Research Policy xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Research Policy

journal homepage: www.elsevier.com/locate/respol

Socio-economic impacts and public value of government-funded research: Lessons from four US National Science Foundation initiatives

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ARTICLE INFO

Keywords:
Evaluation
Broader impacts
National science foundation

ABSTRACT

Interest in evaluating non-economic *social* outcomes of science and technology research has risen in policy circles in recent years. The interest in social impacts of research has not yet given rise to a great proliferation of useful, valid techniques for evaluating such impacts. This study presents detailed case studies of four US National Science Foundation (NSF) programs/initiatives to provide a framework for understanding diverse efforts at addressing social impacts, and to suggest some important gaps in our research approaches for assessing socio-economic impacts of research. The four cases studied – the Experimental Program to Stimulate Competitive Research (EPSCoR), the Innovation Corps (I-Corps), the Arizona State University Center for Nanotechnology in Society, and the NSF "Broader Impacts" criteria—were chosen for their diversity in intent and modality but operating within a single agency. The cases are compared based on criteria important for assessing socio-economic outcomes: the initiative's modality, enabling policy vehicle, benefit guarantor, distribution and appropriability of benefits, specificity of beneficiary, social-economic range, and timing of the benefit stream. The paper concludes with a discussion of the most pressing methodological and theoretical issues that need addressing for greater progress in assessing social impacts.

1. Introduction

The history of evaluation of research is a diverse one, focusing on processes, outputs and, occasionally, on outcomes. With respect to the research outcomes of interest, most studies heretofore have focused on economic outcomes or knowledge outcomes. With respect to the former, a wide variety of economic approaches has been developed, including input-output analysis, simulations, case studies and, especially, cost-benefit analysis. Very different approaches have been employed for evaluating knowledge outcomes. While peer review, either open-ended or structured, remains an important approach to assessing the quality of knowledge outcomes, in past decades researchers and policy-makers have made increasing use of a variety of rapidly developing bibliometric techniques.

Recently, interest in evaluating non-economic *social* outcomes has spiked. In most cases, initiatives aimed at measuring science- and technology-based social outcomes come from high-level policy councils. Thus, the European Commission's (2014) Horizon 2020 Research and Innovation Programme explicitly focuses on social outcomes in its "Science with and for Society" section, as well as in other sections. In the U.S., the National Science Foundation's (NSF) new "Broader Impacts" criteria, i.e, criteria related to socio-economic impacts emerged from the National Science Board, the governing and advisory body for the NSF. According to a 2011 document (NSB, 2011), research proposal review criteria should include not only scientific quality but also "contribute more broadly to achieving societal goals." Particularly relevant for present purposes is the NSB admonition that "assessment and evaluation of NSF projects should be based on appropriate metrics, keeping in mind the likely correlation between the effect of broader impacts and the resources provided to implement projects."

The newfound interest in social impacts of research has not yet given rise to a great proliferation of useful, valid techniques for evaluating such impacts. One reason for the undersupply is simply that insufficient time has elapsed. Economic approaches to research evaluation have at least fifty years of development and bibliometric approaches at least thirty. But the other reason, arguably, is that it is simply much more difficult to measure social impacts. In the case of bibliometric approaches, tracing causal paths is rarely a focus. In almost all cases, bibliometric studies seek to measure outputs not impacts. If the focus is on patents, or publications or citations, bibliometric studies may sometimes correlate with socio-economic outcomes but do not provide causal hypotheses about the mechanisms that lead to these

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http://dx.doi.org/10.1016/j.respol.2017.06.003
Received 13 November 2015; Received in revised form 15 November 2016; Accepted 4 June 2017

outcomes. With respect to economic studies, there is almost always the allure of commodification and monetization of outcomes. In some cases this may actually deflect from understanding the outcome of interest (since even some important economic outcomes are not well captured by monetary indicators), but in most instances the precision of economic data, when taken with assumptions from economic theory, at least permit some robust causal hypotheses about effects of research.

