EU/U.S. Roadmap to Measuring the Results of Investments in Science: The Bellagio Statement

A Report following the "EU/US Science of Science Policy" Rockefeller Foundation Bellagio Center Workshop,

27 June – 30 June 2011



Date: 30-08-2011

The Workshop was made possible through the support of the Rockefeller Foundation.

http://www.iscintelligence.com/event.php?id=22

Summary

Public and private investments in science and technology (S&T) have significantly increased over the past decades in Europe and the United States. The results have been transformative – ushering in the telecommunications and internet revolutions; providing better access to food, water, and shelter; improving health care; combating environmental degradation and climate change; and helping to inform policies to promote social and economic security.

It is essential that these investments continue to create value for the public. Indeed, national governments are increasingly asking complex and probing questions regarding the effects of their investments; they want transparency and accountability for the spending of taxpayers' money; and they want their decisions regarding investments in science to be informed by data-driven analyses. Now more than ever before, the science community must explain and justify the spending on publicly-funded research. While it is clear that research pays off in general, there is great skepticism about both the marginal value of spending, and the chosen investment targets. There is a clear requirement to ensure greater effectiveness and efficiency in the use of public research funding; reduce the reporting burden on scientists; and to exploit the enormous analytical power generated by advances in information technology.

Experts from the European Union and the United States met at the Rockefeller Foundation in Bellagio, Italy, to examine these issues. The task at hand should not be underestimated. Although the potential return from this work is enormous, the scale of the challenge of developing these new ideas into workable solutions for policy makers is also very significant. Despite the major strides already made in the U.S. through the National Science Foundation's Science of Science and Innovation Policy (SciSIP) program and the interagency STAR METRICS program, a shared approach with other nations would certainly both accelerate progress and implementation.

The purpose of the Bellagio conference was to explore the formation of a mutually beneficial multi-national collaboration in documenting the results of investments in science. The group believes science today is a global activity. Scientists and engineers collaborate across borders, move across borders and the benefits of their research know no borders. Expansion beyond current measurement systems could both broaden and deepen participation in science.

The participants at the Bellagio conference agreed that analysis of different research systems will provide a powerful evidence basis for guiding science policy. Such analysis can only be achieved via an international collaborative effort to establish and implement an interoperable platform that provides quality controlled data on research spending, output and impact.

The group expressed commitment to work together to develop a common global referential framework to support the analysis of the results of investment in science, and concluded that the global scientific community would benefit from:

1. Aligning efforts toward the development and implementation of (i) automated systems for the collection of standardized and validated data, and (ii) tools for the analysis of this data to determine the effects of science and technology investments.
2. Collaborative international scholarly research efforts in support of the Science of Science and Innovation Policy.
3. Aligning the efforts of global funding agencies to support a common institutional framework for the Science of Science and Innovation Policy
4. The recommended implementation of complementary data driven approaches, such as the STAR METRICS approach, to document the results of science investments in both the European Union and the U.S.

Details, including implementation steps, are provided in the following document.

Background

Public and private investments in science and technology (S&T) have increased significantly over the past decades in Europe and the United States, as well as in many other countries world-wide. The results have been transformative – ushering in the telecommunications and internet revolutions; providing better access to food, water, and shelter; improving health care; combatting environmental degradation and climate change; and helping inform policies to promote social and economic security.

It is essential that these investments continue to create value for the public. Indeed, national governments are increasingly asking complex and probing questions regarding the effects of their investments; they want transparency and accountability for the spending of taxpayers' money and they want to make decisions regarding investments in science to be informed by data-driven analyses. [1]

The European Union, in developing its Framework Programmes for research and technology development, has always recognized the importance of evaluation and monitoring activities. These have been progressively modernized over the course of successive Framework programmes. Over the last few years, however, there has been a vigorous debate over a series of more radical proposals. This has involved contributions from across the different Institutions which collectively define the European Union, including notably the executive in the form of the European Commission, as well as the European Court of Auditors and European Parliament.

For example, a monitoring system is currently being developed by the Commission within the context of FP7 that will provide a more coherent and systematic use of performance indicators. In addition, EU Finance Ministers, keen to bring public spending under control and plug fiscal deficits, resisted the inclusion of an R&D investment target of 3% of GDP in the 2020 strategy. They called for a new "outcome-orientated" measure for R&D and Innovation.[2] The European Commission has noted the emphasis that is being put on the "science of science" and the importance being placed on forming monitoring systems which can measure the performance and outcome of R&D related projects.

[1] Including expressed interest and capacity in other countries, such as Brazil, Japan, South Africa and China.

