Measuring the Impact of Knowledge Transfer from Public Research Organizations: A Comparison of Metrics Used Around the World

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Abstract

Technology Transfer has been used very generally to describe the movement of ideas, equipment, and people among institutions of higher learning, the commercial sector and the public. However, this conventional approach is now evolving into the broader concept of Knowledge Transfer, which describes the movement of knowledge, ideas, concepts and techniques from a formative location, generally institutions of advanced education, out to all areas of the social and economic environment.

This paper will examine both traditional and innovative methods of quantifying and qualifying the benefits of Knowledge Transfer around the world.

Keywords

Knowledge transfer, measures, effectiveness

INTRODUCTION

In 1980, the United States government enacted the Bayh-Dole Act, allowing universities, small businesses and not-for-profit organizations to control intellectual property (IP) resulting from federally-funded research. This has encouraged institutions to actively develop suitable technologies to be transferred. Since this legislation was passed, the number of patents issued to federally-funded research institutions has increased from 250 to over 2,000 annually.[1]

While most public research organizations (PROs) still consider their primary mandate to be the dissemination of knowledge, the US is serving as an example of how PROs can derive commercial benefits from their technologies. Consequently, institutions of advanced education around the world have followed the lead of the US in the processes of knowledge transfer, and to a certain extent the evaluation of their effectiveness, by creating their own technology transfer offices (TTOs).

TTOs have the responsibility to commercialize the practical applications of fundamental research from PROs. Efforts to transfer knowledge, ideas, concepts and techniques are a critical step in improving the social and economic well-being of society.

The technology transfer industry thrives on its ability to deliver tangible results to its various stakeholders. PROs, such as universities and research institutions, are continuously striving to impact the economy by training highly qualified personnel (HQP) and commercializing new and exciting innovations. The parties interested in how an institution is performing in the latter area include policy makers, taxpayers, venture capitalists, and private sector businesses. There are several key reasons to measure the effectiveness of knowledge transfer activity at PROs:

- To demonstrate the benefit to society from advances in knowledge
- To educate on society's need for innovation
- To ensure sufficient returns on investment
- To provide benchmarks for comparison across the industry
- To promote competition in the global marketplace
- To support future appeals for funding

The vast amount of published literature on the subject indicates the importance of knowledge transfer measurement for all stakeholders. Thus, the purpose of this paper is to compare the metrics used by institutions of higher learning around the world for these reasons:

- To examine the traditional metrics used to quantify and qualify the effectiveness of knowledge transfer activity
- To explore and further develop innovative metrics
- To uncover regional differences in the evaluation of knowledge transfer processes and outcomes

MEASURING EFFECTIVENESS

Providing practical evaluations of effectiveness proves a significant challenge to technology transfer professionals. In order to measure performance, a variety of metrics are used by each organization. Technology transfer industry associations often collect, compile, and analyze performance data in a particular region. The primary method by which these associations collect data from members is voluntary surveys, whose results are generally disseminated through annual reports. The data is commonly of a quantitative nature, although some organizations appear to be moving towards more abstract, subjective measures, such as anecdotes and case studies.

At the present time, the technology transfer industry does not have global evaluation standards, due in part

to the lack of a central authority, within each jurisdiction, managing PROs and their industry liaison offices.

METHODOLOGY

The data used in this paper were collected from a range of sources, including the annual surveys of AUTM, ASTP, and national statistics agencies. Various other associations, universities, research institutions, private sector businesses, and law firms were identified and contacted via e-mail and asked to supply a list of the metrics currently used in their organization. Next, the snowball method was used to generate additional responses; the initial contacts, considered experts in their fields, were asked to forward the e-mail request to other professionals or to suggest organizations that might be able to supply the requested information. Electronic journals were also consulted for relevant academic research. Respondents were then classified for analysis and comparison according to region.

FINDINGS

North America

Headquartered in the US is the Association of University Technology Managers (AUTM), perhaps the most widely regarded industry association. AUTM functions predominantly in the US and Canada, but comprises several thousand global members. Many of the association's American and Canadian members participate in the annual licensing survey. This survey serves as the benchmark with which other associations compare data.

