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Moving towards impact when evaluating research programs: introduction to a special section

Robin M Wagner and Gretchen B Jordan

The theme of 'moving towards impact when evaluating research programs' is timely due to both global pressures and the current state of maturity of the research evaluation field. The first three papers provide R&D portfolio managers with new strategies to maximize the impact of their R&D investments. The remaining three papers move from theory to practice, demonstrating new approaches to evaluating research outcomes and impacts that are applied to specific research problems. These ideas should significantly enhance the abilities of evaluators, program managers and policy-makers to assess the impacts of their research portfolios and programs, and make informed decisions on future research investments.

THIS ISSUE OF *Research Evaluation* offers six stimulating papers chosen from the many excellent papers presented at the 2008 annual conference of the American Evaluation Association (AEA) and sponsored by the AEA Research Technology and Development Evaluation (RTD) Topical Interest Group (TIG). The RTD TIG — in existence since 1995 — disseminates information related to best practices in research evaluation. The RTD TIG is comprised of an international network of research evaluators from government agencies, private industry, academia and the non-profit sector. Each year, the RTD TIG sponsors the RTD portion of the AEA conference (in 2008, the TIG hosted 22 sessions in which 54 papers were presented). Out of these sessions, a subset of thematically related papers is chosen for publication in a special issue of this journal. To learn more about the AEA and the RTD TIG, please visit <http://www.eval.org> and <http://rtd.aea.googlepages.com/>, respectively.

The theme for this year's selected papers is 'Moving towards impact when evaluating research programs'. This theme is particularly timely due to recent global social and economic trends. Throughout the world there are expectations that research and, more generally, innovation is the solution to national and global problems such as poverty, pandemics and climate change. Further, over the past two decades, governments and their publics increasingly have demanded greater accountability for the use of public funds for programs and research. The demand for public accountability and proven impact of public investments has been accelerated by the current global economic crisis — the worst since the Great Depression in the 1930s — which led governments around the world to bolster their respective economies with huge financial stimulus packages.

In the United States (USA), recipients of the stimulus funds to revive the US economy legislated under the American Recovery and Reinvestment Act (2009) — which included billions of dollars for scientific research — must report to the public quarterly on the overall project purpose and outcomes; employment impact; and project completion status.

Dr Robin M Wagner is Chief, Reporting Branch, Division of Information Services, Office of Research Information Systems, Office of Extramural Research, Office of the Director, US National Institutes of Health, 6705 Rockledge Dr., Bethesda, MD, 20892, USA; Email: wagnerr2@mail.nih.gov; Tel: +1 301-443-5234; Fax: +1 301-480-2845. Dr Gretchen B Jordan is Principal Member of Technical Staff, Sandia National Laboratories, Department 01012 MS 0351, PO Box 5800, Albuquerque, NM 87185-0351, USA; Email: gbjorda@sandia.gov; Tel: +1 505-844-9075; Fax: +1 505-284-3166.

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In addition, in October 2009, the US Office of Management and Budget announced a new federal initiative to bolster the evaluation capacity of government agencies, with a focus on impact evaluations aimed at determining the causal effects of programs (Orzag, 2009). There are similar pressures in Europe and Asia.

This year's theme also reflects the current state of maturity of the research evaluation field. Widely accepted methods have been developed and refined to measure the performance of the earlier stages of research; these methods include peer review of research proposals, scientific manuscripts, and projects that are in progress, and bibliometric analyses of publications and patents. Practitioners in the field increasingly have turned their attention to developing robust methods of retrospectively measuring the more downstream effects of research on technical, social and economic outcomes. This task is more challenging than evaluating the earlier stages of research for a number of reasons, including the more distal relationship between the original research and resulting changes in behavior, practice or policy that lead to potential outcomes.

Confounding factors, including other research and external forces, exert influence and make it more difficult to demonstrate impact, that is, a causal relationship between the evaluated research and identified outcomes. Beyond retrospective analyses, public and private research portfolio managers increasingly are seeking new tools to predict the potential impacts of new research projects, to ensure scarce resources are invested wisely. Hence, it is exciting to report in this issue on new developments in the theory and practice of evaluating research outcomes and impacts.

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At the national or international level, it is important to try to understand the forces that affect whether research discoveries will ultimately be translated into useful products or services. Ford *et al*. uses economic theory and models to provide a new and provocative explanation for why basic research findings often fail to result in commercialization due to funding shortfalls in the intermediate stage of research, which is more applied but far from product development and diffusion. Ford *et al.*. posit that this phenomenon — colloquially called the Valley of Death in the innovation sequence — is caused by large investments in early-stage basic research by 'non-economic actors', mainly governments, whose decisions are not driven by potential private gains or profits. When outputs from this basic research exceed what the private sector is willing to fund at the next, intermediate stage of research, the Valley of Death occurs.

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The authors note that while there are important reasons, including societal benefits, for governments to fund basic R&D without regard to profits, there may also be unintended consequences. In addition to causing the Valley of Death, the authors argue that the latter behavior also results in raising the costs of intermediate-stage research, leading private lenders away from investments in this phase. The authors conclude that if governments wish to increase the economic returns on their R&D investments, they might consider investing more in intermediate-stage research or better coordinating research projects across all stages of the innovation process.

