenda intends to promote "Budget and Performance Integration"

---

[234] Ibid.

[235] Ibid.

[236] Office of Management and Budget, "Budget and Performance Integration," The White House, http://georgewbush-whitehouse.archives.gov/omb/budintegration/index.html

[237] Ibid.

[238] Office of Management and Budget, "The President's Management Agenda," The White House (2001), 1, http://www.whitehouse.gov/sites/default/files/omb/assets/omb/budget/fy2002/mgmt.pdf

for improving program performance and financial management simultaneously.[239] Three visions for government reform are projected into the PMA: Citizen-centered, not bureaucracy-centered, Results-oriented, and Market-based.[240]

The PMA and the GPRA share the element of promoting performance budgeting and management at the federal level.[241] Moynihan points out that the PMA of 2001 addressed the "effort to introduce performance budgeting to the federal government" because it "called for the integration of financial and performance information by increasing the quality and range of data available to decision makers, assuming that greater technical and allocative efficiency would result."[242] He also refers to the "Program Planning Budgeting Systems under President Lyndon B. Johnson, Management by Objectives under President Richard Nixon [and], Zero-Based Budgeting under President Jimmy Carter" as examples that share the "basic propositions" of introducing federal-level performance budgeting with the GPRA and the PMA. [243]

However, there are also differences between the GPRA and the PMA. First, the GPRA "does not require strategic plans from organizations below the agency level (cabinet-level

---

[239] Ibid., 4.

[240] Ibid.

[241] Donald P. Moynihan, "What Do We Talk About When We Talk About Performance? Dialogue Theory and Performance Budgeting," *Journal of Public Administration Research and Theory* 16, issue 2 (2005): 151.

[242] Ibid; Office of Management and Budget, "The President's Management Agenda," The White House (2001), http://www.whitehouse.gov/sites/default/files/omb/assets/omb/budget/fy2002/mgmt.pdf

[243] Donald P. Moynihan, "What Do We Talk About When We Talk About Performance? Dialogue Theory and Performance Budgeting," *Journal of Public Administration Research and Theory* 16, issue 2 (2005): 151.

departments and independent agencies)," [244] whereas the PMA expands the scope of organizations that are subject to developing a strategic plan. Second, the GPRA of 1993 has not been successful in creating "a strong linkage between performance information and decision making." [245] Based on this criticism of the GPRA, the PMA was proposed to strengthen this linkage by increasing funding to "more effective programs" and reducing or reorganizing "less effective programs."[246]

Third, the OMB took a leading role in developing the PMA by adding the PART into the GPRA. In order to integrate "performance information and budget process," the main proposal of the PMA, the OMB launched "the Program Assessment Rating Tool (PART)" during fiscal year (FY) 2003. PART is "a set of standard questions that OMB analysts, in consultation with agency representatives, use to develop a summary assessment of a fraction of federal programs."[247] In

[244] National Eye Institute, "The GPRA and NEI Planning Process," National Institutes of Health, http://www.nei.nih.gov/resources/strategicplans/neiplan/frm_gpra.asp

[245] Donald P. Moynihan, "What Do We Talk About When We Talk About Performance? Dialogue Theory and Performance Budgeting," *Journal of Public Administration Research and Theory* 16, issue 2 (2005): 151-152; General Accounting Office, *Performance Budgeting: OMB's Program Assessment Rating Tool Presents Opportunities and Challenges for Budget and Performance Integration*. GAO-04-439T (Washington, DC: GAO, 2004); Office of Management and Budget, "The President's Management Agenda," The White House (2001), http://www.whitehouse.gov/sites/default/files/omb/assets/omb/budget/fy2002/mgmt.pdf; Beryl Radin, "The Government Performance and Results Act and the Tradition of Federal Management Reform: Square Pegs in Round Holes," *Journal of Public Administration and Research Theory* 10, issue 1 (2000) 111–135.

[246] Ibid.

[247] Donald P. Moynihan, "What Do We Talk About When We Talk About Performance? Dialogue Theory and Performance Budgeting," *Journal of Public Administration Research and Theory* 16, issue 2 (2005): 152.

other words, the GPRA of 1993 has laid the foundation for developing federal-level performance management, and the PMA of 2001 described its challenges based on the experiences of the GPRA. The OMB has taken the lead to resolve these challenges by making performance assessment, through the PART, important in budgeting since 2003.

(3) The PMA and R&D Performance Reform

One of the important features of the PMA compared to the previous performance reform movement including the GPRA of 1993 is to specify the reform of federal science R&D activities. For example, the agenda presents the "five government-wide management initiatives" as well as "nine agency-specific reforms."[248] Among these initiatives and reforms, one agency-specific reform, *Better R&D Investment Criteria,* is applicable to science agencies. The previous performance management and budget reform legislation and initiatives didn't provide details of how the performance reform applied to science agencies, and even allowed alternative, non-quantifiable tools to be used in science agencies such as the NSF. However, the PMA and OMB's PART do not limit the application of performance reform ideas to scientific R&D activities.

In particular, in the *Better R&D Investment Criteria* section, the PMA emphasizes the importance of science and technology as a critical factor for "keeping our nation's economy competitive and for addressing challenges we face in health care, defense, energy production and

[248] Office of Management and Budget, "The President's Management Agenda," The White House (2001), 33, http://www.whitehouse.gov/sites/default/files/omb/assets/omb/budget/fy2002/mgmt.pdf

use, and the environment."[249] In order to call for investing "every federal research and development (R&D) dollar" effectively, the PMA points out the problems of the current government R&D system, which are the following;[250]

First, the federal government's goals of R&D investment should be clarified for achieving better results[251];

Second, the federal government should measure the effectiveness of its R&D investments to produce performance information that needs to be linked to the federal government's funding decisions. The agenda states that "without this information, decisions about programs tend to be made on the basis of anecdotes, last year's funding level, and the political clout of local interest groups."[252]

Third, "federal R&D should not compete with or supplant private investments." R&D funding of the Department of Energy (DOE) for "a midsize turbine development project" for commercial use is an example of an unwise investment of federal dollars that "merely" replaces "private research dollars."[253]

Fourth, federal R&D projects should not "benefit corporations that could fund their own R&D projects without federal assistance." DOE's funding for "gas-to-liquid conversion

---

[249] Ibid., 43.

[250] Ibid.

[251] Ibid.

[252] Ibid.

[253] Ibid.

research" overlaps with one oil company's plan for "investing up to $6 billion for new plants based upon this technology."[254]

In order to resolve these issues, the PMA proposes the DOE-specific reform initiative. Details of this initiative are shown in the following.[255] First, "objective investment criteria for federal R&D projects" that are under development by the administration will be used to evaluate "the performance of research programs."[256] Moreover, these investment criteria will not only direct the "R&D portfolio," but also "demonstrate progress towards the portfolio's strategic goals."[257] Second, the DOE is going to "pilot this initiative" for developing "objective investment criteria for federal R&D projects."[258] Third, the DOE and OMB will collaborate to develop "performance criteria for applied research and development programs" that will "guide funding for the 2003 Budget for the Department's Solar and Renew-able Energy, Nuclear Energy, Clean Coal, Fossil Energy, and Energy Conservation programs."[259] Fourth, in order to "improve (R&D) investment criteria and their implementation," the DOE, the OMB, and the White House offices are working together and encouraging "input from other R&D agencies, experts in research management, and groups with an interest in the federal R&D portfolio."[260] Fifth, "uniform investment criteria to the applied energy technology programs" will be transferred to

[254] Ibid.

[255] Ibid., 44.

[256] Ibid.

[257] Ibid.

[258] Ibid.

[259] Ibid.

[260] Ibid.

"the rest of DOE, and other Departments and applicable agencies with applied R&D programs." The OMB and the Office of Science and Technology Policy will also collaborate with "NASA, the National Science Foundation, the Department of Defense, the National Institutes of Health, and DOE" to develop "separate criteria" to evaluate "basic research."

Among these five suggestions, the fourth and fifth ones provide an explanation for (1) the initiation of science of science policy aimed at developing science R&D evaluation models and tools, (2) interagency working groups' participation in this science policy initiative coordinated by the White House OSTP and NIST, (3) the leading role of the DOE in supporting the NSF's SciSIP program and OSTP's SoSP roadmap development, and (4) the SSP community's efforts to develop evaluation models, tools, and data of basic R&D activities.

The government performance management reform movement shows two stages, beginning with the GPRA, and the development of the PMA and PART to correct problems of the GPRA. In the latter stage, science R&D activities gained attention from government performance reformers and science agencies including the DOE and NSF, which began participating in efforts to develop R&D investment and management criteria. The SSP community has provided the platform in which this government-wide performance reform movement in science could be conducted. The Obama administration has continued its support for this performance reform in science agencies and updated the GPRA with the GPRA Modernization Act, which is examined in the following.

(4) The GPRA Modernization Act – Obama Administration

The GPRA Modernization Act forces agencies to "report performance" and provides the detailed requirements of the Annual Performance Plan (APP).[261] For example, Table 4-3 shows the basic format of the APP[262] in which the Act requires the agency to "describe how the agency performance goals contribute to any of the Federal Priority Goals established" in the APP's Chapter II, *Goals and Priorities*.[263]

Table 4-3. Basic Format of the APP

	Requirements
1	Overview
2	Goals and Priorities
3	Strategies and Supporting Analysis
4	Measures and Milestones
5	Budget

Source: Executive Office of the President and Office of the Management and Budget, "Preparation, Submission, and Execution of the Budget," Circular no. A-11 (August 2011).

[261] Executive Office of the President and Office of the Management and Budget, "Preparation, Submission, and Execution of the Budget," Circular no. A-11 (August 2011): 230-1, http://www.whitehouse.gov/sites/default/files/omb/assets/a11_current_year/a_11_2011.pdf

[262] Ibid., 220-2

[263] Ibid., 220-3

Among the many requirements, developing performance indicators and data is one of the Act's emphases. In particular, in the APP's Chapter IV, *Measures and Milestones*, the Act establishes the following requirements for agencies;

(1) Agencies need to "establish a balanced set of performance indicators, milestones or appropriate evidence to be used in assessing progress toward each performance goal, including, as appropriate, customer service, efficiency, output, and outcome indicators."[264]

(2) Agencies should "describe program results as compared to the established performance goals."[265]

(3) "Accuracy and reliability" of the funding and performance data for measuring the "progress towards its performance goals" should be ensured by the agency.[266]

A Congressional hearing, "Roadmap for a More Efficient and Accountable Federal Government: Implementing the GPRA Modernization Act," was held in May 2011 to examine the details and the progress of the Act.[267] If the GPRA of 1993 was enacted to promote better performance management of resources and improve "the effectiveness of Federal programs," the new Act is designed not only to require "the OMB to set Government-wide goals to align

[264] Ibid., 220-4.

[265] Ibid.

[266] Ibid.

[267] Committee on Homeland Security and Governmental Affairs, "Joint Hearing: Roadmap for a More Efficient and Accountable Federal Government: Implementing the GPRA Modernization Act," United States Senate (May 2011): 1, http://www.gpo.gov/fdsys/pkg/CHRG-112shrg67636/pdf/CHRG-112shrg67636.pdf

programs from different agencies to work together to reduce overlap and duplication," but also to allow the performance results and information to be available publicly "on a single searchable website," *performance.gov*, that is part of the efforts to ensure "transparency and accountability of agency performance."[268] The website *performance.gov*, which was officially launched by the OMB in August 2011, is "designed to highlight government efforts to cut waste and improve efficiency."[269]

(5) Annual Performance Plan (APP)

Following OMB Circular Number A-11 *Preparing, Submitting, and Executing the Budget*, which was published in August 2011 to offer "guidance on preparing the FY 2012 Budget and instructions on budget execution," each government agency's submission of its budget "may serve as the performance plan required by the GPRA Modernization Act of 2010."[270] In other words, the agency's submission of both a budget and "performance plan" should not be separated, and the "annual performance plan required by GPRA" needs to be covered in the

---

[268] Ibid., 3.

[269] Government Technology, "Feds Launch Performance.gov," (August 25, 2011), http://www.govtech.com/e-government/Feds-Launch-Performancegov.html; Federal News Radio, "OMB finally launches Performance.gov portal," (August 26, 2011), http://www.federalnewsradio.com/?nid=92&sid=2512607

[270] Executive Office of the President and Office of the Management and Budget, "Preparation, Submission, and Execution of the Budget," Circular no. A-11 (August 2011): 51-4, http://www.whitehouse.gov/sites/default/files/omb/assets/a11_current_year/a_11_2011.pdf

budget submission.[271] Section 220 of OMB Circular A-11 provides the details of the performance plans, which include the following.[272]

Agencies are using performance plans to communicate their "performance goals with other elements of the agency budget request, showing the relationship between proposed funding levels and planned results."[273] It is also important to note that "the measures developed to track performance goals" are included in the Annual Performance Plan (APP).[274]

Second, the APP offers "information on the agency's actual performance and progress in achieving the goals described in the agency's strategic plan and Annual Performance Plan."[275] The APP should contain a specific description of the agency's strategies, an explanation of the reasons "why those strategies have been chosen," and identification of "performance target and key milestones that will be accomplished in the fiscal year ahead."[276]

Third, the performance goals of the APP and the strategic goals of "the agency's strategic plan" should be aligned.[277] The term APP is also used "synonymously with Performance

---

[271] Ibid.

[272] Ibid., 220-1.

[273] Ibid.

[274] Ibid.

[275] Ibid., 230-1

[276] Ibid., 220-1

[277] Ibid.

Budget."[278] In other words, both the strategic and performance plans are used by the agencies as critical components to justify their budget plan and request to the OMB.[279]

Fourth, one of the important functions of the APP is to describe the "agency's contribution to any Federal Priority Goals which OMB has asked the agency to lead or support."[280] In other words, the OMB uses the APP as a way to encourage agencies to follow or show their contribution to federal policy goals, and each agency works together with the OMB to demonstrate that its performance is an integral part of pursuing federal-level policy priorities. The autonomy of agencies seems to be affected by the process of developing the APP because the agency's performance plan should meet the criteria of the OMB as well as the federal priorities to request the budget.

3. New Relationship Among Scientists, Science Agencies, OMB and White House under Performance Regimes

In this subsection, I demonstrate that understanding the government performance management movement in the U.S. is important approach to studying the SSP discourse. More specifically, this performance reform framework provides insight into whether and how the SSP discourse has

[278] Ibid., 220-2

[279] Ibid.

[280] Ibid.

affected the relationship among scientists, administrative and political actors of the science policy community.

One of the key and common consequences of the performance management movement during the Bush and Obama administrations is the increased new administrative discretion of the OMB to "influence agencies" through constructing and using performance data.[281] In other words, administrative performance management reforms have resulted in the enhanced "administrative power" of OMB as well as "the White House more broadly" to "direct agencies" and to "measure them.[282]

For example, GPRA was designed to set "expectations for both the legislative and executive branches" by promoting the involvement of Congress in "strategic plan development" along with the use of "performance indicators" and measurement of the government agencies.[283] However, Radin points out that the government reform movement though GPRA might collide "with the institutional design of separation of power" because, even though GPRA aimed to establish "shared responsibilities between…government and…Congress" when designing and implementing the government reform, the executive branch and Congress have different

---

[281] Donald Moynihan, "The Politics Measurement Makes: Performance Management in the Obama Era," *The Forum* 7, issue 4 (January 2010).

[282] Ibid.

[283] Beryl A. Radin, "The Government Performance and Results Act and the Tradition of Federal Management Reform: Square Pegs in Round Holes?" *Journal of Public Administration Research and Theory* 10, issue 1 (2000), 119-121.

perspective on the Act and GBRA would tend to "create tensions and frequently lead to conflicts" between the government and Congress.[284]

Moreover, "if GBRA is taken seriously, it can lead to centralization – an increase in the federal role" in managing policy projects instead of shared power across the stakeholders and agencies because, first, the Office of Management and Budget (OMB) that is responsible for GBRA has dealt with "the management issues as an aggregate," second, OMB has reflected White House's will "to approach management issues from the perspective of the government as a whole" instead of individual agency's performance management plans, third, GBRA has placed the agencies as "sub-units of the same large system," and fourth, "legal and political autonomy of the agencies" tend to be compromised.[285]

Moynihan also notes Congress has a similar motivation to enhance its political power by using performance management data "to check one another and present opposing viewpoints."[286] Feller makes a similar analysis that new demands for accountability were "coming from both the administration and Congress for "evidence" and documentation of performance and results."[287]

---

[284] Ibid., 121.

[285] Ibid., 124-128.

[286] Donald Moynihan, "The Politics Measurement Makes: Performance Management in the Obama Era," *The Forum* 7, issue 4 (January 2010).

[287] National Research Council (US) Committee on Assessing Behavioral and Social Science Research on Aging; Irwin Feller and P.C. Stern PC, ed. *A Strategy for Assessing Science: Behavioral and Social Research on Aging* (Washington D.C.: National Academies Press, 2007), 45.

In other words, political actors begin to seek and “use the number” and data “for advocacy purpose” under performance regimes.[288]

However, I also note that performance management reform through the SSP discourse would affect science and technology practice, including R&D evaluation, differently compared to other fields of public policy in terms of shifting administrative influence among science policy actors. More detail is described in the following, but the performance management reform would not only increase the discretion of science policy executive officials, but also balance the influence that controls science funding and sets priorities between science agency managers and scientists.

(1) Performance Reform in Science Policy

I look at the efforts of the science policy management community to emphasize both the accountability of science and science funding as well as the performance evaluation of science investment outcomes from the late 1980s and early 1990s as the re-emergence of the tension about who has discretion of the sponsorship of science. This tension has not emerged or gained the attentions of science policy makers and researchers before except the debate over the V. Bush’s proposal to establish the National Research Foundation.

As Smith notes, the U.S. science policy community has maintained the assumption since the WWII that “if basic research could not be shown clearly to foster short-tern economic

[288] Donald Moynihan, “The Politics Measurement Makes: Performance Management in the Obama Era,” *The Forum* 7, issue 4 (January 2010).

performance, at least it might contribute to long-term growth."[289] Under this assumption, the mission oriented agencies such as the Department of Defense has encouraged the "autonomy" of the research institutions and universities.[290]

However, this old element sustaining the government-supported scientific research system didn't fit with a new science policy approach emphasizing the "ideologically oriented controls on the conduct of research," beginning from 1980s when the government officials confronted new science policy debates such as "recombinant DNA research," "animal right," "scientific misconducts" or "women's movement" in bio and clinical research.[291]

New science policies focusing on "women's diseases" or preventing scientific misconduct have emerged to respond to these new debates, but it has been regarded by the science advocacy groups as "the potential for political control over the science."[292] Smith says this fear seems similar to the concerns shared by the scientists shortly before and after WWII about the increased "federal controls on scientific autonomy."[293]

For science community, increased influence of the Congress in the "allocation of funds for university research facilities" through "pork-barrel" actions balancing "geographical equity in overall R&D funding" is also becoming a "potential threat to peer review in the allocation of the

---

[289] Bruce L.R. Smith, "The United States: The Formation and Breakdown of the Postwar Government-Science Compact," in *Science and the State, Domestic Structure and the International Context,* Etel Solingen, ed. (Ann Arbor: The University of Michigan Press, 1994), 50.

[290] Ibid., 50.

[291] Ibid., 51.

[292] Ibid., 51-52.

[293] Ibid.

research funds" or more broadly a threat to the autonomy of science when making "resource allocation decisions." [294] In other words, contrary to V. Bush's idea moving science from "public concerns and attentions," science has moved to the "political mainstream" in recent years. [295]

Form this context, the U.S. science policy community needs new toolkits and skills managing R&D spending efficiently to gain the authority from the science community as well as to deal with science policy issues without being accused as politicizing science policy instead of solely depending on the peer-review or merit based review system that is traditionally known as the efficient way deciding R&D funding.

In other words, changing administrative influence to manage scientific investment, increasing efficiency, and balancing the distance from politics are become new issues for the U.S. science policy community to resolve simultaneously. Based on this emerging new consensus, a series of new government management reforms such as PART and GPRA was introduced and tackled the issues the previous social contract of science model couldn't resolve.

Therefore, from this context, the performance management reforms responding to science agencies' demand for creating new performance management tools and models to follow the GBRA performance requirements will also be likely to result in changing the relationship among science agencies, White House, and Congress that are governing science and technology investment. Guston *et al.* point out that the implementation of the Government Performance and Results Act (GPRA) is the evidence that shows the historical change of the government's efforts

[294] Ibid., 52.

[295] Ibid.

securing the accountability of R&D activities from protecting scientists' autonomy in choosing and conducting research to conducting strategic planning of national R&D.[296]

Guston, Woodhouse, and Sarewitz also contend that "the traditional approach to the management and accountability of research," which relies "on scientists themselves to do everything from asking the right research questions to making the connections between their research findings and marketable innovations," has changed gradually.[297] They refer to the Bayh-Dole Act during the Reagan administration, which "changed intellectual property law to provide monetary incentives to researchers and their institutions for engaging in commercial innovation," as well as "strategic planning in research agencies" and "Advanced Technology Program (ATP)," as examples showing the change of traditional governing and control of science.[298]

Analysis of GPRA also suggests that the endowment of more authority to the federal level from White House, or Executive Office of President, managing science and technology issues under the performance management movement than that of Congress, scientists, and science agencies would be made. GPRA's emphasis on a "highly technocratic, rational approach to decision making" would also increase this tendency in science policy decision making.[299]

---

[296] David H. Guston, E. J. Woodhouse, and Daniel Sarewitz, "A Science and Technology Policy Focus for the Bush Administration" in AAAS Science and Technology Policy Yearbook 2002, Albert H. Teich, Stephen D. Nelson, Stephen J. Lita, ed. (Washington D.C.: American Association for the Advancement of Science, 2002), 35-41.

[297] Ibid.

[298] Ibid.

[299] Beryl A. Radin, "The Government Performance and Results Act and the Tradition of Federal Management Reform: Square Pegs in Round Holes?" *Journal of Public Administration Research and Theory* 10, issue 1 (2000), 129.

Moreover, because of the GPRA's rational seeking to "eliminate consideration of political realities" from measuring the performance, GRPA would be viewed "as a reform effort that attempts to clearly separate politics and administration" even if it would not be possible to "avoid politics" from policy.[300]

However, the potential impacts of the performance reform movement in science policy have taken a different path than in other non-science public policy fields even though the SSP architects including Marburger intended to adjust U.S. science policy to fit with the direction of the performance reform movement. For example, there is criticism about the direct implementation of government performance management in science due to the non-quantifiable results of basic science research: the traditional system of scientist and expert judgment is still valid in supplementing the new performance management tools in science policy to correct this issue.

Mervis points out that it is hard for a science agency to "quantify its activities" when it does manage and support basic science research, and NSF and NIH were seeking to adopt "alternative measures" such as nonquantitative metrics even within one year after initiating the Act.[301] GBRA would make science agencies look accountable to the "OMB and Congress" and the quantitative measurements would "make it easy for the (science) institutions to propose quantifiable targets,[302] but it has limitations as well.

---

[300] Ibid., 132.

[301] J. Mervis, "U.S. Science Policy: Agencies Scramble to Measure Public Impact of Research," *Science* 273, issue 5271 (1996): 27.

[302] Ibid., 28.

The slow implementation of the performance-first idea in science and science policy compared to other public policy areas is another indicator that demonstrates that there is a struggle of authority and influence among science policy actors because the choice of science R&D and policy performance assessment methodologies cannot be separated from the traditional peer review and expert judgment system.

A group of scholars including Jaffe support the Act's emphasis on promoting "systematic efforts to develop multiple and diverse quantitative metrics" to evaluate science and technology agencies' performance.[303] Guston *et al.* also emphasize the need for a "more strategic approach" to publicly funded scientific research due to the increase of federal R&D spending.[304] Guston and Sarewitz further discuss the need to strengthen science and technology programs and R&D evaluation by integrating both social and natural scientists. They refer to the *Steelman Report* to support this idea, which says "that competent social scientists should work hand in hand with the natural scientists, so that problems may be solved as they arise, and so that many of them may not arise in the first instance."[305] In other words, "the major science policy challenges" are to "improve its ability to manage the burgeoning R&D enterprise for the public good, to enhance the capability of publicly funded R&D institutions to respond to the public context of science,

---

[303] Adam B. Jaffe, "The Science of Science Policy: Reflections on the Important Questions and the Challenges They Present," *Keynote Address at NSF Workshop on Advancing Measures of Innovation* (June 2006), http://people.brandeis.edu/~ajaffe/PAPER%20-%20science%20of%20science%20policy.pdf

[304] David H. Guston, E. J. Woodhouse, and Daniel Sarewitz, "A Science and Technology Policy Focus for the Bush Administration" in AAAS Science and Technology Policy Yearbook 2002, Albert H. Teich, Stephen D. Nelson, Stephen J. Lita, ed. (Washington D.C.: American Association for the Advancement of Science, 2002), 35-41.

[305] Ibid.

and to ensure that the scores of billions of dollars in R&D funding represent an intelligent, considered, and well-evaluated investment." [306] It also doesn't mean a complete replacement of the traditional science policy decision making mechanism with the new quantitative tools and models. One example to support this view is that GPRA was not fully accepted by all science research agencies at first.

For example, "the applied research agencies …took the lead in developing GPRA approaches for research, while the basic research agencies held back" because applied research agencies had already conducted all performance measures and strategic planning, whereas basic research agencies had resisted conducting this approach. When the Act was introduced, there was argument that agencies in the field of science and technology "should somehow be exempt from the Act's requirements of quantitative assessment of the outputs and outcomes of government programs" because "the relevant outcomes are too intangible to quantify."[307]

Because of the contradictory relations between GPRA and the unpredictable and long-term nature of the basic research approach, research agencies have "faced some common conceptual and political problems in implementing GPRA." In this context, Cozzens argues that, instead of complex qualitative measures and techniques, "simpler (quantitative) indicators (and hard data) may be necessary to reach the broader audiences that are now entering the assessment process," as well as to provide "the evaluators as backgrounds of their work (success stories,

---

[306] Ibid.

[307] Adam B. Jaffe, "The Science of Science Policy: Reflections on the Important Questions and the Challenges They Present," *Keynote Address at NSF Workshop on Advancing Measures of Innovation* (June 2006), http://people.brandeis.edu/~ajaffe/PAPER%20-%20science%20of%20science%20policy.pdf

etc)" even if the "qualitative measurement (and technology)" for judging the outcomes of science and technology is still evolving.

(2) Balancing Administrative Influence and Authority in Governing Science through the SSP

In terms of the influence of government performance reforms in science and science policy through the SSP, Feller, who is one of the core members of implementing the SSP discourse, notes that policy attention has shifted to allocating the federal resources to the different branches of science R&D activities instead of "overall levels of federal government support of science."[308] He states that "analytical and policy attention and research shifted in recent years to questions relating to the measurement of the social and private rates of return from research in general"[309] since GPRA has changed "attention from statements of an agency's needs and opportunities toward outputs and outcomes." [310]

He also notes that the increased use of quantified measurement at the science agency level is going to happen in a way that is similar to what is being witnessed at other non-science government agencies such as developing new econometric and quantitative evaluation toolkits. Even though expert-and researcher-based "peer review has long been the dominant approach in federal research agencies for evaluating the past performance and future potential of research

[308] National Research Council (US) Committee on Assessing Behavioral and Social Science Research on Aging; Irwin Feller and P.C. Stern PC, ed. *A Strategy for Assessing Science: Behavioral and Social Research on Aging* (Washington D.C.: National Academies Press, 2007), 43-44.

[309] Ibid., 44.

[310] Ibid., 45.

areas and for setting priorities," GPRA and PART require science agencies to "identify (evidence-based) quantitative metrics" to measure the performance of science agencies and their research progress.[311]

Moreover, "quantitative measures are attractive" to science agency managers "because they can be defended as "objective," and this is a challenge to the traditional deliberative peer-review system in the science policy field.[312] This challenge seems to apply to all government agencies similarly. However, based on his examination of "the limitations both of traditional expert judgment and of quantitative approaches" such as cost-benefit analysis,[313]he develops his argument that government performance management in science would work differently compared to the usual changes shown in non-science agency cases for the following reasons:

First, quantification has its own methodological limitation, and there are disagreements on using it especially for assessing the values, outcomes, and progress of scientific research. Second, even though the government performance reforms' emphasis through GPRA and PART on the quantification of assessing performance outcomes is likely to increase the discretion of agency managers and practitioners,[314] this shift of power and influence is likely to work differently in science policy.

In particular, regarding the change of administrative influence of science agency managers, the performance management reform movement is known to give more discretion to

---

[311] Ibid., 47-49.

[312] Ibid., 50.

[313] Ibid., 41.

[314] Ibid., 64.

agency managers than the deliberative methods such as the qualitative review system. He also looks at the peer review system as a way to give more discretion to scientists than to agency practitioners and managers or "weaken the influence of scientists vis-à-vis agency science managers, or of scientists in general vis-à-vis nonscientist decision makers in government."[315] However, in the science policy field, he argues for the need to combine both quantification methods and a peer-review mechanism.

For example, researcher managers at science organizations such as NSF or NIH tend to be "scientists as well as managers," and they are "expected to act as stewards of their scientific fields in the context of the mission" of their agencies as well as to "function as part of this (science) community … as scientists but also as advocates… for research fields."[316] Therefore, in order to provide science policy guidelines, they need to consider both "quantitative measures" as managers and the "deliberative process of peer review" as scientists instead of choosing one and discarding another mechanism.[317]

Moreover, considering the characteristics of science such as that "research in a single area may yield several kinds of outputs" and "each research product may produce several different kinds of value (outcomes)" that are intangible and hard to quantify, the desirable movement for government performance and accountability in the science policy field is balancing "influence and power among researchers, program managers, advisory councils,

[315] Ibid., 59.

[316] Ibid., 62.

[317] Ibid., 63.

extramural scientists, and other interested parties"[318] by promoting the use of both quantification and peer-review (or managers and scientists) together.

Because "the trend toward the increased quantification (under the performance management regimes) is clear," he proposes combining "OMB mandates" that develop and use quantification tools with the need for "experts judgment/peer review procedures" in a way that "informed expert opinion" can be based on the use of "quantitative methods by relevant experts." [319]

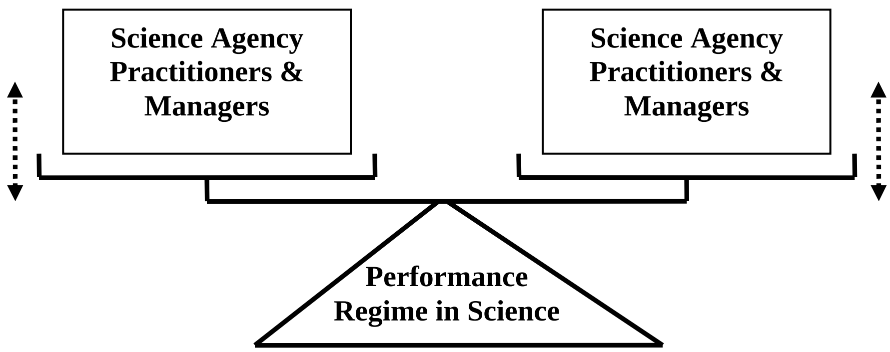


Figure 4-2. Balancing Power at Performance Management Regime in Science

Feller's vision of science policy under performance management reform regimes has influenced the development of science of science policy; he not only supports the development of quantitative tools and models for science policy, but also promotes interactions between academic research community and science policy practitioners. Changing the imbalance of influence among science policy community members is what Marburger intended to achieve

318 Ibid., 41

319 Ibid., 56-57

through the science of science policy, and the involvement of both science agency managers and academic researchers in designing tools and models for science policy making is regarded as an experiment to extend the new expert judgment system that combines both academic and practical sides of science policy.

