

Assessing the Impact of the National Institute of Standards and Technology's Research Collaborations

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ABSTRACT: The Information Services Office (ISO) of the National Institute of Standards and Technology (NIST) conducted a study to assess the impact of NIST research collaborations by analyzing the NIST papers co-authored with other researchers external to NIST. This request from NIST senior management focused on the number of unique non-NIST co-authors on NIST authored papers and the number of unique institutions and countries with which NIST collaborated on publications for the past five years. This paper describes the methodology used to assess the impact of NIST's publication collaborations, and shares the results of ISO's study.

INTRODUCTION

The National Institute of Standards and Technology (NIST) is a non-regulatory federal agency within the U.S. Department of Commerce (DOC). NIST's mission is to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve the quality of life.

One means by which NIST performs its mission is through technology transfer. Technology transfer activities at NIST are designed to disseminate fundamental measurements, and standards research results to industry and other interested parties. In order to perform leading-edge scientific and technical work, NIST must maintain high levels of collaboration with organizations and individuals with diverse capabilities. For more than a century, laboratories at NIST (formerly the National Bureau of Standards) have successfully collaborated with others to provide the measurement techniques and technical tools needed by U.S. innovators (U.S. Department of Commerce 2013).

The Information Services Office is responsible for creating, maintaining, organizing, and disseminating information to support the research and programmatic needs required to fulfill the scientific and technical mission of NIST. ISO supports the work of NIST through its assessment activities and works closely with the NIST Program Coordination Office to help NIST senior management determine the impact of NIST's research.

The Information Services Office, in response to a request from NIST senior management, looked at five years of NIST papers (2009-2013) to determine the number of unique non-NIST co-authors, the number of unique institutions, and the number of countries represented by the non-NIST co-authors. This information is reported in the yearly, statutorily-required, U.S. Department of Commerce's "Annual Report on Technology Transfer." The results of the study also support NIST's activities to meet the requirements of the October 28, 2011 Presidential Memorandum Accelerating Technology Transfer and Commercialization of Federal Research in Support of High-Growth Businesses (White House 2011). ISO's findings revealed a 33 % increase in the number of unique co-authors, ranging from 3,297 in 2009 to 4,386 in 2013.

LITERATURE REVIEW

While co-authorship does not provide the entire view of research collaboration, it is a practical and inexpensive means of analyzing collaborations. Research collaboration can take on many forms: correspondence by mail or email, visits to institutions, exchanging ideas at conferences, sharing and exchanging data sources and papers, and the writing of research papers. Of these, the collaboration in writing research findings is the most easily measured (Frame 1979). In a 1983 review paper, bibliometric methods are described as offering "a convenient and non-reactive tool for studying collaboration in research" (Subramanyam 1983).

The bibliometric study of research collaborations has a relatively long history. Studies of multiple authorship trends in scientific papers were conducted as early as 1963 and 1964 (de Solla Price 1963 and Clarke 1964). As early as 1958, the results of studies of multiple authorship in the field of psychology were reported in the literature (Smith 1958).

Several research collaboration studies have looked at co-authorship in specific fields of study. One study examined research collaborations in health management and found that while collaboration behavior was growing steadily it needs to be enhanced to promote the progress and internationalization of health management (Zhang 2013). Other studies have examined international co-publications as an indicator of the quality of scientific research (Schmoch 2008).

Bibliometrics have also been used to study the relationship between collaboration and financial aid for research. In four disciplines (political science, psychology, biological science, and chemistry) financial support for research was associated with the total number of persons, including co-authors, involved in the production of knowledge per research paper (Heffner 1981).

While co-authorships can be analyzed in a number of ways, validity questions are associated with co-authorship studies. Some forms of collaboration do not generate co-authored papers and some co-authored papers do not reflect actual collaboration (Melin 1996). Despite these issues, co-authorship of scientific papers remains a popular and practical means of assessing research collaboration. In recent years, the creation of visual representations in order to analyze different aspects of collaboration has become a very useful aid for the study of collaboration patterns (Chinchilla-Rodríguez 2010).