The Alliance for Commercialization of Canadian Technology (ACCT) is the spin-off of AUTM created by Canadian members. ACCT is working with Statistics Canada, the national statistics agency, to develop standard measures that will ensure consistency in evaluations across Canadian PROs.

Furthermore, the governments of both Canada and the US have each created initiatives to support domestic R&D and the transfer of these innovations to the private sector. These funding agencies often require institutions to submit performance results on a regular basis.

In general, North American associations appear to provide the most widely used measures of knowledge transfer effectiveness. The primary metrics used by most PROs are:

1. Number of invention disclosures
2. Number of US patent applications
3. Number of licenses executed
4. Total income from licenses
5. Number of start-up companies formed

Secondary metrics:

1. Value of sponsored research expenditures
2. Number of US patents issued
3. Number of active licenses
4. Total income from royalties
5. Number of full-time professionals in TTOs
6. Legal expenditures on protection of IP

In addition to these traditional measures, some TTOs also consider these aspects of knowledge transfer:

1. Ability to attract and retain distinguished, entrepreneurial faculty
2. Average faculty salary
3. Ability to attract outstanding graduate students
4. Contribution to the institutional reputation for innovation[2]

These results present an innovative look at the effectiveness of knowledge transfer activities. Items 1 and 2 of the preceding list are related in that average faculty salary is perceived to be an indicator of faculty quality. Likewise, the ability to attract high-quality graduate students suggests that the PROs and research conducted therein is reputable.

Europe

The Association of European Science and Technology Transfer Professionals (ASTP) is considered one of the primary industry groups in the region. ASTP counts several hundred global members, but unlike AUTM, it focuses on knowledge transfer activity in European countries. ASTP explicitly compares its survey to that of AUTM, although it acknowledges some issues that decrease the comparability of the two independent surveys.

The University Companies Association (UNICO) survey concentrates solely on university-industry linkages and thus does not include data from other federally-funded research institutes. Each year, UNICO publishes its annual survey on university commercialization activity. Similar to ASTP, UNICO created its survey in view of the metrics used by AUTM.

The Pan-European Network of Knowledge Transfer Offices (ProTon) promotes the advancement of knowledge transfer in Europe through establishing good practices and providing networking opportunities for its members. In 2005, ProTon unveiled its first annual survey, which the association is confident will become the European equivalent of the AUTM survey.

ProTon's Ethical Forum is an opportunity for members to discuss the ethical issues associated with patenting acquired knowledge. The association offers the critique that the license model, in which PROs license their technologies to companies for sale and distribution around the world, is unsuccessful in Europe for a number of reasons. This is in contrast to the success of the license model in the US since the Bayh-Dole Act. The first reason is that many European countries have not adopted the US practice of ownership of results. For example, employees at many European PROs are allowed to retain the rights to their IP. These employees may lack the resources or interest to commercialize their technologies to the same extent as TTOs. Furthermore, European PROs face a significant challenge in the patenting process at the European Patent Office, which is much less efficient than that of the US Patent and Trademark Office. This idea has been echoed by other European organizations. Perhaps the most significant reason is that European industry has not been provided incentives to support domestic PROs. Consequently, most license agreements with PROs in Europe

are signed with foreign firms.[3] However, it should be noted what constitutes "best practices" for US PROs may not necessarily work for those in Europe and other regions. We must also be cautious in our definition of success.

As the European surveys are based primarily on those from North America, it is not surprising to find that most measures used are unremarkable. However, ProTon provides to its members a set of comprehensive guidelines with which knowledge transfer offices (KTOs) can evaluate their activities.

Some progressive metrics advocated by ProTon include:

1. Annual KTO operational budget (excluding financial resources for IP protection or seed capital)
2. Share of KTO budget by origin
3. Number of confidential disclosure agreements executed during the year to enable disclosure of PRO know-how
4. Number of material transfer agreements executed for material originating from the PRO
5. Number of licenses/options executed within the year based only on know-how
6. Licensee profile
   a. Domestic SMEs
   b. Domestic large companies
   c. Foreign companies
7. Number of technical services executed and revenues deriving from these services
8. Number of public collaborative research project proposals submitted with KTO assistance
9. Spin-offs that have realized a capital increase during the year
10. Spin-offs that have ceased operation
11. Relationship between PRO and spin-off
12. Number of investments in PRO made within the year
13. Seed capital managed, invested within the year
14. Number of and revenue generated from companies and other entities that are clients/partners of the PRO in knowledge transfer activities serviced by its KTO

Item 6c would not be applicable to all PROs, as guidelines for licensing to foreign companies vary between organizations and regions.

