NIST Economic Analysis Briefs 6

NIST Impact on Patenting

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October 2016

Key Findings

- NIST has a large and growing impact on invention - two orders of magnitude greater than indicated by NIST-invented patents alone.
- Laboratory practices that prioritize only one type of technical output could negatively impact NIST's ability to effectively transfer technology.
- Technology transfer policy focused primarily on patented inventions will miss opportunities to enhance impacts through alternative outputs.
- Growth in citations to NIST laboratory outputs exceeds comparison groups.
- Past NIST extramural programs have long-lasting and increasing impact on private sector invention.

Introduction

Called to action by a 2011 Presidential Memorandum and recognizing the varied approaches the institute takes to ensuring that knowledge, capabilities and facilities produced and managed by the National Institute of Standards and Technology (NIST) are disseminated to its stakeholders, NIST adopted a new and broad definition of technology transfer. Technology transfer is the overall process by which NIST knowledge, facilities, or capabilities in measurement science, standards and technology promote U.S. innovation and industrial competitiveness in order to enhance economic security and improve quality of life. This encompasses knowledge transfer to individuals and organizations as well as commercialization or adoption of NIST research outputs by businesses and other organizations. Under this broad definition, previous technology transfer metrics do not capture the totality of NIST impacts on invention. NIST recently commissioned an analysis to comprehensively examine NIST impact on inventive activity.

NIST and Inventive Activity

Historically, NIST has measured its impact on inventive activity by counting the number of patents issued each year to NIST-employed inventors. Annually, the number of NIST-assigned patents varies but is rarely over twenty. Given that inventors refer to these patents as prior art, reference NIST publications, use NIST data and reference materials to calibrate their scientific equipment, reference NIST software and algorithms and cite less formal outputs such as NIST workshop presentations, it is likely that the count of NIST-assigned patents understates the true impact of NIST on inventive activity.

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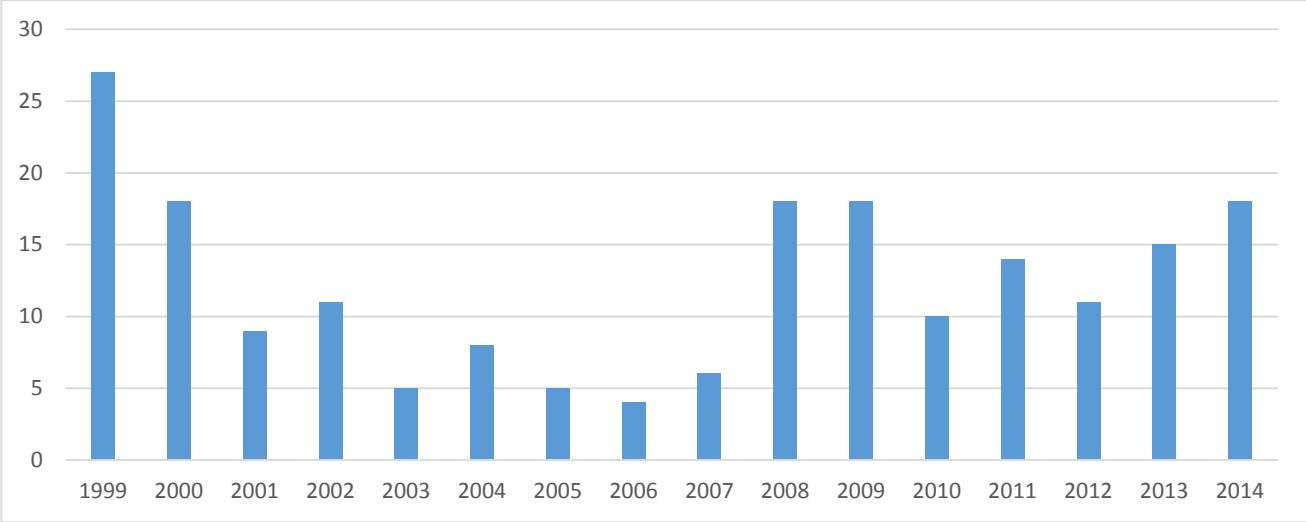
Figure 1: NIST-Assigned Patents