OVERVIEW OF NIST PUBLICATIONS

NIST conducts research across a broad swath of science and technology fields, from physics, chemistry, and biology to engineering, mathematics, and computer science. While publishing many papers in these core science areas, all of NIST's research supports measurement science, standards, and technology. Much of NIST's work is interdisciplinary and collaborative, and this is reflected in the body of publications it produces.

NIST's published body of work includes journal articles, conference papers, books, book chapters, and technical reports. This paper focuses on NIST collaborations as studied in the peer-reviewed journal literature. Between 2009 and 2013 NIST published in 97 distinct research areas. NIST published most heavily in the areas of physics and chemistry with 2,928 physics papers and 1,513 chemistry papers (Figure 1).

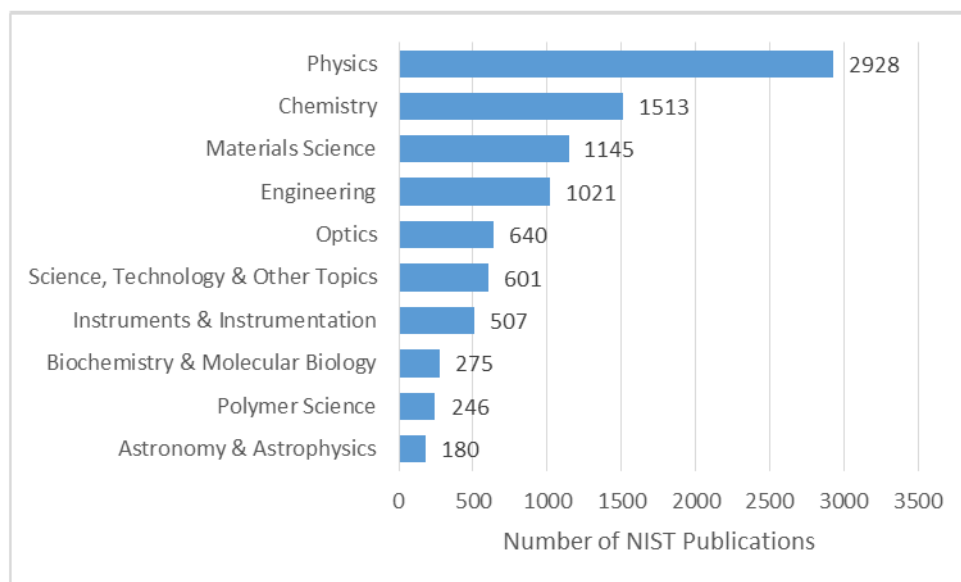


Figure 1: NIST Publications by Research Areas (Top Ten), 2009-2013

METHODOLOGY

Unique co-authors and institutions were identified by performing a search for all NIST authored papers in the *Web of Science*¹ database for the years 2009-2013. The search incorporated a complex *Web of Science* search strategy that included many address variations for NIST including its former name, the National Bureau of Standards. While *Web of Science* does offer the organization-enhanced feature for searching by address, the same original search strategy has been used since ISO first began studying publication collaborations. This lends consistency to the study of trends and ensures additional precision in retrieving NIST's body of work. The search included publications in the peer-reviewed literature (journals) while excluding most conference proceedings papers and all NIST technical series publications or reports.

While *Web of Science* offers an author analysis feature for analyzing search results sets, this feature does not associate names with institutions, which would allow ISO analysts to easily remove NIST authors. To disambiguate authors, ISO downloaded the full record for each NIST publication. From there, analysts created an Access database to extract the authors and affiliated institutions. Several database queries were used to attach author names to their affiliated institutions. The list of authors required manual manipulation to normalize author names and consolidate record counts.