[2] Council conclusions on Europe 2020, 3003rd ECONOMIC and FINANCIAL AFFAIRS Council meeting, Brussels, 16 March 2010

The United States is similarly moving to build a stronger basis for science policy as evidenced by (i) The White House requirement for agencies to do so: the joint OMB/OSTP R&D Priorities memo[3] issued in preparation for the FY 2011 budget requested agencies to "develop outcome-oriented goals for their science and technology activities, establish procedures and timelines for evaluating the performance of these activities, and target investments toward high-performing programs" [4]. (ii) The looming imperative to document the impact of the nearly $20 billion in R&D investments embodied in the 2009 American Recovery and Reinvestment Act (ARRA). (iii) The Digital Accountability and Transparency (DATA) Act of 2011 introduced in both the U.S. House and Senate which would extend the ARRA reporting requirements to all federal awards exceeding $25,000. (iv) The increasingly competitive Federal budget environment and the desire to invest in sectors yielding measurable societal dividends.

Accordingly, the United States has established the "Science and Technology for America's Reinvestment: Measuring the EffecTs of Research on Innovation, Competitiveness and Science" (STAR METRICS) program, led by an agency Consortium consisting of the National Institutes of Health (NIH), the National Science Foundation (NSF), the Department of Energy (DOE), the Environmental Protection Agency (EPA) under the auspices of the White House Office of Science and Technology Policy (OSTP). The goal of the program is to create a data infrastructure that will combine, in a useful fashion, scientific investment data, with data acquired from voluntarily participating research institutions. The Consortium has already used this data to generate various measures of the social, economic, and scientific value of the analyzed investments. Level I was successfully demonstrated in cooperation with the Federal Demonstration Partnership (FDP)[5] and includes documenting who is supported by science funding. Level II includes using existing data -- such as patents issued, patent applications filed, publications and citations of scholarly publications to develop and validate new metrics and outcome measures based on participatory feedback from non-Federal sources, including academic researchers, science practitioners, and others with expertise in the science of science policy.

The Bellagio workshop was held on June 27-30 at the Rockefeller Foundation. It was organized as an outreach activity by the Science of Science Policy Interagency group, which is chartered under the National Science and Technology Committee. The goal was to bring together a group of subject matter experts to establish an understanding of parallel and methodologically coherent opportunities,

[3] http://www.whitehouse.gov/sites/default/files/omb/assets/memoranda_2010/m10-30.pdf
[4] http://www.whitehouse.gov/sites/default/files/omb/assets/memoranda_2010/m10-30.pdf
[5] http://thefdp.org

challenges and gaps. This understanding, while informal in nature, could be used to help develop a common framework for the U.S. and the E.U.[6] which, hopefully, will be subsequently extended to elsewhere in the world.

Findings

Participants at the Bellagio conference expressed a consensus that now more than ever before, the science community must explain and justify spending on publicly-funded research. While it is clear that research pays off, there is great skepticism about both the marginal value of spending, and the chosen investment targets. There is a clear requirement to ensure greater effectiveness and efficiency in the use of public research funding; reduce the reporting burden on scientists; and to exploit the enormous analytical power generated by advances in information technology.

Workshop participants recognized the importance of developing joint initiatives. They recognized the importance of measurement, since you cannot manage what you cannot measure; but they also recognized that what you measure ultimately dictates what you get. The group felt that it is critical that both regions develop a system of measurement that fosters and enables the better practice of science within a global context to address global challenges.

The group found that funding agencies in both regions are operating within a common context. Each is facing increased requirements to report results, yet is limited by burdensome manual reporting systems that generate low quality data. This common context sets the stage for great potential gains from international collaboration in developing common data, tools and analyses to support generating joint products – such as reports, visualizations, analysis and international benchmarking. The extension of STAR METRICS to the European science community will enable the analysis of results and the mapping of intellectual capacity over a wider network of investigation and innovation which includes major international collaborations (e.g., CERN, the European Organization for Nuclear Research) to which international scientists make key contributions.

Broader participation in STAR METRICS will enable further refinement of the metrics used by the U.S. application, and ultimately more efficient use of all science funding. Data collection and analysis can also

[6] Japan, which has recently instituted a SciSIP and a STAR METRICS programme sent an observer to the workshop. Japan is likely to be a leader in expanding the E.U./U.S. collaboration to other parts of the world

deliver other benefits in a number of ways. These include accelerating discovery by helping researchers map what is known, and enabling funding agencies to determine which areas may be underfunded relative to impact. In addition, agencies could identify global thought leaders in current and future fields. In the longer run, this collaboration may be extended globally, although that expansion would need to consider differences in initial conditions in terms of economic development.