Role of Citation Analysis

While inventors are required to cite prior art in their patent applications, researchers have found that these references are an important indicator of knowledge flow.[1] Even if these references are a "bit noisy,"[2] studies show there is a strong positive correlation between citations and technological importance[3] as indicated by awards,[4] expert judgement[5] and continued payment of maintenance fees.[6] Research has also found a positive relationship between patent citation indicators and business financial performance.[7] Further, patent to publication citations have been used to indicate application of science to technology[8] as well as to measure knowledge transfer from public[9] and federal scientific institutions.[10] Finally, patent references have been used to demonstrate knowledge transfer from voluntary consensus standards groups.[11]

Methodology

To identify the range of citations to NIST, the analysis first assembles data on an array of outputs of NIST research. The report leverages existing data on NIST-invented intellectual property maintained by the Technology Partnerships Office, employs a novel database containing all NIST peer-reviewed

Table 1. NIST Technical Outputs	
Traditional Technical Outputs	**Grey Literature**
1. NIST-Assigned Patents	4. Educational Networking
2. NIST Government Interest Patents	5. Software/Standard Reference Databases/Algorithms
3. NIST-Authored Peer-Reviewed Publications	6. Standard Reference Materials/Resource Materials/General Information
	7. Official NIST Publications (not peer-reviewed journals)
	8. Joint Partnership Publications (not peer-reviewed journals).
	9. Other NIST (non peer-reviewed) publications
	10. Communication / Correspondence / Inquiries
	11. "Other"

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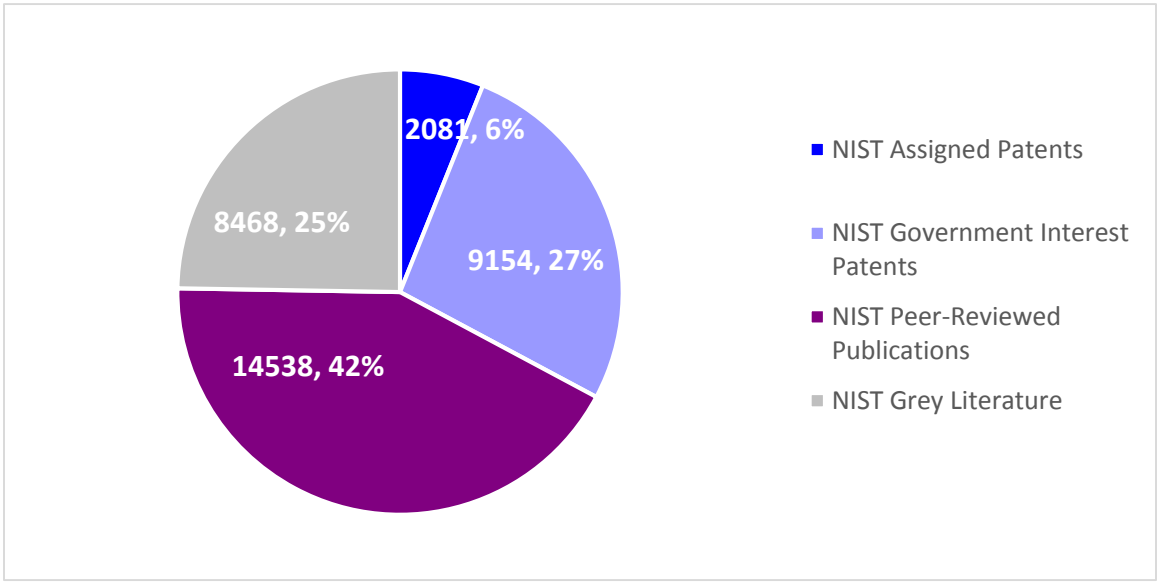
publications since 1900 constructed using NIST's subscription to Thompson-Reuter's Web of Science,[12,13] and develops search algorithms to identify a set of patents that cite NIST in the Government Interest Section of patents.[14] References to these NIST outputs indicate that businesses and other organizations have adopted and used NIST knowledge, facilities, or capabilities in their own inventions. Additionally, the analysis develops algorithms to identify any other references to NIST technical outputs cited in the non-patent references section of patents. Together, this array of additional outputs is referred to as "grey literature." The analysis analyzes the role of grey literature as a whole and considers the impact of distinct types of technical outputs such as Standard Reference Data, Standard Reference Materials, official NIST publications and less formal outputs such as conference and workshop presentations.