In other words, the SSP architects intended to develop a new science policy system that not only meets the requirement of the government performance reform movement, but also bring a balance of influence among science policy community actors, especially between science agency managers and scientists, in the science policy making process. In particular, if science agency managers are scientists, then the introduction of the SSP models would help them make their decisions with fewer dilemmas as a government managers and scientist, whereas, for the non-scientist managers, the SSP toolkits and models would allow them to improve the scientific accountability of their decision as well as balance their views with those of scientists. I provide more details of this aspect of the SSP discourse in the following.

(3) Performance Reform in Science Policy & SSP

The Government Performance and Results Act (GPRA), which focuses on the systematic quantitative assessment of government agencies' performance, is a primary impetus for the SSP discourse. GPRA, or the Results Act, passed in 1993 to "overcome the limitations of formal program evaluation by supplementing it with short-term performance monitoring" as well as by requiring "each agency to submit three documents to Congress: a strategic plan, covering all major agency functions over a minimum five-year period; a performance plan, setting specific, quantified target levels of performance for a particular fiscal year; and a performance report, giving actual versus targeted performance."[320] After the five-year pilot study, by FY 1998, the Act began forcing government agencies to perform "five-year strategic planning, annual program performance plans, and annual program performance reports."[321]

The problem was that science and technology agencies didn't have sufficient experience in developing and applying systematic and quantitative tools to measure their performance. As shown in the discussion about the difficulty in adopting systematic quantitative measurement strategies to assess and improve the management of science and technology projects, science and technology agencies and national laboratories were not fully ready to accomplish the Act's requirements.

Due to the lack of experience as well as a reluctance to adopt systematic and rigorous measuring and assessment of intangible outcomes of scientific and technological programs, science and technology agencies have begun searching for new quantitative models and toolkits they can use to adjust their measurement to fit the requirements of the Act.

The Office of Science at the Department of Energy is one of the first government agencies to pay attention to this issue as well. To support the efforts of improving the office's new performance measurement models and toolkits, Valdez, who took over the Office of Science of DoE in 1999, formulated a task group to initiate preliminary research, including a literature review, to identify methods and approaches developed by the academic field that he could

---

[320] Susan E. Cozzens, "Assessing Federally-Supported Academic Research in the United States," *Research Evaluation* 9, issue 1 (2000), 5-10.

[321] Office of Management and Budget, "Senate Committee on Government Affairs GPRA Report," The White House, http://www.whitehouse.gov/omb/mgmt-gpra/gprptm#h2

recommend to agencies in need of new assessment models.[322] The task group found that several policy schools, including Georgia Tech and Arizona State University, have research outcomes on the evaluation of science R&D and policies.[323]

When Valdez ran the Office of Science, one of the national laboratories under the supervision of the Department of Energy, the Brookhaven laboratory, made a contract with the "Brookhaven Science Associates" to research the improvement of the laboratory management system beginning 1998.[324] The Associates' new president was Dr. John Marburger, who became the director of the Office of Science and Technology Policy later in 2001. What Marburger had done to improve the management of the lab has inspired his science policy initiative, Science of Science Policy, to improve the management and evaluation of national R&D policies and programs when he was at the OSTP.

Marburger's experience in improving the management of the science laboratory, as well as Mr. Valdez's search for new methods for the systematic management and assessment of science and technology programs later became the outline of science-of and science-based science policy. Both had the chance to discuss this issue when Dr. Marburger took his position at the Office of Science Policy, and it resulted in Dr. Marburger's speech on "science-based" science policy in 2002 at the 27th Annual AAAS Colloquium on Science and Technology Policy in Washington, D.C.

---

[322] interview

[323] interview

[324] interview

This performance first idea in science and science policy is likely to keep developing through the SSP discourse. For example, the Office of Science at the Department of Energy plans to initiate in FY 2011 a research program that is "consistent with" the Science of Science Policy (SoSP) initiative through its research awards.[325] OSTP has continued to support and encourage the implementation of the scientizing science policy discourse in FY 2011. A four-page "Memorandum for the heads of executive departments and agencies: Science and Technology Priorities for the FY 2012 Budget" issued jointly by the Office of Management and Budget (OMB) and the Office of Science and Technology Policy (OSTP) on July 21, 2010, shows this effort of OSTP to encourage the use of and adopt the science of science policy toolkits across government agencies.[326]

More specifically, an FY 2011 memorandum states that "agencies should develop outcome-oriented goals for their science, technology, and innovation activities, establish timelines for evaluating the performance of these activities, and target investments toward high-performing programs in their budget submissions."[327]

In order to set the outcome-oriented and performance-based target investments, "agencies should support the development and use of "science of science policy" tools that can improve management of their R&D portfolios and better assess the impact of their science, technology,

---

[325] Department of Energy, "FY 2011 Congressional Budget Request," http://www.mbe.doe.gov/budget/11budget/Content/FY2011Highlights.pdf

[326] Richard M. Jones, "White House Issues FY 2012 Science and Technology Priorities Memo," American Institute of Physics (August 9, 2010), http://www.aip.org/fyi/2010/087.html

[327] Ibid.

and innovation investments."[328] This part of promoting the science of science policy approach has been carried over from previous memoranda issued for FY 2010 and 2011, which indicates that science of science policy is gaining continuous support from the OSTP and OMB in the Obama administration.[329] Two previous memoranda also emphasize the need for using science for science and technology policy process, stating that "sound science should inform policy decisions, and agencies should invest in relevant science and technology as appropriate."[330]

In this context, I raise the question about what kinds of change would be expected in science policy if performance management reform idea were projected into the science policy by the SSP actors. To answer this question as well as make suggestions for developing the SSP discourse, in the following, I articulate the expected change of system for R&D evaluation as well as the recommendations for the SSP discourse. By doing so, I develop and support my study on the performance reform movement's affect on U.S. science policy practices through the SSP discourse.

First, the SSP discourse is likely to contribute to enhancing administrative influence of the OMB and the White Houses in science and science policy because the science agencies have

[328] Ibid.

[329] Richard M. Jones, "White House Memo on FY 2011 Science and Technology Priorities," American Institute of Physics (August 10, 2009), http://www.aip.org/fyi/2009/104.html; The White House, "Memorandum for the Heads of Executive Departments and Agencies," (August 4, 2009), http://www.whitehouse.gov/sites/default/files/omb/assets/memoranda_fy2009/m09-27.pdf

[330] Ibid.

tried to use the SSP tools and models as a way to develop new performance evaluation toolkits and metrics to satisfy "OMB criteria" like other government agencies have done.[331]

Second, Feller's proposal examined above also confirms the interview project data in several ways. For example, there is a consensus among interviewees that choosing quantitative mechanism in science policy doesn't imply removing qualitative or deliberative approaches such as peer-review from the science decision making and evaluation process. Moreover, the science of science policy is an effort to develop a new expert judgment system that combines both new quantitative methods and a peer-review mechanism. Therefore, I also argue to balance quantitative and qualitative methods for science policy gives hope for both regimes for performance management reform and the SSP to successfully implement performance-first ideas into science and science policy.

Third, the performance management reform community in science is expected to encourage the collaborative performance management system by promoting interdisciplinary work with social and natural scientists. In this context, the SSP discourse can be evaluated as an effort to develop a new collaborative system by fixing the imbalance of influence among science policy actors. For example, during the interview, when he explained his role in developing the SciSIP, the former director of the Office of Science Director at the Department of Energy, B. Valdez, mentioned that the SSP toolkits and models are not a replacement but rather a

---

[331] Donald P. Moynihan, "The Politics Measurement Makes: Performance Management in the Obama Era," *The Forum* 7, issue 4 (January 2010); Donald P. Moynihan and Alasdair S. Roberts, "The Triumph of Loyalty Over Competence: The Bush Administration and the Exhaustion of the Politicized Presidency," *Public Administration Review* 70, issue 4 (2008), 572-581.

substitution for the scientists-based expert judgment system to evaluate science R&D investment. From the perspective of influence in science and science policy, this evidence supports the argument that the intention of science agency managers to support and develop the SSP discourse includes not only developing a new method to report their performance of R&D investment to the OMB, but also to create a balance of discretion in deciding and assessing science R&D investment between science agency managers and scientists. And the latter element seems more obvious when science agency managers are not from natural science fields because non-scientist managers including B. Valdez are more likely to be motivated for their agencies to influence decisions on science investment and the R&D portfolio.

Fourth, considering that economics is the dominant discipline of the Science of Science Policy groups, the tendency to maintain the ambiguity of the meaning of science and reframing economic science as science will continue. By doing so, the SSP would provide more administrative authority to the non-scientist managers in science agencies so that they can justify their R&D investment decisions scientifically as scientists do or when working with scientist groups. In other words, the SSP tools can be used for legitimizing and promoting the discretion of non-scientist managers and practitioners in the science policy field by labeling the SSP discourse as the economics of science policy or social science of science policy.

Fifth, the task the SSP community needs to tackle is promoting the democratic values in science and technology policy making. Otherwise, the same criticism can be applied to the SSP discourse regarding the rhetoric of the SSP community getting politics out of science policy or enhancing the power of science managers over other science community members. To address this issue, in the concluding chapter, I conduct a comparison between the U.K. and U.S.

experiences of scientizing science policy and propose the evidence-informed and evidence - critical science policy model.

Chapter 5: Interview Data Analysis: External Logics and Internal Dynamics of the SSP

In holding scientific research and discovery in respect, as we should, we must also be alert to the equal and opposite danger that public policy could itself become the captive of a scientific-technological elite.

—Dwight Eisenhower, January 17, 1961[332]

In the previous chapters, I described the history of the U.S. science, technology, and innovation policy since WWII along with the rise and institutionalization of what I call the scientizing science policy (SSP) discourse that is affected by the government performance management reform movement and the revised social contract of science. For example, since the 2000s, a consensus of doing science policy "scientifically" has been growing in the STI policy community. Scientific evaluation of science and technology policies and programs and the use of scientific evidence to settle debates on science and technology issues are examples of this new consensus. It has permeated the science policy community, including science policy practitioners, social scientists and scientists.

In the first part of this chapter, I analyze the interview data to support my argument regarding the close interactions among the performance reform movement, new social contract of science, and the SSP discourse. In particular, I group the key aspects of the SSP based on the interview data not only to describe the SSP discourse, but also to demonstrate what kinds of logical links exist among the ideas of performance reform, new social contract of science, and scientizing science policy.

[332] Text retrieved from http://cnx.org/content/m34605/latest/

It is also important to note that science policy community has not accepted the new consensus of scientizing science policy without modification or criticism. For example, the emerging consensus of scientizing science policy has generated concerns and uneasiness even among science policy research community members even located within the SSP discourse. This STS affiliated group has maintained their research affiliation with or gained research support, including research funding, from the SSP discourse, but hold a critical stance about the current or future direction of this discourse.

Therefore, in the second part of this chapter, I try to answer the following questions to examine these internal dynamics of the SSP: Why do different communities co-exist under the same SSP discourse even though they share different sociotechnical imaginaries of science and science policy? What aspects of the SSP discourse bring these different science policy actors and research groups as well as their different visions and imaginaries of science and politics into it? What is the origin of the uneasiness some science policy researchers have about the course of the development of the SSP? What issues about the SSP discourse need to be discussed or examined?

By examining and answering these questions through an in-depth analysis of the interview data, articles and documents in this chapter, I show that the visions and meaning of the science-based and science-of science policy have been continuously reshaped by the interactions among the heterogeneous science policy community actors within and outside the SSP discourse. In other words, instead of following the single path set by the leading actors via the top-down approach, science policy community actors have participated in the process of constructing SSP discourse through the bottom-up based approach so as to improve and exercise their power for designing and implementing science and technology policy strategies in the United States.

1. Analysis of the Interview Data on the SSP Discourse

I have conducted 29 interviews so far, part of which has been supported by the NSF STS Program Dissertation Improvement Grant. Interviewees, who have an affiliation with either the NSF's SciSIP or SOSP, are labeled as inside or inside core, and those who have followed the development of the Science of Science Policy initiative more closely than others even though they don't have an official affiliation with the SSP are labeled as outside. I describe and highlight what these interviewees told me about the SSP discourse, as well as the common and broader themes and issues related to U.S. science policy and politics that have or would be caused by the SSP discourse.

Moreover, instead of dispersing the interview finding throughout the chapters, I grouped them and describe the interview data in the following. By doing so, the interview data can be used as evidence to support and confirm the main arguments presented in the previous chapters and serve as an intellectual bridge to connect the arguments and analyses in the previous and following chapters. For example, the interview data that point out the micro-level internal dynamics of the SSP discourse will be examined further in the second part of this chapter, and the extensive analysis of the macro-level external and political dynamics of the SSP discourse in the next chapter. Here is the complete list of 29 interviewees I have met as of July 15, 2012.

Table 5-1. List of Interviewees

Name / Institution	Field	SSP Affiliation
NRDC: David Goldston	Science Policy	Inside
Japan: Takashi Ohama	Japan S&T Agency	Inside
Georgia Tech: Mark Z. Taylor	SoSP	Inside
National Academies: Stephen A. Merrill	Science Policy	Inside
SciSIP: Ping Wang	Computer Science	Inside
SciSIP: Barry Bozeman	Public Administration	Inside
SciSIP: Juan Rogers	Science Policy	Inside
AAU: Tobin L. Smith	Science Politics	Inside
UT Dallas: James C. Murdoch	Economics	Inside
GWU: Nicholas S. Vonortas	Science Policy	Inside
SciSIP: Eric Fisher	STS	Inside
SciSIP: Kaye Husbands Fealing	Economics	Inside + (core)
SciSIP: Daniel R. Sarewitz	Science Policy	Inside + (core)
AAAS: Irwin Feller	Economics	Inside + (core)
SciSIP Director: David Croson	Economics	Inside + (core)
OSTP: Kei Koizumi	OSTP	Inside + (core)
Congress: Dahlia L. Sokolov	Congress	Inside + (core)
SciSIP: Susan E. Cozzens	Public Policy	Inside + (core)
NSF (former): David W. Lightfoot	Science	Inside + (core)
DOE: Bill Valdez	Science Agency Manger	Inside + (core)
OSTP (former): Sharon L. Hays	OSTP	Inside + (core)
Gary Edmond	Law	Outside
SRI: Jeffrey Alexander	Science Policy	Outside
George Mason: Todd M. La Porte	Public Policy	Outside
National Academies: Rachelle Hollander	Sociology	Outside
UCS: Francesca T. Grifo	Science	Outside
WTEC: Robert D. Shelton	Economics	Outside
George Mason: Christopher T. Hill	Public Policy	Outside
Harvard: Venkatesh Narayanamurti	Science Policy	Outside

I reserved the 30th interview remains undone in honor of the central figure of this research, John Marburger, who passed away during the course of my research.

(1) Diverse Interpretation of the SSP

The interviewees expressed diverse opinions regarding the main motivations, background, and goals for initiating and developing the SSP even though the interviewees commonly point out that the SSP focuses on a new understanding of science and science policy as well as the development of systematic science policy tools to deal with the emerging new issues related to science and technology.

For example, Juan Rogers says science of science policy initiative is about “knowledge to develop science policy.”[333] Irwin Feller says that “the essence of initial Marburger’s” proposal of SoSP is not only to guide the allocation of science funding, but also to provide a “guideline for science” or the core dynamics of science, whereas not many studies address this challenge.[334] During the interview with the NSF SciSIP program co-director, David Croson explains the program as an “inherently entrepreneurial program.”[335] He emphasizes that “the (main) idea (behind SciSIP) is that we are looking for an area that is imperfectly understood but largely payoffs” and thus “learning more (about science and science policy through SciSIP) is better.”[336] Thus, rather than “analyzing particular types of science policy,” SciSIP aims to create innovation

---

[333] Juan Rogers, in discussion with the author, June, 2011.

[334] Irwin Feller, in discussion with the author, August, 2010.

[335] David Croson, in discussion with the author, September, 2011.

[336] Ibid.

infrastructures like the iPhone does so that people can use it creatively to promote scientific and technological innovation.[337] "Science policy is a series of decisions related to science" and SciSIP is conducting a "scientific study about it."[338] Thus, collectively "thinking about techniques (that are applicable) to science and innovation policy" instead of answering specific policy questions is what SciSIP has pursued.[339]

Regarding Marburger's call for science of science policy, Croson says "this was consistent with his idea of what science is all about, which is that the point of scientific inquiry is to understand what we are doing, understand the world around us," and "he took that attitude from every piece of science he had touched."[340] Thus, the science of science policy and SciSIP represent "how he views the world" when he emphasized the need for having more "scientific understanding of science policy."[341]

Before telling me a story of his interactions with Marburger for initiating the SSP discourse, Daniel Sarewitz explained the main idea of CSPO (Consortium For Science, Policy and Outcomes) at Arizona State University.[342] He said that "we try to take social dynamics of science and technology and connect them to science policy practice and public debate to improve the awareness of structure R&D enterprise and wide range of social aspects related to R&D

---

[337] Ibid.

[338] Ibid.

[339] Ibid.

[340] Ibid.

[341] Ibid.

[342] Daniel Sarewitz, in discussion with the author, October, 2010.

enterprise." [343] He and Michael Crow (executive vie provost at Columbia at that time and president of Arizona State University since 2002) discussed this idea with Marburger in 2002 and emphasized the need to support this science policy research area. [344] Since then Susan Cozzens at Georgia Tech organized the initial NSF workshop on science of science policy, and Sarewitz got the first stage SciSIP funding for his research on public value mapping with Barry Bozeman at the University of Georgia.

David Lightfoot, a former assistant director for NSF's Social, Behavioral and Economic Sciences division, also explains the main aspects of the NSF SciSIP. He is known as the architect projecting John Marburger's vision of science of science policy into NSF's new program, Science of Science and Innovation Policy (SciSIP). He came to NSF in 2005, just a couple of months before Marburger's 2006 speech on SoSP at AAAS in 2006. Marburger was head of the Brookhaven National Laboratory, where he found there was no systematic way to decide funding for science projects except by considering historical factors such as the previous year's funding.[345] Lightfoot points out that Marburger's frustration with the lack of management tools to evaluate science projects at Brookhaven continued after getting his position at the White House's OSTP, so he initiated SoSP to change this science management practice.[346]

The science workforce is becoming a new and important issue to science policy makers, and the science policy community has initiated and supported the SSP discourse to examine this

---

[343] Ibid.

[344] Ibid.

[345] David Lightfoot, in discussion with the author, August, 2010.

[346] Ibid.

issue. For example, Bill Valdez at DoE said that one of the premises of science of science policy is that "science policy is done by scientists."[347] Therefore, instead of a traditional core data-point such as a citation or money, the scientist is becoming a "unit of analysis" scientist, and SciSIP has intended to account for and analyze scientists.[348] Robert Shelton at the World Technology Evaluation Center (WTEC) also mentions the importance of analyzing scientists emphasizing that there are "lots of human involvements" in science, which the science of science policy community tends to measure, and thus the field of sociology has a good opportunity to contribute to the SSP discourse.[349]

Several interviews point out that the NSF SciSIP program can be regarded as a revival of previous programs that had similar goals with the SciSIP. For example, Christopher Hill mentions that the NSF's National R&D Assessment Program, which changed its name to Policy Research and Analysis Program, had the "same objective as the SciSIP program."[350] For example, NSF's National R&D Assessment Program is also grant giving program as the SciSIP for evaluating R&D and understanding the innovation process, which ended in late 1980s.[351] He argues that "Marburger wanted to bring back the old program" and NSF "eventually announced the SciSIP program."[352] Stephen Merrill also notes that the SciSIP is a revival of the previous

[347] Bill Valdez, in discussion with the author, October, 2010.

[348] Ibid.

[349] Robert Shelton, in discussion with the author, September, 2010.

[350] Christopher Hill, in discussion with the author, August, 2010.

[351] Ibid.

[352] Ibid.

NSF's Policy Research and Analysis Program.[353] Merrill emphasizes that the "concern about the U.S. economic performance" in the 1970s and 1980s compared to Japan led the NSF to launch this program to support research on "technology and productivity."[354]

Some interviewees look at the SSP discourse in the global context. Robert Shelton at the WTEC mentions several points about the science of science policy as well as global science policy.[355] He says that one of the major issues related to U.S. science policy is "related to the rise of China" as a super power of scientific research, and it would be one of the main motives for science policy makers to initiate science of science policy to cope with the global competition with China.[356] More specifically, he says the outside players such as China's increasing scientific investment push the U.S. to develop new science policy models. In other words, in the U.S., there was little need to measure publication and other types of scientific outputs before, but now the situation has changed.[357] He said making scientific output is a "zero sum game" and, in global competition, the U.S. realized the need to determine what's wrong with its scientific investment when scientific publication is decreasing compared to other countries.[358]

SciSIP has had international impacts as well. For example, when David Lightfoot gave a speech about SciSIP in Japan in 2006, audiences from NISTP (National Institute of Science and

---

[353] Stephen Merrill, in discussion with the author, August, 2010.

[354] Ibid.

[355] Robert Shelton, in discussion with the author, September, 2010.

[356] Ibid.

[357] Ibid.

[358] Ibid.

Technology Policy) showed interest in it.[359] The Japanese government launched a similar program, "Science of Science, Technology and Innovation (STI) Policy" in 2011 to support "objective evidence-based policy forming."[360] Lightfoot also talks about STS engagement in SciSIP, emphasizing that the STS approach combining both "scientific … and non-scientific point of view" would be beneficial to this new science research.[361]

Promoting the collaboration among research disciplinarians and science agencies is one of the common aspects that most of the core members of the SSP community point out. In terms of the collaboration with OSTP that "organizes and hosts the SoSP committee," David Croson says "the roles of NSF at this (committee) meeting is to form a bridge to a research community. It's not brining something to OSTP."[362] Instead, because he knows who the experts are, SciSIP panels have tried to show what relevant research results out there to committee participants after listening to concerns of science policy agencies.[363] In this process, he calls himself "the curator of library of published science results."[364] SciSIP is also working with other NSF programs to co-fund research.

Through the collaboration with the Task Group when developing the SoSP roadmap, Bill Valdez explains that Marburger wanted to establish a new research program to develop these

---

[359] David Lightfoot, in discussion with the author, August 2010.

[360] Ibid.

[361] Ibid.

[362] David Croson, in discussion with the author, September, 2011.

[363] Ibid.

[364] Ibid.

tools and construct a community of practices.[365] Similar to social science or nanoscience, SciSIP was launched to build a new research community of practice.[366] Moreover, he emphasizes that, "each agency takes responsibility for its own needs" and the NSTC interagency task group on SoSP helps coordinate interagency collaboration because "one size (single R&D evaluation model and method) would not fit all (agencies)."[367]

Feller points out that Marburger "did articulate long demands" of putting different perspectives together to build systematic science policy approaches.[368] In other words, building "bridges among disciplines" in the science policy field hasn't work so far, whereas the NSF's SciSIP was designed to resolve this issue by promoting "interdisciplinary dialogue."[369] Science of science policy is a hybrid type of discourse valuing a "different skill sets" as well as "bringing together the (different) theoretical maps" on science policy.[370]

Another emphasis of the NSF's SciSIP program is bridging academy and science policy practitioners by bringing both communities together to share what SciSIP- funded researchers found in their research as well as what science policy practitioners need from the academic community.[371] Because not all the SciSIP grantees have experience connecting their research results to the science policy process, some of them don't have much knowledge about how to

---

[365] Bill Valdez, in discussion with the author, October, 2010.

[366] Ibid.

[367] Ibid.

[368] Irwin Feller, in discussion with the author, August, 2010.

[369] Ibid.

[370] Ibid.

[371] Ibid.

communicate with science policy practitioners.[372] However, SciSIP creates the space for academic researchers can be exposed to the science policy environments as well as for members from both research and policy practice communities to interact with each other.

Some interviewees mention the potential collaboration between STS and SPP communities. For example, when discussing the relationship between STS and science policy making, Juan Rogers says the STS-type approach emphasizing "normative and descriptive (aspects) of science policy" needs to be integrated into science policy research instead of adopting positivism-centric approaches that separate the normative dimensions of science policies.[373] Eric Fisher, who conducted a laboratory engagement study funded by the NSF's SciSIP program, also mentioned that he intends to encourage a more laboratory open-door policy with social scientists by integrating research between natural and social scientists.[374] In his or a broader social scientific perspective, research on culture or the context of the laboratory through quasi-experiment or hybrid methods is as important as a statistically significant research approach.[375] For example, he says that the "personality of the primary investigator (PI) is strong in terms of informing laboratory culture" and thus the interview becomes an important research tool.[376]

(2) Impacts of the Performance Management/Budget Reform on the SSP

[372] Ibid.

[373] Juan Rogers, in discussion with the author, June, 2011.

[374] Eric Fisher, in discussion with the author, December, 2010.

[375] Ibid.

[376] Ibid.

In Chapter 4, I argue that the rise and development of the SSP discourse is a strategic reaction of science policy community actors to the government performance management reform movement. During an interview, Christopher Hill, who is a faculty member at the School of Public Policy at George Mason University, points out that new management models such Just-In-Time (JIT) or "Total Quality Management" (TQM) became popular in the U.S. around the 1990s," and GPRA and PART were "directly inspired by this quality movement."[377] He refers to the research of Edward Deming who invented the "fundamental ideas of TQM" to describe the emphases of this new management model such as understanding and controlling the process "at all of the stages" to "enhance the quality of the products" and to ensure "the conformant of specification" by allowing each worker to collect data and improve his own performance. In this process, "each worker is responsible for each work" which is a "radical change from Fordism," which requires the workers to do without thinking.[378]

Hill emphasizes that this idea was picked up by public policy makers and politicians such as Al Gore who "was a major proponent of GPRA" to require the federal government to "measure and demonstrate the performance and achievement of the government agencies."[379] GPRA and PART also require government agencies to "set (performance) goals and (to) measure their performance and to improve the measuring (tools and techniques)."[380] He also quotes Deming, saying, "Anything you measure gets better," which influences "the management of

[377] Christopher Hill, in discussion with the author, August, 2010.

[378] Ibid.

[379] Ibid.

[380] Ibid.

large-scale bureaucratic and administrative systems."[381] Hill points out that "Marburger was facing demands from OMB and Congress to justify the (science R&D) budget in the same framework, Total Quality Management Framework, and he was having hard times."[382]

In this situation, Hill participated in the committee of the National Research Council of the National Academies to produce a report, *Measuring Research and Development Expenditures in the U.S. Economy*, and the committee chairmen and staffs met Marburger to brief him on the report.[383] The report examines the NSF's "R&D expenditure surveys" and data generated by the surveys, and emphasizes that "these (survey) data have become the accepted measures of the amounts of R&D spending, and of public and private investment in areas of science and engineering."[384]

In particular, the report points out that "the science of measuring R&D" in the U.S. resulted in developing the NSF's R&D statistics such as R&D survey data that "are used by federal agencies, Congress, and the public to frame the national debate over the investment strategy for R&D."[385] It also recommends that as a "growing science to support innovation measurement," the Science Resources Statistics Division (SRS) has been successful in measuring the impacts of innovation, but at the same time needs "more resources and capacity to explore

---

[381] Ibid.

[382] Ibid.

[383] Lawrence D. Brown, Thomas J. Plewes, and Marisa A. Gerstein, ed. Panel on Research and Development Statistics at the National Science Foundation, *Measuring Research and Development Expenditures in the U.S. Economy*, National Research Council (2004).

[384] Ibid., 1.

[385] Ibid., 1-52.

the impact of innovation on the U.S. economy" as well as "resolve the methodological issues related to collecting innovation-related data."[386] Basically this report is for the Science Resources Statistics Division (SRS), and Marburger was known to say during the briefing that "we could make a science of science policy."[387] Then Marburger gave his science of science policy speech at the 2005 AAAS meeting where community members got excited to hear his speech, which adopted the main ideas of the 2004 report.[388]

SciSIP has encountered an economic disaster, and SciSIP community members, including Lightfoot, argued that "if government wants to stimulate economy, then fund science" because paying scientists would result in not only employing researchers, but also increasing economic benefits through the results of scientific research.[389] This is the same as what V. Bush argued, and government included funding science as a part of the economic stimulus package. But then the OMB was concerned about managing and tracking spending in science transparently and accountably, and it also provided an opportunity for SciSIP to do research on tools and models to resolve these concerns. For the SciSIP community, "giving money to science and seeing the effect of this money" became an experiment to test its models, and the STAR project was implemented as a tracking device to show "how to track the money and link to job creation."[390] The STAR Metrics program also has helped agencies show the tracking of money and evidences

---

[386] Ibid., 101.

[387] Christopher Hill, in discussion with the author, August, 2010.

[388] Ibid.

[389] David Lightfoot, in discussion with the author, August, 2010.

[390] Ibid.

scientifically to OMB how stimulus funding is spent. Putting extra funding into the SciSIP program in 2009 made the program set the stimulus package itself as an object of the research.[391]

Valdez also points out the direct impacts of the government performance reform movement on the rise and development of the SSP discourse.[392] Even though the science community has developed an "expert judgment" system in a situation lacking data, there were needs from agencies to develop and adopt new tools, especially after the implementation of GPRA and PART.[393] Most science agencies' interest in such tools originated from GPRA, but no tools were available for the agencies to evaluate their programs, which GPRA wanted. In this situation, Valdez and Marburger agreed that "expert judgment is not sufficient," and thus there was a need to develop "data and tools that science policy makers didn't have before."[394] Most science agencies that came out of GPRA and PART couldn't evaluate the impacts of science, so there were internal needs to develop new tools to meet the requirements imposed by GPRA and PART.[395]

Jeffrey Alexander at SRI talks about Marburger's idea that "it was very aligned to Republican administration policy," emphasizing "fiscal responsibility and accountability" when "managing government operations."[396] So, the Bush administration's officials began looking at a "better way for the evaluation of the (science) programs to justify the cut in the

---

[391] Ibid.

[392] Bill Valdez, in discussion with the author, October, 2010.

[393] Ibid.

[394] Ibid.

[395] Ibid.

[396] Jeffrey Alexander, in discussion with the author, August, 2010.

programs…especially social programs” that is a “more logical justification for (the) shrinking budget.”[397] Under the limited government budget, for cutting spending, it was the “rational approach,” and the White House emphasized “evaluation of science programs” in the budget process.[398] The White House OMB’s PART program was launched as a “systematic approach” to attempt to “come up with a systematic way … (to) identify and compare” government programs, including science projects.[399] However, the main issue was that “PART couldn’t be applied directly to (science) agencies such as NSF” because, under the PART framework, the quantification tools were not fit for science programs.[400]

Thus, science policy makers including Marburger launched the new initiative through the *Roadmap of Science of Science Policy* for developing science policy funding decision tools or science performance management and “investment strategies” that fit with the PART framework.[401]

The interviewees point out that there are two distinctive characteristics of the performance management movement. The first is to emphasize the evidence-based approach, and the SSP discourse has put its emphasis on developing scientific evidence and data for science policy management and decision making. For example, Stephen Merrill notes that Marburger’s science of science policy statement is a response to the call for establishing an “evidence-based

[397] Ibid.

