

**Social, Behavioral and Economic Sciences**  
**Science of Science and Innovation Policy: A Prospectus**  
**September, 2006**

**Introduction**

The Directorate for Social, Behavioral and Economic Sciences (SBE) at the National Science Foundation (NSF) aims to develop the knowledge, theories, data, tools, and human capital needed to cultivate a new Science of Science and Innovation Policy (SciSIP). Science and innovation policy discussions are frequently based upon past practice or data trends that may be out of date or have limited relevance to the current situation. Traditional models available for informing investment policies are often static, unidirectional and not developed for domain-specific applications. Past investments in basic scientific research have had an enormous impact on innovation, economic growth and societal well-being. However, there is modest capability of predicting how future investments will yield the most promising and important opportunities.

SBE's SciSIP activities will develop the foundations of an evidence-based platform from which policymakers and researchers may assess the impacts of the nation's scientific and engineering enterprise, and improve their understanding of its dynamics and predict outcomes. Parallel research and data development will help answer pressing questions, such as: What are the critical elements of creativity and innovation? What are the likely futures of the technical workforce and what is its response to different forces of change? What is the impact of globalization on creativity and productivity in the science and engineering fields? Are there significantly different outcomes from federal and private investments in R&D and innovative activities? How does state support for public universities influence the national innovation system?

Economic models offer guidance to Federal Reserve Board officials as they set interest rates, even when they encounter conflicting policy goals. SciSIP's activities will advance the scientific basis of science policy, through the development of data collection, analyses and modeling tools, so that future policy decisions may be made based on current data, sound science and informed judgment, more closely analogous to the way that economic models have helped economic policy makers. Quantitative and qualitative tools will be developed to enable the collection of longitudinal and multi-sectoral data, and to facilitate better retrospective analysis of the impact of federal investments on scientific discovery and innovation, the economy and society. In this way, lessons learned from past investment strategies can be used to refine the accuracy of predictive models.

**Goals**

SciSIP's goals are to understand the contexts, structures and processes of science and engineering research, to evaluate reliably the tangible and intangible returns from investments in research and development (R&D), and to predict the likely returns from future R&D investments within tolerable margins of error and with attention to the full spectrum of potential consequences. Specifically, the research, data collection and community development components of SciSIP's activities will: (1) develop usable knowledge and theories of creative processes and their transformation into social and economic outcomes; (2) improve and expand science metrics, datasets and analytical tools, yielding changes in the bi-annual S&E indicators and other data collections; and (3) develop a community of experts across the Federal government, industry and universities focused on SciSIP. Characterizing the dynamics of discovery and innovation is important for developing valid metrics, for predicting future returns on investments, for constructing fruitful policies, and for developing new forms of workforce education and training.

## Scope

SciSIP's activities will build research capabilities along three dimensions: measurement, understanding and community development. The first focus is on the development of data and related studies and involves the improvement and expansion of science metrics. Included here are studies that better identify, characterize, measure, and evaluate the investments, processes, and social and economic returns of scientific and engineering research. Some of SBE's efforts in this area will expand and enhance surveys that the Division of Science Resources Statistics (SRS), the federal statistical agency for science and engineering, now conducts. Some resources will be devoted to the design and development of new surveys by SRS. These surveys will be based on scientific frameworks that identify important new indicators for understanding the system of innovation and on a new taxonomy of leading twenty-first century science and engineering fields. In addition, NSF has a leadership role in the newly formed Interagency Task Group on Science of Science Policy, which has been established by the National Science and Technology Council's Subcommittee on Social, Behavioral and Economic Sciences. Efforts such as these will improve the comparability, scope, relevance, and availability of national and international data. New cyberinfrastructure-based data extraction and matching techniques will be used to develop new ways to visualize and evaluate research investments and their derived returns. Qualitative and quantitative methods will enable the collection of real-time data that facilitate up-to-date analysis of the impact of federal and private investments on scientific advancement, the economy and society.