Results

Figures 1 and 2 below show the magnitude of NIST impact on inventive activity and highlight the diverse channels through which these impacts are felt. In total, there are over 34,000 patent references to NIST research outputs between 1970 and 2014. The plurality of these references are to NIST peer-reviewed publications but references to NIST grey literature and government interest patents[15] each account for over 25% of the references. Nearly all of the Government Interest Patents are inventions created by companies funded through NIST's Advanced Technology Program and Technology Innovation Program. Over time, the number of annual citations has risen. In 2014, there were more than 4,500 references in more than 3,000 unique patents. Given overall increases in patenting and natural growth in the collection of NIST outputs, additional analysis is needed to identify the extent to which these trends indicate an increase in impact or relevance rather than general trends in patenting and an accumulation of NIST outputs. Breitzman and Thomas (2016) use standard normalization techniques to examine citations to NIST patents. While NIST assigned patents underperform patents with a similar technological focus and age, the limited number of patents – just 122 patents between 2005 and 2014 – diminishes the significance of this result. On the other hand, NIST Government Interest Patents are cited over 60% more frequently than expected. Due to the novelty of the approach used in this paper, there are no established normalization techniques for

Figure 1: Citations to NIST Technical Outputs 1975-2014



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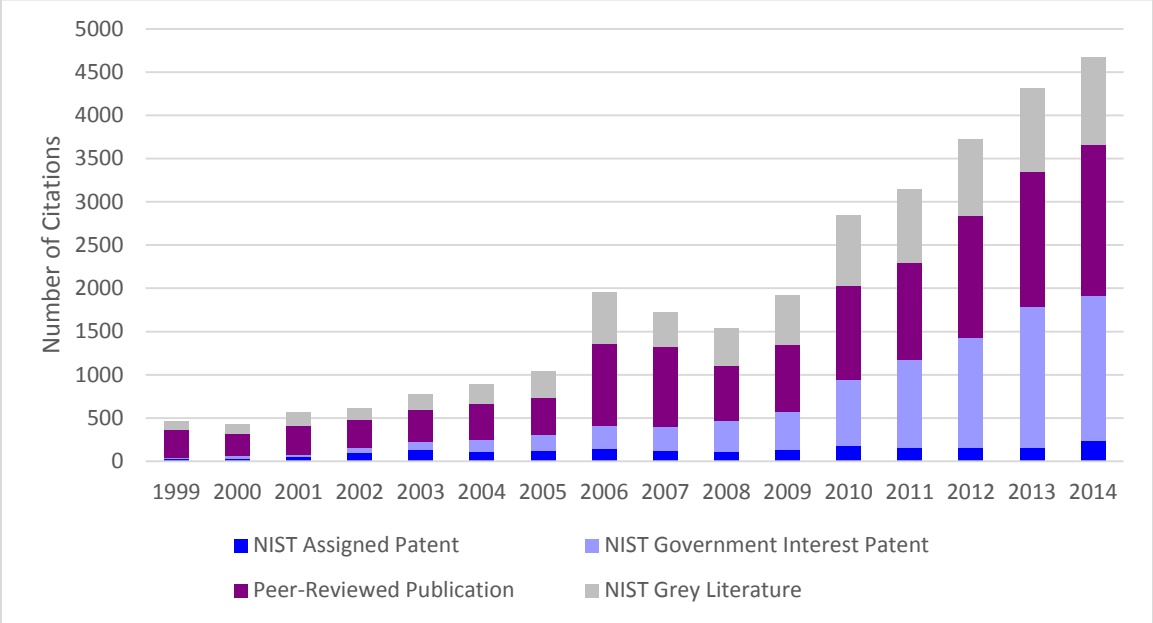
patent to publication citations. Therefore, patent to NIST paper and patent to NIST grey literature trends were compared to publications from a selective group of journals and a leading academic institution respectively. The growth in patent citations to NIST publications has outpaced the growth in patent citations from the 40 most active patenting companies to papers in leading journals. Additionally, the growth in patent references to NIST Grey Literature has marginally exceeded the growth in references to grey literature from the Massachusetts Institute of Technology.[16] Breitzman and Thomas [7] find that the performance of NIST technical outputs in generating subsequent citations is "impressive."