[398] Ibid.

[399] Ibid.

[400] Ibid.

[401] Ibid.

way" to manage science R&D programs from both the "executive branches and Congress."[402] In other words, Marburger "was voicing the concerns (of evidence-based science policy)" which can be re-phrased as "science of science policy."[403] The second characteristic of the performance management movement is to regard government spending in the framework of an investment instead of an expense that doesn't provide a return.[404] Merrill says the SSP discourse also reflects the change in view of R&D spending from expense to "capital investment" that contributes to national economic outputs such as GDP. [405]

David Goldston at the Natural Resources Defense Council also points out that the "main emphasis of the Science of Science Policy" came from "traditional ongoing budget questions."[406] Similarly, Goldston notes that the lack of evidence and data to support decisions on the federal science budget motivated Marburger to initiate the science of science policy approach.[407] For example, the "physical science community would come and say all money goes to biological science…and (science funding allocation) didn't used to be that way…(and) that's bad."[408] In response to this criticism, Goldston says Marburger said it's different and asked physical scientists to prove to him it's bad whereas "nobody has good answers to that."[409] So the main

[402] Stephen Merrill, in discussion with the author, August, 2010.

[403] Ibid.

[404] Ibid.

[405] Ibid.

[406] David Goldston, in discussion with the author, September, 2010.

[407] Ibid.

[408] Ibid.

[409] Ibid.

emphasis of science of science policy is closely related to the budgetary constraints for science as well as the evidence to justify the federal R&D budget decisions.[410] He also refers to the National Academies of Science 2005 report *Rising above the Gathering Storm*, which "laid out the proposal for significant increase of federal investment in science and technology" and says that the lack of data for justifying this claim became the issue, especially in a situation where securing new research funds is difficult.[411]

As Goldston points out, because the SSP's main focus is not "science for environmental issues" or politically contentious regulatory debates, but science budget and management questions, the SSP discourse is becoming less political or more bipartisan.[412] It also has been designed to resolve the questions on the science R&D budget that every administration has tried to answer. Goldston notes that science of science policy is asking "social science to solve the questions that are not ideological, not political."[413]

In particular, one of the major political issues in the U.S. nowadays is to create new jobs to revive economic activities. If "domestic and economic concerns" are behind of the rise of the SSP discourse, as Goldston points out, then the SSP community is not free from this political pressure.[414] Because there is little evidence, data, and models to show how science R&D would contribute to creating new jobs and improving economic performance, Goldston states that

---

[410] Ibid.

[411] Ibid.

[412] Ibid.

[413] Ibid.

[414] Ibid.

Marburger was disappointed with this situation and initiated the SSP to change it.[415] And the Obama administration's stimulus package for science was regarded as an opportunity for the SSP community to demonstrate how it can justify science R&D funding with new data and evidence that would indicate a return for boosting the economy and creating jobs.[416] Goldston also says that Congress has been supportive of the NSF SciSIP because of its political interest in job creation from the stimulous package for science.[417] The SSP's emphasis on the statistical and econometric measurements of R&D outputs and outcomes is the result of this effort of the SSP community.

(3) Impacts of the Performance Reform & a Revised Social Contract of Science I: Economizing and Mathematizing Federal R&D Decision Making

As I have shown in the previous chapters, scientific methods such as quantification and econometrics are dominant in SSP-type research activities. The interviewees seem also to agree that the SSP community's overall emphasis on economizing or quantifying research skills would be useful in developing new R&D evaluation models and data for evaluating science R&D investment, but some of them are critical about the tendency of the SSP community to put more weight on these econometrics and quantitative methods than on qualitative or mixed-research methods.

---

[415] Ibid.

[416] Ibid.

[417] Ibid.

For example, Valdez points out that SciSIP prefers “data- driven and quantifying” methods but that doesn’t mean excluding other disciplines using qualitative methods.[418] Regarding the NSF’s SciSIP, Eric Fisher says “a lot of economists are interested in SciSIP” and there are some constraints on the STS angle partly because of SciSIP’s emphasis on the “economists’ way of thinking” of research outcomes through systematic, rigorous, and structural analysis.[419] Marburger also wants to promote econometrics as the standard method. From this perspective, Fisher mentions SciSIP as “very positivistic.”[420]

David Lightfoot points out that, even though economists provide information to science policy makers, Marburger thought systematic economic tools were “not fully scientific” and so decided to challenge social science to come up with a new scientific approach science policy makers could use when managing and evaluating government science programs.[421] From his view on Marburger’s science of science policy initiative, the NSF SciSIP is designed to go beyond economic models and methods to support science policy makers.[422]

Sarewitz also points out some issues of the current SSP movement, saying that among NSF SciSIP-funded research projects, “most of the tools are economic tools” and “science output measuring tools,” whereas these aspects are “only a small part of science policy.”[423] Thus, there is also a “need to figure out how to not just say science is productive and creative,” or “the area

[418] Bill Valdez, in discussion with the author, October, 2010.

[419] Eric Fisher, in discussion with the author, December, 2010.

[420] Ibid.

[421] David W. Lightfoot in discussion with the author, August, 2010.

[422] Ibid.

[423] Daniel R. Sarewitz, in discussion with the author, October, 2010.

of science creates more wealth…deals with health and environment problems (successfully)."[424] He continues his argument that research and discussion on the way benefits are distributed or addressing social conflicts surrounding science and technology should also be supported by the science policy community.[425] He proposes the research of public value mapping as one of the solutions to change the science policy discussion.[426] "Science policy is almost always justified on the basis of those kinds of public value claims" such as "if we invest into national cancer institutions, then less people would die because of cancer" or "if we don't invest into this kind of research, then this would lead to this kind of outcome," whereas there are few detailed case studies that try to understand the structure of different science programs' influence and outcomes.[427] Moreover, many science policy research activities focus on creating "socially robust knowledge with properly structured (scientific) institutions," but it doesn't simple mean quantification is the ultimate solution to resolve real-world science policy issues.[428]

Referring to the failure of research funding for cancer research or climate science, he points out that "those sorts of failures are very strong indicators that we are not asking the right kinds of (science policy) questions."[429] Some SSP community actors are "big believers, all about the measurement," but science policy is "not all about the measurement... but (also) about thick descriptions…about understanding social and political dynamics… (and) about understanding

---

[424] Ibid.

[425] Ibid.

[426] Ibid.

[427] Ibid.

[428] Ibid.

[429] Ibid.

history (of science and technology)" that are hard to be quantified.[430] Moreover, he observes some shared bias of "what kinds of data count" or what kinds of disciplines matter inside the SSP community because of the "social status" of quantification methods in this community.[431]

Juan Rogers also contends that "the issue is not quantification but causal connection," and thus the combination of qualitative and quantitative methods would be desirable to help design new science policy strategies and programs.[432] Jeffrey Alexander is also skeptical about the broader impacts of SoSP on science policy mainly because of its emphasis on the quantification and economization of science policy.[433] First, funding as well as regulations, tax, and financing aspects are important to science policy decision making.[434] He emphasizes that "dealing with policy" is "social activity" and "all (of these) activities are not quantifiable."[435] Therefore, the SSP might result in excluding "entire qualitative (approaches)" that "would be help for science policy makers."[436] Second, there is "plenty of (academic) research" on the process of scientific and technological innovation, but the SSP community didn't recognize these

---

[430] Ibid.

[431] Ibid.

[432] Juan Rogers, in discussion with the author, June, 2011.

[433] Jeffrey Alexander, in discussion with the author, August, 2010.

[434] Ibid.

[435] Ibid.

[436] Ibid.

research results.[437] Moreover, a "vast majority of participants" in the SSP come from economics, whereas "very little (are coming) from other (social science) fields."[438]

He also argues that "many questions should have been answered" when initiating the SSP discourse.[439] For example, computational models and tools would be useful for evaluating or promoting "transformative research" instead of curiosity-driven basic research, and thus SSP toolkits and models would affect basic research activities negatively.[440] Japan' case of emphasizing data-driven quantitative evaluation, computational budgeting, and systematic algorism for all science programs couldn't capture "non-quantifiable outcomes" and thus the Japanese government tried to cut funding for basic research activities, including superconductor research.[441] From a scientific point of view, Japanese experience suppressing basic science research due to the lack of short-term outcomes would be the worst-case scenario as well as a potential danger the SSP approach might bring to the U.S. science community.[442] In this context, he emphasizes that science and technology policy should be departing from early scientific view of science policy such as adopting a mathematical equation in the analysis of the science policy process.

Some interviewees also made suggestions to improve the activities of the SPP approach and to correct its shortcomings. For example, Jeffrey Alexander says "there is a deep division

---

[437] Ibid.

[438] Ibid.

[439] Ibid.

[440] Ibid.

[441] Ibid.

[442] Ibid.

(between) econometric and qualitative social studies" and proposes the creation of a "subdivision (under the SSP)" to narrow this gap.[443] There is a perception that qualitative methods are "less reliable" and thus we can only "trust quantitative approaches," whereas this subdivision would promote discussion or research on how to (conduct) "scientifically qualitative research" in both science and the science policy field.[444] This hybrid scientific perspective would be helpful for science policy makers.

Robert Shelton, who was a former National Science Foundation science policy analyst and ran a private research company on global science policy and indicators, WTEC, suggests that the SSP community needs to "look at the intersection" between the social aspects and new scientific and technological innovation.[445] For example, if there is little effort to change the public perception of the potential negative impacts of nanoscience and technology, then even though the scientific-evidence supported reality is different from the public perception, the field of nanoscience and technology would lose the public support and not exist any more.[446] In other words, "many elements of science policy," including social implications of science, "can't be ignored."[447] In addition, he argues that "government funding is more effective in producing science papers," and thus instead of measuring or boosting academic research, a "full cooperation with industry" is needed.[448] For example, in the U.S., two-thirds of total R&D

---

[443] Ibid.

[444] Ibid.

[445] Robert D. Shelton, in discussion with the author, September, 2010.

[446] Ibid.

[447] Ibid.

[448] Ibid.

funding comes from the private sector, and thus a more sophisticated “implementation plan” of science policy is urgent so as to get research investors, including global companies, to “invest money (in the) U.S.” instead of other countries such as China.[449]

(4) Impacts of the Performance Reform & a Revised Social Contract of Science II: Improved Authority of Scientific Claims & Evidence

In relation to the potential change of the policy and politics of science, the SSP seems to contribute not only to an increase in the authority of the scientific claim, but also to the demise of the authority of scientists simultaneously to justify the policy and political decision on science R&D investment. In other words, using the scientific claim and evidence-based decisions is more likely to be considered transparent and accountable than decisions made by scientific experts, and the SSP community’s emphasis on the scientific way of implementing science policy and R&D decision making tends to reflect and reinforce this aspect of science policy and politics.

The SciSIP director, David Croson, emphasizes that “SciSIP is one of the rare areas getting support both from science and politics” because its goals include “better understanding science policy” as well as “scientific analysis of R&D.”[450] From his point of view, “innovation is good for society” in the long term, and both qualitative analysis and quantitative tools are scientific methods as long as they are “rigorous enough to pass the SciSIP panel.”[451] Rigorous

---

[449] Ibid.

[450] David Croson, in discussion with the author, September, 2011.

[451] Ibid.

and scientific analysis means more “believable” analysis, he emphasizes.[452] Bill Valdez also emphasizes that scientific knowledge on how they corroborate and produce knowledge would be valuable for developing science policy.[453] Robert Shelton at the World Technology Evaluation Center argues that scientific methods that are based more on procedure of “observation, testing, validation, and replication” should be the model of science policy.[454]

Jeff Alexander at SRI notes that the SSP community’s emphasis on brining “scientific methods into policy making,” excluding “subjective value judgment,” and developing “logical evidence based … investment strategies” can be understood from the perspective that the SSP approach was primarily designed to support the development of objective evaluation tools and methods to measure the outcomes of R&D investment.[455] From his analysis, for the SSP community, science means “scientific evidence” and based on “logical positivism,” they have tried to conduct experiments to develop science policy decision tools to answer the questions of investing “where to and how much.”[456] So the SSP can be defined as a “scientifically based science policy approach.”[457] And this approach emphasizing an objective “investment decision” meshes with the Obama administration’s “evidence based policy” discourse; thus the SSP discourse has been carried over from the previous administration.[458]

---

[452] Ibid.

[453] Bill Valdez, in discussion with the author, October, 2010.

[454] Robert D. Shelton, in discussion with the author, September, 2010.

[455] Jeffrey Alexander, in discussion with the author, August, 2010.

[456] Ibid.

[457] Ibid.

[458] Ibid.

Irwin Feller also says that, as shown in cases such as the National Academy's report *Rising above the Gathering Storms*, many science policy goal statements regarding federal investment in science and technology or the distribution of federal funding have been made with "very limited" evidences or have become a political process.[459] Therefore, contrary to political earmarking, Marburger proposed an interdisciplinary as well as a science policy-oriented research approach for managing or measuring the performance of science policies and programs systematically instead of politically.[460] From this perspective, SoSP is similar to the NPM (New Public Management) movement.[461]

Interview data commonly implies that scientific claim with evidence and data is becoming more important politically for the federal government to justify its support for science R&D activities. From this perspective, in chapter 6, I develop my arguments that, first, the SSP not only represents but also strengthens a new politics of science that emphasizes the scientific claim as a way to justify the decisions of science policy and politics instead of depending on the authority of scientists and science agency managers; and second, the SSP's contribution to shaping a new politics of science resulted from the less political or neutral position it occupies.

(5) Impacts of the Performance Reform & a Revised Social Contract of Science III: New Focus on the R&D Evaluation

---

[459] Irwin Feller, in discussion with the author, August, 2010.

[460] Ibid.

[461] Ibid.

One of the obvious impacts that Performance Reform & a Revised Social Contract of Science would have on science policy research and practice through the SSP discourse is renewed interest in the evaluation of R&D activities. R&D evaluation is one of main emphases of SciSIP, and David Croson argues that evaluation techniques have not made significant improvements during the last decades.[462] Therefore, SciSIP has made efforts to develop better and more complex techniques to evaluate the investment of R&D along with funding "scientific ground and policy oriented" research.[463]

Bill Valdez at the DOE also said that one of the premises of the science of science policy is to develop a new data-point for measuring science R&D instead of using a traditional one such as a citation or money.[464] In particular, he said, the scientist is becoming a "unit of analysis" scientist, and the SciSIP has intended to account for and analyze scientists with the belief that scientific knowledge on how they corroborate and produce knowledge would be valuable for developing science policy.[465] He was the director of a small sub-unit within the Office of Science at DOE from 1999 to 2009, and during the first years, he realized that there was no "data-driven analysis" model for federal agencies to plan and evaluate their programs.[466] He said that "(most of) past evaluation attempts…either very high level or very specific level," whereas "no study for federal science policy agencies…addresses the needs of federal science agencies."[467]

[462] David Croson, in discussion with the author, September, 2011.

[463] Ibid.

[464] Bill Valdez, in discussion with the author, October, 2010.

[465] Ibid.

[466] Ibid.

[467] Ibid.

Moreover, techniques developed by the private sector did not fit the needs of federal science agencies because, first, the "motivation for investment is different," and second, "the complexity of (R&D) investment is higher than (that of the) private sector."[468] So, he began trying to find solutions to develop new tools and models while he was at the Office of Science.[469] And he had a chance to give a presentation to Marburger about his view and work on developing new tools, models, and data.[470] During the meeting, Valdez mentioned that Marburger said, "We need an interagency working group for science of science policy."[471] The DOE was co-leading the SoSP working groups, and the DOE budget was the "only federal budget for SoSP."[472]

During the interview, the Congressional committee on science and technology staff director Dahlia Sokolov mentioned that "measuring R&D impacts" is difficult, and some measuring criteria such as "quality of life" are "subjective terms."[473] However, even though the social impact of R&D investment is not easy to quantify, she points out that quantification or analyzing tools to measure the outcomes is important politically because it would "bring the confidence to maintain" certain science policy strategies and decisions supported by Congress.[474]

Juan Rogers, who conduct research on knowledge-value mapping in various social systems, points out that scientific research results should be analyzed considering the various

---

[468] Ibid.

[469] Ibid.

[470] Ibid.

[471] Ibid.

[472] Ibid.

[473] Dahlia L. Sokolov, in discussion with the author, October 2010.

[474] Ibid.

social contexts.[475] From this perspective, analyzing how knowledge flows through these social contexts should be one of the key components for evaluating scientific R&D. He also emphasizes that it is difficult to develop a "clear cut model" allowing one to "compare and evaluate social impacts" of R&D activities because there are many "social dimensions" such as human capital.[476] Therefore, there are not many models showing a "casual connection" between R&D activities and social impacts. He agrees with the importance of the interdisciplinary approach to promote the creativity of scientific research because it would help in analyzing the "(favorable) contextual facts affecting the ability of researchers."[477] In addition to the social contexts, he furthers his argument that the evaluation of R&D should also focus on "the (social or public) value" instead of "checking (research) goals" because a "goal is one aspect," whereas there are "many values that are realized or not realized" and "not all values are integrated in goals."[478]

With respect to R&D indicators, he talks about OECD's efforts to create a "uniform set of data and criteria… indicator," but also points out that indicator design should be related to theory.[479] For example, citation analysis is one of the most used indicators, but the theoretical discussion about how and why citation data is important to access scientific impacts should be promoted as well.[480] This argument supports the idea that the U.K.'s Science of Science

[475] Juan Rogers, in discussion with the author, June, 2011.

[476] Ibid.

[477] Ibid.

[478] Ibid.

[479] Ibid.

[480] Ibid.

Foundation-type approach would be useful for the science policy community to make the SSP discourse more sustainable and profound than the current form.[481] More details of this idea are described in the concluding chapter.

(6) New Politics of Science I: Micro-Level Dynamics among Disciplines & Actors

In 2006, Lightfoot convinced the NSF to assign $2.8 million for research on this new initiative and hired Kaye Husbands Fealing as the director of the SciSIP program to invite a broader range of sociologists into it.[482] One of the goals of the program was to conduct scientific analysis of the factors influencing the research institutions/universities as well as individual scientists who were successful in their research. Lightfoot wanted to research the sociological and cognitive facts about how scientific discoveries happen.[483] In 2007, around $8 million was assigned to the program.[484]

So, the initial goal of SciSIP is "beyond economic," and Lightfoot intended to create research alliances among a wide range of social and human science researchers to bring their perspectives to the science policy domain.[485] He says, "I want the broader view … psychology … to look at the different aspects of (scientific and technological) innovation" and the wide

---

[481] Ibid.

[482] David W. Lightfoot in discussion with the author, August, 2010.

[483] Ibid.

[484] Ibid.

[485] Ibid.

range of first-stage SciSIP funded research is the evidence to support the program's direction he tried to achieve.[486] This view was also addressed by one of the federal science policy reports.

As a co-chair of the National Science and Technology Council's subcommittee on Social, Behavioral and Economic Sciences, Lightfoot led the development of the report Social, Behavioral and Economic Research in the Federal Context with the collaboration of seventeen government agencies as well as the White House's OSTP.[487] One of the priorities of SBE research on "systematic data-gathering" and sharing or "system integration" is the "integration of disciplines" or supporting "interdisciplinary collaborations" among SBE scientists.[488]

He emphasizes that "no one person (can) understand physics, biology…" and thus any researcher who is interested in scientists' behaviors or the dynamics of science was considered for SciSIP funding.[489] And SciSIP's first-round awards show a broader range of topics. In other words, SciSIP has provided a research platform to build a new science policy research community. In this context, Lightfoot defines the Science of Science Policy as a "branch of social science" to discuss "what can we count as evidence now and in the future" or "what constitute evidence" in science?[490] Through SciSIP, a "new science is being constructed." Building a new science that "bears in mind (science) policy" is what he and Marburger agreed to achieve.[491]

---

[486] Ibid.

[487] Ibid.

[488] Ibid.

[489] Ibid.

[490] Ibid.

[491] Ibid.

However, it is also important to note that, from the perspective of some SSP community actors, funded research agendas addressed under the first SciSIP solicitation didn't match Marburger's vision of the SoSP contrary to Lightfoot's interpretation of it. For example, Valdez points out that "the first solicitation was a sketch," and "people responding to it are assuming it's for academic purposes," which is "not what Marburger wanted."[492] Some research groups were "interested in academic community (publishing new ideas…etc)," whereas he and Marburger were more interested in the "movement for practical applications of these (SciSIP funded researches) for agencies."[493] Valdez emphasizes that SciSIP is seeking "immediate application to solve problems science agencies have."[494]

One interviewee mentions that, even if Marburger intended to develop "methodology to evaluate programs" and SciSIP is a "vehicle to carry this (purpose)," the NSF's bottom-up mechanism puts more focus on "developing science for better policy decision" than Marburger's initial priority.[495] More specifically, some SciSIP funded researchers may or may not agree with Marburger's visions and initiation of science of science policy and thus SciSIP funded research "doesn't mean what Marburger wants to be done" because NSF SciSIP is a "investigation driven program" allowing social scientists to research and develop science to support science policy.[496] Moreover, proposal review panels rather than the founding actors of the SSP including

---

[492] Bill Valdez, in discussion with the author, October, 2010.

[493] Ibid.

[494] Ibid.

[495] Interviewee whose name remains unanimous, in discussion with the author, 2010.

[496] Ibid.

Marburger decide what research would link to the program.[497] In this context, he contends that "what I believe Marburger would like to do is something more technical and more directed specific items" and "NSF starts from correct premise," whereas "the way it works" at the NSF, through the bottom-up approach, decides what is important research instead of dictating funded research to get what Marburger or science policy makers wanted.[498]

David Goldston at the Natural Resources Defense Council points out the same issue that the NSF SciSIP is to let academic researchers do what they are interested in, whereas, considering the main purpose of the Science of Science Policy initiative, science policy makers should "dictate methodology (of) and primary questions to be answered" by the SciSIP-funded research results.[499] Robert Shelton notes that, since Marburger is no longer in the OSTP director position, there is a possibility that the science of science policy would be "redirected."[500] Based on these interview data, I point out that there are internal dynamics, conflicts, and politics among SSP community actors regarding the direction and management of the SciSIP program or the SSP discourse at large, and these international conflicts or dynamics are described in the latter part of this chapter.

One of the observations Daniel Sarewitz describes on the NSF SciSIP is the tension among disciplines.[501] For example, there are actors "who already occupied the space of measurement that the (NSF SciSIP) program has created for them," and thus it would be difficult

---

[497] Ibid.

[498] Ibid.

[499] David Goldston, in discussion with the author, September, 2010.

[500] Robert D. Shelton, in discussion with the author, September, 2010.

[501] Daniel R. Sarewitz, in discussion with the author, October, 2010.

for other fields of research to come into it.[502] In other words, the tension between the "need for more formal disciplinary structure" and crossing disciplinary boundaries exists inside the NSF SciSIP. [503]

Eric Fisher also notes that there are "tensions between SciSIP projects" and other science policy research communities because the SciSIP has been developed based on an "econometric framework," whereas there are many other science policy researchers not funded by SciSIP.[504] Therefore, building an "eco-system of science policy research" by accommodating "methodologically different communities" would be an issue for the SciSIP community.[505] Fisher also mentions the tensions "between practitioners and academy.[506] A lot of (science policy) practitioners feel academics don't give something they need" or academic research is "not good enough" for them to use.[507] Their view is based on the "supply and demand" of science policy-relevant knowledge between academic research and the science policy practitioner community.[508]

He points out the tensions among science policy "practitioner communities" as well.[509] For example, some agencies such as the DoE believe Merton's description of normal and value-

---

[502] Ibid.

[503] Ibid.

[504] Eric Fisher, in discussion with the author, December, 2010.

[505] Ibid.

[506] Ibid.

[507] Ibid.

[508] Ibid.

[509] Ibid.

free science and thus are concerned about the "politicization of science."[510] For them, politicizing science would include congressional debate on science funding. On the other hand, in post-normal science area, values are embedded in scientific research and science policy decisions need to be urgent, and thus reorganizing science and science policy to be transparent and democratic could not be considered as a politicization of science. However, many practitioners who agree on this view don't have the power to adopt it for their science policy and management practices. Feller even points out some of the current NSF SciSIP's limitations such as that many of the SciSIP-funded research awards deal with the "innovation process."[511]

Considering this internal conflicts, disagreements, and politics of the SSP discourse, open and interdisciplinary aspects of the SciSIP program are promoting this internal political tendency, which could be regarded as a weakness of the NSF SciSIP program by some SSP actors However, I argue that this complexity of the SSP research agreeing and disagreeing, or aligning and mismatching with Marburger's initial visions or science policy makers' demands would also be a strength of the NSF SciSIP in terms of its long-term and sustainable contribution to science policy making and research.

More detail to support my argument is described in the concluding chapter through the comparative study between the U.K. Science of Science Foundation and the U.S. Science of Science Policy, but to sum in advance, I contend that the different funding stages, from supporting the fundamental understanding of modern science practice and scientists to funding the development of econometric models to address the specific science policy concerns, should

---

[510] Ibid.

[511] Irwin Feller, in discussion with the author, August, 2010.

be made instead of limiting the subjects and methodologies of funded research without creating synergy between the previous and current research. The U.K. SSF has laid the foundation of modern science indicator research by emphasizing the socio-cultural studies of science at first and then developing the research using these research results on the basic understanding of science, scientific knowledge, and scientists. This experience would be useful for the SSP community in the U.S. to make the SSP discourse to be sustainable even though projecting the U.K. and European science policy models into the U.S. might not be possible due to cultural, political, and social differences among the U.K., Europe, and the U.S. that have shaped the different science policy environments and tools in these countries.

(7) New Politics of Science II: Macro-Level Promotion of Science-Based Politics

Potential implications of the SSP discourse for the current and future politics of science is another issue that some of the interviewees point out. For example, one of the interesting perspectives David Lightfoot points out is the impact of the SSP discourse on science politics.[512] He addresses his view of the role of scientific research and evidence in re-shaping policy decisions, especially related to science policy and funding.[513] In the case of a policy program allowing some fiscally poorer states to access special funds for supporting science, science seems to show that investing money in universities in urban areas would be better than in rural areas, whereas science policy makers look at this special funding program as a political one.[514]

[512] David W. Lightfoot in discussion with the author, August, 2010.

[513] Ibid.

[514] Ibid.

Therefore politicians and policy makers still need to know what would be the outcomes of their funding decision.[515] So a new scientific data and models generated by Science of Science Policy can reshape political questions and decisions.

During the interview with Irwin Feller, he mentioned that, through the science of science policy approach, science policy makers can develop the solutions to resolve societal problems because the academic community has solutions.[516] The problem is that policy makers rarely use these solutions. He questions "why not political process accepts them (solutions offered by the academic community)?"[517] Of course there had been some efforts to connect knowledge and political power to resolve science policy issues during the last decades, but rarely were these efforts institutionalized or successful for building a community due to the different perspectives existing among academic disciplines when so many are dealing with the same science policy issues. In this circumstance, the NSF's SciSIP is a "rebirth of interest" narrowing these intellectual gaps among the pragmatic research communities on various science policy issues such as funding allocation or the social impact of science investment by integrating these different perspectives.[518]

Jeff Alexander also describes the change of politics and its impacts on the rise of the SSP discourse. Historically, during the "golden era of science" from 1950 to 1970, he says government officials put their trust in scientists and provided funds for building scientific

[515] Ibid.

[516] Irwin Feller, in discussion with the author, August, 2010.

[517] Ibid.

[518] Ibid.

enterprises such as laboratory infrastructures, assuming beneficial outcomes from scientific research.[519] In other words, a positivist approach dominated science policy decision making during this period. However, throughout the economic crisis during 1970 and 1980, policy makers began to realize that spending money on scientific research would not be enough to improve economic competitiveness.[520] Thus, the White House has begun trying to gain control over spending money for scientific research as well as to steer technological development.[521]

From the 1980s to the current administration, there have been tensions about the national government's role in science enterprise between Republican ideas that "hand off" from scientific research activities and spending money for basic research, and Democratic ideology promoting the administration's engagement.[522] The latter "interventionist's approach" focuses on specific policy outcomes and thus is more concerned with increasing "economic returns" from the investment in science as well as bridging the gap between science and technology development.[523] And he points out that the science of science policy would be an example showing the combination of this dynamic of U.S. science policy and politics.[524]

Jeff Alexander also points out that, as shown in the funding decisions of the NIH, the political process and the engagement of interest groups are inevitable components, and science

---

[519] Jeffrey Alexander, in discussion with the author, August, 2010.

[520] Ibid.

[521] Ibid.

[522] Ibid.

[523] Ibid.

[524] Ibid.

policy makers “always have to deal with political aspects.”[525] Considering that “subjective (and political) criteria” are “driven by social interaction,” scientists need to contribute to science policy by developing a way to better communicate with science policy makers and other social actors instead of banishing political dimensions from science policy.[526] He emphasizes that public policy is a social and political mechanism, and there is “no way to change (this) science policy equation.”[527]

Juan Rogers argues that public policy is related to “norms and social action” and thus politics allowing “normative discussions” as well as the participation of all parties into these discussions can’t be separated from developing science policy strategies.[528] In this context, the combination of science and politics for science policy through the SSP discourse seems to contribute for reshaping the politics of science.

Based on the interview with Dahlia Sokolov of Congress, it is also important to note that Congress’s support of the SciSIP is politically motivated.[529] First, she emphasizes that the R&D investment decision is a “political decision,” and politics can’t be separated from the science policy decision making process.[530] Of course, any arbitrary political decision should not affect the strategies of R&D investment, but rigorous measurement can’t replace political

[525] Ibid.

[526] Ibid.

[527] Ibid.

[528] Juan Rogers, in discussion with the author, June, 2011.

[529] Dahlia L. Sokolov, in discussion with the author, October 2010.

[530] Ibid.

considerations even though data generated by the computation or quantitative measurement would bring more certainty to R&D investment decision making.[531]

Second, another example indicating the roles of politics in science policy is the interest of Congress members in bringing more resources and investment to research or higher educational institutions located inside their districts.[532] This interest would be "sort of earmarking," but there is nothing wrong with that when they are in a better position to know the strengths or an institution's potential better than others.[533] Because politicians need to convince the public to justify their decision on national R&D investments or funding local institutions, SciSIP is a "politically important tool" for them.[534] In other words, members of Congress "don't have tools for them to go back to their constituency" to explain their investment decisions to and convince the public.[535] Therefore, the NSF needs to build new science policy toolkits to connect the dots of the facts, which can be used as "talking points" by Congress.[536]

Third, she points out that the recent economic crisis has resulted in promoting the policy goal of "more effective (federal) investment" in science, and thus SciSIP has its ground on responding to this demand.[537] Moreover, politically, the current administration "would like to

---

[531] Ibid.

[532] Ibid.

[533] Ibid.

[534] Ibid.

[535] Ibid.

[536] Ibid.

[537] Ibid.

justify its recovery act" and thus supports the SciSIP.[538] In addition, the political environment of a 2-4-year election cycle makes Congress look at the short-term impacts instead of the long-term outcomes of science R&D investment, which can't be easily changed even though most members of Congress hold a pro-science position and know "investment in science is good for the country."[539] The SciSIP's focus on measuring the short-term social and economic impacts of science and technology investment thus makes sense politically.