The second focus involves producing a body of usable analytical and empirical knowledge. This includes, but is not limited to: theoretical and conceptual models related to the development of innovative ideas; the development of statistical and econometric tools to understand the science and engineering enterprise in the national and global context and estimate returns from R&D investments; and focused studies that bring qualitative and quantitative analytical tools and longitudinal data together to yield a rich understanding of knowledge creation and innovation within organizations and institutions. The fundamentals of discovery and innovation will be examined from cognitive, organizational and national perspectives. These new models will incorporate the potential stages and feedback mechanisms that influence discovery, innovation processes and outcomes, as well as their relationships to individual, organizational, economic and social entities. The complex interplay of forces in the system of scientific discovery and innovation also invites retrospective studies of science and technology. All of these efforts will involve coordination and collaboration among the three divisions within SBE, as well as other NSF directorates, other Federal agencies and potential contributors to and users of the research worldwide. International collaborations will be encouraged, with expected partnerships between SBE and other international funding agencies.

Community development is the third facet of SciSIP's activities. The scientific underpinnings of education and training in science and engineering will be a component of the research and data collection. In addition, the broadening and deepening of the national STEM workforce capabilities is an important focus of this activity. SciSIP's activities are also expected to foster the development of a new interdisciplinary field, which will draw on research techniques, models and tools that are utilized in several traditional disciplines.

## Portfolio of Activities

SciSIP's activities will foster a rigorous and comprehensive portfolio of research through a wide range of funding mechanisms. Research will be funded at different levels, ranging from single investigators to collaborative teams. Workshops will actively engage researchers in interdisciplinary activities as they develop new tools for understanding and evaluating science policy.

The workshops will also provide high-profile venues for reporting on discoveries, new data collections, models and analyses. Supported research and workshops are important elements for the continuous enhancement of workforce development.

*Contracts and Interagency Agreements.* SRS will be funding new and expanded data-collection activities including expanded interactions with data users and respondents, enhancing the usefulness of the data to the development of the science of science and innovation policy. Cyber-facilitated data extraction mechanisms will be employed to expand and develop new data sets; cyber-linked metrics and methods for evaluating inputs, outputs and outcomes of scientific development will greatly improve the utility of data collections. New surveys and indicators of R&D, innovation and the science and engineering (S&E) workforce will be developed. For example, SRS will develop new indicators that reflect more accurately the way in which R&D is currently being conducted. There are also plans for gathering information about innovative activities that occur at a later stage of product development than is typically captured by existing R&D indicators. SRS is also planning to deepen their database on the S&E workforce, focusing particularly on post-doctorates. The new surveys will be developed based on the expertise and experience of social psychologists, sociologists, economists, and other social scientists as well as researchers across the full spectrum of science and engineering.

*Grants.* SBE's goal of building a rigorous and comprehensive science of science and innovation policy research portfolio will be accomplished through NSF's usual merit-review process. In the spring of 2007 SBE intends to issue its first solicitation for proposals comprising disciplinary and interdisciplinary research on knowledge generation and innovation. The emphasis areas will be data, models and tools. The solicitation will invite research that is conducted in the broad spectrum of social, behavioral, cognitive, and economic sciences. Research will include psychological and organizational studies of innovation, as well as the development of agent-based models and network analyses. For example, scientists in the natural and social sciences could collaborate on projects about cognitive pathways and interaction strategies that lead to new discoveries, optimizing team strategies in the innovative process, as well as study the relationships between ethics, values and public policies.

The research objectives will go beyond the traditional input-output linkages, to broader outcomes, such as implications for national health, security, education, and well-being. New statistical and econometric tools for estimating social and economic returns to science and engineering investments will be encouraged, including domain-specific comparisons of public and private R&D expenditures and returns. The research will not be limited to quantitative assessments. Qualitative tools, such as case studies, ethnographic studies, historical analyses and cross-national comparisons will also be welcomed and interdisciplinary collaborations will be encouraged. International collaboration among scholars will also be encouraged, since much can be learned about country-based methods of scientific exploration and science policies, particularly as the scientific community globalizes. SBE will partner with funding agencies primarily in Europe and Asia to facilitate these international collaborations. Collaborative research projects between U.S. investigators and researchers in developing countries and emerging economies are anticipated.