Figure 2: Patent Citations to NIST Technical Outputs



The report also examined how different companies, industries, and technology sectors cite various types of NIST technical outputs. While the full report looks at both grey literature as a whole and examines the more detailed categorization identified in Table 1, for brevity Figure 3 only shows the results by industry and detailed classification scheme. The results clearly show both that particular industries rely on a variety of NIST technology transfer tools and that there is significant variation across inventors with respect to the type of NIST technical output cited. So while industrial equipment relies heavily on peer-reviewed publications, grey literature is the most frequently relied upon technology transfer tool within the software industry. Different types of NIST technical outputs - different technology transfer tools - are used by different sectors and companies.

Findings

The variety of NIST technical outputs considered in this analysis closely corresponds to the technology transfer tools identified in NIST's response to the 2011 Presidential Memorandum on Technology Transfer. The data presented in Figures 1 and 2 show that NIST has a large and growing impact on invention. NIST impact on invention is at least two orders of magnitude greater than indicated by counting NIST-assigned patents. Counting patents attributed to NIST-employed

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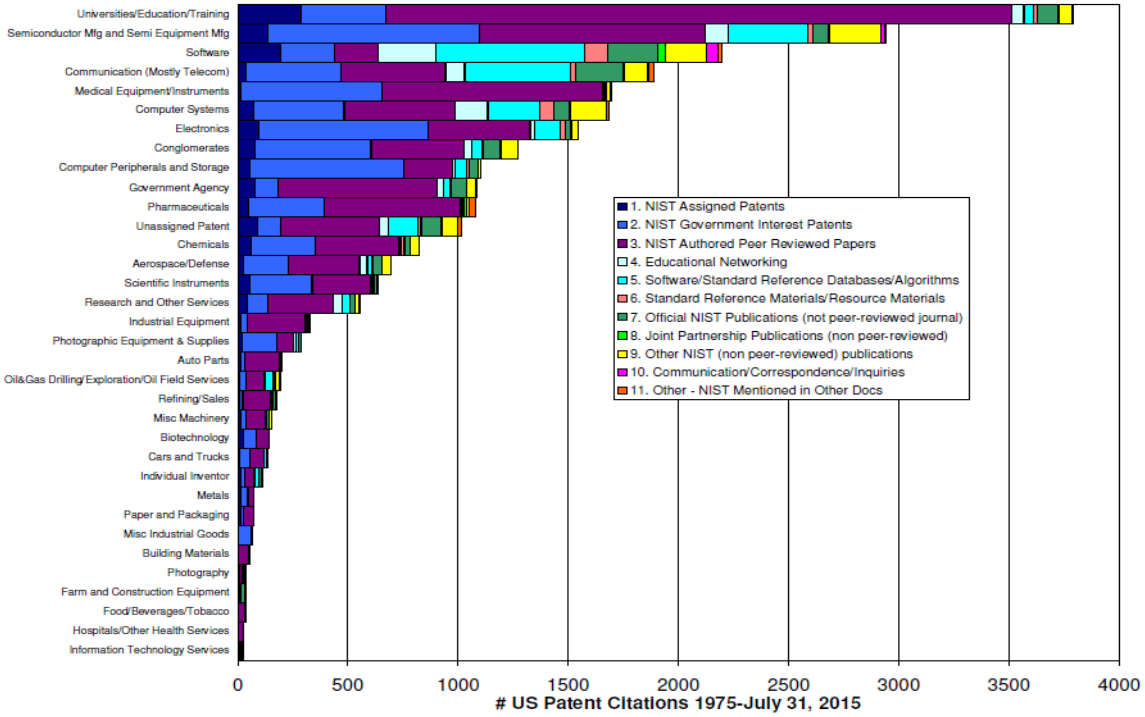
Figure 3: Usage of NIST Technical outputs by Industry