Because the requestor was also interested in tracking the data on an annual basis to observe trends over time, the data for this study were gathered for each year back to 2009. These yearly sets of data (2009-2013) will then be compared to the yearly data going forward. Earlier trend analysis is not possible because the *Web of Science* database does not link authors to institutions prior to 2008. For example, there might be ten authors listed for an article with four addresses given but author affiliation cannot be determined using the *Web of Science* record.

FINDINGS

NIST researchers collaborated with extramural authors on 74 % (1,033) of the 1,389 NIST publications produced in 2013 (Figure 2). While the total number of publications fluctuates from year to year, the percentage of papers with outside collaborators ranges from 73 % to 75 % over the five-year period.

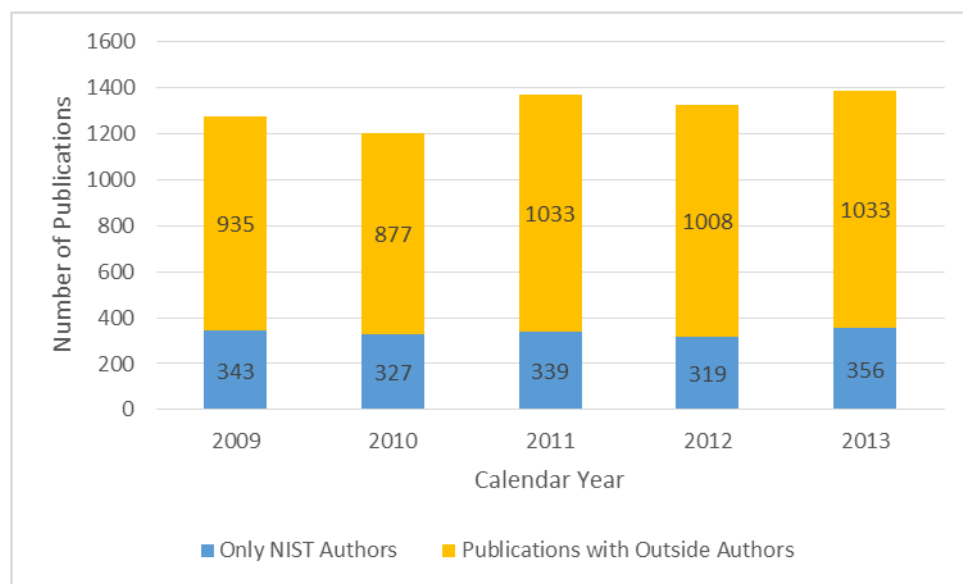


Figure 2: Number of NIST Publication Collaborations, 2009-2013

¹ Identification of commercial products is not intended to imply recommendation or endorsement by the National Institute of Standards and Technology.

NIST researchers collaborated with 4,386 unique non-NIST authors in 2013. Between 2009 and 2013, the number of collaborators increased from 3,297 to 4,386, a 33 % increase over the five-year period (Figure 3).