The paper by Chang *et al.* presents government and other R&D managers with another strategy to balance their portfolios to enhance the probability of better economic outcomes from their research investments. Chang *et al.* have developed a novel method that uses patents to *prospectively predict* emerging high-impact technological research areas. The authors identified 'hot patents' — the subset of patents whose impact on recently issued patents is particularly strong — and 'next generation patents' — those patents that cite hot patents. The next generation patents were then scored and ranked to determine which represent likely emerging high-impact, technical clusters of research and innovation.

Chang *et al.* validated their methodology by constructing next generation clusters from earlier years (1998 and 2002), predicting which ones were emerging clusters, and then confirming which clusters actually had developed into high-impact clusters in the subsequent years. There was excellent concordance between predicted and actual high-impact clusters. The authors performed a second validation by taking a known set of emerging, high-risk patents and determined they were twice as likely to be found in next generation clusters as in the general patent population. The authors concluded that next generation clusters had a greater concentration of high-risk, emerging technologies than the patent population as a whole. While this method needs to be validated on additional types of research portfolios, it represents a true advance in giving R&D managers, policy-makers and evaluators a tool to predict which R&D areas are likely to have a high payoff and, therefore, are worthy of support.

Hyvärinen moves the research evaluation field forward by combining additionality theory and talented behavior theory to identify the most innovative and exceptional researchers or research groups that should be funded. Additionality theory was used to evaluate whether the research project inputs and outputs would have occurred if public funding for the project had not been available. The influence of public research funding on R&D talent in terms of risk-taking and other characteristics that are likely to increase discovery and innovation is an important early outcome. This new methodology is embedded in a system to assess outcomes all along the spectrum of performance as described in the September 2007 AEA issue of this journal (Hyvärinen, 2007).

Hyvärinen identified seven characteristics associated with exceptional scientific talent. He then applied both theories to interpret the results of pre- and post-funding evaluations of research projects supported by Tekes, the Finnish funding agency for technology and innovation. The results were used to develop new guidelines on how this funding agency could identify and promote the development of the most creative and innovative researchers and groups to support in future research. The author suggests enhancements to this approach to make it even more useful to funding agencies in future.

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Orians *et al.* develop a conceptual model to guide the assessment of outcomes resulting from asthma research funded by the National Institute for Environmental Health Studies, part of the US National Institutes of Health. The authors sought to glean insights on research impacts from asthma researchers and individuals who use their findings to develop policies and practice, through interviewing a sample of both groups. The asthma researchers were asked their opinions on how their research influenced downstream outcomes, while the research end users were asked about how asthma research findings had influenced their knowledge and practice. This bi-directional approach provided a more complete and nuanced picture of research translation, including identifying non-traditional means of disseminating research findings.

However, researchers were unaware of or uncomfortable asserting a causal relationship between their work and specific changes in guidelines, regulations, clinical or business practices or public knowledge. The end users were aware, in general, that research had influenced policy and practice but were unable to attribute specific research agencies or studies to these changes. This suggests that self-reported impact assessments can enrich the understanding of how knowledge is translated and used, but they are best combined with quantitative methods that trace research outputs to impact to provide a more comprehensive picture.

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Ruegg *et al.* demonstrate the value of complementing qualitative with quantitative evaluation techniques to obtain a full picture of research impacts. A strong case for additionality can be made if there is careful historical tracing of the linkages between the public R&D and private technology development. These authors adopted a historical tracing framework and multiple evaluation techniques to study linkages between 30 years of wind energy research funded by the US Department of Energy (DOE) and downstream commercial power generation in utility-scale and distributed-use power markets. Methods used included interviews with industry and government experts; analyses of documents and databases; patent citations; and publication co-authorship and citations. Both the qualitative and quantitative methods found linkages between DOE's research investments and key innovations in the wind energy industry and other industries which took advantage of these technological advances.

Finally, Kohmoto *et al.* used another quantitative evaluation tool — cost–benefit analysis — to estimate the economic impact of public R&D expenditures on Japan's photovoltaic R&D research projects. In particular, this work examined the different outcomes or additionality due to the presence or absence of public R&D funds. First, the relationships between public and private R&D investments and the price of the photovoltaic power system were modeled using regression techniques. Based on data separately obtained, consumer surpluses were calculated from product prices assuming the presence or absence of public R&D funding; the additional surplus associated with the presence of public R&D funds was taken as the additional consumer surplus. The cost–benefit analysis defined the additional public R&D funding as the cost and the additional consumer surplus as the benefit.

The results suggested that public R&D support for this industry resulted in lowering the price of the photovoltaic system to levels affordable by households which, in turn, led to implementation of Japan's photovoltaic installation grant incentive program. The authors were able to use information collected in surveys that follow five years after project completion, an excellent example of the importance of routine data collection. The authors concluded that the public R&D investment in photovoltaic power systems, in combination with the installation grants program, spurred technological advances and expanded consumer installation, yielding significant long-term economic benefits. This approach can be extended to other R&D industries and other countries.

In conclusion, the ideas presented in this section should significantly enhance the abilities of evaluators, program managers and policy-makers to assess the impacts of their research portfolios and programs, and make informed decisions on future research investments.

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