It might have appeared to Congress that political reasoning is behind supporting the SSP discourse. From this perspective, she disagrees with any intention to separate politics from science policy when she emphasizes the importance of politics in the science policy process.[540] With respect to public engagement in science policy, she points out that NSF's responsibility is to "disseminate the results of its funded research," whereas each science agency should take over the responsibility to "provide a venue to the public" as well as to collect the public's input and feedback because "public technology acceptance" is important, especially in emerging technology fields.[541] This is the point where the results of SSP-funded research can make a unique contribution, and I examine in more detail the potential impact of the SSP on improving the democratic values in science policy making in the concluding chapter.

2. Main Components and Development Stages of the SSP Discourse

[538] Ibid.

[539] Ibid.

[540] Ibid.

[541] Ibid.

Based on the interview data, in this subsection, I argue that the SSP discourse consists of three main components and three developmental stages, which overlap, but still maintain a relatively different meaning and position inside the discourse.

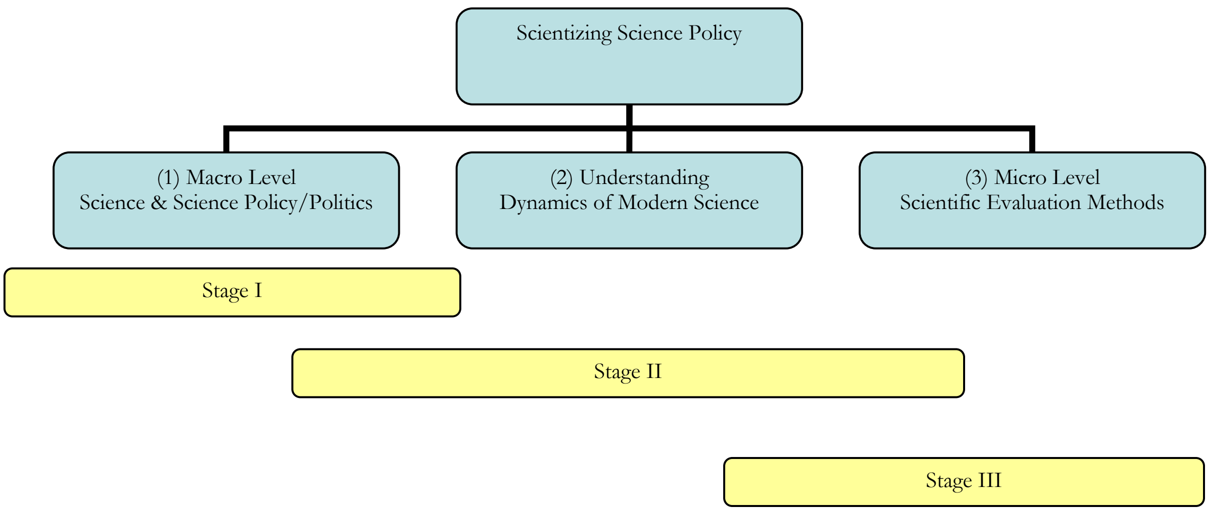


Figure 5-1. Three Stages and Components of the SSP Discourse

(1) Three Components

a. Science & Macro-Level Science Policy

The first component is comprised of actors who use science in science and innovation policy processes at the macro-level, including the scientific implementation of science policy. Actors in this component focus on resolving science policy issues and controversies using the scientific methods and evidence. Marburger, who initiated the science of science policy approach, is one of these main actors. Some of actors who are located in this component tend to express their frustration about politics or political influence on science and technology policy issues.

b. Understanding Science & Its Implications for Science Policy

The second component is constructed with a group of social scientists, former NSF management-level staff, and science policy researchers whose foci include the dynamics of modern science as well as its relationship with society. These actors include the NSF staff and participants in the first NSF workshop on the science of science policy, as well as the first round of NSF SciSIP program funding grantees. This group maintains a critical stance on the development of the SSP discourse, while at the same time trying to infuse its research foci into the discourse.

Congressional hearing also confirms that Congress' science and technology policy subcommittee tries to drive the SSP discourse into meeting the goals of promoting science education and assessing the social outcomes of scientific and technological innovations based on the assumption that the SSP will deepen the understanding of scientific institutions and scientists.

c. Science & Micro-level Science Policy

The third component is comprised of actors whose foci include the use of social and economic science for science and innovation policy at the micro-level, including R&D program evaluation and scientific methods for project selection. One of the significant features of the SSP discourse through this component is that it seeks to improve science policy practice and research by funding micro-level innovative practices and methods in the science research/innovative research system along with science policy analysis research.

In this component, actors try to establish a new dataset, scientific methods, and toolkits that science policy practitioners can directly adopt and use to analyze and assess the performance of their internal science R&D programs and investments. By doing so, each science agency can not only evaluate their micro-level science activities and investments, but also produce reports to meet the criteria imposed by other agencies, including the OMB.

The main actors in this component include the Department of Energy's (DoE) Office of Science staffs (coordinating inter-agencies collaboration) as well as science policy practitioners from multi-government agencies who have participated in developing the Science of Science Policy Roadmap. Economic scientists at the managerial level of the NSF are also located in his component of the SSP.

(2) Three Development Stages

Even though groups of actors from all three components mingle within the SSP discourse, there is a shift of dominant roles and influence among them that shape the discourse. For example, the first group of actors focusing on macro-level science and science policy initialed the discourse, whereas the second and third groups of actors who focus on understanding science as well as the micro-level approach to science and policy, respectively, participate in designing and institutionalizing the discourse in the latter stage of the discourse's development. In the current form and stage of the SSP, the third group plays the dominant role in developing SSP.

More specifically, there are three development stages of the SSP discourse, and the major influences of each component described above are different at each development stage. Stage-I represents the period when Marburger initiated the science of science policy approach. In this moment, the interactions and conflicts between science and politics in the STI policy process are the main foci of the main Stage-I actors.

Stage-II shows the time when the science community responded to Marburger's call for establishing the science of science policy. In this moment, developing science policy based on the understanding of science and scientists is the primary emphasis of the actors. NSF's proposal for establishing a new science policy research program as well as the first two NSF workshops on it (before the SciSIP's first solicitation in 2007) represent this Stage-II.

Stage-III, which is corresponding to the SciSIP's second, third, and fourth funding solicitation, indicates the period after the initial institutionalization of the discourse such as NSF's SciSIP program to promote the development of the scientific models, toolkits, and dataset, as well as the bridge between academic research and policy practitioner groups.

There have been continuous transitions of the foci of actors across the development paths. For example, during the interview meeting with Dr. Feller, he and I talked about the need to build a strong connection between SciSIP research and science policy making. I mentioned the difficulty of scheduling interviews with NSF SciSIP fund grantees; this was mainly because many of them said science policy is not their research interest so they felt their participation would not be appropriate for my science policy research interview.

However, that doesn't make sense because SciSIP-funded research results are supposed to be connected to science policy making. Dr. Feller agreed and mentioned the new efforts of NSF SciSIP to create a strong relationship between funded research and science policy. He said the NSF workshops will include SciSIP grantees and will expose them to the rigorous process/training of connecting SciSIP-funded research to science policy fields. Based on the interview, SciSIP has done the first step of formulating a new research community and now moves forward to the next step of connecting its research to the actual science policy field.

(3) Heterogeneity of Actors' Engagement in the SSP Formation

Three major groups of actors have influenced the initiation and development of the SSP discourse from their own perspectives.

The first group is science policy practitioners. Federal science policy agencies in the U.S. such as the Department of Energy (DoE) running its own science R&D programs have begun complying with the new R&D investment management procedures established by the Government Performance and Results Act (GPRA) of 1993 and the Performance Assessment Rating Tool (PART) of the Office of Management and Budget (OMB).[542]

So the science policy practitioners need to have new tools, models, and data sets to respond to the requirements of these Acts. They see the potential of the science of science policy for developing new policy toolkits to serve this purpose. For this group of technocrats, economic methodology is very useful for administrative purposes because of the economic models' proximity to facts and statistics,[543] and by injecting economic models and tools into the science policy process, science policy practitioners have begun shaping their image as the "state engineers."[544]

---

[542] Irwin Feller and George Gamota, "Science Indicators as Reliable Evidence," Minerva, 45 (2007): 17-30.

[543] Philip Mirowski, *Natural Images in Economic Thought: "Markets Read in Tooth and Claw,"* (Cambridge [England]: Cambridge University Press, 1994), 147.

[544] Ibid., 146.

Table 5-2. Three Groups with Different Values and Motivations

Technocrats /Science Policy Practitioners	- Need new performance management tools and methods to comply with (1) Government Performance and Results Act (GPRA) of 1993 and (2) Performance Assessment Rating Tool (PART) of the Office of Management and Budget (OMB) - Boundary Work: Emphasizing Economic Models and Data
Value-centric Science Policy Research Groups	- Social scientists in the fields of social studies of science, psychology, anthropology, or political science - Understanding the dynamics of science, scientists and scientific knowledge - Crossing Boundary: Focusing on the process, socio-cultural & intangible value, and the outcomes of science policy instead of outputs
Marburger & Economic Scientists	- Lack of centralized S&T policy system ➔ Relatively poor resources and information to help science policy makers formulate S&T related policy strategies ➔ Politics instead of science - OSTP has relatively less resources and supporting systems to assist him to formulate the coordinated S&T policy strategies. Other countries such as Japan and South Korea have the independent science policy department to construct the model of national innovation system (NIS), but due to the pluralistic political cultures, the demand on establishing the NIS has not gained enough supports. - Boundary Work: Assume there is a boundary between science and policy or politics.

A second group is science policy community members ranging from the NSF assistant director to science policy scholars in the academic field who share similar visions of science and science policy. They look at the science of science policy initiative as the way to improve the understanding of modern science and scientists. This group didn't make any accorded voices due to its heterogeneous characteristics across disciplines, but some actors of this group made critical contributions to the institutionalization of science of science policy. However, through the development of the SSP, these actors either work away from participating in the formation process of the SSP discourse or are critical about the current direction the SSP discourse is pursuing.

The third group includes Marburger and economic scientists. Marburger tried to formulate the science of science policy discipline and community hoping to use the resources provided by them as a science policy advice system for formulating and discussing national economic policy strategies. Economic scientists who are involved in federal science R&D are other key actors of this group. Marburger and economic scientists share the same sociotechnical imaginaries of science and science policy because of their vision on the use of numbers or quantification models as the best tool not only dissolve the political process, but also to give more power to them when they propose science policy strategies. Dynamics of Constructing the SSP Discourse among these heterogeneous groups can be shown in the following figure.

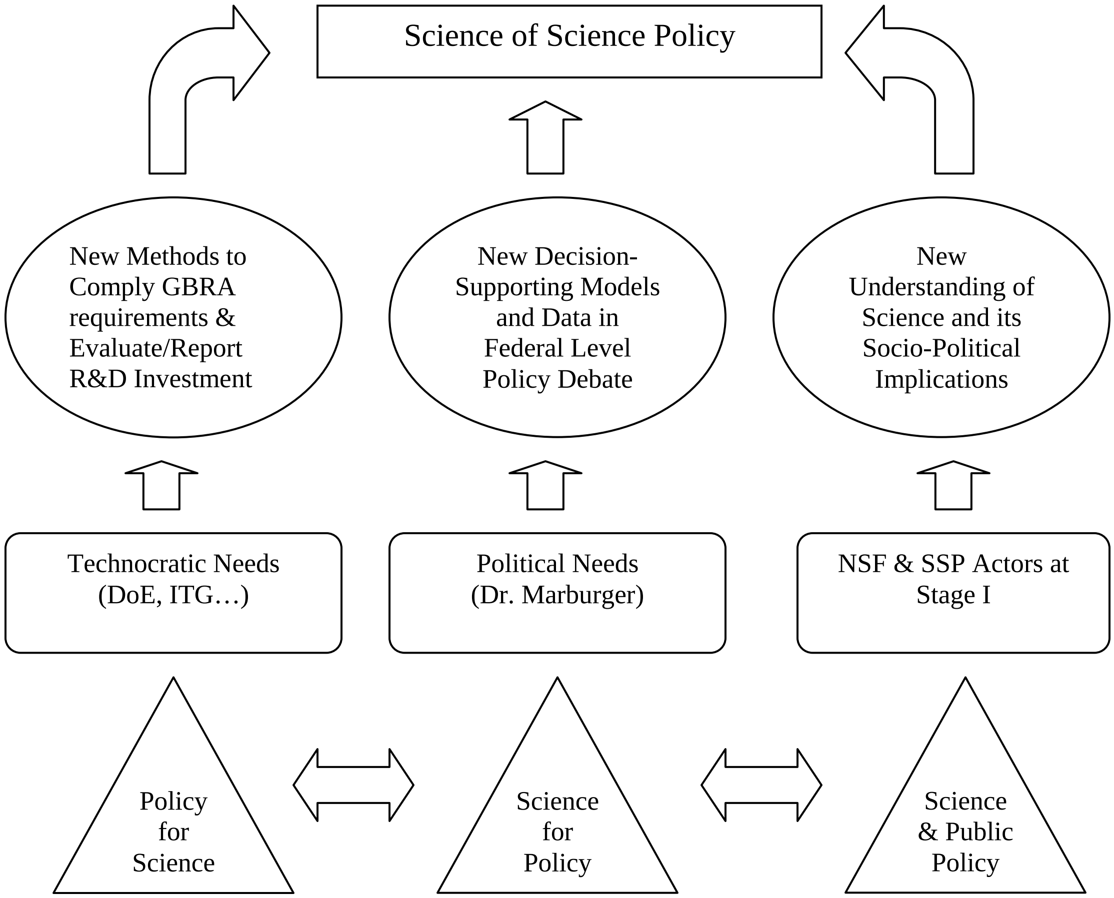


Figure 5-2. Heterogeneous Groups' Involvement in Shaping the SSP

Beyond the dynamic interactions of heterogeneous groups of the SSP, there is also a commonality among these groups. They maintain the ambiguity of the meaning of science so as to put forward their visions into the discourse, arguing that they are doing their own version of science. The vision of conducting science offers them the credentials to participate in the process of SSP formation, the so-called science of science policy instead of the social science of science policy or the economics of science policy. One meta imaginary of science and science policy these actors share is that science equates with trust and conducting science gives them a rationale to engage in the SSP process

3. Criticisms on the SSP

A number of interviewees expressed concern that many of the original framers of the SSP discourse, especially Marburger, rely on the "myth of scientific authoritativeness" in resolving science policy questions. Sarewitz claims that authoritativeness, which means "scientific information provides an objective basis for resolving political disputes," is simply a myth of science and technology policy.[545] Based on Bijker's accounts of the social constructivist view of science and technology, the "political dimension of scientific controversies" is "quite normal" because even "science cannot deliver complete certainty."[546] Jasanoff also points out that the emphasis of objectivity by state science and technology institutions comes from the belief that "neutral approaches" such as "objective, quantitative decision-making techniques" would lead to conflict resolution.[547]

---

[545] Daniel R. Sarewitz, *Frontiers of Illusion: Science, Technology, and the Politics of Progress*, (Philadelphia: Temple University Press, 1996).

[546] W.E. Bijker, "Understanding Technological Culture through a Constructivist View of Science, Technology and Society," in *Visions of STS: Counterpoints in Science, Technology, and Society Studies*, Stephen H. Cutcliffe and Carl Mitcham, ed. (Albany: State University of New York Press, 2001).

[547] Sheila Jasanoff, *States of Knowledge, The Co-production of Science and Social Order*, (London: Routledge, 2004).

In terms of the use of quantitative research methods in science, Porter states that "quantification is a form of rhetoric that is especially effective for diffusing research findings to other laboratories, languages, countries, and continents…This does not mean that mathematics is a neutral language, that anything can be translated into mathematics, and thereby simply made more precise."[548] In his book *Trust in numbers*, Porter emphasizes that "possibly the most influential term in what is called the new sociology of science is negotiation."[549] Because even "universal scientific laws are never sufficiently definite or concrete to apply to the richly detailed circumstances of experience and experiment," Porter argues that negotiation, or political aspects of science, is the term to understand the modern scientific and technological process.[550]

Pursuing the econometric, statistic, and mathematical methods under the SSP discourse would also result in limiting the range of expertise of the science and technology policy. During the interview, Koizumi at OSTP pointed out that a majority of the main actors of the SSP discourse formulated their network long before the rise of the SSP discourse. In other words, the range of core actors and the target audiences of the SSP discourse are still limited to pre-existing experts instead of expanding the range to others in different fields, including the public. Moreover, the public is regarded as a passive actor who is waiting for the information from the science policy actors within the SSP discourse instead of an active participant in discussing or shaping the direction of the SSP discourse.

---

[548] Theodore E. Porter, "Quantification and the Accounting Ideal in Science," in *The Science Studies Reader*, M. Biagioli (London: Routledge, 1999).

[549] Theodore M. Porter, *Trust in Numbers: the Pursuit of Objectivity in Science and Public Life* (Princeton, N.J : Princeton University Press, 1996).

[550] Ibid.

Bijker claims that the "constructivist view of knowledge and technology implies the existence of a variety of expertise."[551] Since "different relevant social groups" possess "their specific kinds of expertise," he claims that "we are all experts in specific ways."[552] More specifically, "scientists have their own invaluable form of expertise, as do STS scholars, and also groups of citizens, politicians, and other experts."[553]

Bijker doesn't contend that "an average citizen is able to design a nuclear reactor or a river dike"; instead, he argues that "more is involved in designing large projects such as nuclear power stations and water management systems than is described in the engineer's handbooks."[554] Thus "others are experts and need to be involved." Moreover, "they need to be involved in the whole design process in as early a stage as possible."[555] Irwin emphasizes that "direct dialogue with the public should therefore 'move from being an optional add-on to science-based policy making' and instead become 'a normal and integral part of the process.'"[556] Moreover, under the initial and current stage of the SSP, science or scientific method has been used as a gate keeper

[551] W.E. Bijker, "Understanding Technological Culture through a Constructivist View of Science, Technology and Society," in *Visions of STS: Counterpoints in Science, Technology, and Society Studies,* Stephen H. Cutcliffe and Carl Mitcham, ed. (Albany: State University of New York Press, 2001).

[552] Ibid.

[553] Ibid.

[554] Ibid.

[555] Ibid.

[556] Alan Irwin, "The Politics of Talk: Coming to Terms with the 'New' Scientific Governance," *Social Studies of Science* 36, no. 2 (2006): 299-320.

to screen and expel the experts who are holding different worldview of science and science policy or not coming from economic science related fields.

More specifically, through the interview project, except for those who don't have a direct or indirect affiliation to the SSP community, one of the common issues I found is that there is not a favorable assessment of the development of the SSP discourse. The details of their criticism expressed by the interviewees could be summarized as follows:

First, the current SSP discourse's bottom-up approach through the NSF funding mechanism doesn't effectively achieve the initial goals of the SSP. Second, the SSP discourse could not be the mainstream science policy discourse in the U.S. Third, the positivist approach to resolving science policy issues limits the broad participation of science policy researchers in the discourse. Fourth, the SSP tends to develop the toolkits and models for evaluating science policy programs and strategies without considering the socio-cultural values embedded in them. Fifth, the meaning of science or the scientific approach the SSP community has tried to adopt is narrow. Sixth, research on the social aspects of science and technology tends to be excluded from the SSP point of view.

Even though I recognize the importance of the SSP in shaping the new direction of U.S. science policy, there are also a couple of criticisms I would like to emphasize as well. First, the process of initiating and developing the SSP discourse can't be identified as unique or different from other fields of policy or political process. More specifically, the SSP discourse itself practices the political process that is common in the public policy field. The evidence to support this criticism can be identified as follows. The practice of administrative influence by limiting the research methods to be applied into the discourse, the technocratic motivations of simplifying the evaluation and report process to meet budgetary and management requirements, and the limited and negative understanding of political process in science policy would be examples to support this argument.

Moreover, the rise and demise of science policy researchers who have been involved in the initial design of the SSP discourse, as well as the debate between the actor and one funded research on politics and science are other indicators showing that the complex process of whom to invite and whom to exclude has been exercised inside the SSP discourse. Thus, science policy practice through the SSP discourse is not that much different from other fields of performance management reform based public policy in many respects, so the argument of adopting science and scientific objectivity into science policy cannot be easily justified.

Second, the current SSP discourse puts more focus on the supply side of science policy by emphasizing the production and performance of scientific knowledge instead of the demand side in society. Sarewitz and Pielke develop the concepts of the supply and demand side of scientific knowledge in science policy context by conceptualizing that producing scientific knowledge and information can be regarded as a "supply" function, whereas the "societal outcomes" are a ‘‘demand’’ function.[557] They argue that, in order to support better decisions in science policy, the balance between the supply side of producing scientific knowledge and the demand side of "desired societal outcomes" should be made. [558]

---

[557] Daniel Sarewitz and Roger A. Pielke Jr., "The Neglected Heart of Science Policy: Reconciling Supply of and Demand for Science," *Environmental Science and Policy* 10 (2007): 5-16

[558] Ibid.

Third, there are concerns about the establishment of a new SSP discourse that scientifically objective evidence cannot be assumed or used as a magic pill to eradicate scientific controversies because evidence-based scientific assessment is not always right, and scientific knowledge, consensus, and expert opinion are constructed and negotiated instead of being endowed by evidence.[559] Another problem related to forcing social scientists to adopt quantitative research methods only listed in the roadmap is that a social science researcher who is conducting science policy–relevant research has burdens to prove his/her research method is scientific even though his/her original research approach is widely accepted as a scientific method among the discipline. For example, around 80% of social science research uses a qualitative research interview method, but because that interview is not listed as a scientific method in the roadmap, the research results from interview methods could not be recognized by the SSP community and institutions.

Fourth, the relatively low level of interests of some SciSIP funded researchers on science policy itself would also limit the development of the SSP discourse. Evidence to support this view includes interviews with the actors implementing this new science policy discourse as well as email communications with some of the NSF SciSIP-funded researchers who expressed little or no interest in discussing science policy even if his/her research is supposed to make a contribution to science policy research and processes.

Fifth, it can also be claimed by science policy actors outside the SSP community that the SSP discourse was initiated to improve the resource allocation process by decreasing the

---

[559] H.M. Collins and Robert Evans, "The Third Wave of Science Studies: Studies of Expertise and Experience," *Social Studies of Science* 32, no. 2 (2002): 235-296.

conflicts among science policy experts, especially between science policy advocates and technocrats, or limiting the democratic process of science policy. By adopting Sarewitz's argument, SSP's current emphasis needs to be expanded to encompass the social values and benefits of science policy decisions.

Sixth, in responding to Marburger's call, "many sociologists and other social scientists remain curious and generally supportive of Marburger's potentially energizing proposal" even though there was no immediate reaction from the sociology of science and technology field.[560] In terms of updating and redefining S&T policy data sources as well as examining how "qualitative and comparative" studies can contribute to deepening science policy debates, the engagement of social sciences fields is recommended,[561] whereas the actual fields of social science affiliating with the SSP discourse are mainly limited to economic science. Moreover, as shown in Marburger's speech on the contribution of anthropologists in the fight against terrorism around the world, social science fields, including economics, are being promoted to use their intellectual merit to serve the purposes of developing the SSP strategy formation. However, the debate inside the anthropology community on the legitimacy of using their research on serving for the political purpose has caused the concerns, and the instrumental use of non-laboratory or social science fields in designing and developing science policy strategy also has a potential to cause the similar problem because social science would not be value-free

[560] Sally T. Hillsman, "Indicators for a New Social Science of Science Policy," *Footnotes* 33, no. 9 (December 2005), http://www2.asanet.org/footnotes/dec05/exec.html

[561] Ibid.

4. New Hope and New Space for Debating and Shaping New Science Policy

In the subsection, I emphasize that the SSP discourse is still worthy of attention from the science policy research community including STS and politicians because of the new possibilities it offers to resolve the unresolved science policy issues, which cross the boundaries of science, politics, and society.

My study also shows that Marburger meant gaining winning position in science policy against other political actors, not against the public, and thus there is hope to combine both Marburger's vision of science of science policy and the democratic values simultaneously.

The development of the SSP discourse since the 2000s also shows that it's not a monolithic, accorded, and linear process of constructing a new science policy framework, but rather the result of the negotiation and dynamic struggle among heterogeneous science and technology policy community members such as science policy decision makers, administrative officials of the science agencies, advocacy groups, Congress, and social science researchers.

As shown in the three stages and components of the SSP discourse above, there are heterogeneous actors who have played major roles in shaping the direction of the SSP discourse. The first group tries to let science policy be constructed and performed scientifically with limited political influence. Second group puts greater emphasis on the research of science and scientists. Actors of this group have engaged in the design of the long-term plan of SSP discourse at the initial stage of NSF SciSIP. Third group argues that the research disciplines using the econometric and statistical methods as the main body of research methods. Actors of this group also emphasize the need for rigorous methodologies to resolve science policy debates and issues.

The interaction among these actors is getting weaker, whereas the each group of actors is still trying to infiltrate their visions on the science and science policy into the design and implementation of the SSP discourse. There is no formal meeting in which these heterogeneous actors can meet to discuss the SSP, but throughout the workshop, conference, research grant award, and hearing, these actors have opportunities to learn about each other's unique perspectives of science and science policy. This is another example of crossing the boundaries of the micro, macro, and fundamental sides of science and politics initiated by the SSP discourse. Without establishing the SSP discourse, such diverse actors' involvement in science policy research across disciplines simultaneously would not be possible.

Thus I also argue that science policy research and practice community actors find hope that the SSP discourse will accept and incorporate their views of science policy into science policy practice. They also retain their views of the science of science policy with efforts that promote these visions of science policy through the SSP discourse. Some actors left the construction of the SSP discourse building process when they found little hope of projecting their view of science policy into the SSP, whereas some others have remained in the SSP community, becoming the major criticizer of the SSP.

Chapter 6: New Politics of Science and Science Policy

In this chapter, I demonstrate the influence of the SSP discourse on the change of U.S. science politics. I use the term *politics* to indicate the relationship among science, government, and society. Politics is fluid, changing through interactions among actors in these three sectors. In particular, the history of U.S. science and technology policy shows that there have been tensions among science policy community actors, including scientists, Congress, science agency managers, OMB, and the White House, to shape and reshape the relationship that governs science, and the SSP discourse is likely to re-calibrate this relationship or politics in the science policy context.

In particular, I notice that this change in the relationship among science policy community actors through scientizing strategies, including the economizing, quantifying, and legalizing science policy, would result in shaping new political orders of science that promote the use of scientific claims and evidence to justify the science policy and political decisions, in accordance with the American political culture, which emphasizes a checks and balance systems among government officials, politicians, and the public. Therefore, in the following, I highlight that the SSP discourse's emphasis on imitating natural science and its practices through the economic science model, quantification, or mathematization of the science policy process would change the politics of science, which affects how science policy decisions and strategies are justified as well as the relationship among science policy community actors in managing science R&D programs and steering the direction of U.S. science policy.

1. Discussion on the Scientizing Science Policy Discourse & Moore's Research on Scientific Claim

The analysis of the development of NSF's SciSIP and OSTP's SoSP roadmap, based on interviews, participation in Congressional hearings and the SciSIP Grantees Workshop, and literature reviews, including Marburger's speeches, suggests the following characteristics of the SSP discourse.

First, the development and rise of the scientizing science policy discourse suggests that the traditional discourse of science policy and politics has not been able to resolve various modern public policy issues concerning scientific and technological development. As the new government performance management act introduced, the government agencies couldn't meet its the requirements, thus compelling them to find new methods. More specifically, scientizing science policy actors including science policy practitioners have tried to improve the science policy making process by (1) constructing a new science policy research community and (2) building bridges between them and academic researchers. By doing so, the scientizing science policy discourse has been designed to offer new scientific toolkits to science policy makers and practitioners that they can use to formulate and evaluate science policies and R&D programs. In this context, the development of the SSP discourse has also promoted the belief that the politics of science should work in scientific ways or based on scientific claim the same as the science laboratory being managed because the traditional politics of science is not adequate to meet new social and political expectations from society toward science and science policy communities.

Second, the efforts for developing scientific evidence-based science policy tools and models also reflect the changing social contract of science and how science operates in modern society. For example, creating jobs via the stimulus package for science R&D is not a major goal of science, whereas the new socio-political anticipation of the contribution of science on economic development is becoming one of the main reasons to support public R&D programs.

In this situation, the emphasis of the politics of science shifted from a focus on the gradual increase of the expenditure of science to a science R&D investment toward socio-economic development. This political paradigm shift resulted in (1) determining an adequate level of government financial support for science, technology, and innovation activities instead of making incremental increases or pork barrel allocations of funds, and (2) assessing the outcomes of the government budget allocation.

In other words, the scientizing science policy discourse has emerged as an attempt stimulating the use of scientific, systematic, and quantitative methods and data to investigate these new science and technology policy issues, including R&D priority setting and assessment. In other words, the old politics of science is being replaced by a new one, which motivated the SSP architects to propose and design a new science policy system that identifies socially beneficial R&D investments. In return, the SSP discourse has reinforced the change of the traditional relationship among science, the state, and, society.

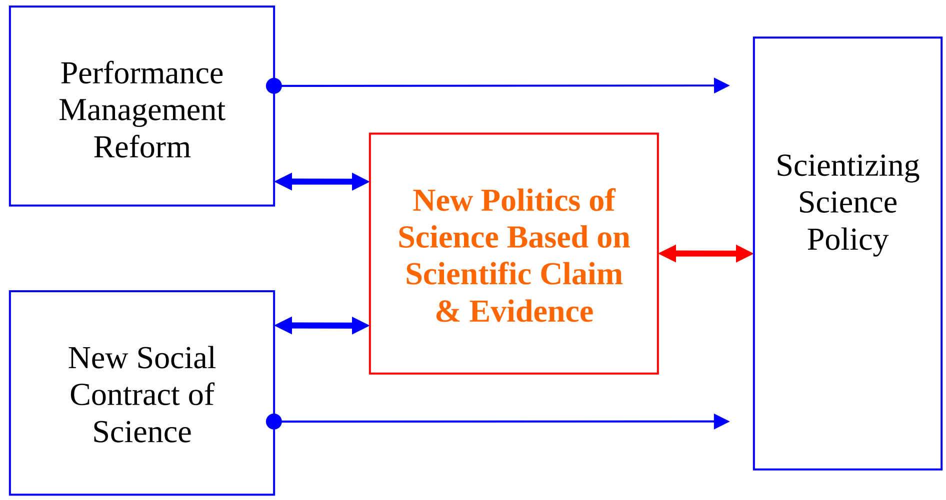


Figure 6-1. Conceptual Model of the SSP and the New Politics of Science

Third, the involvement of the new community of science policy practitioners and social science researchers in constructing the scientizing science policy discourse itself can be regarded as the construction of new expert judgment system. Under this system, scientists or scientific experts still play key roles in judging the research, but they are no longer the sole group of actors organizing the system. Instead, the sharing of scientific evidence and claims on science policy issues as well as the diversity of disciplines of experts seem likely to combine to shape the new dynamic political and democratic process of discussing, negotiating, and shaping the proper science policy direction and strategy, including the evaluation of the social impacts of R&D grant proposals. The boundary between science and politics is becoming blurred through this process.