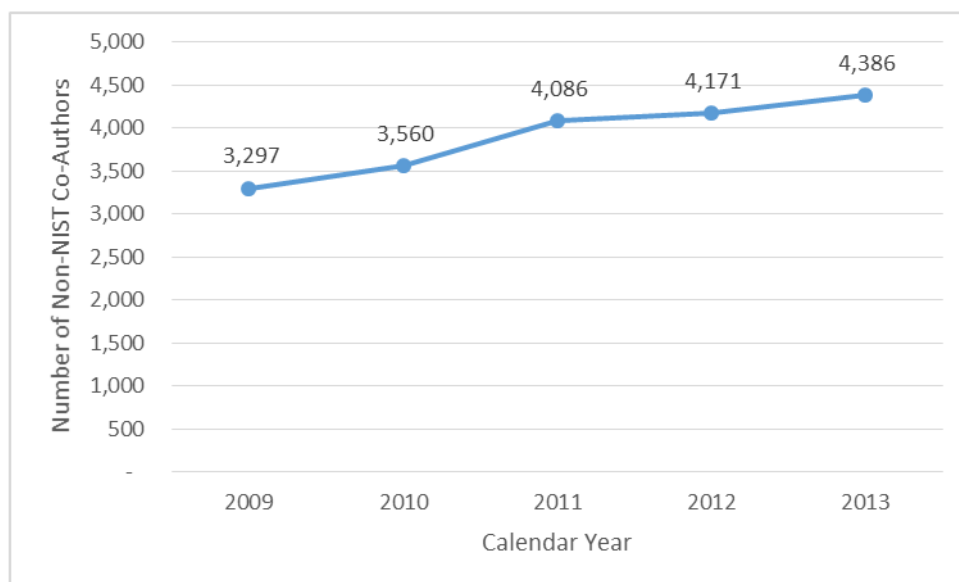


Figure 3: Number of Non-NIST Researchers Co-Authoring on NIST Publications, 2009-2013

NIST researchers collaborated with researchers from 1,027 institutions in 2013 (Figure 4). These institutions include universities and colleges, other Federal research labs, other Federal agencies, National Metrology Institutes (NMIs), research institutes in other countries, companies, hospitals, zoos, and high schools. Between 2009 and 2013, the number of collaborating institutions grew from 877 to 1,027 institutions, a 15 % increase over a five-year period. Since 2011, the number of collaborating institutions has leveled off and remains fairly constant just above 1,000.

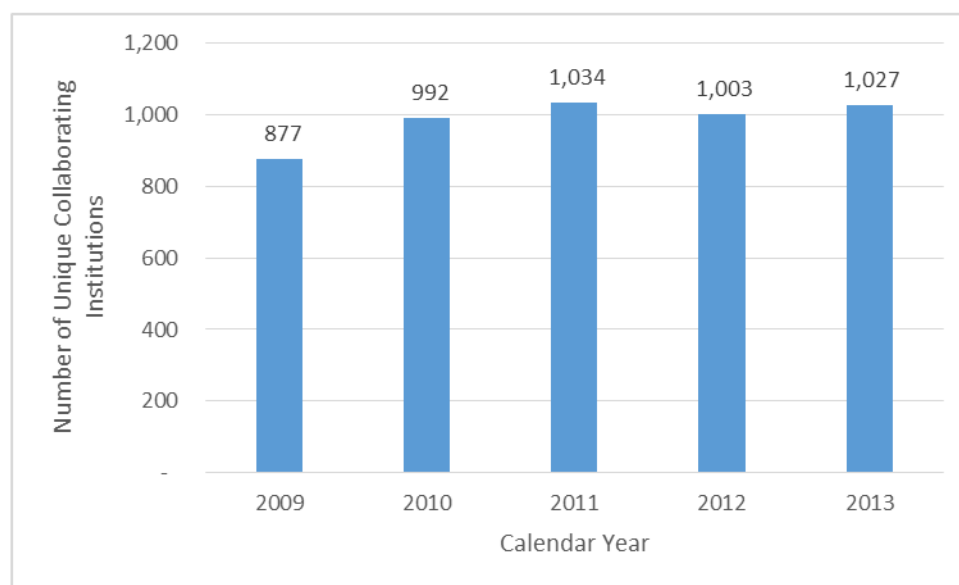


Figure 4: Number of Unique Institutions Collaborating on NIST Publications, 2009-2013

The University of Maryland is the organization NIST collaborated with most frequently on papers (1,095) published from 2009-2013 (Table 1). The University of Colorado is second, co-authoring 692 papers with NIST during the same period. These results are not surprising since NIST has formal relationships with both universities. The top 15 collaborating institutions include 11 U.S. academic institutions and 4 Federal research laboratories.