inventors neither indicates that the invention is used by other companies or organizations nor accounts for the variety of channels through which NIST impacts inventive activity. As discussed above, citations are a noisy but important indicator of knowledge transfer. Identifying the magnitude and varied usage of different types of NIST outputs represents a significant improvement in NIST impact metrics.

Further, the results clearly indicate that different companies, industries and technologies rely on different types of NIST technical outputs. That is to say different stakeholder groups rely in different modes of technology transfer. Because of this variation in stakeholder usage of types of NIST technical outputs and technology transfer tools, any policy that prioritizes or encourages one type of NIST technical output over another could negatively impact NIST's ability to transfer technology. Similarly, technology transfer policy that focuses primarily on increasing the number of NIST inventions will miss significant opportunities to enhance NIST impacts on invention through other channels.

The results also indicate the high quality of NIST scientific and technical outputs. The growth rate in citations to NIST publications and grey literature outpaces prestigious and highly selective comparison groups like MIT. Finally, Figure 2 shows that NIST extramural programs have long-lasting and increasing impact on private sector invention. The number of citations to patents resulting from the NIST's Advanced Technology Program and Technology Innovation Program continue to increase even though these programs have been discontinued. NIST government-interest patents have over 60% more citations that patents of identical age and technology area. Further, citation indices show that the magnitude and breadth of the impact of these patents is highest for more recent time periods.

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[1] See Jaffe and Lerner [11] and Jaffe and Trajtenberg [14] for an overview and critique.
[2] See Jaffe *et al.* [15].
[3] See Breitzman and Mogee [4].
[4] See Carpenter *et al.* [8].
[5] See Albert *et al.* [1].
[6] See Haroff *et al*. [10].
[7] Research has examined correlation with market valuations (Zhen *et al*. [9]), stock price movements (Thomas and Narin [29]), as well as sales and profitability (Narin *et al*. [19]).
[8] For recent examples, see Breitzman [5,6]and Azoulay at al. [3].
[9] Roach and Cohen [22]
[10] See Narin *et al.* [20] and Reugg and Thomas [23], [24], [25] and [26].
[11] See Breitzman [5] and [6].
[12] A commercially available product is identified in this paper in order to specify the experimental procedure adequately. Such identification is not intended to imply recommendation or endorsement by NIST, nor is it intended to imply that the materials or equipment identified are necessarily the best available for the purpose.
[13] NIST subscribes to the Science Citation Index Expanded and Conference Proceedings Citation Index-Science databases.
[14] Jaffe and Lerner [12] demonstrate both assignees and government interest sections need to be searched to identify the complete set of government inventions.
[15] The data demonstrate that over 90% of the patents identified through the Government Interest search are attributable to NIST extramural programs. Citations to these patents are a NIST impact but not indicative of technology transferred from NIST laboratory research programs.
[16] Due to a lack of established benchmarks and normalization approaches for publications and grey literature, growth rates in publication and grey literature citation rates were compared to previous work performed by 1790 Analytics. For more details, please see Breitzman and Thomas [7].

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