For example, interdisciplinary researchers with holding different socio-political understanding and visions of science also have been engaged in not only organizing a new community of science policy research and practice, but also bringing more diverse issues and perspectives into formulating and developing the scientizing science policy discourse. Intellectual learning or networks of these heterogeneous actors within and outside the scientizing science policy community have progressed to shape the new direction of the politics of science. In this situation, the scientizing science policy discourse has been moving in a direction that resolves the complex science policy issues that have both political and scientific aspects simultaneously rather than making sharp distinctions between science and politics.

In order to revisit the discussion of the rise, development, and impacts of the SSP discourse and its influence on the politics of science based on the findings of the research described above, I adopt Kelly Moore's research on the role of scientific claims in the history of the social movement in science. In her book *Disrupting Science*, she points out that the unbound of scientific authority from scientist has made it possible for "claims in the name of and about science" to be made by many groups other than scientists.[562]

She argues that the authority of scientists "as legitimators of political projects" has declined, whereas that of science as the "legitimating icon" has increased.[563] As shown in the new social contract of science, the traditional view that scientists are governed by an autonomous and "self regulating system" has changed, which has resulted in the decline of the scientists'

---

[562] Kelly Moore, *Disrupting Science: Social Movements, American Scientists, and the Politics of the Military, 1945-1975*, (Princeton: Princeton University Press, 2008), 190.

[563] Ibid., 190-193.

authority.[564] In this regard, Bijker et al. also note the paradox of scientific authority, which indicates that the demands for advice from scientists have increased, whereas the criticism of the scientists' report by non-scientists groups such as the public and politicians has increased simultaneously.[565] By adopting these research findings into the analysis of the SSP, I also argue that efforts to scientize science policy tools and models reflect the increased authority of science, or scientific claims, data, and models, in science policy and politics, whereas they would also affect the change of the scientists' or science agency managers' authority even though the final outcomes of this change would be balance of power and authority among science policy community actors, politicians, and the public.

2. V. Bush's Science, the Endless Frontier and the Politics of Science

In this subsection, I examine the issue of who is managing and controlling science at the federal level that emerged after V. Bush's report *Science, the Endless Frontier*. The politics of science in the U.S. has been shaped by the Bush report and has affected the implementation of the visions of Vannevar Bush for post-war science policy. President Truman's initial rejection of establishing the National Research Foundation proposed in Vannevar Bush's report, *Science: The Endless Frontier*, in August 1947, which "recognized the report as the centerpiece of post-WWII's science policy proposing," and the contribution of the report, *Science and Public Policy:*

---

[564] Ibid., 201.

[565] Wiebe E. Bijker, Roland Bal, and Ruud Hendriks, *The Paradox of Scientific Authority: the Role of Scientific Advice in Democracies* (Cambridge, Mass: MIT Press, 2009), 1.

A Program for the Nation (called Steelman Report), which was issued by “the President's Scientific Research Board (PSRB), chaired by John R. Steelman” in the same year, are little known now.[566]

Blanpied emphasizes that the Steelman Report deserves “a better fate than to have remained virtually discarded for half a century” because the Steelman Report not only offered “a careful detailed analysis of the Federal and non-Federal research systems,” but also stimulated ”wide discussion of the nature and scope of science-government relations during a critical period in the immediate postwar era.”[567]

Blanpied points out that the president’s veto of one of the main recommendations of the Bush Report, creating an independent agency such as a National Research Foundation, as well as the Steelman Report’s failure to create “appreciable impact,” were “closely related” each other and “illustrate the divergent perspectives on science-government relations that prevailed in the years immediately after World War II.”[568]

Blanpied continues his analysis on these two reports. First, he argues that “the recent salutes to Vannevar Bush and his report have tended to distort both past and present realities.”[569] The Bush Report, which was “prepared at the request of Franklin D. Roosevelt,” was “never intended as a detailed blueprint for science policy.”[570] In other words, the main recommendations of the report were to support “self-directed basic (science) research” activity

---

[566] William A. Blanpied, “Inventing US Science Policy,” *Physics Today* 51, issue 2 (February 1998), 34-40.

[567] Ibid.

[568] Ibid.

[569] Ibid.

[570] Ibid.

instead of supporting “science for government policy” by allowing “scientists to make their own decisions on how to spend government funds.”[571]

He criticizes that the report was written based on the “naive assumption that a government agency with little or no mission beyond funding unspecified research could operate in virtual isolation from normal political processes.”[572] The problem is that this “unpolitical” assumption was agreed on by “neither the Bureau of the Budget (BoB) nor some of the country's most influential scientific leaders.”[573] Supporting the Bush Report was undercut not only by government officials whose concerns include control of the budget, but also by scientists concerning the independence of scientific research.

However, “some mid-level managers in the Truman Administration were impressed with Bush's concept,” and “they decided to explore various options for policy-related functions they hoped the agency would adopt, which they renamed the National Science Foundation,” and “together with Steelman, they persuaded Truman to issue an executive order in October 1946 to create the PSRB,” which was “charged to review current and proposed research and development activities both within and outside of the federal government."[574] The president appointed Steelman as the board's chairman, and the final report was written to “provide a rational system that would enable the government to manage its own research and development programs and

[571] Ibid.

[572] Ibid.

[573] Ibid.

[574] Ibid.

establish effective coordination among the diverse research activities of government, industry, universities, and other institutions."[575]

Blanpied argues that "a comparison of the Steelman Report and the Bush Report reveals a good deal about the political and scientific contexts and concerns of the postwar 1940s."[576] Based on his argument, "the Bush Report was confined to questions on postwar science" and relied on "powerful rhetoric to make his case that scientific and technological progress were essential to advance the nation's economy, security, and welfare" instead of making use of available data.[577]

"By contrast," the PSRB generated "much of the data" for its report, such as "data on the steadily declining share of the nation's research outlays going to universities since 1930 and the erosion of academic faculty engaged in research."[578] By doing so, "the Steelman Report was able to make a considerably stronger case for Federal funding" of research and development "than the Bush Report."[579]

Blanpied also notes the "difference between the reports" arguing that "Vannevar Bush was a classical laissez-faire conservative who distrusted large bureaucracies … and proposed providing universities with research funds …. to avoid bureaucratic control and political favoritism."[580] Members in the PSRB, however, "drew on their wartime experiences to argue in

[575] Ibid.

[576] Ibid.

[577] Ibid.

[578] Ibid.

[579] Ibid.

[580] Ibid.

favor of a coordinated approach that would involve industry, academia and government," and recommended doubling the nation's R&D expenditures "through a planned program of expansion" with direct links to the nation's targets including the increase of Gross National Product.[581]

"Coordinating the research agenda within the Federal system" is one of the prominent differences between the Bush Report and the Steelman Report even though "the Steelman Report, like the Bush Report, identified basic research as the principal arena for concerted Federal action."[582] The Steelman Report also asserts the need for establishing conditions of international scientific research cooperation with other countries.

Blanpied argues that "a radically altered political landscape" including "Republican majorities to the House and Senate" in 1946, which led the 80th Congress to be "far less inclined than the more liberal 79th Congress."[583] Moreover, "republican leaders of the 80th Congress were determined to dismantle or at least limit many of the programs created in Franklin Roosevelt's era," including Bush's proposals.[584]

One of the Steelman Report's recommendations, Blanpied emphasizes, is that "the bureau should . . . continue to take the initiative in the allocation of research functions among executive agencies" and that the BoB "is not and should not be charged with the task of developing a broad scientific research program for the nation" because "the latter job, presumably, would fall within

---

[581] Ibid.

[582] Ibid.

[583] Ibid.

[584] Ibid.

the scope of the new NSF."[585] However, due to the creation of the NSF during the cold-war period of 1950 as well as "a consequence of the Sputniks," including "the widespread worry about possible deficiencies in US scientific capabilities and technical resources compared to the Soviet Union," the fate of the NSF had changed.[586] The public media called for "government support of science and education," and Congress responded to this request by allocating funds for the NSF with the belief that "academic basic research might contribute to America's victory in the cold war."[587]

In the "Political Non-Politics of U.S. Science Policy," Blanpied and Hollander further analyze the negation of the roles of federal government in implementing Bush's proposal, "the creation of a National Research Foundation as a means to provide direct support for basic research" from 1945 to 1950 "when President Truman signed a modified version of Bush's proposal into law and thus established the National Science Foundation."[588] They argue that the reason for taking five years to "establish a National Science Foundation for the support of basic research and education" is that, first, "the idea of direct federal support for non-mission oriented basic research in universities was, in the United States, completely novel," and second, this new idea "challenged deeply held beliefs in both science and government about issues of governance, accountability, autonomy, as well as the proper definition and defense of public interests."[589]

[585] Ibid.

[586] Ibid.

[587] Ibid.

[588] William A. Blanpied and Rachelle D. Hollander, *Political Non-Politics of U.S. Science Policy* (Washington DC: National Science Foundation, 1985), http://www.law.uh.edu/ihelg/monograph/85-11.pdf

[589] Ibid.

Prolonged debate on several questions, including the public interests link "between science and government," scientific autonomy, the relationship between science and society, and the control of scientific research and procedures were needed during that five years. Most of these questions still remain unanswered.[590]

Along with the establishment of "the Department of Defense (The Office of Naval Research within DoE), the Atomic, Energy Commission, and the National Institutes of Health...as supporters of basic research in universities in areas broadly related to their missions," Blanpied and Hollander evaluate that the creation of the NSF and "a pluralistic, decentralized system of basic research support" after WWII could be regarded as positive because, under this federal R&D supporting system, "individual investigators could seek funding from more than one agency.[591]

Moreover, because "the growth of basic research support within the so-called mission agencies encouraged" the linkage between basic and applied research, scientific R&D support by mission-oriented agencies has been regarded as facilitating "the transfer of basic research results into tangible products and processes" as well as "blurring the boundaries between basic research and other types of science and engineering activities."[592]

Blanpied and Hollander further propose the renewal of debate on science policy because the expectations shared by science policy makers and scientists have changed since the 1950s. They emphasize that the debates on "the relationships between science and government" after

---

[590] Ibid.

[591] Ibid.

[592] Ibid.

WWII until now show the shared expectations including making a separation "between long-term, non-mission oriented basic research conducted in universities, and other mission-oriented research and development activities (related to national defense, atomic energy, health, and agriculture, for example) supported by, or engaged in directly by, the federal government," and disengaging "basic research" from "questions of social responsibility" as well as from "interest group politics."[593]

These expectations only require "a minimum set of essentially non-interventionist policy guidelines that would assure that autonomy for science within an accountability discourse," and "the National Institutes of Health (NIH) and NSF institutionalized this presumption in the form of peer review."[594] However, Blanpied and Hollander argue that this kind of presumption has been eroded, which "led in turn to renewed debate over issues of autonomy and accountability, as well as to suggestions that the minimalist policy discourse of the late 1940s may be incommensurate both with the augmented scale of science today and the heightened public perception of the significance of science to all aspects of life."[595]

In addition, Alic mentions that "the debate set off by *Science: The Endless Frontier* continues as policy makers struggle to draw lines between basic research of a sort that nearly everyone finds appropriate for public support and more applied work, closer to the immediate

---

[593] Ibid.

[594] Ibid.

[595] Ibid.

concerns of private firms but lacking direct connection with accepted government missions such as defense."[596]

Through the discussion and analysis of Vannevar Bush's visions of science and science policy, I note that the one of the common issues raised by multiple authors is that the V. Bush report has been modified to reflect the politics of science, and at the same time the politics of science has played a role in modifying the strategies and visions expressed in the report. The postwar politics of science has raised questions about who manages and controls science with what tools and to what degree through the debate on V. Bush's report, and the report also has influenced the change of the politics of science, or the way in which science policy community actors have been debating and negotiating each other since then. And I demonstrate the same mutual influences between the SSP and the U.S. politics of science in the following.

3. Marburger's SSP and the New Politics of Science

The scientizing science policy discourse initiated by Marburger during the G.W. Bush administration can be considered as one of the critical movements that changes science politics since V. Bush's *Science, the Endless Frontier*, for the following reasons.

First, it has been gaining bipartisan support from political actors sharing different political ideologies, and thus carried over from the previous administration to the current Obama administration. Second, the SSP discourse opens up a new space in which heterogeneous science

---

[596] John A. Alic, "A Weakness in Diffusion: US Technology and Science Policy after World War II," *Technology in Society* 30, issue 1 (January 2008): 17-29.

policy community actors can join, discuss, and share their view on science and innovation policy. From this perspective, the SSP can be assumed to be a boundary entity in which the policy and political actors who don't share much about the ideas of science policy are capable of interacting with each other in this space to build new visions and practice of science policy. A congressional hearing on the NSF's SciSIP and the discussion between Congressmen and witnesses regarding evaluating the social impact of scientific and technological innovation and science policy education also shows the importance of the scientizing science policy discourse in this context. Third, the belief that scientific claims and evidence-based expert judgment system can improve the allocation process and evaluation of the federal funding for R&D programs at research universities and national laboratories would affect the politics of science and science policy.

In particular, decision-making on R&D funding has historically involved a combination of expert judgment and political considerations, whereas interviewees advocating the early and current SSP discourse support efforts to improve the expert judgment as well as to bring new balance among scientific data and evidence, expert judgment, and political influence. The traditional system of using peer-review or expert judgment has been expanding under the SSP discourse, but one of the main differences from the previous expert advisory system is that it emphasizes scientific claims and evidence along with expert collaboration. This means that, instead of depoliticizing the science policy process, the scientizing science policy discourse would improve the legitimacy of the political decisions on science by combining scientific data and evidence with political ideas. Figure 6-2 shows this aspect of the new politics of science in which the authorities of scientific claims and scientists are weighted equally instead of the previous expert judgment system that put the authority of scientists over politics or other elements of science policy.

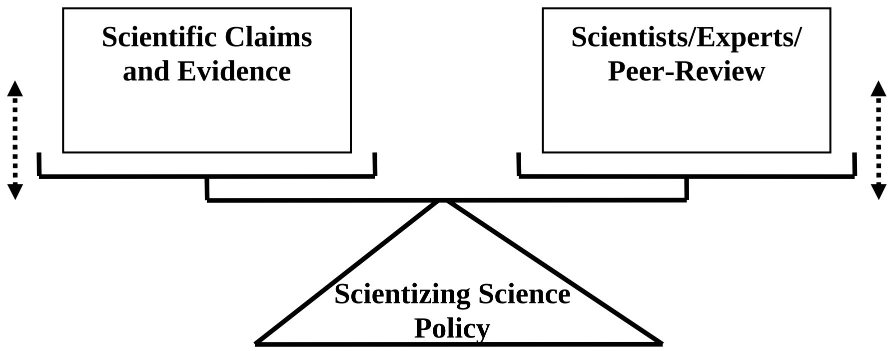


Figure 6-2. New Balance between the Authorities of Scientific Claim and Scientists

In addition to these three elements of the SSP, I also notice that heterogeneous actors, rather than traditional elite groups or scientists, have been involved in shaping the discourse, which resulted in the demise of the authority of scientists as well as the increase of a diverse interpretation of the roles of scientific claims and evidence in science policy and politics. In this context, I view the SSP discourse as a venue for “interpretative politics” in which the political actors who have scientific claims as well as interdisciplinary science policy community members and researchers join and share or debate their visions of science and science policy.

For example, economic science is still a dominant discipline under the SSP discourse and SciSIP funding data shows that more than 30% of funded researchers have a primary field of research in economics or management. However, non-economic social science disciplines, including sociology and STS, account for the second and third largest portion of SciSIP funding.

Thus the SSP offers a place in which heterogeneous science policy researchers and practitioners debate their different views on science or scientific methodologies, or learn from each other's approach to science and science policy. This new practice is becoming a key element of the U.S. politics of science that has not been witnessed before.

An examination of the new macro-cultural and political orders' influence (ex: performance reform movement and social contract of science) on the initiation and development of the SSP approach leads to the need for additional discussion points analyzing the potential outcomes of the SSP discourse in the field of science policy at the macro-level. Micro-level analysis of the SSP is presented in the chapter 5. The macro-level analysis of the SSP discourse is conducted in the following subsection, where I emphasize the potential outcomes of the SSP discourse in reshaping the policy and political orders of science. In particular, I point out that the change of the stability of U.S. science policy through the rebalance of authority among science, scientists, and politics is one of the macro-level impacts of the SSP discourse.

For example, there are discrepancies between the understanding science policy makers possess about science and politics and the public discourse on them, and I argue that this gap is one of the backdrops of the emerging SSP discourse. The issues of science in the public domain tend to be altered by politics, whereas the architects of the SSP intended to correct this situation through the SSP discourse. During his interview with R. Pielke, Jr., Marburger expressed his view of science as "non-political" even in Congress, except for area such as "the distribution of resources or allocation of new funds."[597] Whereas, by referring to climate science debates and the criticism from the public about the U.S. climate policy, he pointed out that "the public discourse" of science tends to be fixed and politicized through media and political campaigns.[598]

Therefore, as a science policy advisor, he emphasized that his job is to let science enter the discussions of science policy issues as well as make policy makers recognize "what the best science really is saying" instead of letting politics, or public discourse, dominate the science policy decision process.[599] Contrary to the public discourse of science that is "what we want to believe," he proposed that the "scientific community has a responsibility to try to separate the science from our beliefs or from non-scientific issues."[600] He also contends that science policy advocates who are not "based on science" should be separated from the science policy and political process.[601]

In this context, he continues his arguments that the direct engagement of the public in science policy is not the ideal type of science policy strategy, and instead the public voice should only be heard indirectly through "their elected officials."[602] Public engagement in "setting the research priorities" and deciding research funding in the basic science field is also not

---

[597] John H. Marburger, "Science Advice in the George W. Bush Administration," in *Presidential Science Advisors Perspectives and Reflections on Science, Policy and Politics*, Roger Pielke and Roberta A. Klein, ed. (Dordrecht: Springer Netherlands, 2010), 65-90.

[598] Ibid.

[599] Ibid.

[600] Ibid.

[601] Ibid.

[602] Ibid.

recommended, but from Marburger's view, the public can participate in defining its expectations of applied science such as research on "public heath or environment or national and homeland security" through the deliberative political system.[603] The public would not be involved in deciding basic science research, but limited engagement would be possible in the field of applied science. The main idea he proposes here is balancing politics and science in science policy making, the public through the political system, and science agency managers through science.

In addition, the "democratic political process" through public engagement is not applicable to government agencies because public officials and practitioners in these agencies should also take "their scientists seriously" and use science "in appropriate ways in their regulatory processes and decision making" such as "how to spend public funds."[604] Marburger situates both the public and science in a way that balances each other.

Marburger's visions of science policy thus do so much combine politics, scientists, and science in the science policy process instead of demarcating science from politics as well as balance these three institutions, science, scientists, and politics, when formulating science policy mechanisms. The rise and development of the science of science policy initiative also has its root in these renewed conceptions of science, scientists, and politics.

More specifically, Marburger shows how his visions of science policy have influenced initiating the science of science policy.[605] In this chapter, he uses the terms "stability versus

[603] Ibid.

[604] Ibid.

[605] Ibid.

change" as the main theme of the history of U.S. science policy since WWII.[606] Referring to Sarewitz's analysis of U.S. federal science funding, which has been increasingly stably over the years since WWII except in the 1960s when space programs including Apollo project were executed, Marburger agrees with Sarewiz's argument that this "stability" of science funding would be evidence of the lack of "centralized, strategic science policy planning in the U.S." [607]

Marburger also emphasizes Sarewitz's analysis that this stable science funding trend also indicates that the authority and discretion of science policy makers including the OSTP director, have not been "exercised" significantly nor been influential over "(science) budgetary planning." [608] Moreover, even though the influence of science policy makers could be exercised through "the Office of Management and Budget (OMB)," there is un-harmonized jurisdiction of the various science and technology related subcommittees at the Congress over "various pieces of the R&D enterprise." [609] From Marburger's point of view, all these science policy environments have made it difficult for science policy makers to change this stability issue and to regain science policy makers' authority to plan and manage federal investment in science.

Based on his writing and interview, I could articulate my analysis of science of science policy proposal as follows: first, science policy makers needs to gain their administrative authority to manage or change not only science policy decisions mechanism, especially on R&D funding, but also science agencies' own science programs. The OMB has the potential to be used

[606] Ibid.

[607] Ibid.

[608] Ibid.

[609] Ibid.

as a tool to support OSTP's activities for a struggle against Congress, or in broader terms the public, as well as the science agencies, or scientists, science advocacy groups, and institutions. In other words, constructing new orders of science policy seems to be what Marburger intended to achieve through the SSP.

Second, a new culture of scientific claim-based or scientific evidence-based political advocacy has been emphasized and is to be promoted in the politics of science. Scientific evidence can be interpreted as facts produced by scientific methods and data, whereas Marburger seems to assume that politics or the political culture of science in the U.S. seems to stem from the advocacy of scientific institutions and scientists who are not coming from scientific reasoning or facts. For example, Marburger is known to criticize the National Academy's report, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. For him, the arguments and recommendations described in this report, such as annually recruiting the certain number of science and mathematics teachers and attracting America's brightest students to the teaching profession do not have a scientific ground.

Considering that the National Academy is one of the most well known science institutions advocating government support for science, the criticism Marburger raised thus is directly related to his argument for promoting science or scientific-evidence-based science policy. In other words, his initiation of a science of science policy, which is based on his view of the atmosphere surrounding science and politics in the U.S., also supports a change not only science policy practices, but also the broader cultural and political landscapes of science. In other words, the SSP discourse, in this context, is also likely to co-produce political cultures such as fact/evidence-based science advocacy affecting science and technology policy discussions.

4. Issues of the New Politics of Science

Based on my examination of the SSP discourse and its relations to the new politics of science, I argue that the change of politics of science among or the relations of science actors, including the White House, Congress, science community, science policy administrators and practitioners, is another key to understanding the SSP. In other words, the heterogeneous SSP community actors have adopted and developed the new science policy strategies and toolkits which would result in changing the political relations among each other because the SSP discourse can be seen as the federal government's and the Congress's reaction to the public's call for the efficient use of taxpayers' money for scientific research and development during the economic downturn.

I also examine the potential impacts of the SSP discourse on the politics and policy making of science: emphasizing data sets and models, professionalizing science policy, focusing on the evaluation of scientific research investment, and promoting evidence-based science advocacy in the politics of science. In addition, there are implicit consequences of the SSP, such as opening a new environment to debate the meaning and direction of science policy.

In this subsection, I discuss the potential issues the new politics of science might cause so as to make the SSP community members and the science policy researchers aware of the unintended consequences that would clash with the American political culture in governing science and science policy.

First, a conflict among science policy community actors would emerge if they chose the narrow view on the role of politics in formulating and implementing science policy. In particular, if scientists request funding from the federal government but don't want political influence involved in their scientific research, then a non-favorable relationship between science and politics would emerge. That relationship would result in separating funded research from politics even though one of the shared visions of the SSP on SciSIP research is that SciSIP funded researchers are not to separate political influence from the science policy decision process on R&D investment, but to establish new politics of science in which science policy community members negotiate and interact with each other based on scientific evidence, data, and models.

Second, federal investment in scientific research in the U.S. has been made through not only the peer-review process, but also the political considerations of distributing funding resources instead of concentrating them in specific states or institutions that have more competitive research capacities than others. Competition among the science fields such as physics, computer science, biology, and energy research to get the limited federal resources is another field in which political consideration has been working. Therefore, the SSP community members need to convince Congress that scientific evidence and data have the potential to evaluate or justify these political decisions on R&D funding as well.

Third, the discussion on how the construction of the SSP discourse would change the checks and balances system of science is needed. For example, because the establishment of a new Department of Science Policy would not be easily achieved in the pluralistic U.S. political culture, new science policy toolkits, models, and data are likely to endow more central authority to science policy makers. In particular, the SSP tools and models would let government executives take over the discretions about science funding, both from science agencies, which have traditionally based their decisions on the peer review process, and from Congress, which has exercised its discretion on science and technology policy issues. In other words, the SSP discourse would result in not only minimizing the discretion of science agencies and scientists, but also increasing the influence of the White House and executive branch, including OSTP and OMB, in selecting and managing science policy projects. Therefore, even though changing this critical components of politics to be favorable for top administrative executive offices is not the intention of Marburger and other SSP architects, an extended discussion on whether the SSP would create an imbalance in the politics of science in relation to the OMB and the White House, science agency managers, scientists, and the public (Congress) would be needed.

In particular, in this regard, the case study of the Research Assessment Exercise (RAE) in the U.K. would be useful to further the discussion about the unintended influence of the SSP discourse on the politics of science. The RAE in U.K. is known as "one of the most institutionalised forms of research evaluation" in the OECD countries.[610] The RAE is the U.K.'s "national research evaluation system" covering "all higher education institutions" including universities.[611] Its initial form was based on "a periodic national peer review organized by units of assessment" to ensure the principles of scientific research and policy making such as "clarity," "consistency," "continuity," "credibility," "efficiency," "neutrality," "parity," and "transparency."[612]

---

[610] Katharine Barker, "The UK Research Assessment Exercise: the evolution of a national research evaluation system," *Research Evaluation* 16, issue 1 (2007), 3-12.

[611] Ibid.

[612] Ibid.

By examining the development of the RAE from 1986 to 2008, Barker argues that "the debates among universities and policy-makers" caused by the "tensions around the nature of university research" have resulted in replacing the RAE with "a metrics-based system of assessment" emphasizing "economic rationale and expected economic returns" of investing national resources into scientific research.[613] As a result, the RAE's initial form as a peer-review-based evaluation system has been replaced by the metrics-based approach, the RAE 2008. One of the reasons for shifting the basic form of the RAE is because "uncertainties about the effectiveness of (traditional) peer review-based evaluation in allocating resources for economically useful university research" have increased the "desire by government and industry" to choose "a metrics-based system."

However, Barker also notes that the initial peer-review form can be understood as an effort of science community to "give academic control back to universities in a period of funding constraints through the harnessing of peer review and internal quality control."[614] In other words, by choosing a metrics-based system over a peer-review mechanism since 2008, the policy and political power of controlling science funding in the U.K. has also shifted from the scientist community to science policy makers and politicians. This type of political consideration or outcome would be possible in the development of the SSP discourse, which would result in motivating science policy makers to increase their control of science over the scientific community because the SSP discourse also aims to emphasize the econometric analysis of public investment in science.

[613] Ibid.

[614] Ibid.

One of the important analyses of the RAE that I can also adapt to the examination of the SSP discourse is the arguments against the RAE's "metric-driven system."[615] Opponents of this new RAE system point out that "developing, collecting and verifying indicators are likely to be costly in itself and that the performance of "outlying institutions, particularly small ones" or teaching-focused institutions would not be properly evaluated through a metrics-driven mechanism.[616] Moreover, they argue that this new system would tend to change the behavior of research institutions to support "high cost capital-intensive science" as well as to ignore the "known problems with citation analysis and journal impact factors."[617] Therefore, without resolving these concerns, the SSP discourse, which adopts a series of econometric metrics-driven strategies, would result in increasing the science community's concerns of the discourse's unintended impacts on scientific practice. In other words, the Research Assessment Exercise (RAE) would be useful to predict the SSP discourse's potential impacts on the politics of science as well as to discuss the general concerns of the scientizing science policy tools.

[615] Ibid.

[616] Ibid.

[617] Ibid.

Chapter 7: Conclusion

1. Summary of Research Findings and Arguments

Do we have a better understanding of modern science and scientists as well as the science policy process through the research and policy practices supported by the SSP discourse? What kinds of improvement in science and innovation policy has the SSP discourse tried to make, including the renewed relations between science and politics or R&D funding evaluation activities? What is the future outlook of the SSP discourse and what meaningful contribution can I make to address the concerns about SSP described in the previous chapters? These are the three fundamental questions I have tried to answer throughout this dissertation research. The first two have been examined in the previous chapters and I present the findings here.

First, the SSP discourse can be understood as the expansion of the government performance reform movement into managing federally supported science R&D programs and projects as well as the implementation of the revised social contract of science in science and technology policy. Performance reform regimes and the new social contract of science have mutually affected each other to reinforce science policy makers for restructuring the policy system governing science and technology investment. Emphasis on the accountability, transparency, efficiency, and effectiveness of federal science policy decisions as well as the quantitative measurement of social outputs and outcomes of federal R&D investment have emerged as central themes of science policy, which motivated the SSP architects to initiate and develop the science of science policy approach. In return, the SSP discourse has attempted to correct or revise the visions and goals of performance management as well as the social contract between science and the state through the development and articulation of unique science policy tools and models that are applicable to the practice of science agencies. In this context, I also argue that the SSP discourse has the potential to redirect U.S. science policy without conflicting with the American political and democratic culture.

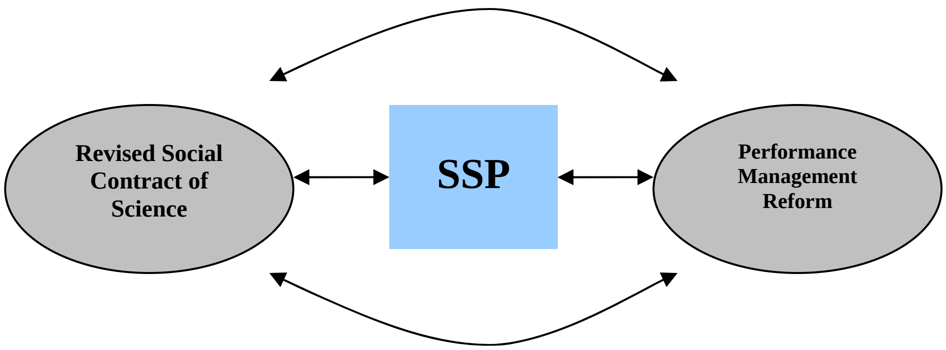


Figure 7-1. Interactions among Performance Reform,
the New Social Contract of Science, and SSP

Second, the development of the SSP discourse itself reveals the dynamic aspects of the science and innovation policy process with the involvement of the heterogeneity of science policy actors in this process. Actors from the White House OSTP and OMB, science policy practitioners, NSF, non-federal science institutions such as AAAS and the National Academy of Science, science policy researchers in academic fields, science advocacy groups, and Congress have directly and indirectly affected the initiation and construction of the SSP discourse. The involvement of these heterogeneous actors in the SSP discourse has resulted in not only diverse views of science policy, but also tensions among them. These tensions, as described in the previous chapters, include disagreement on the ideal type of science policy with and without the involvement of politics as well as on the change in the range and foci of NSF SciSIP-funded research when comparing the first against the other three solicitations.

Third, interviewees who are classified as “affiliated” or “non-affiliated” commonly expressed concern about emphasizing quantitative tools and methods in science policymaking and evaluation under the SSP discourse. They commonly argued that value can’t be separated from science policy and politics, whereas the mathematization or quantification of science policy of the SSP discourse would discourage the input of value judgments into science policy. Moreover, none of the core-SSP members who participated in the interview project said that economics or the economic model or the mathematic tool was the sole and major emphasis of SSP. However, they also tended to judge the scientific and non-scientific fields of research using each field’s dominant research methodologies. For example, any research method not listed in the SoSP roadmap is regarded as not appropriate to the SSP discourse. Considering the way in which this list was constructed through interagency collaboration, it is not difficult to see that number-centric methods are an important part of SSP, so the encouragement of economic scientists’ involvement in SSP has been made. There was also a debate between science policy practitioners and an NSF SciSIP-funded researcher on the meaning of scientific research method.