Participants recognized that there were potentially enormous transformations in the way in which data acquisition could be automated – recognizing that useful quantitative and qualitative information about the contributions of various actors to science, innovation and economic growth can be found beyond existing and emerging national and transnational data sets. Participants discussed the reality that some forms of scientific discoveries are more likely to be patented than others, that the patentability of certain discoveries varies across countries and that although patents are growing in importance in relation to impact assessment, patents alone cannot be the terminal measure of impact. Other forms of intellectual property, e.g., trademarks, copyrights, and geographical designations, may be appropriate and measurable outcomes of science as well as papers and publications. Scientific output may be systematically underestimated if these forms of output are excluded. Participants felt that a combined effort could capture broader measures of protected intellectual property and enhance the accuracy of future analysis.

Participants also noted that the EU and U.S. faced substantially similar strategic and tactical challenges which joint activity could help to overcome. A major strategic challenge faced is the natural barriers to change; a fairly small number of influential actors (institutions and individuals) can halt action. Joint activity that demonstrates the value of a common framework can help address such challenges. A major tactical challenge is the hesitancy to share institutional data. Cooperative development of governance rules could help overcome such barriers.

Conclusions

The group of experts concluded that the following joint activities would provide a strong basis for the development of a common framework that would help demonstrate the overall power of investments in science.

1. Aligning efforts to develop and implement common approaches. Examples could include collaboration in the development of persistent researcher identifiers; extending the accessibility, usability and interoperability of U.S. and European publication and patent databases; development of interoperable and authenticated research datasets as well as common analysis tools; and identification of quantitative and qualitative information concerning the contributions of various actors to science, innovation and economic growth beyond existing and emerging national and transnational data sets.
2. Collaborating on international scholarly research efforts in support of the Science of Science and Innovation Policy. The two regions could collaborate in developing parallel research agendas in support of the Science of Science and Innovation Policy.
3. Aligning the efforts of funding agencies to support a common framework for the Science of Science and Innovation Policy. The two regions could coordinate policy efforts in support of a common framework for the Science of Science and Innovation Policy.
4. Implementing complementary data driven approaches, such as the STAR METRICS approach, to documenting the results of science investments in both the European Union and the U.S. The E.U. and the U.S. could cooperate in developing an automated data platform by building on existing initiatives to develop and extend the STAR METRICS programme. The development of the E.U. programme would serve to both inform and be informed by the U.S. programme. The results would generate key analysis and reports in both national and international contexts.

Development and Implementation Steps

The following steps are recommended:

1. Aligning efforts in the development and implementation of common automated and validated data, tools and analysis.

   An effective system must appreciate the international nature of science and technology. Scientists collaborate across borders, move across borders and the benefits of their activities know no borders. In developing an international system that takes this fact into account, the Bellagio group identified five specific areas of action that require urgent development.

   Common development of persistent and universal researcher IDs: Name disambiguation is a major road block to tracking and identifying scientists for the correct attribution of research results. Currently, name disambiguation can be achieved through automated, computational linguistic technologies with a reasonable degree of confidence. However, this can be expensive and needs to be carried out for each specific data repository. An international, permanent and unique identifier that accurately labels scientists and engineers would be imperative. Such identifiers would be automatically incorporated into publications, citations, patents and other scientific outputs.

   Several approaches can be taken to develop a researcher ID that has the essential characteristics described above. Existing initiatives, like ORCID[7], will be examined as to their potential for building a comprehensive, sustainable platform for developing an international ID. In addition a strong "bottom-up" initiative to encourage the participation of individual scientists could be very fruitful, because the vast majority would probably be enthusiastic to have a unique ID.

   Common development of interoperable Information systems: The Bellagio group encourages examination of the development of interoperable information systems in Europe and in the U.S. that build on existing investments (CERIF[8] and CASRAI[9]).

   Parallel development of automated CV reporting. Funding agencies require their grantees to report, at different times, on their research activities. A useful information system should

[7] Open Researcher and Contributor ID http://www.orcid.org/
[8] The Common European Research Information Format http://cordis.europa.eu/cerif/
[9] The Consortia Advancing Standards in Research Administration http://casrai.org/

include features that help streamline this process, enhancing the quality and the use of the information entered, while decreasing reporting burden for the researcher and responsible administrative units. An important joint activity would include developing a parallel system to automate CV reporting by drawing from internet resources to autopopulate the CV so that researchers can simply verify, and eventually edit, the content. Part of the information could also be directly entered by the researchers (e.g. narrative about achievements and goals). These CVs should have the capability of tailored formatting based on requirements of the participating funding agencies, alleviating burden for scientists, and drawing on the Brazilian experience. In addition, the text should be tagged such that it is possible to automatically mine CVs as a resource for understanding what science is being funded to enhance collaboration and avoid unintentionally duplicative funding efforts. Just as with unique IDs, it would be important, and fruitful, to make automated CVs an attractive approach for individual scientists to document their scientific achievements.