Table 1: Top Fifteen Collaborating Institutions, 2009-2013

Institution	Number of Papers
University of Maryland	1,095
University of Colorado	692
Oak Ridge National Laboratory	180
University of California, Berkeley	174
Argonne National Laboratory	124
Los Alamos National Laboratory	120
University of Michigan	113
University of Delaware	111
Johns Hopkins University	108
California Institute of Technology	104
Indiana University	101
University of Pennsylvania	100
Massachusetts Institute of Technology	98
Princeton University	98
NASA	94

The majority of institutions that NIST collaborates with fall into the Academic Institution category. Second is Industry, which shows support of NIST’s mission to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life. The “Other” category includes organizations such as hospitals, museums, airports, and police departments (Figure 5).

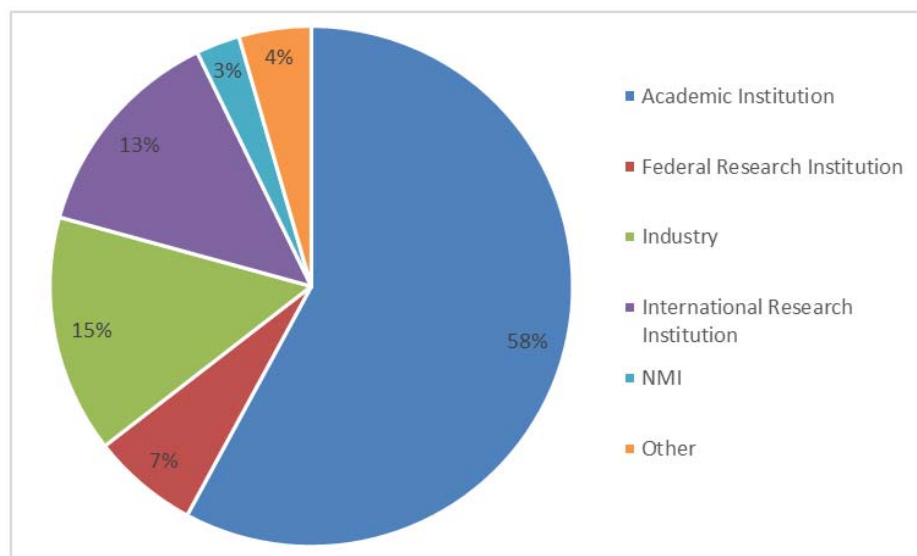


Figure 5: NIST Publication Collaborations by Organization Type, 2013

ISO also studied NIST publication collaborations by state (Figure 6). California, Colorado, Illinois, and Maryland are the states with the most authors collaborating on NIST publications. These results are not surprising since the University of Maryland, the University of Colorado, and several academic institutions in California and Illinois have formal collaborative relationships with NIST.

Figure 6: NIST Publication Collaborations by State, 2009-2013

ISO was able to demonstrate the breadth of NIST collaborations across the entire world. NIST researchers have co-authored papers with researchers from every continent except Antarctica (Figure 7). Visualizing the data in this manner makes it easy to see that NIST collaborates most heavily with European countries (Figure 8), but Asia is also an important partner on publications.

Studying research collaborations by analyzing paper co-authorships is a useful way to demonstrate the impact of an institution and the breadth of its work. This study demonstrated that NIST has a strong history of collaborating with other institutions across the U.S. and across the world. Studying collaborations through co-authorships is just one of several tools that NIST and ISO use to demonstrate the impact of NIST. Other organizations faced with the same task of showing their value may find the methods discussed in this paper to be a helpful starting point on the road to demonstrating the impact of their institution. They can be used to help enhance the prestige of an institution or garner financial support.