Fourth, SSP discourse has created a new science research community on science policy as well as a bridge between these groups and science policy practitioners. In this process, there is a group of “knowledge brokers” at the NSF SciSIP who exercise power as main science policy actors by transferring the findings of SciSIP funded research into a domain of science policy. The NSF has collaborated with OSTP through the regular SoSP committee meetings in which science agencies express their needs and concerns of the issues they have, and the NSF SciSIP actors try to answer immediately using their funded research or published academic research results. The NSF's SciSIP has provided relevant knowledge to science policy practitioners assuming it's a form of certified, reliable and scientific science-policy-relevant knowledge. Even though there is no single case showing the successful transfer of the SSP-type research results into the actual science policy process, the SSP discourse has built up an imaginary of this group as a thought-collector and certified advisor for science policy.

Fifth, the new venue the SSP discourse has created through NSF's bottom-up mechanism has a potential to be valuable for the development of science policy research and discussion because (1) there is an anxiety shared among some SSP community members on the need of incorporating the wide range for social science disciplines in the discourse, and (2) the interdisciplinary communities' involvement would promote learning, sharing, and discussion about the diverse social understandings of science, policy, and politics. Considering that the initial actors of the SSP discourse had called for the need to understand the mechanism of modern science and scientists so as to perform better science policy, promoting interdisciplinary science policy regardless of their preferred research methods would be valuable to sustaining the SSP discourse. It would also be applicable to the research of R&D evaluation. More specifically, SSP needs to create a division of responsibility for evaluating science programs by which not only interdisciplinary science policy research communities can participate but also the public. Efforts need to be made for stirring the interests and participation of the existing science policy research communities such as STS and their research achievements.

Sixth, the SSP discourse focuses on research collaboration crossing the boundaries between social and laboratory science. In terms of the interdisciplinarity of research, the NSF focuses on supporting collaborations among social, behavioral, and laboratory scientists to "understand how to evaluate investments made in those disciplines or problem areas."[618] From this perspective, among the NSF SciSIP funded research projects, Fisher's "Socio-Technical Integration Research (STIR)" project represents this emphasis very well. In Fisher's research, he intends to "understand through participant-observation the micro-foundations of responsible innovation" by coordinating 20 laboratory studies using the ethnographical engagement of social science researchers in "semistructured interactions" with laboratory scientists, which is similar to Latour's laboratory studies. [619]

Seventh, there are several potential impacts of SSP in the politics of science. For example, the SSP discourse has the strong potential to shift the focus of science policy makers and politicians from planning and implementing to evaluating federal R&D programs. The SSP discourse would encourage the use of science claims and evidence in science policy and politics. The SSP discourse would also alter the balance of authority and influence among science policy actors, including the NSF, science agency managers, scientists, Congress, and executive branch offices, such as the OMB (Office of Management and Budget) in the decision-making process on federal R&D priority and investment.

---

[618] National Science Foundation, *FY 2008 Budget Request to Congress* (February 5, 2007), http://www.nsf.gov/about/budget/fy2008/pdf/EntirePDF.pdf

[619] Eric Fisher and David Guston, "STIR: Socio-Technical Integration Research," http://www.aaas.org/spp/scisip/2010%20abstracts/Fisher.pdf

2. Toward a Democratic Science of Science Policy

In this concluding chapter, I intend to answer my third question, which is about my policy recommendations for addressing the issues of and advancing the SSP discourse. In order to achieve this goal, first, I explore and adopt the STS discussion on scientific governance and policy and show the potential contribution of STS scholarship for moving forward the SSP discourse that is applicable to the democratic society regime. Second, I compare the Science of Science Foundation in the U.K./Europe and the SSP discourse to suggest policy recommendations to the SSP community for remodeling the current course of development and for constructing an evidence-informed and evidence-critical scientific science policy regime. To summarize in advance, STS research on science and technology policy provides the theoretical ground for democratic and scientific science policy values to co-exist: the U.K./Europe's Science of Science Foundation supports this argument by demonstrating that socially responsible science policy can be mutually beneficial for the development of scientific or quantitative science policy.

Moreover, through the comparative study, I intend to not only introduce the science of science policy type initiative to other countries, but also propose that the SSP community can investigate the history and development of the U.K. and European Science Indicator research starting from the Science of Science Foundation so as to get some lessons that can be projected into the development of the SSP discourse. Of course there are cultural, political, and social differences among the U.K., Europe, and the U.S. that have shaped the different science policy environments and tools in these countries. Thus adopting the U.K. and European science policy model into the U.S. might not be possible or desirable. However, this comparative approach would help the SSP community to prepare for challenges that would emerge as the SSP discourse is being constructed or to propose new plans to lay a solid foundation for the SSP after investigating the SSF or similar cases in other countries. This kind of comparative study also opens the door for new research that promotes collaboration between the South and North, or the scientific and technologically developed and developing countries in the field of science and technology policy.

(1) Performance Reform, SSP, and Democracy: STS Perspective

One of my main arguments in this dissertation research is that the SSP discourse is a series of science policy strategies adopted by the executive government branch to change the science and technology policy system surrounding the promotion and management of science. My research also identifies that, through economizing, legalizing, and mathematizing the science policy process, SSP actors aim to provide scientific information to the science policy makers for resolving science and technology issues. Based on his observation on the performance management movement in the United States, Posner defines "accountability to mean addressing the public's expectations for government performance." [620]

However, the performance-first vision also has the potential to risk the hybrid and democratic characteristics of science and technology policy. Some interviewees even argue that the success of scientizing science policy requires democratizing experts' opinions and program

[620] Paul L. Posner, "Accountability Challenges of Third-Party Government," in *The Tools of Government, A Guide to the New Governance*, Lester M. Salamon, ed. (New York: Oxford University Press, 2002), 547.

evaluation methods as well as politicizing the selection of the best practices and methods by the agencies. Moynihan points out that "democratic values, such as equity, transparency, due process, and citizenship" would be at risk of being compromised if "performance systems" are emphasizing "measuring program mission" because "managers are trained to develop logic models between inputs and outcomes, but are not trained or otherwise encouraged to consider that democratic values are part of that logic model."[621] He also quotes Radin's argument that "performance assessment or programs with redistributive goals generally fail to measure impact on different groups" in society.[622]

Moreover, "performance-based incentives" would deter the "responsible and public-spirited individuals" in government.[623] In other words, even if performance regimes focus on improving the transparency and responsibility of policy decisions, it would not automatically promote the democratic values that citizens have asked of government officials. How does this concern apply to the performance management movement in science via the SSP discourse?

As Feller describes, if "making public expenditures accountable to the taxpayers and ensuring rational priority setting among research expenditures" are the emerging goals of the

---

[621] Donald Moynihan, "The Politics Measurement Makes: Performance Management in the Obama Era," *The Forum* 7, issue 4 (January 2010).

[622] Ibid. and Beryl Radin, *Challenging the Performance Movement: Accountability, Complexity, and Democratic Values* (Washington, DC: Georgetown University Press, 2006).

[623] Donald Moynihan, "The Politics Measurement Makes: Performance Management in the Obama Era," *The Forum* 7, issue 4 (January 2010).

government performance movement,[624] then it also implies that the public understanding of or public engagement in science R&D decision-making and expenditures is a critical component that the actors of the performance management movement, including the SSP community, should consider when designing and implementing performance management tools and strategies for science and science policy. In this context, Moynihan argues further that the performance management system "has implications for other research areas," such as the interactions "between the state and the citizens."[625]

For example, the performance reforms have the potential for the diversificiation of science policy actors who influence the decisions on science R&D funding and direction. Along with analyzing the peer-review process for making science R&D budget decisions, Resnik explores public engagement in the science policy process with a case of the NIH budget decision process.[626] He argues that "there are several ways that U.S. citizens can influence the NIH's decisions by communicating directly with the agency…for example, since the late 1980s, HIV/AIDS activists have been very successful at securing funding for research into the diagnosis, etiology, pathology, prevention, and treatment of HIV/AIDS."[627]

---

[624] Irwin Feller and Paul C. Stern, ed. *A Strategy for Assessing Science, Behavioral and Social Research on Aging,* Committee on Assessing Behavioral and Social Science Research on Aging (Washington, D.C.: The National Academies Press), 41. Available at http://www.ncbi.nlm.nih.gov/books/NBK26380/pdf

[625] Donald Moynihan, "The Politics Measurement Makes: Performance Management in the Obama Era," *The Forum* 7, issue 4 (January 2010).

[626] David B. Resnik, *The Price of Truth: How Money Affects the Norms of Science*. Practical and professional ethics series (Oxford: Oxford University Press, 2007), 170-186.

[627] Ibid.

Due to this active engagement of the public, Resnik points out that "the U.S. government now spends more money on research on HIV/AIDS than any other disease." [628] The "Council of Public Representative (COPR)" established at the NIH to channel the advice of the public to the NIH director is another example that shows possible public engagement for influencing science funding decisions. [629]

From this perspective, encouraging the public and science advocates' engagement in the process of selecting the best evaluation methods of R&D investments would be an example of democratizing and politicizing science policy for the successful implementation of the SSP discourse. However, the impacts of SSP on modern democratic norms and values due to the involvement of the small science and economic policy elite community have not been addressed, and the current SSP discourse puts less emphasis on this aspect. In other words, scientific evidence-based science policy still has the risk of decreasing democratic values such as public engagement in the process of science and technology policy. In a chapter of the book *Governance, Strategy and Policy*, Kakabadse *et al.* argue that economic and political interests in the age of science and technology would become more powerful tool than before to ignore the democratic values and questions in the policy decision making process.[630]

The discomfort about SSP shared by science policy research community members can be understood from this perspective, and thus the question of whether and how science and

[628] Ibid.

[629] Ibid.

[630] Andrew Kakabadse and Nada K. Kakabadse, ed. *Governance, Strategy and Policy: Seven Critical Essays*, (New York: Palgrave Macmillan, 2006).

technology would enhance democratic ideals in modern society should be examined and answered. In particular, considering that economically focused and scientific methods-based approaches have shaped the current SSP discourse through the engagement of the policy elite and economists, public opinion and democratic ideas about the control of science and science policy decisions would be eclipsed, and instead, centralized management of science would emerge.

Therefore, in this subsection, I show that public-engagement, democratic values, and critic-driven science policy making can be imbedded in the SSP discourse along with the performance reform movement's emphasis on scientific and economic evidence-based science policy making, which tend to limit the democratic inputs to science policy making. I adopt the merits of STS's call for constructing a hybrid discourse encompassing blurred boundaries between science and politics to address this issue.

(2) STS Research on Science Policy

The STS analytical approach is important when examining the SSP discourse and its new relations with the public and society because the field of STS has been expanding its research areas by focusing not only on traditional scientific and technological practices, but also on their application to practical issues, including the engagement of STS in science policy fields and formation. In other words, there is a profound intellectual body of knowledge achieved by STS scholars regarding modern science politics and policy, that would be useful in re-formulating and implementing performance management in science as well as the SSP discourse.

a. Co-producing Science and Social Orders

In her book *Designs on Nature: Science and Democracy in Europe and the United States*, Jasanoff conducts a comparative analysis of three different interpretative frames of biotechnology development in the United States, Britain, and Germany for policy purposes, emphasizing the roles of different policy cultures or "civic epistemology" in formulating distinctive science policy approaches.[631]

In his article *Crossing Boundaries, Social Science in the Policy Room*, Webster calls for "serviceable STS" for developing "serviceable [science] policy" by proposing three forms of "boundary crossing" engagement of STS with science policy formation, including "the characterization and anticipation of emerging technoscience fields, the exploitation of [future] technoscience, and the context of use of technoscience applications."[632] One of the examples of the "boundary crossing" of STS he introduces is technology foresight with the integration of the "STS analytical model of innovation/foresight"[633]

In response to Webster's argument of STS engagement with science policy making, Nowotny proposes a new way to maximize the use of "serviceable and flexible STS expertise" in policy areas by building new institutions that "are capable of responding to the dynamics of innovation and the social impacts that the latest scientific and technological advances bring with

---

[631] Sheila Jasanoff, *Designs on Nature: Science and Democracy in Europe and the United States* (Princeton and Oxford: Princeton University Press, 2007).

[632] Andrew Webster, "Crossing Boundaries, Social Science in the Policy Room," *Science, Technology, and Human Values* 32, no. 4 (July 2007).

[633] Ibid.

them," even though she points out some limitations of the STS policy engagement Webster proposes.[634]

STS theories and ideas such as the actor network theory also lead to the theoretical development of science policy research among the social studies of science researchers. For example, one of the prominent influences of actor network theory on science policy research is that it results in the development of discussions on the blurring boundary between science and science policy. In other words, crossing the boundary between science and non-science such as science policy and politics has gained more attention from science policy researchers with its theoretical roots in actor network theory.

Guston claims that Bruno Latour's actor network theory has affected Jasanoff's idea of "coproduction," which refers to "the simultaneous production of (scientific) knowledge and social order." [635] For example, in *Designs on Nature*, Jasanoff examines the co-producing aspects of science, technology, and society. She points out that the debate on life-science issues during Europe's evolution to a new political entity contributed to co-producing the legitimacy and character of a united Europe and the European public as well as its bio-policies and politics.

Through promoting discussion and "coordinating biotechnology policy," the EU could not only develop the coordinated policy strategies to promote biotechnology across the European countries, but could also resolve the legitimacy issue of the EU through the "characterization of

---

[634] H. Nowotny, "How Many Policy Rooms are There? Evidence-Based and other Kinds of Science Policies," *Science, Technology, and Human Values* 32, no. 4 (July 2007).

[635] David H. Guston, "Boundary organizations in environmental policy and science: an introduction," *Science, Technology & Human Values* (2001).

the European public," such as developing a European ethical standard for biotechnology. With the means of biotechnology in relation to European citizens, both a new socio-political order and science and technology policy order have emerged.

Jasanoff points out that the progress of the STS approach labeled as "co-production" of science and social orders raises new questions in the discussion of the relationships of science and citizenship because "advances in science and technology are opening up new spaces for citizen actions." [636] She claims that the category of determining who counts as the public or a citizen in the process of public engagement in the S&TI process is not given but is still being constructed. [637] Because the traditional view of citizens tends to exclude the participation of some groups, including children, women, and "racial, religious and ethnic minorities" from science and technology, [638] she adds that "constructedness of categories of inclusion and exclusion" of some public groups needs to be discussed between "STS and political and social theory." [639]

The hybrid and boundary organizations located in the "two relatively different social worlds of politics and science" are engaged in this "coproduction" process by either facilitating "collaboration between scientists and nonscientists" or creating the "combined scientific and social order through the generation of boundary objects and standardized packages."[640] Guston points out that the "blurring of boundaries between science and politics, rather than the

[636] Sheila Jasanoff, "Science and Citizenship: A New Synergy," *Science and Public Policy* 31, no. 2 (2004): 90-94.

[637] Ibid.

[638] Ibid.

[639] Ibid.

[640] David H. Guston, "Boundary organizations in environmental policy and science: an introduction," *Science, Technology & Human Values* (2001)

intentional separation often advocated and practiced" would result in science policy making being more productive if both sides of the boundary regard the hybrid boundary organization as a "necessary resource."[641]

In response to Labinger's approaches to *policy for science*, which means the "allocation of limited resources between scientific and non-scientific programs, among scientific fields, between big and little science, fundamental and applied research programs," and *science in policy*, which refers to "policy debates with high scientific content, such as global warming, ozone depletion, (and) resource management," Jasanoff argues the boundary issues between science and policy, emphasizing the need for "constructive engagement" of social study of science researchers with scientists.[642]

The STS analysis of science policy examined above shows that the STS community has the intellectual interest and merits to expand its research areas into science policy as well as the SSP discourse in this research.

b. Participatory and Democratized Science and Technology Policy

STS scholarship has also developed discussions for balancing the optimistic and pessimistic aspects of S&TI and has developed the following perspectives on the participatory processes and institutions.

---

[641] Ibid.

[642] Sheila Jasanoff, "Cooperation for What?: A View from the Sociological/Cultural Study of Science Policy," *Social Studies of Science* 25, no. 2 (May, 1995): 314-317.

Gonçalves introduces the concept of the "Constructive Technology Assessment (CTA)" approach, which aims not only to investigate decision-making processes about risk management, but also to stimulate learning and "reflexivity and anticipation" of possible positive and negative impacts of STI."[643] The CTA's role is to involve a wider range of actors by formulating "democratic expertise" in the innovation system, so that "the openness of scientific production and the social robustness of science" can be ensured along with "the recognition of the relevance of non-scientific sources of knowledge."[644]

Collins and Evans propose the "Third Wave of Science Studies" by examining the "theory of expertise" and its implication for "technical decision making."[645] Following Collins and Evan's accounts, "Wave One" didn't raise the question of expertise, whereas "Wave Two" blurs the "distinguish between experts and non-experts" and pays attention to the "network nature" as well as "the contingency and uncertainty" of scientific knowledge.[646]

"Wave Three" shifts the focus to expertise by emphasizing "the role of expertise as an analyst's category as well as an actor's category, and this will allow prescriptive, rather than merely descriptive, statements about the role of expertise in the public sphere."[647] From this perspective, they label Wave Three as the "SEE" model (Studies of Expertise and Experiences)

---

[643] Maria E. Gonçalves, "Risk and the governance of innovation in Europe: An introduction," *Technological Forecasting and Social Change* 73, issue 1 (2006): 1-12.

[644] Ibid.

[645] H.M. Collins and Robert Evans, "The Third Wave of Science Studies: Studies of Expertise and Experience," *Social Studies of Science* 32, no. 2 (2002): 235-296.

[646] Ibid.

[647] Ibid.

to deal with the “the Problem of Extension.”[648] In other words, the “Wave Three” SEE model approaches “the question of who should and who should not be contributing to decision-making in virtue of their expertise.”[649] In order to answer the question of the extension of expertise in scientific controversies, Collins and Evan distinguish types of expertise into several new categories including “experience-based experts” “contributory expertise,” “interactive expertise,” and “referred expertise.”[650]

Through this examination, they argue that “institutions are needed that can translate the knowledge of such pockets of experienced-based expertise so as to make it less easy for certified scientists to resist their advice.”[651] In other words, as they state, “expertise should feed into the decision-making,” but more focus needs to be made on that “different kinds of expertise should be combined to make decisions in different kind of science and in different kinds of cultural enterprise.”[652]

Moreover, by recognizing the contributions to science and technology by “specific sets of lay people, as demarcated by gender and colour” through “their special experience,” Collins and Evans develop the idea of democratizing expertise.[653] In this Wave Three SEE model, Collins and Evans also emphasize that “the contributions of women or members of ethnic groups to science” would continue in regards to the contribution of “women, blacks, and other groups” into

---

[648] Ibid.

[649] Ibid.

[650] Ibid.

[651] Ibid.

[652] Ibid.

[653] Ibid.

“specific experience-based expertise which could be gained no other way, except through participation as members of those groups.” [654]

In the book *Questioning Technologies*, Feenberg develops the idea of the “democratization of technology,” emphasizing the role of communication in the design process of technology.[655] One implication of his argument is that it successfully lays out the post-modern science and technology approach. In other words, the post-modern science and technology approach can be understood as emphasizing the human, social, and democratic values of technology.

Moreover, one of the noticeable changes in the science associated with shaping new scientific and political cultures is the increased public distrust of science due to the demise of “impersonal, objective, and technical” images of “value-free” science in society.[656] In particular, the increase of scientific objectivity in science and innovation policy making can’t be free from the risk of manipulating the data or loosing the humility and morality of science policy makers.

As shown in the misconduct of the climate science case, there are calls for re-shaping the relations between science and the public due to the change of imagination of science or scientific objectivity.[657] Jasanoff suggests increased public consultation and participation for promoting the

---

[654] Ibid.

[655] Andrew Feenberg, *Questioning Technology* (New York : Routledge, 1999), 128.

[656] Yaron Ezrahi, “Science and Political Imagination in Contemporary Democracies,” in *States of Knowledge: The Co-production of Science and Social Order*, Sheila Jasanoff, ed. (New York : Routledge, 2004), 254-273.

[657] Sheila Jasanoff, “Testing Time for Climate Science,” *Science* 382, no. 5979 (May 2010): 695-696. http://www.sciencemag.org/content/328/5979/695.full

accountability of science.[658] The scientific objective doesn't automatically warrant the transparent or accountable science policy making. Thus science policy based on the science or scientific approach in modern society requires the process in which the public uneasiness about the scientific doing in policy context should be addressed by inviting more public inputs and engagement.

More specifically, there are gaps between the traditional or enlightenment image and post-modern understanding of scientific objectivity. Thus science policy based on the science or scientific approach in modern society also requires a process in which the public's uneasiness should be addressed by inviting more public input and engagement.

c. A New Mode of Science

Academic science is changing, reflecting new methods or modes of scientific knowledge production. Nowotney, Gibbons, and others have argued that the heterogeneous Mode 2 network, via a wide range or actors and organizations, contributes to knowledge production.[659] Mode 2, which emerged from the work of Gibbons and colleagues since 1994, shows characteristics of open, hybrid, and "overrunning disciplinary" boundaries.[660]

When Ziman describes the differences between Mode 1 and Mode 2 knowledge production, he explains that scientific objectivity is "one of the features that makes science so

[658] Ibid.

[659] Michael Gibbons, Camille Limoges, Helga Nowotny, Simon Schwartzman, Peter Scott, and Martin Trow, *The New Production of Knowledge: the Dynamics of Science and Research in Contemporary Societies* (London: Sage, 1994).

[660] Ibid.

valuable in society," and that it is an "emergent cultural property of academic science."[661] Thus public trust of the objectivity of post-academic research should become the basis of the scientizing science policy discourse.

By describing the shifts in modes of scientific knowing and political doing, Ezrahi states that new collective scientific and political imaginations have emerged and have constructed inclusive, accessible, democratic, and participatory orders in modern society instead of hierarchical, standardized, directed, impersonal, and elite-mediated scientific and political systems.[662] This change results not only in blurring the "boundaries between facts and fictions" as well as correct and incorrect procedures, but also in promoting the political freedoms of citizens.[663] In other words, applying the scientific mode and objective knowledge to public policy and the political context has ironically promoted the need for the engagement of the public in the policy process instead of excluding them from this process.

In *Democracy and Technology*, Sclove shows that "democracy (can) provide the precondition for being able to decide fairly and effectively what further questions to ask and what actions to take in light of answers" through a case of Amish farming.[664] Sclove argues that we don't need to become Amish, but the Amish teach us that "citizens can become critically engaged with choosing or designing technologies."[665]

[661] John Ziman, *Real Science: What it is and What it Means* (New York: Cambridge University Press, 2000), 153.

[662] Yaron Ezrahi, "Science and Political Imagination in Contemporary Democracies," in *States of Knowledge: The Co-production of Science and Social Order*, Sheila Jasanoff, ed. (New York : Routledge, 2004), 254-273.

[663] Ibid.

[664] Richard E. Sclove, *Democracy and Technology* (New York: Guilford Press, 1995).

[665] Ibid.

In subsequent chapters of his book, Sclove continues his argument that “citizen’s active engagement in reviewing existing technological arrangement,” monitoring emerging technologies, and ensuring that “technological order is compatible with informed democratic wishes” are needed.[666] For achieving this goal, Sclove proposes democratic design criteria.[667] When describing the consensus conference, Sclove also emphasizes the role of informed discussion along with integrating the perspectives of expert and citizens.[668]

The review of STS research on science, technology and democracy shows that reframing the role of the public in science and technology policy process is critical to enhance effective and democratic policymaking related to science and technology issues. However, the notion of productivity and efficiency seems to prevail over the concept of democracy through the performance management regimes. Moreover, the SSP discourse aimed at increasing scientific objectivity in science and innovation policymaking can’t be free from the risk of diminishing democratic values and process or losing the humility and morality of science policy makers when dealing with science and innovation policy issues.

Therefore, in the following subsection, I examine and propose the scientific governance model as a way for performance regimes in science to produce performance information and promote the democratic process together by reframing the SSP discourse and establishing a division of responsibility for evaluating R&D investment. I also intend to argue that

[666] Ibid.

[667] Ibid.

[668] Ibid.

democratizing the science and technology policy effort is also likely to ease the discomfort of science policy community members with the scientizing science policy movement.

(3) New Scientific Governance to Increase Scientific Objectivity and Democratic Values Simultaneously

Projecting scientific objectivity into science policy making is one of the main emphases of the SSP discourse, assuming that scientific objectivity and evidence-based science policy should be regarded as an improvement of science policy making. However, as examined above, STS research on the implications of objectivity in science on science policy and politics raises concerns about this optimistic relationship between scientific objectivity and policy/politics. Based on this theoretical understanding of STS, I attempt to modify the SSP movement to achieve democratic governance in science and technology.

The STS discussions on scientific objectivity examined above can now be shifted to the discussion about the democratic process and public accountability and transparency of the SSP movement. In particular, because the SSP discourse aims to establish the scientific process in science policy design and implementation, it's also calling for increased public and democratic values such as transparency through public engagement in science policy instead of excluding public input or feedback in the science policy process.

Moreover, the recent economic crisis has become the impetus for both the science and SSP communities to further develop the science of science policy discourse. In order to gain or maintain public support of science under this policy environment, the SSP community needs to address the concerns that society has about transparent and accountable science. This is what the

SSP community also needs to focus on so as to maintain public support for science. If the SSP's Stage I, II, and III are the periods that support new model building and data development for science policy, a new strategy for Stage IV should be made. In this context, I am encouraging public engagement in science policy by using the new scientific governance model.

a. New Scientific Governance

In his article "STS Perspectives on Scientific Governance," Irwin adopts the ANT (Actor Network Theory) to discuss a new scientific governance model.[669] Irwin discusses the relations between science and democracy, pointing out that "the study of scientific and technological governance is at the core of STS" and governments should "play a part within de-centralized networks and shifting assemblages of power" by "expanding the range of entities, actors processes and relations."[670] By doing so, he emphasizes the role of "situated knowledge (citizen science)" on which scientific governance should depend.[671]

He continues his argument on the importance of public dialogue and engagement in the scientific and technological innovation process by analyzing a case study of UK's *GM Nation?* debates, in which he tests "a more open process of social management and evaluation" of

---

[669] Alan Irwin, "STS Perspectives on Scientific Governance," in *The Handbook of Science and Technology Studies*, E.J. Hackett, O. Amsterdamska, M. Lynch, and J. Wajcman, ed. (Cambridge: The MIT Press, 2007).

[670] Ibid.; Alan Irwin and Mike Michael, *Science, Social Theory, and Public Knowledge* (Philadelphia: Open University Press, 2003), 114.

[671] Ibid.

scientific and technological innovation through projecting a bottom-up public view into the innovation. [672]

More specifically, by using the case study of the UK debate over GM food, Irwin emphasizes the importance of "*social consensus through engagement.*" [673] The GM food debate during the summer of 2003 involved "a series of nationwide 'top tier' events attended by more than 1,000 people, as well as 40 or so regional and county events and 629 local meetings." [674] The main thrust of the report on GM crops "characterizes public opinion over the commercialization of GM crops as 'not yet – if ever'." [675] In this case study, Irwin claims that "both increased openness and a more professional/centralized control over risk-management" are the main arguments of new scientific governance.[676]

Doubleday and Wynne also describe and characterize "several key developments in UK public engagements" over the GM science and innovation debate as the "muddling through" process in which a constitutional understanding of the relations among "British state, science, and citizenry" has been reshaped.[677] They emphasize that the debates about the new practices

[672] Alan Irwin, "The Politics of Talk: Coming to Terms with the 'New' Scientific Governance," *Social Studies of Science* 36, no. 2 (2006).

[673] Ibid.

[674] Ibid.

[675] Ibid.

[676] Ibid.

[677] Robert Doubleday and Brian Wynne, "Despotism and Democracy in the United Kingdom: Experiments in Reframing Citizenship," in *Reframing Rights, Bioconstitutionalism in the Genetic Age*, Sheila Jasanoff, ed. (Cambridge, Massachusetts: MIT Press, 2011), 239-262.

and techniques of genetic manipulation through diverse actors' engagement, including the public, has reordered not only "the understandings of science and its object nature," but also "the roles and rights of the state and the citizens."[678]

In the story of GM controversy, the state's opposition to public concerns appeared through GM controversies as well as the state's depending on "science as authority" providing the meaning of the public issues related to GM food and technology "provoked a significant shift in scientific governance in Britain."[679] Instead, by promoting public engagement in the GM controversies and opening up a new "place for public debate about the meaning of the policy issues," the public concerns can be equated to "public interests," which the democratic state needs to address and protect instead of denying.[680]

Moreover, this shift toward balancing or democratizing science policy as well as making it more responsible through public engagement has resulted in promoting public trust, accountability, and social consensus on genetic modification science and policy through which "citizenship was reframed."[681] In this context, the relations between state and citizens have been reshaped and, regarding science and technology, citizens began being "recognized as legitimate authors of the public meanings which science…should respectfully negotiate with, as well as inform."[682]

---

[678] Ibid.

[679] Ibid.

[680] Ibid.

[681] Ibid.

[682] Ibid.

b. Open Evaluation in Science: Crowd-sourcing and Division of Responsibility in Scientific R&D Evaluation

How can this new scientific governance model to be with performance management reforms in science and science policy? I propose two strategies, the crowd-sourcing method and the division of responsibility in scientific R&D evaluation.

First, the crowd-sourced system is an emerging new subject that is gaining attention from both the scientist and science policy research communities. For example, the International Science & Engineering Visualization Challenge created by the NSF and the journal *Science* has awarded prizes since 2003. Last year there was a new category called "Interactive Games," and among the five finalists in this category, Foldit won the first prize.[683] Foldit is an "interactive game" that presents "players with puzzles that start with a snaking arrangement of amino acids, identical to the sequence of an actual protein."[684] The goal is for players in the game to "fold that sequence into a complex 3-D structure" to get a higher score.[685]

Science magazine features a report of this challenge in its February 2012 issue and explains the detail of this interactive game saying, "Foldit takes advantage of the human mind's savvy for solving spatial problems" because "the efforts of Foldit's 200,000-plus players have

---

683 National Science Foundation, "National Science and Engineering Visualization Challenge: 2011 Winners," http://www.nsf.gov/news/special_reports/scivis/winners_2011.jsp

684 National Science Foundation, "Interactive Games," http://www.nsf.gov/news/special_reports/scivis/winners_2011.jsp#interactive

685 Ibid.

helped researchers understand how a number of important proteins loop and scrunch inside cells."[686] Anyone interested in Foldit can register and install the program.[687]

This challenge draws attention to the rising interests in not only interactive gaming in science, but also how the new socio-technical system can (1) facilitate the citizen science and engineering, and (2) develop an open system of science instead of a black-boxed one occupied by the experts. Zhai *et al.* note that information and computer software technology has enabled "public engagement in citizen-based (science and engineering) projects" because it harnesses the "collective intelligence (of the crowds)" to achieve research goals.[688] From this perspective, Foldit can be labeled as an example showing the "power of collective intelligence" in science and engineering.[689] Liu *et al.* also quoted Praetorius's argument that Foldit is designed mainly for engaging "non-scientists in challenges and competitions of solving" scientific puzzles.[690] Ciampaglia explores the development of social computing that Foldit players could "identify the

---

[686] American Association for the Advancement of Science, "2011 International Science & Engineering Visualization Challenge: Interactive Games," *Science* 35 (February 3, 2012): 532-533, http://www.sciencemag.org/content/335/6068/532.full

[687] Download available at http://fold.it/portal/

[688] Zhi Zhai, David Hachen, Tracy Kijewski-Correa, Feng Shen, and Greg Madey, "Citizen Engineering: Methods for "Crowdsourcing" Highly Trustworthy Results," *45th Hawaii International Conference on System Sciences* (2012).