Common automated visualizations. The Bellagio group emphasizes the development of visualization tools that can generate maps of science and scientists that facilitate the understanding of who is funding, where is research being concluded and when is science being funded. The group believes that rigorous analyses and effective visualization of complex data and researchers' networks will be a powerful tool for understanding how innovation occurs, capturing its complexities, but making complex analyses tractable without oversimplifications.

Common development of databases. The Bellagio Group encourages the development of an international system that can ingest and link information from different patent, trademark and copyright databases. This will serve, in certain cases, as an indication of outputs, but also as an entry point to capture scientific collaborations and relationships. In the case of biomedical research, for example, evident benefits have been accrued by the availability of centralized information systems of publications such as PubMed[10] and genetic information repositories such as those developed by the National Center for Biological Information (NCBI).[11] In addition, the joint effort should identify and develop quantitative and qualitative information about the contributions of various actors to science, innovation and economic growth beyond existing and emerging national and transnational data sets.

[10] http://www.ncbi.nlm.nih.gov/pubmed/
[11] http://www.ncbi.nlm.nih.gov/

2. Encouraging collaborative international scholarly research efforts: The two regions could collaborate in developing parallel research agendas in support of the Science of Science and Innovation Policy. Participants underlined the importance of Europe, both at EU and national level, supporting counterpart activities to the US and Japanese activities in this area. They felt that the timing of Horizon 2020 provided a major opportunity which should not be missed.

3. Aligning the efforts of funding agencies: The two regions could coordinate policy and programme efforts in support of a common framework for the Science of Science and Innovation Policy. Although at this stage it is not necessary to set out the specific administrative details, it is was envisaged that both parties should seek to establish full and equal ownership of the initiative through some form of steering group comprising the full range (of different stakeholders).

4. Implementing complementary data driven approaches, such as the STAR METRICS approach, to documenting the results of science investments in both the European Union and the U.S. This could involve leveraging existing administrative data to develop better information about the scientific workforce, particularly information about the faculty, graduate students, undergraduate students and postdoctoral fellows supported by science funding. It could then be extended to jointly examine the ways in which R&D investments fuel the innovation ecosystem by advancing science, stimulating the economy, training the workforce and fostering social well-being. This could be done by drawing on such common elements as the automated CV platform described above, but would consist of developing a data infrastructure capable of linking data from different sources to describe the innovation process – connecting the sources of funding, recipients of funding, interactions among scientists—both in the public and private sector—and the products of research over time. It would not be based on building new, expensive datasets, or burdening researchers with more reporting requirements. Rather, the STAR METRICS approach will, with scientists' permission, leverage existing investments in data collection, such as the Patent Collaboration Network[12] and the Citeseerx[13] publication data, as well as existing administrative data housed in statistical agencies to link inputs with outputs and outcomes to better understand the complex innovation process.

[12] http://www.iq.harvard.edu/programs/patent_collaboration_network
[13] http://citeseerx.ist.psu.edu/

One important element of the cascading approach to broader implementation of the STAR METRICS approach, both in the United States and EU, is the identification and development of quantitative and qualitative information about the contributions of various actors to science, innovation and economic growth beyond existing and emerging national and transnational data sets. Inclusion of this type of data in both US and EU STAR METRICS reports and analyses, in both the short term and long term, is strongly encouraged. For example, efforts are underway in the United States to capture the broad range of impacts of colleges and universities on their regional economies.

Access to the expanded STAR database should encourage third-party analysis on an open source basis which can provide additional insights into creative relationships and discovery and innovation pathways.

A Google mapping metaphor might indicate the kind of enrichment which could be brought in by the different perspective of "outside" contributors. Qualitative studies of science projects and institutions[14] would benefit from the ability to identify the key individuals rapidly and clearly. Such studies could in turn be mapped onto the STAR METRICS framework. This richer analysis across a larger population would enable both the identification of potentially productive groupings and collaborations and the monitoring of the effectiveness and productivity of existing groups. Further expansion could follow, bringing in other regions and countries such as Latin America and East Asia.

Longer term activities: developing metrics for less tangible outcomes and impacts

The quantitative foundation provided automatically by STAR delivers the prospect of moving on to the identification and verification of less tangible outcomes than those directly attributable to specific funding inputs, but which nevertheless represent valid impacts of science funding. With the involvement of stakeholders from industry, research institutions and federal and regional governments, both more diffuse innovation pathways and the creation and transfer of new capacities could be identified.