Measuring the social impacts of research seems an order of magnitude more difficult. Why? First, there is a terminology problem, with terms such as "socio-economic" impacts, "social impacts," "societal impacts," and "broader impacts" being used, sometimes interchangeably. Some of these terminologies emerged from enabling policy vehicles of a program or initiative of the cases presented in this paper. For example, the 21st Century Nanotechnology Research and Development Act (P.L. 108–153), which was an enabling vehicle for the Center for Nanotechnology in Society at Arizona State University, used the term "societal" throughout the act to refer to "improvements in quality of life" from nanotechnology research. As previously discussed, the term "broader impacts" represents terminology used by the National Science Foundation in its new criterion regarding the contribution of research toward societal goals. The term "social impacts" itself has been used to indicate an emphasis on non-economic impacts of public R&D programs to achieve social goals (Bozeman and Sarewitz, 2011). However, the most important problem, one not entirely foreign to economic analysis, is not necessarily the terminology, but rather the "over-determined" causality involved in any large-scale social change. Partly as a result of the difficulty of partitioning the impacts of research from all other exogenous factors affecting highly complex social outcomes, most approaches to measuring social impacts have been qualitative in nature, relying especially on case studies, interviews, or narratives. For example, the UK Research Excellence Framework (REF) performed a cross-case and text mining analysis of 6679 case studies of impacts from UK universities (HEFCE, 2015); but even with this large number of case studies which cover a broad range of disciplines and types of impacts, partitioning difficulties have been indicated, such as distinguishing impacts involving teaching, public engagement, and commercial beneficiaries, the latter due in part to an inability to disclose confidential information (Manville and Grant, 2015). In some cases peer review approaches have been used to evaluate social impacts of research, typically with little or no modification from approaches used to assess scientific quality. Methodological innovation or methodological synthesis has not been common in studies of social impacts of research, though some (Jordan, 2010 Hyvärinen, 2011) have suggested or applied approaches based on mapping or logic models.

1.1. Objectives

The overall objective of our study is to identify gaps in previous efforts to deal with the socio-economic impacts, particularly the social impacts, of research so as to suggest possible approaches to remedying these shortcomings. Currently, the literature on social impacts of science and technology programs remains quite modest. Thus, rather than reviewing literature, criticizing it and suggesting new alternatives we instead review four policy initiatives, all from the US NSF, their respective policy approaches and intents, and we use an analytical framework we develop here to examine the relationships among program components and possible approaches to evaluating social impacts.

The four cases we examine include:

1. The Experimental Program to Stimulate Competitive Research, much better known by its acronym EPSCoR, which, since its initial authorization in 1978, has aimed to build research capacity at universities in states that historically have not been competitive in open research solicitations.
2. The Innovation Corps (I-Corps). I-Corps began in 2011 with the objective of accelerating commercialization of science-intensive research.
3. The Arizona State University Center for Nanotechnology in Society, one of two NSF-sponsored centers tasked with developing and diffusing research related to the social implications of nanotechnology.
4. The NSF "Broader Impacts" criteria initiative. While not a program, the Broader Impacts initiative is a policy change requiring grant proposers to focus not only on the content and quality of the science in their proposals but also socio-economic impacts.

We employ an analytical framework for comparing these four very different cases and, in doing so, we hope to understand specific challenges involved in assessing the social impacts of "on the ground" science and technology policy programs. Application of this framework suggests gaps in current approaches. Reflecting on the cases, the authors' experience as evaluators and such modest literature as exists on evaluation of social impacts of science and technology policy, we suggest in the concluding section not only the apparent gaps but some possible resolutions.

The analytical framework we use for comparing these very different programs, presented in detail in a later section, seeks to characterize science and technology programs in terms of their institutional, economic and policy attributes. Since few such analytical devices have been developed for comparing science and technology policy programs, we draw from the general public policy literature, frameworks developed in other policy areas and our previous work in research and evaluation. We feel that our systematic, analytically based comparison of these four cases potentially presents cues as to what may be required for progress in assessing the social impacts of science and engineering research. Some of the requirements for such assessments differ little from those for virtually any evaluation research target. However, after examining these four cases we shall argue that they illustrate some of the particular needs and challenges of evaluating the broader impacts of science and engineering research at the level of the solicitation policy, capacity-development program, commercialization program, and a societal research center, as opposed to, say, school nutrition programs, or welfare benefit studies or other such topics that have been the sustained focus of evaluation researchers.

We do *not* present here an overview of approaches to conceptualizing and measuring the social impacts of research. In part this is because there are already very useful assessments of this literature (Bornmann, 2013; Gaunand et al., 2015; Joly et al., 2015), but in part this is owing to the desire to keep the verbiage in a paper that is a four-case comparison to tolerable limits. Moreover, we refer to relevant literature throughout the paper.

2. Four NSF socio-economic impact program initiatives

In this section we examine the four US NSF program initiatives aimed at enhancing socio-economic impact of science and engineering research, specifically with an aim to understand how the content and objectives of these programs present implications for *evaluation* of impacts from research.

While we feel these four cases provide an excellent basis for understanding different programmatic approaches to social impacts, we cannot infer a great deal from their respective evaluations and approaches; the programs vary greatly in the extent to which they have been evaluated. The EPSCoR program has often been a focus of systematic evaluations and the evaluations have to some extent focused on social impacts, but also economic impacts. The I-Corps program has been evaluated but almost always using traditional economic approaches, not focusing on social impacts except from the standpoint of assuming social value flowing from economic impacts. The Nanotechnology in Society center began in 2005. An evaluation was conducted in 2017. Finally, the Broader Impacts criteria initiative is not truly a program but rather an initiative. While controversial it has not