[689] Ibid.

[690] De Liu, Xun Li, and Radhika Santhanam "Digital Games and Beyond: What Happens When Players Compete," Forthcoming at *MIS Quarterly* (2012), Draft.

best configuration of a retroviral protein connected to the AIDS disease."[691] One of the key elements of these crowd-sourcing approaches is to promote the engagement of citizen into shaping new socio-technical systems.

Foldit represents a change in modern scientific practice that promotes citizens' engagement in scientific research. Foldit also has the potential to lead to the discussion of making scientific practice or science policy open instead of a closed or black-boxed one occupied by the trained scientists or experts as well. Therefore any discussion on how this crowd-sourcing practice would affect and change citizens' engagement in science and engineering projects, such as R&D evaluation and environmental risk assessment, would be needed. In particular, because visualization is one of the main research emphases of the NSF SciSIP program, the development of Foldit-type visualization tools for evaluating scientific R&D performance and outcomes is likely to achieve effective quantitative solution-based toolkits, enhancing public engagement with it.

Crowd-sourcing is already used by the science community to evaluate scientific research results when there are few evaluation models or experts available to assess the research results. Oprea *et al.* exercise a crowd-sourcing method for evaluating the "quality and druggability" of the chemical probes at NIH because of "the absence of a completely objective way" such as metrics to evaluate the research results as well as a "lack of skilled experts who can individually

[691] Giovanni Luca Ciampaglia, *User Participation and Community Formation in Peer Production Systems*, Ph.D. dissertation, Università della Svizzera Italiana (2011).

determine…the quality of these probes."[692] The open crowd-sourcing method they chose was asking "a team of 11 scientists with diverse backgrounds in small-molecule discovery" to evaluate and rank the probes by "confidence scores."[693] They conclude that crowd-sourcing in this case study proves to be "a cross-disciplinary alternative that pools multiple levels of expertise from translational disciplines to provide a more rigorous chemical probe evaluation process."[694] Considering the increase of inter- and trans-disciplinary research collaboration in recent years, a crowd-sourcing method would be beneficial for science policy community members to evaluate the outputs and outcomes of R&D investment in these new research fields.

Second, among the many possible variations, the discussion of the proposed evidence-based science policy model in the science R&D evaluation field can be extended to define and produce "sound scientific data"-based science policy decision making. Pursuing the combination of scientific facts and socio-cultural values when designing and implementing science policy is not a new argument in the United States. In September 1998, the Committee on Science of the U.S. House of Representatives published a report, *Unlocking Our Future, Toward a New National Science Policy*, in which the committee made a couple of science policy

[692] Tudor I. Oprea, *et al.*, "A Crowdsourcing Evaluation of the NIH Chemical Probes," *Nature Chemical Biology* 5, no. 7 (2009): 441-442.

[693] Ibid., 443-444.

[694] Ibid., 446.

recommendations including that science and technology policy decisions should be based on "sound science."[695]

The report proposes the "sound science"-based science and technology policy even though it states that "science can inform issues, but it cannot decide them." The meaning of "sound science" can be specified as "sound scientific data."[696] The committee also calls for continuous support of the government to develop scientific data because "the development of scientific information requires time and resources to conduct research that is targeted to resolve [science policy] issues." [697]

In particular, the report sheds light on the need to understand the characteristics of science, such as the uncertainty of scientific research when implementing science policy or evaluating science R&D activities. Instead of punishing the failure of scientific research, science policy makers should understand the risk and uncertainty of science and let scientists continue their research with public R&D support. [698]

Based on combining these perspectives expressed in the report on the relations between science and science policy, the following arguments can be made. First, science policy decisions should be made by policy and political actors, not by scientific data and information, even though policy actors should make their decisions using these scientific data sets. Second,

[695] Committee on Science, *Unlocking Our Future, Toward a New National Science Policy*, US House of Representatives (September 1998), http://www.gpo.gov/fdsys/pkg/GPO-CPRT-105hprt105-b/pdf/GPO-CPRT-105hprt105-b.pdf

[696] Ibid.

[697] Ibid.

[698] Ibid.

continuous investment in developing a complete scientific data set should be made to advance the support system for science policy decision-making. Third, understanding modern science, scientists, and scientific research should be projected into science policy R&D evaluation and decision-making.

From this perspective, the democratic processes of science policy making are not un-scientific in terms of producing the sound scientific data effectively. For example, looking at the long-term aspects of science while focusing on short-terms output of the investment of science is the dilemma of both performance management reforms and the SSP discourse. However, under this new approach, R&D evaluators are able to assess the possible impacts of R&D investment on "moral values and norms" as well as on ethical perspectives that are not easily identified by scientists along with economic returns.[699] In this regard, Rip suggests that R&D evaluation should play a role in articulating new "divisions of responsibilities" to let these moral and ethical considerations work out,[700] and the engagement of diverse-background actors including the public, or more specifically, ethnic minority groups and women contribute to producing the sound scientific data for evaluating the social outcomes of R&D investment.

As shown in the *GM Nation* case, the crowd-sourcing method examined above can also encourage expert as well as public engagement in assessing the social outcomes of R&D programs along with statistical models and toolkits to make science policy decisions not only

[699] Arie Rip, "Societal Challenges for R&D Evaluation," in *Learning From Science and Technology Policy Evaluation*, P. Shapira And S. Kuhlmann, ed. (Northampton, Massachusetts: Edward Elgar Publishing, Inc, 2003).

[700] Ibid.

socially responsible but also scientifically supported. This application is useful for any R&D programs that contain a potential risk to the public, and the STS discussion of risk society supports this application. The development and history of the social recognition of risks is closely related to "the history of the demystification of the sciences."[701] One of the implications of the risk society approach to S&TI research is to call for new forms of democracy to look into scientific and technological risks from socio-cultural and political perspectives.[702]

Therefore, incorporating scientific and democratic inputs into R&D decision making and evaluation is needed, and crowd-sourcing is likely to be considered the solution to achieve this goal, as well as to reduce the time and cost the government might need to spend when the statistical tools developed by SSP are used to provide the platform and analysis of the data from this crowd-sourcing practice. Moreover, contrary to conventional wisdom, as shown in the case of AIDS treatment activists' efforts for "democratizing expertise," the public is capable of formulating its own new expertise,[703] and scientifically designed survey tools would encourage the formation of this type of new expertise.

3. Lessons from The Science of Science Foundation in the U.K./Europe: Socially Responsible Science Policy

---

[701] Ulrich Beck, Risk Society: Towards a New Modernity, (Newbury Park, California: Sage Publications, 1992)

[702] Ibid.

[703] Steven Epstein, 2000, "Democracy, Expertise, and AIDS Treatment Activism," in *Science, Technology, and Democracy,* D. Lee Kleinman, ed. (Albany, NY: SUNY Press, 2000).

Based on my research findings as well as a literature review, I have observed that, without fundamental research support for discussing the meaning of scientific indicators, criteria, or quantitative rating tools such as citation analysis, the SSP discourse has limitations for developing the research discipline about science policy. In order to address this issue and provide solutions, in this subsection, I choose to compare the U.K./Europe Science of Science Foundation movement and the U.S. SSP discourse. In particular, the current SSP has its methodological roots in scientometrics that resulted from the Science of Science movement in the 1960s. The SSP has both similarities and differences with the U.K. Science of Science Foundation, which successfully laid an interdisciplinary research base for the E.U. Science Indicator research.

(1) The Science of Science Foundation

The calling for a "Science of Science" to "devise explicit and rational science policy" in the U.K. during the 1960s was a very similar movement to the science of science policy approach initiated by Dr. Marburger in the 2000s. Goldsmith determines that the science of science includes the "sociology of science; the psychology of scientist and of scientific work; the economics of science; the analysis of the flow of scientific information; operational research of science…the study of the role of science in diverse types of societies; and the relation of science and technology."[704]

---

[704] Anthony de Reuck, Maurice Goldsmith, and Julie Knight, ed. *Decision Making in National Science Policy*, Ciba Foundation Symposium (Boston: Little, Brown and Company, 1968), 10.

However, contrary to European approaches to science of science initiatives combining social studies of science and technology, it is clear from Dr. Marburger's remarks that economic methods were getting special attention to design and develop the science of science policy initiative in the United States.

The Science of Science initiative was institutionalized in the UK in 1965 by establishing the "Science of Science Foundation."[705] The goals of the Science of Science Foundation were to "encourage and promote the scientific investigation of national and international science policy and the interactions of science and technology and society."[706]

In a situation where government officials are "struggling with decisions on investments in science and technology," the Science of Science drive was developed to provide "hope [for the development] of expert guidelines" for government decisions on investing in science by combining quantitative policy tools.[707] It has resulted in the development of scientometric techniques, including "citation studies."[708] OECD began coordinating the efforts of the Science of Science initiative and published a series of reports, including "the Research and Development Efforts (1965)" and "Fundamental Research and the Policies of Governments (1966)."[709]

---

705 David Edge, "Reinventing the Wheel," in *Handbook of Science and Technology Studies*, Sheila Jasanoff, Gerald E. Markle, James C. Petersen, and Trevor Pinch, ed. (Thousand Oaks: Sage Publications, 1995), 3-24.

706 Anthony de Reuck, Maurice Goldsmith, and Julie Knight, ed. *Decision Making in National Science Policy,* Ciba Foundation Symposium (Boston: Little, Brown and Company, 1968), 10.

707 David Edge, "Reinventing the Wheel," in *Handbook of Science and Technology Studies*, Sheila Jasanoff, Gerald E. Markle, James C. Petersen, and Trevor Pinch, ed. (Thousand Oaks: Sage Publications, 1995), 3-24.

708 Ibid.

709 Ibid., 21.

In other words, a need for knowledge about science that "would underpin rational policy decisions on its finance and development" was the main motive for initiating the idea of Science of Science. And the visions of the Science of Science initiative that aimed to offer "objective, value-free foundations" for policy decisions has inspired "quantitative approaches of STS studies."[710]

In particular, the Science of Science Foundation (SSF) was designed to "promote the scientific investigation of science itself as a social phenomenon by advancing studies of the science of science."[711] Based on the efforts supporting this research, the SSF has also offered a way to study and discuss the "practice and principles" of national science policy to set "priorities and the criteria for allocating scarce resources whether in men, money or materials, to scientific research."[712] In this context, both the SSF and SSP have very similar mechanisms and goals, supporting research to improve science policy making in R&D budget and priority setting.

However, the SSF possesses a fundamentally different worldview and imaginary about science, policy and politics. For example, the SSF points out that "final decisions in the allocation of research resources are essentially political" and that these decisions are "not purely scientific decisions but must involve the political process directly in which, no doubt, scientists themselves should have powerful and persuasive voices."[713]

---

[710] Ibid., 13.

[711] Anthony de Reuck, Maurice Goldsmith, and Julie Knight, ed. *Decision Making in National Science Policy*, Ciba Foundation Symposium (Boston: Little, Brown and Company, 1968), x.

[712] Ibid., xii.

[713] Ibid., xii.

At the Ciba Foundation and Science of Science Foundation symposium, Todd emphasized that "we must remember that in government the ultimate decisions are political and not scientific."[714] In the book covering this symposium, Zuckerman noted that "science is … in the public arena, and decisions about the deployment of our scientific resources must in the end inevitably be political."[715] From this context, politics for the SSF actors means public responsibility and thus it is at the core of science policy. Moreover, for them, the "political nature" of science policy decisions should not imply that "the ultimate criteria are exclusively or even largely economic" because "the possibility of economic return on investment is just one factor."[716]

In addition, even though the SSF also aimed to inject "quantitative assessment into decision making in national science policy," which is the same as the main goal of the SSP, the SSF has specified that the accumulation of research on social, cultural, and philosophical issues surrounding the science policy need is necessary before implementing quantitative models and tools in science policy.[717] In this respect, SSP and SSF show distinctive differences.

---

[714] Lord Todd, "Chairman's Introduction," in *Decision Making in National Science Policy*, Ciba Foundation Symposium, Anthony de Reuck, Maurice Goldsmith, and Julie Knight, ed. (Boston: Little, Brown and Company, 1968), 1.

[715] Solly Zuckerman, "Scientists in the Arena," in *Decision Making in National Science Policy*, Ciba Foundation Symposium, Anthony de Reuck, Maurice Goldsmith, and Julie Knight, ed. (Boston: Little, Brown and Company, 1968), 24.

[716] Anthony de Reuck, Maurice Goldsmith, and Julie Knight, ed. *Decision Making in National Science Policy*, Ciba Foundation Symposium (Boston: Little, Brown and Company, 1968), xii.

[717] Ibid., xii-xiii.

Table 7-1. Comparison between SSF and SSP

Aspect	**Science of Science (UK)**	**Science of Science Policy (US)**
Politics	Father of Science Policy	Enemy of Innovation
Economics	One of Many	Only
Social, Cultural & Philosophical Research	Obligatory Passage Points	What for?
Common Goal	Developing Quantitative Tools in Science Policy	

Source: Anthony de Reuck, Maurice Goldsmith, and Julie Knight, ed. *Decision Making in National Science Policy*, Ciba Foundation Symposium (Boston: Little, Brown and Company, 1968).

Chen *et al.* quote Garfield's research and define scientometrics as "the study of the measurement of scientific and technological progress." [718] More specifically, scientometric indicators have been used by "science policy and program evaluation studies" to "measure the scientific strength of various countries, regions, or research institutions."[719] Chen *et al.* also note that the origin of scientometrics is "in the quantitative study of science policy research, or the science of science, which focuses on a wide variety of quantitative measurements, or indicators, of science at large." [720]

[718] Chaomei Chen, K. McCain, H. White, and X. Lin, "Mapping Scientometrics (1981-2002)," *Proceedings of the ASIS Annual Conference (ASIS2002),* (Philadelphia, PA, 2002). 26.

[719] Ibid.

[720] Ibid.

In Europe, the development of "indicators and policy analysis of science, technology and innovation" have continued, and there was a series of conferences under the name *Blue Sky* in the 1990s and 2000s about "developing new indicators to respond to changing policy and user needs in the STI area." [721] Chen *et al.*'s historical analysis of science policy measurement and indicator design in Europe demonstrates not only the evolving nature of the field, but also that the SSF laid the foundation for today's development of science indicators, starting the interdisciplinary research on the diverse aspects of science and technology and their relationship with science instead of focusing on the economic aspects of innovation.

(2) Lessons from the Science of Science Foundation

In this subsection, I discuss three lessons from the SSF case in the UK/Europe that the SSP community needs to consider.

First, the Science of Science Foundation during the 1960s and its continuation to the current stage of science policy via the science indicators give lessons to this aspect of the SSP discourse in the United States. Considering the involvement of social scientists and STS scholars at the early stage made the concrete foundation on which the scientific science policy regime has developed in Europe, the current SSP community actors need to put more focus on why certain

[721] Alessandra Colecchia, *What Indicators for Science, Technology and Innovation Policies in the 21st Century?: Blue Sky II – Background* (2006) (Editor note: "This draft, written by Alessandra Colecchia (OECD) is based on Arundel, Colecchia and Wyckoff (2005) and has benefited from comments of colleagues and members of the Steering Group for the Blue Sky II Conference.")

techniques or models are needed for designing science policy or evaluating science R&D investment.

Interview data confirmed that the early stage SSP showed a similar development course to that of the Science of Science Foundation, but such efforts were met with resistance from both technocrats and economists. It resulted in distancing the initial groups of science policy researchers from the SSP discourse building, even though they still hoped to be invited and to make meaningful contributions to the SSP.

Second, in terms of the proper practice of the Science of Science Foundation, Ackoff argues that "science and other subsystems of our nation-system must become the subject of experimental study," and thus "the science of science must become an experimental science."[722] In other words, the science of science movement should not only support new research of science policy, but also try to test how new research results, toolkits or models are working in science and technology policy regimes. In the United States SSP case, the STAR Metrics study supported by the NSF's SciSIP program finished its pilot study and produced the results, and this case would fit what Ackoff called for. However, there is no other case study showing how NSF-funded research results affect the practice of science R&D policy, and it is not too late to examine how the SSP shaped and reshaped science policy practices.

Third, among the many similarities and differences between the Science of Science Foundation and the Science of Science Policy examined above, it is also important to note that

[722] R.L. Ackoff, "Operational Research and National Science Policy," in *Decision Making in National Science Policy*, Ciba Foundation Symposium, Anthony de Reuck, Maurice Goldsmith, and Julie Knight, ed. (Boston: Little, Brown and Company, 1968), 89.

"the tensions regarding the science-technology-society relationship" in the 1960s were one of the backdrops motivating the rise of the science of science movement. For example, Cutcliffe argues that America's response to these tensions resulted in the creation of the Office of Technology Assessment (OTA) to deal with the "social impacts of technology," while in Europe, concerns about the "potentially disastrous exponential growth in government funding of science" resulted in the rise of the science of science movement and the establishment of the SSF along with the "Societies for 'Social Responsibilities of Science'" in England around that time.[723]

In other words, ensuring social responsibility of the state under the growing positive and negative influences of scientific and technological development on society was one of the main engines instantiating SSF, whereas, in the United States, the science of science policy assumed that scientific and technological innovation is good for society and thus the state needed tools and models to support it. The development of quantitative methods was pursued by both the SSP and SSF, but the rationales to set up this goal were quite different.

Thus, I argue that the SSP community needs to investigate its taken-it-for-granted assumptions about the relationship among science, technology and society for several reasons. First, the end results of the SSP discourse would fundamentally shape or change this relationship in the science policy context, and second, the concerns and fears addressed behind the SSF in the 1960s are also on-going in the United States context. How can the SSP be restructured to contribute to constructing a socially responsible science policy regime? As an answer to this

---

[723] Stephen H. Cutcliffe, "The Historical Emergence of STS as an Academic Field in the United States," *Argumentos de Razón Técnica* 4 (2001) 283.

question, I propose taking the lessons from the OTA experience and projecting them into SSP research when designing and implementing quantitative policy tools and models.

For example, Fuller refers to one of the OTA's approaches regarding the quantification of voices from minority actors in the science community. He explains that, before it was shut down by Congress, "the Office of Technology Assessment had begun to take stock of science's missing voices by highlighting statistical data on groups that do not fit the stereotypical scientist: graduate students, women, ethnic minorities … [in] the scientific workforce."[724] He argues that these data "already suggested that the scientific community had not been uniformly sold on the idea of competitiveness as a peacetime goal."[725] In other words, quantitative science policy tools can be useful not only for counting the number of jobs created by federal R&D investment, but also for investigating how such investment affects the social minority groups in science, which needs to be one of the emphases of the SSP discourse for developing socially responsible governance.

In addition, the SSP discourse can contribute to the design and implementation of new science policy practices by investigating how quantitative tools developed by the SSP discourse can address and resolve the potential risks to society imposed by scientific and technological innovation. As Leo Marx says about the concept of technological progress, advancing new scientific knowledge and technological power doesn't always result in social, political,

---

[724] Steve Fuller, "The Secularization of Science and a New Deal for Science Policy," *Futures* 29, issue 6 (August 1997): 483-503.

[725] Ibid.

intellectual, and material progress.[726] Therefore, there is a need for the SSP community to reconsider its sociotechnical imaginaries that improved technology means progress. In addition to these optimistic expectations, pessimistic accounts should be made by the SSP community for the examination of the SSP toolkits and models to make and evaluate science and technology policy choices. In order to achieve this goal, I develop a new model, what I call Evidence-Informed and -Critical Science Policy, in the following discussion section.

4. Discussion: From Evidence-based to Evidence-informed and -critical Science Policy

In this chapter, I examine the government performance management movement in the United States, STS research on scientific governance, and the Science of Science Foundation in the U.K./Europe to propose recommendations for the SSP community. Through this examination, I show that the struggle of administrative power and influence is useful for understanding performance management and the SSP discourse. For example, the tension between supporting and controlling science or checking and balancing each other's authority among science policy community actors is one of the key components to the rise and development of the SSP discourse. I now understand SSP as a response to changes in the practices of science policy and the need to rethink how the relationship among science-policy-society is crafted.

In this subsection, I demonstrate that the SSP discourse has the potential to redirect U.S. science policy without conflicting with the American political and democratic culture if it uses

---

[726] Leo Marx, "Does Improved Technology Mean Progress?" in *Technology and the Future*, Albert H. Teich, ed. (New York: St. Martin's Press, 1997).

the new scientific toolkits and models to identify and enhance social values in science and science policy. And the STS theoretical approaches and empirical findings of this research suggest that the STS-minded SSP model, what I call Evidence-informed and -critical Science Policy, would be useful for revising the SSP discourse to achieve this goal. In other words, I propose that the SSP discourse needs to switch its focus from evidence-based to evidence-informed science policy.

In particular, throughout the examination of the SSP discourse and interviews with science policy community actors inside and outside SSP, I show that the SSP discourse needs to be redesigned. If carrying out science policy objectively is the goal of the evidence-based SSP discourse, then carrying out science policy objectively with the recognition of socio-cultural and political values in science is the main aspect of evidence-informed science and innovation policy.

An evidence-informed approach also shares some aspects with evidence-based science policy, including identifying evidence for S&T policy, but contrary to the evidence-based science policy approach, evidence-informed science policy has the following three main characteristics summarized in Table 7-2.

First, a description of evidence-informed science policy is that it places priority on meeting the demands of scientific advocates, science policy technocrats, and the public by merging objective as well as subjective evidence. By doing so, the tension between objectivity and advocacy in the science policy process would be reconciled. To do this, it must focus on reshaping relations between the public and science policy by making the SSP discourse advance the involvement of the public in the science policy environment, whereas public engagement is limited under the current evidence-based SSP discourse. A new system channeling information and data from the technocratic level is what the SSP community is pursuing, but little attention is paid to the public as a source of not only data and information, but also concerns and uneasiness toward scientific and technological innovation.

Second, the categories of scientizing science policy would also be expanded to include ethical scientific science policy, environmental scientific science policy, ecological scientific science policy, and green scientific science policy. By combining objective science policy tools with subjective science policy themes, the constructive scientific science policy process would incorporate scientific advocates and science policy technocrats in the process of analyzing evidence and constructing policy recommendations. From this perspective, evidence-informed science policy strategy would also follow a value-critical scientific policy approach, which is neither value-free nor value-given.

Third, instead of focusing on a narrow concept of science, evidence-informed science policy model emphasizes identifying and adjusting the limitation of quantitative and rigorous methods in SSP research. In order to achieve this purpose, by adopting Bruner's suggestion, integration and a balance of "multiple research methods" including "qualitative and quantitative" as well as "explanatory and confirmatory" are needed so that each method can cover blind spots created by the other methods.[727] By doing so, as shown in the case of the Science of Science Foundation in the U.K./Europe that I examined above, STS scholarship and other non-economic social science disciplines would have new opportunities to work with the SSP community actors so that they can depart from the linear and monolithic image of science and technology.

---

[727]Ronald D. Brunner, "The Policy Science as Science," *Policy Science 15* (1982): 115-135.

Table 7-2. Proposed Evidence-informed and -critical Scientific Science Policy

	Three Main Descriptions
1	Public engagement in Science Policy → Decrease the tension between science politics and science policy technocrats
2	Value-critical scientific policy approach → Various interpretations of translating data into evidence
3	Hybrid research methods combining both qualitative and quantitative approaches

One of the possible forms of collaboration between the evidence-informed or evidence-critical idea and the SSP's performance and efficiency-first vision is the creation of a crowd-sourcing platform online in which citizens would not only provide their feedback to the R&D projects, but also use their diverse backgrounds and value judgments to rank R&D investments' social impacts and responsibility. This could be applied in fields such as nanoscience and technology where there is little quantitative or econometric skills available due to the research's interdisciplinary aspects or expected multiple social outcomes. This form of collaboration will build bridges among science, technology, and social issues, especially related to the risk of science and technology.

Because of science and technology controversies such as debates on the safety of nuclear facilities, that lack "integrating the individual's ethical and social values with facts from scientific experts," public interest groups began arguing that "the primary role of science and technology (policy) should be shifted from that of production function (i.e., science's role in economic growth) to an adaptive function that will be essential to long-range adjustment and survival."[728] In other words, as Rich and Rydell quote Nelkin's writing on this issue, "concern for the undesirable impacts of science and technology has dampened the celebration of progress, and the central issue in the field of science, technology, and public policy has shifted from support to direction and control."[729] Thus, modern science and technology policy should pay attention to both the progress and the decline aspects of scientific and technological innovation in terms of the social impacts of science and technology. Therefore evidence-based and -critical science policy would tackle this issue because it allows science policy makers to use SSP tools to analyze the imaginaries or "expectations and visions" of society and to address and resolve the uneasiness society has for certain science R&D projects and programs.

There are three additional benefits I could identify if the evidence-informed idea is incorporated into the SSP discourse building.

First, the evidence-informed idea would allow SSP toolkits and models to be developed and used not only progressively but also for non-favorable outcomes for society. Much of the science and technology policy literature holds that U.S. science policy after WWII "has been the promotion of economic growth, jobs, and production through investments in science and technology" and that "each president has seen it in the national and public interest to increase public investments in science and technology" expecting positive returns of the investments such as increasing the "overall welfare of American citizens."[730] This tendency also has promoted

[728] Robert F. Rich and Randy Rydell, "Who Is Making Science Policy?" *Science* 19, issue 6 (July/August, 1979):18-22.

[729] Ibid.

[730] Ibid.

performance management ideas as well as the scientific science policy movement in the United States. However, in a situation when "the serious social consequences of scientific progress came to light, and the respective responsibilities of science and government became less apparent," the value-critical view would allow the SSP community to balance its assessment of R&D investment through the perspective that the relationship among science, technology, and society is becoming more important than before.

Second, science policy decisions informed by non-economic evidence or social and democratic values through the evidence-informed and -critical science policy would be useful for the SSP community to design new science policy models and toolkits that maximize those intangible benefits of science. For example, the value of social capital, which emphasizes and promotes collaboration among scientists and scientific institutions, would not be easily captured by economic tools and models, and thus SSP strategies and models are unlikely to pay attention to it. However, the intangible outcomes of social capital such as research collaboration capacity, increased networking ability, or the encouragement of women in science are known as a valuable foundation for supporting the development of scientific research. Thus efforts to identify these values through the evidence-critical approach supported by the SSP models and data would be useful to the science policy makers in identifying and promoting these social values in science.

Third, the evidence-informed science policy strategy I propose has also the potential to motivate the SSP actors for collecting various interpretations of data in the process of transferring data to evidence. For example, in the process of converting data to evidence for supporting the STAR Metrics program, discussion about measuring the contributions of small groups of scientists in the S&TI process as well as in the process of interpreting the data would occur. By doing so, evidence-informed science policy would allow the SSP institutions such as the NSF's SciSIP to play roles as boundary organizations, collecting and addressing concerns about science policy from the social, political, and science domains. The establishment of a boundary entity would provide a new platform in which the scientific, political, and democratic values can be collected and addressed scientifically in the science policy context.

Fourth, Fuller and Collier criticize the "equation of statistically normal behavior and normatively desirable action" occupying the science policy space so as to develop their discussion on the STS contribution for "alternative strategies for funding and evaluating research."[731] They emphasize that science policy makers need to "reject this equation" and to perceive the potential incommensurability of "facts and values."[732] From this perspective, an evidence-informed approach instead of an evidence-based one would offer a way for science policy makers to blur the sharp distinction between facts and values, because the evidence-informed and -critical idea would allow science policy makers to have not only the maneuverability between the statistical facts and values, but also "a multiplicity of independent decisions" instead of making decisions based on the facts or evidence without value judgment.[733]

What kinds of strategy can be implemented under the SSP discourse when the evidence-informed model is projected into it? One of the main emphases of this model is that the public is a legitimate stakeholder for evaluating federal R&D investment. This evidence-informed model

---

[731] Steve Fuller and James H. Collier, *Philosophy, Rhetoric, and the End of Knowledge, A New Beginning for Science and Technology Studies*, 2ed Edition, (New Jersey: Lawrence Erlbaum Associates Press, 2004), 221-222.

[732] Ibid.

[733] Ibid.

can be implemented under the SSP discourse if the new R&D data, models, and tools developed by the NSF SciSIP-funded research are coupled with a new government performance website in which the public can access the information of federal R&D activities as well as provide feedback to science policy makers. In South Korea, this type of R&D information portal is implemented by the National R&D Evaluation Agency, which aims at not only disseminating the quantitative information and data of R&D investment, but also encouraging citizen input and feedback on national R&D projects.

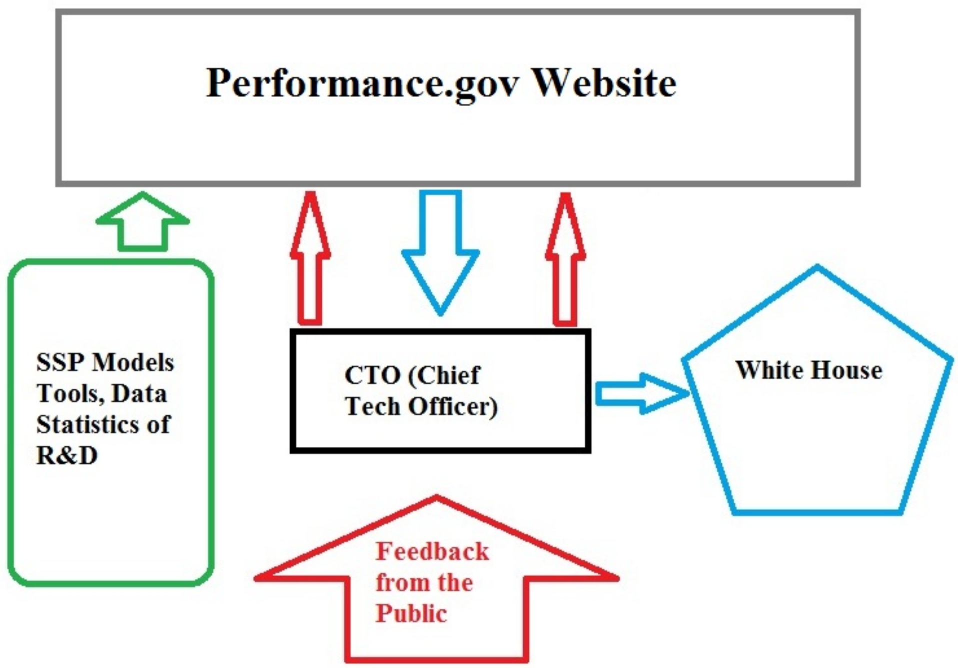


Figure 7-2. An Example of the Evidence-Informed Science Policy by Combining SSP Data/Models, Performance Website Platform, and the White House CTO

The public is a legitimate stakeholder of R&D investment, and the scientific data is the key element for the public to examine and provide feedback for R&D activities. Considering the emphasis of measuring the social outcomes of R&D investment, the public is also becoming a user of scientific knowledge and technological innovation created by R&D investment. In the private sector, the position of CTO (Chief Technology Officer) focuses on the collection of user feedback at the R&D stage of the company, and I propose that the newly appointed CTO at the White House during the Obama administration is playing a similar role in managing the government performance website using new data and scientific evidence produced by the SSP community actors as well as collecting feedback from the public on national R&D investments and projecting that feedback into the R&D decision process.