Table 2: Top Fifteen Collaborating Countries, 2009-2013

Countries/Territories	Number of Papers
Germany	402
China	313
England	312
Canada	275
France	261
Japan	238
South Korea	179
Australia	131
Italy	130
Russian Federation	121
Netherlands	118
Spain	103
Switzerland	103
Poland	95
Belgium	80

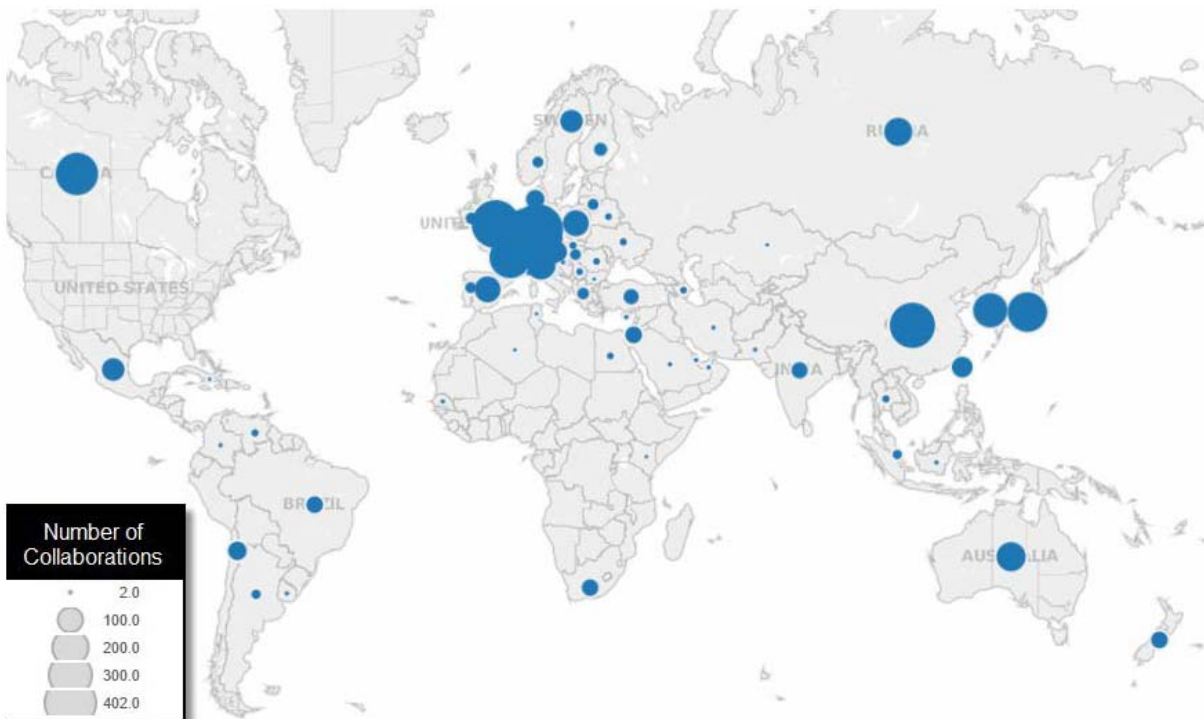


Figure 7: International Collaborations on NIST Publications, 2009-2013

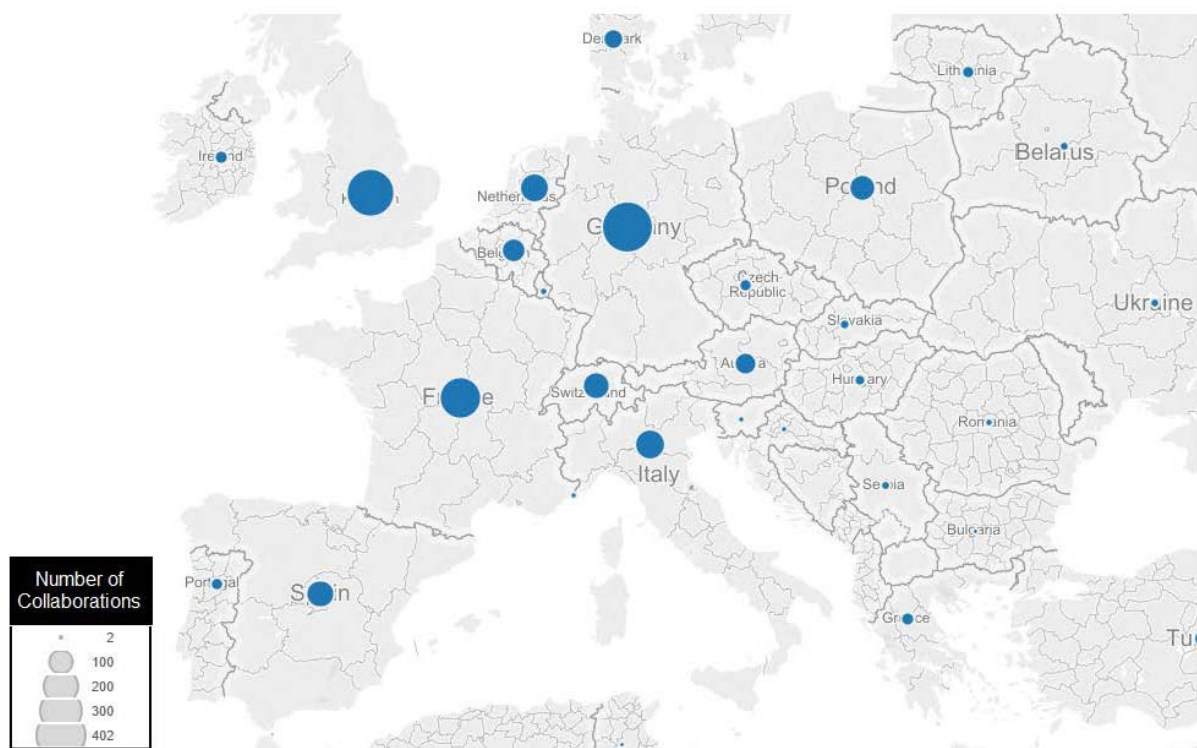


Figure 8: European Collaborations on NIST Publications, 2009-2013

While this study initially analyzed collaboration metrics specific to the number of non-NIST co-authors, and the number of institutions and countries with which NIST collaborates, its scope was expanded to include an analysis by organization type and to determine to what extent NIST collaborates with researchers and institutions in each state within the U.S. Future analyses might be performed to determine to what extent each NIST operating unit (lab, division, etc.) collaborates with outside institutions. ISO also wants to study and map internal collaborations.

Assessing the impact of NIST's research collaborations is just one means of determining the impact of an institution. ISO has also studied the extent to which NIST publishes in the "top tier" journals as a way to assess NIST's impact. ISO developed a methodology for determining the top journals within subject fields and this information was used by senior management in the DOC Technology Transfer Report and NIST's Balanced Scorecard. ISO continues to develop other methodologies to assess the impact of NIST's research.

Analysis and visualization software are valuable tools for displaying the results of findings. The visualization of data through the use of tables, graphs, and maps used in this study are simple yet effective means of demonstrating impact. However, to meet the growing needs to assess and demonstrate impact, ISO intends to expand its portfolio of data visualization tools to include network mapping and interactive visualizations.

While ISO has many tools at hand for conducting its publication and impact analyses, the staff is constantly working to enhance their analysis skills by identifying new tools and applications. This has led ISO to create a work space within the NIST Research Library for both Library customers and ISO staff to use innovative tools to analyze data in new ways. As such, the Library's Innovation Corner offers opportunities for all to learn and develop a portfolio of bibliometric, analysis, and data visualization skills.

CONCLUSION

In response to a request from NIST senior management, ISO developed a methodology for assessing the impact of NIST research collaborations by studying co-authorships on peer-reviewed papers. It continues to develop and refine this methodology through the use of new tools and techniques. Through its assessment activities, ISO was

able to demonstrate that the impact of NIST's publications is broad and far-reaching. Each year NIST collaborates with thousands of authors from about 1,000 institutions in almost 70 countries.

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