*Workshops.* SBE initiated the SciSIP activities by sponsoring three agenda-setting workshops dealing with knowledge creation and innovation. In May 2006, the Division of Behavioral and Cognitive Sciences hosted the "NSF Innovation and Discovery Workshop: The Scientific Basis of Individual and Team Innovation and Discovery." Researchers from the psychological sciences, together with members of the engineering community, focused on the cognitive processes of researchers working alone or in teams to develop new ideas and to overcome stumbling blocks. Frontiers of collaborative research that were identified during the workshop include: memory and analogy mechanisms in creative design processes; computational models of creativity; models of

synergy between individuals and teams to improve performance; ways to build more innovative teams; management and leadership issues in innovation and creativity; and impacts of disciplinary cultures on transformative work.

SRS conducted the second workshop in June 2006, entitled “Advancing Measures of Innovation: Knowledge Flows, Business Metrics, and Measurement Strategies.” Participants brainstormed about better measures of innovation and alternative data resources and tools at the national and international levels. They also focused attention on the need for theoretical frameworks that point to data that should be gathered and models that could be used for analysis of the data.

Lastly, the Division of Social and Economic Sciences sponsored a workshop on “The Social Organization of Science and Science Policy” in July 2006. Participants examined the social organization and the political, economic and sociological contexts within which science policy and science succeed or flounder, and the need to develop concepts that further the understanding of interrelationships between inputs, outcome and policies in the national innovation system. Since human capital is a critical driver of scientific discovery and innovation, workshop attendees stressed the need for new strategies and vehicles for the education, training, mobility, and diversity of the STEM workforce. For reports on these workshops, please see the web sites for each of these SBE divisions (<http://nsf.gov/dir/index.jsp?org=SBE>).

Going forward, three to six workshops are expected to occur each year. Workshops will create an important medium for the development of future scholars whose work informs science policy. In year three of this activity there will also be a summative conference, where leading scholars and policymakers will give their assessments of research findings, identify areas for future research and draw lessons for future indicators.

*Community Building and Training.* Continuous enhancement of human capital requires community building and training of future generations of researchers. Broad involvement of constituencies, including universities and researchers, labs and corporations, policymakers and community leaders is critical to the success of human-capital development. Furthermore, SciSIP’s activities can be a catalyst that brings these groups together for the purpose of formulating methods and designing curriculums critical for developing, instructing and advising twenty-first century scientists and engineers.

The aim is to create a cadre of scholars who marshal data, analyses and advice on the scientific underpinnings of science policy. As one means of facilitating this objective, a summer institute in 2008 will host leading researchers and graduate students in the field. The summer institute and other community-building efforts are expected to support education and training opportunities for the development of the next-generation workforce, including activities to broaden workforce participation in the STEM disciplines. Ultimately, SciSIP will facilitate transformative research on an immensely policy-relevant topic—the ecology of innovation.

## **Milestones**

Over the course of these SciSIP activities, we anticipate several milestones. In the near term the quantitative and qualitative capabilities supporting science policy decisions will be improved. The building blocks of the national science and engineering enterprise will be more comprehensively represented by data that are collected by federal agencies and independent data-developers. Researchers and analysts will have new datasets, metrics, indicators and roadmaps with which to understand current and historical scientific discovery and innovation activities in the U.S. and abroad. Researchers will also contribute to this understanding by providing new theoretical models that inform the data-collection process.

In the medium term, results of interdisciplinary research will germinate, creating a full spectrum of knowledge from individual cognitive pathways of discovery and innovation to relationships between investment and outcomes at the national or global scale. New models will also be useful for simulations that inform investment strategies, particularly when real-time data are accessible through the use of cyber-tools. Collaboration between social and behavioral scientists and physical and biological scientists will facilitate the development of domain-specific models, thereby offering flexibility to policymakers and mitigating mistakes that result from one-size-fits-all measurement and policies.

All of this has implications for the long term. SciSIP will establish an interdisciplinary, evidence-based understanding for science policy, in part because a generation of researchers will have developed effective theories, data, tools, and expertise in this area. This body of knowledge will be used to better nourish and harness the capabilities of the national STEM workforce and will have provided answers to the pressing questions posed at the beginning of this prospectus.

### **Contact**

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