5. Conclusion

"Science of science" is becoming a new trend in scientific research, public policy, and education fields. The Science of Science Tool (Sci^2) refers to a "modular toolset" designed "for the study of science" providing, for example, "temporal, geospatial, topical, and network analysis and visualization of scholarly datasets."[734] Science of science education has been proposed to use "research skills" laboratories for improving science education.[735] "Science of science

[734] Cyberinfrastructure for Network Science Center, "The Science of Science (Sci^2),"
https://sci2.cns.iu.edu/user/index.php

[735] Serendip, "The Science of Science Education: A Look at Undergraduate Science Education in the U.S.,"
http://serendip.brynmawr.edu/exchange/node/8723

management" supported by NIH is similar to SSP in terms of its focus on "providing evidence-based information" and creating "assessment models" for evaluating R&D performance.[736]

SSP shares with these movements the common goal of using scientific tools and models for improving the activities of each field. However, considering the inherent characteristic of public policy such as deliberativeness, the "science of" or scientific movement for science policy should be approached more carefully than other fields by both science policy researchers and practitioners. For example, SSP has the potential to affect the American policy and political landscape in relation to science and technology more significantly than before. In particular, as shown in the case of the SSF, the "science-of" movement in science policy in the United States would promote responsible science policy for society, or as the performance reform movement shows, SSP would reinforce the power and discretion of public officials against scientists or the public. In both scenarios, the public is the group most influenced by the change of science policy through SSP, and thus I hope to use my research as a tool to promote the efforts of the SSP research and practice communities that the relationship among science, public policy, and society are emphasized and promoted instead being compromised in favor of technocratic or political purposes.

In this context, my argument is that scientific science policy and R&D investment can support research on and implement the mathematized, economized, and quantified skills, data, and methods supporting science policy decision making, as well as promote the democratic values and procedure in these decision- making processes. In other words, democratized science

[736] Office of Program Evaluation and Performance, "Science of Science Management," National Institutes of Health, http://dpcpsi.nih.gov/opep/science_management.aspx

policy can be another name for scientific science policy in which science policy community actors combine scientific facts and democratic values instead of separating them and emphasizing one over the other. Science and technology policy is about promoting democracy in science and technology, and SSP should not differ from this perspective.

References

Ackoff, R.L., “Operational Research and National Science Policy,” in *Decision Making in National Science Policy*, Ciba Foundation Symposium, Anthony de Reuck, Maurice Goldsmith, and Julie Knight, ed. (Boston: Little, Brown and Company, 1968).

Alic, John A., “A Weakness in Diffusion: US Technology and Science Policy after World War II,” *Technology in Society* 30, issue 1 (January 2008).

American Association for the Advancement of Science, “2011 International Science & Engineering Visualization Challenge: Interactive Games,” *Science* 35 (February 3, 2012), http://www.sciencemag.org/content/335/6068/532.full

Barke, Richard P., *Science, Technology, and Public Policy* (Washington, D.C.: CQ Press, 1986).

Barker, Katharine, “The UK Research Assessment Exercise: the evolution of a national research evaluation system,” *Research Evaluation* 16, issue 1 (2007).

Beck, Ulrich, Risk Society: Towards a New Modernity, (Newbury Park, California: Sage Publications, 1992).

Bijker, Wiebe .E., “Understanding Technological Culture through a Constructivist View of Science, Technology and Society,” in *Visions of STS: Counterpoints in Science, Technology, and Society Studies*, Stephen H. Cutcliffe and Carl Mitcham, ed. (Albany: State University of New York Press, 2001).

________________, Bal, Roland, and Hendriks, Ruud, *The Paradox of Scientific Authority: the Role of Scientific Advice in Democracies* (Cambridge, Mass: MIT Press, 2009).

Blanpied, William A. and Hollander, Rachelle D., *Political Non-Politics of U.S. Science Policy* (Washington DC: National Science Foundation, 1985), http://www.law.uh.edu/ihelg/monograph/85-11.pdf

___________________, “Inventing US Science Policy,” *Physics Today* 51, issue 2 (February 1998).

Briggs, Charles L., *Learning How to Ask: A Sociolingustic Appraisal of the Role of the Interview in Social Sicnece Research* (Cambridge: Cambridge University Press, 1986).

Britt, Ronda, “Federal Government is Largest Source of University R&D Funding in S&E: Share Drops in FY 2008,” *National Science Foundation Info Brief: Science Resources Statistics* (September 2009), http://www.nsf.gov/statistics/infbrief/nsf09318/nsf09318.pdf

Brown, Lawrence D., Plewes, Thomas J., and Gerstein, Marisa A., ed. Panel on Research and Development Statistics at the National Science Foundation, *Measuring Research and Development Expenditures in the U.S. Economy,* National Research Council (2004).

Brunner, Ronald D., “The Policy Science as Science,” *Policy Science 15* (1982).

Cawthorne, Pamela, “Identity, Values and Method: Taking Interview Research Seriously in Political Economy” *Qualitative Research* 1 (2001).

Chen, Chaomei, McCain, K., White, H., and Lin, X., “Mapping Scientometrics (1981-2002),” *Proceedings of the ASIS Annual Conference (ASIS2002),* (Philadelphia, PA, 2002).

Chubin, Daryl E., and Hackett, Edward J., *Peerless Science: Peer Review and U.S. Science Policy* (Albany, NY: SUNY Press, 1990).

Ciampaglia, Giovanni Luca, *User Participation and Community Formation in Peer Production Systems,* Ph.D. dissertation, Università della Svizzera Italiana (2011).

Colecchia, Alessandra, *What Indicators for Science, Technology and Innovation Policies in the 21st Century?: Blue Sky II – Background* (2006) (Editor note: “This draft, written by Alessandra Colecchia (OECD) is based on Arundel, Colecchia and Wyckoff (2005) and has benefited from comments of colleagues and members of the Steering Group for the Blue Sky II Conference.”)

Collins, H.M. and Evans, Robert, "The Third Wave of Science Studies: Studies of Expertise and Experience," *Social Studies of Science*, 32, no. 2 (2002).

Committee on Assessing Behavioral and Social Science Research on Aging, Irwin Feller and Paul C. Stern, ed. *A Strategy for Assessing Science, Behavioral and Social Research on Aging* (Washington, D.C.: The National Academies Press).

Committee on Homeland Security and Governmental Affairs, “Joint Hearing: Roadmap for a More Efficient and Accountable Federal Government: Implementing the GPRA Modernization Act,” United States Senate (May 2011), http://www.gpo.gov/fdsys/pkg/CHRG-112shrg67636/pdf/CHRG-112shrg67636.pdf

Committee on Science, *Unlocking Our Future, Toward a New National Science Policy*, US House of Representatives (September 1998), http://www.gpo.gov/fdsys/pkg/GPO-CPRT-105hprt105-b/pdf/GPO-CPRT-105hprt105-b.pdf

Cozzens, Susan E., "Assessing Federally-Supported Academic Research in the United States," *Research Evaluation* 9, issue 1 (2000).

_________________, "Science Policy: Two Views from Two Decades," *Prometheus: Critical Studies in Innovation* 21, issue 4 (2003).

_________________, Regan, Priscilla, and Rubin, Beth, *Final Report: NSF Workshop on Social Organization of Science and Science Policy*, http://www.nsf.gov/sbe/scisip/ses_sosp_wksp_rpt.pdf

Crumpton, Amy and Teich, Albert H., "The Role of AAAS in U.S. Science Policy: The First 150 Years," in *AAAS Science and Technology Policy Yearbook 1999*, Committee on Science, Engineering, and Public Policy, (Washington, DC: American Association for the Advancement of Science, 1999), http://www.aaas.org/spp/yearbook/chap26.htm

Cutcliffe, Stephen H., "The Historical Emergence of STS as an Academic Field in the United States," *Argumentos de Razón Técnica* 4 (2001).

Cyberinfrastructure for Network Science Center, "The Science of Science (Sci^2)," https://sci2.cns.iu.edu/user/index.php

Demeritt, David, "The New Social Contract for Science: Accountability, Relevance, and Value in US and UK Science and Research Policy," *Antipode* 32, issue 3 (2000).

Dennis, Michael A., "Reconstructing Sociotechnical Order: Vannevar Bush and US Science Policy," in *States of Knowledge: The Co-production of Science and Social Order*, Sheila Jasanoff, ed. (London: Routledge, 2004).

Department of Energy, "FY 2011 Congressional Budget Request," http://www.mbe.doe.gov/budget/11budget/Content/FY2011Highlights.pdf

Dickson, David Dickson, *The New Politics of Science* (Chicago: University of Chicago Press, 1993).

Doubleday, Robert and Wynne, Brian, “Despotism and Democracy in the United Kingdom: Experiments in Reframing Citizenship,” in *Reframing Rights, Bioconstitutionalism in the Genetic Age*, Sheila Jasanoff, ed. (Cambridge, Massachusetts: MIT Press, 2011).

Edge, David, “Reinventing the Wheel,” in *Handbook of Science and Technology Studies*, Sheila Jasanoff, Gerald E. Markle, James C. Petersen, and Trevor Pinch, ed. (Thousand Oaks: Sage Publications, 1995).

Ehlers, Vernon J., Opening Statement at the Congressional Hearing (Subcommittee on Research and Science Education, U.S. House of Representatives) on the Science of Science and Innovation Policy (September 23, 2009). http://gop.science.house.gov/Media/hearings/research10/sept23/ehlers.pdf

Elzinga, Aant and Jamison, Andrew, “Changing Policy Agendas in Science and Technology,” in *Handbook of Science and Technology Studies*, Sheila Jasanoff, Gerald E. Markle, James C. Petersen, and Trevor Pinch, ed. (Thousand Oaks: Sage Publications, 1995).

Epstein, Steven, 2000, “Democracy, Expertise, and AIDS Treatment Activism,” in *Science, Technology, and Democracy*, D. Lee Kleinman, ed. (Albany, NY: SUNY Press, 2000).

Etzkowitz, Henry, “Science, Technology, and Innovation Policy in the US” in Namik K. Pak, Kostadinka Simeonova, and Ergun Türkcan, ed. *Strategies of the International Scientific Cooperation in South-East Europe*, (Amsterdam: IOS Press, 2000), Proceedings of the NATO Advanced Research Workshop on Strategies of the International Scientific Cooperation in South-East Europe, Sofia, Bulgaria, October 28-31, 1998.

________________, “The Commodification of Academic Research: Science and the Modern University” *Contemporary Sociology: A Journal of Reviews*, 40 (2011).

Executive Office of the President and Office of the Management and Budget, “Preparation, Submission, and Execution of the Budget,” Circular no. A-11 (August 2011), http://www.whitehouse.gov/sites/default/files/omb/assets/a11_current_year/a_11_2011.pdf

Ezrahi, Yaron, “Science and Political Imagination in Contemporary Democracies,” in *States of Knowledge: The Co-production of Science and Social Order*, Sheila Jasanoff, ed. (New York : Routledge, 2004).

Federal News Radio, "OMB finally launches Performance.gov portal," (August 26, 2011), http://www.federalnewsradio.com/?nid=92&sid=2512607

Feenberg, Andrew, *Questioning Technology* (New York : Routledge, 1999).

Feller, Irwin and Gamota, George, "Science Indicators as Reliable Evidence," *Minerva*, 45 (2007).

____________ and Stern, Paul C. Stern, ed. *A Strategy for Assessing Science*, *Behavioral and Social Research on Aging*, Committee on Assessing Behavioral and Social Science Research on Aging (Washington D.C.: The National Academies Press). http://www.ncbi.nlm.nih.gov/books/NBK26380/pdf

____________ and Cozzens, Susan, "It's about More Than Money," *Issues in Science and Technology* (summer 2008), http://www.issues.org/24.4/p_feller.html

Fischer, Hanna, "Turnover and Output Measurement for Scientific Research and Development Activities in Germany," 25th Vooburg Group Meeting, Vienna, Austria (September 20 to September 24, 2010). http://voorburggroup.org/Documents/2010%20Vienna/Papers/2010%20-%2076.pdf

Fisher, Eric and Guston, David, "STIR: Socio-Technical Integration Research," http://www.aaas.org/spp/scisip/2010%20abstracts/Fisher.pdf

Fuller, Steve, "The Secularization of Science and a New Deal for Science Policy," *Futures* 29, issue 6 (August 1997).

____________ and Collier, James H., *Philosophy, Rhetoric, and the End of Knowledge, A New Beginning for Science and Technology Studies*, 2ed Edition, (New Jersey: Lawrence Erlbaum Associates Press, 2004).

Fumihiko Satofuka, "Review: Science, Technology and Society in Postwar Japan," *Historia Scientiarum* 2, no. 3 (March 1993): 238.

General Accounting Office, *Performance Budgeting: OMB's Program Assessment Rating Tool Presents Opportunities and Challenges for Budget and Performance Integration*. GAO-04-439T (Washington, DC: GAO, 2004)

Gibbons, Michael, Limoges, Camille, Nowotny, Helga, Schwartzman, Simon, Scott, Peter, and Trow, Martin, *The New Production of Knowledge: The Dynamics of Science and*

Research in Contemporary Societies (Thousands Oaks, California: SAGE Publications, 1994).

Gonçalves, Maria E., "Risk and the governance of innovation in Europe: An introduction," *Technological Forecasting and Social Change* 73, issue 1 (2006).

Government Technology, "Feds Launch Performance.gov," (August 25, 2011), http://www.govtech.com/e-government/Feds-Launch-Performancegov.html

Guston, David H., "Boundary organizations in environmental policy and science: an introduction," *Science, Technology & Human Values* (2001).

_________________, Woodhouse, E. J., and Sarewitz, Daniel, "A Science and Technology Policy Focus for the Bush Administration" in AAAS Science and Technology Policy Yearbook 2002, Albert H. Teich, Stephen D. Nelson, Stephen J. Lita, ed. (Washington D.C.: American Association for the Advancement of Science, 2002).

Hillsman, Sally T., "Indicators for a New Social Science of Science Policy," *Footnotes* 33, no. 9 (December 2005), http://www2.asanet.org/footnotes/dec05/exec.html

Hoffman, Dennis and Hill, Kent, "The Contribution of Universities to Regional Economies: A Report from Productivity and Prosperity Project (P3)," Center for Competitiveness and Prosperity Research (May 2009), http://wpcarey.asu.edu/seidman/Reports/P3/ContributionUniv_5-09.pdf

Holstein, James A. and Gubrium, Jaber F., *Inside Interviewing: New Lenses, New Concerns* (Thousand Oaks: Sage Publications, 2003).

Irwin, Alan and Michael, Mike, *Science, Social Theory, and Public Knowledge* (Philadelphia: Open University Press, 2003).

___________, "The Politics of Talk: Coming to Terms with the 'New' Scientific Governance," *Social Studies of Science* 36, no. 2 (2006).

___________, "STS Perspectives on Scientific Governance," in *The Handbook of Science and Technology Studies*, E.J. Hackett, O. Amsterdamska, M. Lynch, and J. Wajcman, ed. (Cambridge: The MIT Press, 2007).

Interagency Task Group, White House National Science and Technology Council, *The Science of Science Policy: A Federal Research Roadmap* (November 2008)

International Society for Ecological Economics, Silvio Funtowicz, Jerry Ravetz, Robert Costanza (editor), "Post-Normal Science," Encyclopedia of Earth, http://www.eoearth.org/article/Post-Normal_Science

Jaffe, Adam B., "The Science of Science Policy: Reflections on the Important Questions and the Challenges They Present," *Keynote Address at NSF Workshop on Advancing Measures of Innovation* (June 2006), http://people.brandeis.edu/~ajaffe/PAPER%20-20science%20policy.pdf

Jasanoff, Sheila, "Cooperation for What?: A View from the Sociological/Cultural Study of Science Policy," *Social Studies of Science* 25, no. 2 (May, 1995).

______________, *States of Knowledge, The Co-production of Science and Social Order*, (London: Routledge, 2004).

______________, "Science and Citizenship: A New Synergy," *Science and Public Policy* 31, no. 2 (2004).

______________, *Designs on Nature: Science and Democracy in Europe and the United States* (Princeton, N.J. : Princeton University Press, 2007).

______________, "Testing Time for Climate Science," *Science* 382, no. 5979 (May 2010). http://www.sciencemag.org/content/328/5979/695.ful

Jones, Richard M., "White House Issues FY 2012 Science and Technology Priorities Memo," American Institute of Physics (August 9, 2010), http://www.aip.org/fyi/2010/087.html

Kakabadse, Andrew, and Kakabadse, Nada K., ed. *Governance, Strategy and Policy: Seven Critical Essays*, (New York: Palgrave Macmillan, 2006).

Keegan, Sheila, *Qualitative Research: Good Decision Making Through Understanding People, Cultures and Markets* (London: Kogan, 2009).

Lane, Julia, "The Statement to the Congressional Hearing (Subcommittee on Research and Science Education, U.S. House of Representatives) on the Science of Science and Innovation Policy," (September 23, 2009), http://gop.science.house.gov/Media/hearings/research10/sept23/Lane.pdf

Lawton Smith, Helen, *Universities, Innovation and the Economy* (London: Routledge, 2006).

Leath, Audrey T., “Marburger Speaks at AAAS Colloquium,” American Institute of Physics, http://www.aip.org/fyi/2002/046.html

Lempinen, Edward W., “Marburger Says Success Has Created Unexpected Challenges for U.S. S&T Research,” American Association for the Advancement of Science, http://www.aaas.org//news/releases/2006/1127marburger.shtml

Lightfoot, David W., “Social and Behavioral Scientists Building Cyberinstrastructure,” *First Monday* 12, no. 6 (June 2007), http://firstmonday.org/htbin/cgiwrap/bin/ojs/index.php/fm/article/viewArticle/1907/1789

Liu, De, Li, Xun, and Santhanam, Radhika, “Digital Games and Beyond: What Happens When Players Compete,” Forthcoming at *MIS Quarterly* (2012).

Lundvall, Bengt-Åke and Borrás, Susana, “Science, Technology and Innovation Policy,” in *Innovation Handbook*, Jan Fagerberg, David C. Mowery, and Richard R. Nelson, ed. (Oxford: Oxford University Press, 2005).

Marburger, John H., “Science and Technology Policy After September 11” in *AAAS Science and Technology Policy Yearbook 2003*, Committee on Science, Engineering, and Public Policy, Albert H. Teich, Stephen D. Nelson, Stephen J. Lita, and Amanda E. Hunt, ed. (Washington, DC: American Association for the Advancement of Science, 2003).

_________________, “Wanted: Better Benchmarks,” *Science*, 308, 1087 (2005).

_________________, Speech at the *30th Annual AAAS Forum on Science and Technology Policy in Washington, D.C.*, American Association for the Advancement of Science (April 21, 2005), http://www.aaas.org/news/releases/2005/0421marburgerText.shtml

_________________, “What Indicators for Science, Technology and Innovation Policies in the 21st Century?” Blue Sky II, Ottawa, Canada (September 25, 2006).

_________________, “The Science of Science Policy,” Pegram Lecture, Brookhaven National Laboratory (November 18, 2008).

_________________, "Science Advice in the George W. Bush Administration," in *Presidential Science Advisors Perspectives and Reflections on Science, Policy and Politics*, Roger Pielke and Roberta A. Klein, ed. (Dordrecht: Springer Netherlands, 2010).

Marcus, Alan I. and Bix, Amy S., *The Future is Now: Science and Technology Policy in America since 1950* (Amherst, N.Y: Humanity Books, 2007).

Martin, Ben R., "The Use of Multiple Indicators in the Assessment of Basic Research," *Scientometrics* 36, no. 3 (1996).

Marx, Leo, "Does Improved Technology Mean Progress?" in *Technology and the Future*, Albert H. Teich, ed. (New York: St. Martin's Press, 1997).

Merton, Robert K., "Normative Structure of Science," in *The Sociology of Science: Theoretical and Empirical Investigations*, Robert K. Merton and Norman W. Storer (Chicago: University of Chicago Press, 1973).

Mervis, J., "U.S. Science Policy: Agencies Scramble to Measure Public Impact of Research," *Science* 273, issue 5271 (1996).

Mirowski, Philip, *Natural Images in Economic Thought: "Markets Read in Tooth and Claw,"* (Cambridge [England]: Cambridge University Press, 1994).

Moore, Kelly, *Disrupting Science: Social Movements, American Scientists, and the Politics of the Military, 1945-1975,* (Princeton: Princeton University Press, 2008).

Morin, Alexander J, *Science Policy and Politics* (Englewood Cliffs, NJ : Prentice-Hall, 1993).

Moris, Francisco, Jankowski, John, and Perrolle, Pierre, "Advancing Measures of Innovation in the United States," *The Journal of Technology Transfer* 33, no. 2 (2008).

Moynihan, Donald, "What Do We Talk About When We Talk About Performance? Dialogue Theory and Performance Budgeting," *Journal of Public Administration Research and Theory* 16, issue 2 (2006).

________________ and Roberts, Alasdair S., "The Triumph of Loyalty Over Competence: The Bush Administration and the Exhaustion of the Politicized Presidency," *Public Administration Review* 70, issue 4 (2008).

________________, "The Politics Measurement Makes: Performance Management in the Obama Era," *The Forum* 7, issue 4 (January 2010).

National Eye Institute, "The GPRA and NEI Planning Process," National Institutes of Health, http://www.nei.nih.gov/resources/strategicplans/neiplan/frm_gpra.asp

National Institutes of Health, “GPRA and PART, NIH Systemic Assessments,” http://sourcebook.od.nih.gov/SD%20Orientation/GPRA%20.pdf

National Research Council (US) Board on Agriculture (BOA), *Colleges of Agriculture at the Land Grant Universities: Public Service and Public Policy* (Washington D.C.: National Academy Press, 1996), http://www.nap.edu/openbook.php?record_id=5133&page=1

______________________________ Committee on Assessing Behavioral and Social Science Research on Aging; Irwin Feller and P.C. Stern PC, ed. *A Strategy for Assessing Science: Behavioral and Social Research on Aging* (Washington D.C.: National Academies Press, 2007).

National Science Foundation, *FY 2007 Budget Request to Congress* (February 6, 2006), http://www.nsf.gov/about/budget/fy2007/pdf/fy2007.pdf

__________________________, *FY 2008 Budget Request to Congress* (February 5, 2007), http://www.nsf.gov/about/budget/fy2008/pdf/EntirePDF.pdf

__________________________, “Science of Science and Innovation Policy: Program Solicitation,” (2008), http://www.nsf.gov/pubs/2008/nsf08520/nsf08520.htm/

__________________________, *Science of Science and Innovation Policy Newsletter* 2, no. 1 (October 2009).

__________________________, “Interactive Games,” http://www.nsf.gov/news/special_reports/scivis/winners_2011.jsp#interactive

__________________________, “National Science and Engineering Visualization Challenge: 2011 Winners,” http://www.nsf.gov/news/special_reports/scivis/winners_2011.jsp

Nowotny, H., “How Many Policy Rooms are There? Evidence-Based and other Kinds of Science Policies,” *Science, Technology, and Human Values* 32, no. 4 (July 2007).

OECD Global Science Forum (GSF), *Workshop on Science of Science Policy: Developing our Understanding of Public Investments in* Science (July 12, 2006), http://www.oecd.org/dataoecd/42/63/37470200.pdf

Office of Management and Budget, “Government Performance Results Act of 1993,” The White House, http://www.whitehouse.gov/omb/mgmt-gpra/gplaw2m#h6

______________________________, *The President's Management Agenda*. (Washington, D.C.: Government Printing Office, 2001).

______________________________, "Budget and Performance Integration," The White House, http://georgewbush-whitehouse.archives.gov/omb/budintegration/index.html

______________________________, "Senate Committee on Government Affairs GPRA Report," The White House, http://www.whitehouse.gov/omb/mgmt-gpra/gprptm#h2

Office of Program Evaluation and Performance, "Performance," National Institutes of Health, http://dpcpsi.nih.gov/opep/performance.aspx

______________________________, "Science of Science Management," National Institutes of Health, http://dpcpsi.nih.gov/opep/science_management.aspx

Olsen, Kathie L., Call, Neysa M., Summers, Melissa A., and Carlson, Ann B., "The Evolution of Excellence: Policies, Paradigms, and Practices Shaping US Research and Development," *Technology in Society*, 30, Issues 3-4 (August-November 2008).

Oprea, Tudor I., *et al.*, "A Crowdsourcing Evaluation of the NIH Chemical Probes," *Nature Chemical Biology* 5, no. 7 (2009).

Patton, Michael Q., *Qualitative Research and Evaluation Methods* (Thousands Oaks, California: Sage Publications, 2002).

Porter, Theodore, *Trust in Numbers: the Pursuit of Objectivity in Science and Public Life* (Princeton, N.J : Princeton University Press, 1996).

_______________, "Quantification and the Accounting Ideal in Science," in *The Science Studies Reader*, M. Biagioli (London: Routledge, 1999).

Posner, Paul L., "Accountability Challenges of Third-Party Government," in *The Tools of Government, A Guide to the New Governance*, Salamon, Lester M., ed. (New York: Oxford University Press, 2002).

Proposal Exponent, "Resource 2. Federal R&D Funding: Quick Agency Profiles," http://www.proposalexponent.com/federalprofiles.html

Radin, Beryl A., "The Government Performance and Results Act and the Tradition of Federal Management Reform: Square Pegs in Round Holes," *Journal of Public Administration and Research Theory* 10, issue 1 (2000).

______________, *Challenging the Performance Movement: Accountability, Complexity, and Democratic Values* (Washington, DC: Georgetown University Press, 2006).

Resnik, David B., *The Price of Truth: How Money Affects the Norms of Science*. Practical and professional ethics series. (Oxford: Oxford University Press, 2007).

Reuck, Anthony de, Goldsmith, Maurice, and Knight, Julie, ed. *Decision Making in National Science Policy*, Ciba Foundation Symposium (Boston: Little, Brown and Company, 1968).

Rich, Robert F. and Rydell, Randy, "Who Is Making Science Policy?" *Science* 19, issue 6 (July/August, 1979).

Rip, Arie, "Societal Challenges for R&D Evaluation," in *Learning From Science and Technology Policy Evaluation*, P. Shapira And S. Kuhlmann, ed. (Northampton, Massachusetts: Edward Elgar Publishing, Inc, 2003).

Ruscio, Kenneth P., "Policy Cultures: The Case of Science Policy in the United States," *Science, Technology, & Human Values* 19, no. 2 (Spring, 1994).

Sarewitz, Daniel R., *Frontiers of Illusion: Science, Technology, and the Politics of Progress*, (Philadelphia: Temple University Press, 1996).

_________________, "Social Change and Science Policy," *Issues in Science and Technology* (Summer 1997). http://www.issues.org/13.4/sarewi.htm

_________________ and Pielke Jr., Roger A., "The Neglected Heart of Science Policy: Reconciling Supply of and Demand for Science," *Environmental Science and Policy* 10 (2007).

Sclove, Richard E., *Democracy and Technology* (New York: Guilford Press, 1995).

Serendip, "The Science of Science Education: A Look at Undergraduate Science Education in the U.S.," http://serendip.brynmawr.edu/exchange/node/8723

Smith, Bruce L.R., "The United States: The Formation and Breakdown of the Postwar Government-Science Compact," in *Science and the State, Domestic Structure and the International Context*, Etel Solingen, ed. (Ann Arbor: The University of Michigan Press, 1994).

Stephen Campbell, Stephanie Shipp, Tim Mulcahy, and Ted Allen, “Informing Public Policy on Science and Innovation: the Advanced Technology Program’s Experience,” *The Journal of Technology Transfer* 34, no. 3 (2009).

Suchan, Trudy A. and Brewer, Cynthia A., “Qualitative Methods for Research on Mapmaking and Map Use” *The Professional Geographer,* 52, Issue 1 (2000).

Todd, Lord, “Chairman’s Introduction,” in *Decision Making in National Science Policy*, Ciba Foundation Symposium, Anthony de Reuck, Maurice Goldsmith, and Julie Knight, ed. (Boston: Little, Brown and Company, 1968).

Webster, Andrew, “Crossing Boundaries, Social Science in the Policy Room,” *Science, Technology, and Human Values* 32, no. 4 (July 2007).

Weiss, Robert, *Learning from Strangers, The Art and Method of Qualitative Interview Studies* (New York: The Free Press, 1994).

White House, “Memorandum for the Heads of Executive Departments and Agencies,” (August 4, 2009),http://www.whitehouse.gov/sites/default/files/omb/assets/memoranda_fy2009/m09-27.pdf

Zhai, Zhi, Hachen, David, Kijewski-Correa, Tracy, Shen, Feng, and Madey, Greg, “Citizen Engineering: Methods for “Crowdsourcing” Highly Trustworthy Results,“ *45th Hawaii International Conference on System Sciences* (2012).

Ziman, John, *Real Science: What it is and What it Means* (New York: Cambridge University Press, 2000).

Zuckerman, Solly, “Scientists in the Arena,” in *Decision Making in National Science Policy*, Ciba Foundation Symposium, Anthony de Reuck, Maurice Goldsmith, and Julie Knight, ed. (Boston: Little, Brown and Company, 1968).

APPENDIX A: Informed Consent Form for Interviewees

Overview and Procedures

I, ____________________, agree to take part in this study of the fields of science and innovation policy as well as STS (Science and Technology Studies).
I understand that, as a participant in this study, I will be asked to respond to interview questions, and I recognize that participation in this study may involve answering questions about:

- my work and/or professional experiences in the fields and/or sub-fields of Science and Innovatio n Policy as well as STS.
- my feelings and/or academic attitudes toward certain aspects of the field of science and innovati on policy as well as STS

I understand that this interview will be audio-recorded, and that the principal investigator may use selections from this interview in his dissertation and resulting publications.

Extent of Anonymity and Confidentiality

I understand that neither the full transcript nor the audio recording of this interview will be made public. Further, I recognize that the principal investigator has offered to provide me with a copy of interview audio recording.
I understand that the principal investigator for this project will provide me with an opportunity to review the use of selections from the interview before he submits such selections for any kind of publication or review.
In reviewing any interview selections and/or associated publications, I understand that I will have an opportunity to indicate whether the investigator may include my name in his study, or whether I would prefer my remarks to remain anonymous, in whole or in part.

Benefits of This Project

I understand that while I am not likely to benefit directly from this study, the information gained may contribute to the production of new knowledge on various fields, such as innovation policy projects and Science and Technology Studies (STS).

Subject's Permission

I have read the informed consent form, understand the conditions of this project, and have had all of my questions answered. I understand that if I elect to participate, I may withdraw at any time without penalty according to the above conditions. I hereby acknowledge the above, give my voluntary consent for participation, and release my interview to the investigator to be used as outlined.

________________________________ ________________________________

Interviewee's Signature and Date Investigator's Signature and Date

________________________________ ________________________________

Interviewee's Printed Name Investigator's Printed Name

If you have any questions or concerns about this study, please contact the principal investigator (Gouk tae Kim) or Principal Investigator/Project Supervisor (Saul Halfon).