[14] E.g. CERN-MODE https://espace.cern.ch/MODE/Public%20documents/

Appendix

PARTICIPANT DIRECTORY – BELLAGIO CONFERENCE, June 2011

Stefano Bertuzzi
Director, NIH Return on Investment Programme
Office of Science Policy
U.S. Department of Health and Human Services
Stefano.bertuzzi@nih.gov

Thomas Brandtner
Head of Unit for Competitiveness, Lisbon Strategy, Industry
General Secretariat of the Council of European Union
Thomas.brandtner@consilium.europa.eu

Lisa Cook
Assistant Professor, James Madison College and Department of Economics
Michigan State University
lisacook@msu.edu

Patrick Cunningham
Chief Scientific Adviser to the Irish Government
Patrick.cunningham@chiefscientificadviser.ie

Ian Foster
Distinguished Fellow and the Associate Division Director in the Mathematics and Computer Science division
Argonne National Laboratory
foster@anl.gov

Richard Freeman
Faculty co-Director of the Labor and Worklife Programme
Harvard Law School
freeman@nber.org

Cristina Gutierrez-Cortines
Member
European Parliament
cristina.gutierrez-cortines@europarl.europa.eu

Michael Holland
Senior Advisor and Staff Director for Steve Koonin, Under Secretary for Science
U.S. Department of Energy
Mike.holland@science.doe.gov

Cynthia Hope
Assistant Vice President for Research and Director of the Office for Sponsored Programs
The University of Alabama
Cindy.hope@ua.edu

Declan Kirrane
Founder and Managing Director
ISC Intelligence in Science
Declan.kirrane@iscintelligence.com

Kei Koizumi
Assistant Director for Federal Research and Development
White House Office of Science and Technology Policy
Kei_koizumi@ostp.eop.gov

Gabrielle Kotsis
Professor, Telecooperation Department
Johannes Kepler University Linz
Gabriele.kotsis@jku.at

Anna Krzyzanowska
Head of Unit, Evaluation and Monitoring
DG Information Society of the European Commission
Anna.krzyzanowska@ec.europa.eu

Masahiro Kuroda
President, Tohoku University of Community Service and Science
Principal Fellow, Center for Research and Development Strategy, Japan Science and Technology Agency
Kdb.kuroda@gmail.com

Julia Lane
Program Director of the Science of Science & Innovation Policy programme
National Science Foundation
jlane@nsf.gov

Stephen Little
Senior Lecturer in Knowledge Management
The Open University Business School, U.K.
S.e.little@open.ac.uk

Erik Lium
Assistant Vice Chancellor, Office of Innovation, Technology & Alliances
University of California San Francisco
Erik.lium@ucsf.edu

Luis Martin Oar
Former Head of Unit, ITRE Committee Secretariat
European Parliament
luis.martinoar@gmail.com

Neville Reeve
Policy Adviser
Unit for Framework Programme Evaluation in the Directorate General for Research and Innovation
European Commission
Neville.reeve@ec.europa.eu

David Robinson
Interim Provost and Vice President for Academic Affairs
Oregon Health & Science University
robinsda@ohsu.edu

Robert Samors
Associate Vice President for Innovation and Technology Policy
Association of Public and Land-grant Colleges
RSamors@APLU.org

Susan Sedwick
Associate Vice President for Research and the Director of the Office of Sponsored Projects
The University of Texas at Austin
sedwick@austin.utexas.edu

Richard Seligman
Associate Vice President for Research Administration
California Institute of Technology
Richard.seligman@caltech.edu

Bernard Silverman
Chief Scientific Adviser
Home Office, UK
Bernard.silverman@stats.ox.ac.uk

Toby Smith
Vice President for Policy
Association of American Universities
Toby_smith@aau.edu

Bill Valdez
Acting Director, Office of Economic Impact and Diversity
U.S. Department of Energy
Bill.valdez@hq.doe.gov

Pieter van Nes
Adviser to Director General, Brussels' office of the Joint Research Centre
European Commission
Pieter.van-nes@ec.europa.eu

Cornelis Mario Vis (Observer)
Adviser
Bureau of European Policy Advisors
Cornelis-mario@vis.ec.europa.eu

Robb Wilcox
Associate Director
U.S. Office of Naval Research Global
Robb.wilcox@onrg.navy.mil

John Wood
Professor
Imperial College, London
j.wood@imperial.ac.uk

Kurt Zatloukal
Professor of Pathology, Institute of Pathology
Medical University of Graz
Kurt.zatloukal@medunigraz.at