Asia

Few countries in Asia appear to have well-organized technology transfer industry associations that collect data on performance and effectiveness. The Asian and Pacific Centre for Transfer of Technology (APCTT) operates under the United Nations Economic and Social Commission for Asia and the Pacific, and serves to enhance knowledge transfer capabilities in the region. However, it is unclear if APCTT publishes a survey on knowledge transfer performance.

The areas in Asia on which this paper intends to focus are China, Japan, and Singapore; these countries are considered to be the most prominent emerging players in the technology transfer industry in Asia at this time.

Although the technology transfer industry in Asia is growing at a rapid rate, it is still considered to be in its infancy and is therefore following the lead of other regions in its activities and evaluations. Our research failed to reveal any notable metrics of an innovative nature in Asian TTOs besides the number of national or provincial scientific awards garnered by the PRO.

Generally, it appears that TTOs in Asia use similar metrics to those outlined in the annual AUTM licensing survey. However, data gathered from organizations in Asia suggest that there are relatively fewer measures used compared to their North American and European counterparts. Common metrics include the abovementioned primary measures for North American knowledge transfer.

DISCUSSION

Few organizations were able to provide a comprehensive list of metrics; most were brief, comprising only four or five measures. Although the original request for information sent to various organizations requested only a list of metrics, some respondents expressed a genuine interest in the study and were eager to be of assistance. As a result, we received written testimonials of the lack of success experienced in regards to accurately evaluating knowledge transfer activity.

Since there is no internationally recognized or accepted standard, the general consensus is that organizations are unsure of how to most accurately gauge the effectiveness of their knowledge transfer activity. A high number of respondents suggested that this is a widespread problem and indicated the desire to have a standard set of metrics with which an organization could compare itself to others in the industry. It is widely acknowledged that creating a standard set of metrics would be challenging, primarily because of the lack of consensus on what the measures should be and who should develop and enforce these measures.

While some technology owners perform commercialization activities in-house, others seek the services of external parties who specialize in technology transfer. These independent service providers often approach the evaluation of knowledge transfer effectiveness in a different way than their clients would. For example, these clients may be conglomerations of smaller departments, each of whom uses its own set of metrics to measure performance. Thus, the metrics used by different divisions within a single organization often reflect the varied objectives.

Interestingly, some organizations count the number of references to a research project in scientific literature as a measure of knowledge transfer effectiveness.

Case Study

TRIUMF is a subatomic physics research laboratory operated by a consortium of Canadian universities, pri-

marily under a contribution from the Canadian government. In addition to the basic research performed at the facilities, TRIUMF develops and commercializes practical applications of its technologies.

TRIUMF's funding agreement outlines its responsibility to "pursue activities designed to maximize the economic benefits to Canadian companies through the vigorous pursuit of technology transfer activities, contracts and procurement policies." This presents a conflict between the principal mandate to focus on basic research and the necessity to secure funding for these activities.

TRIUMF has adopted an approach to performance metrics based on output rather than input because of its focus on achievements instead of effort expended. Due to its obligations to the federal government, TRIUMF measures its knowledge transfer activity largely with quantifiable economic metrics. However, in addition to those commonly used by other PROs, the Technology Transfer Division at TRIUMF strives to use innovative measures of effectiveness. These non-traditional metrics include:

1. Number of students employed
2. Value of TRIUMF-sponsored Canadian conferences
3. Number of public visitors participating in tours of the TRIUMF facilities
4. Number of Saturday scientific lecture attendees
5. Number of industrial alliances with whom TRIUMF has interacted[4]

Items 3 to 5 were recently introduced to measure more intangible contributions to Canadian society and the economy through different means of communication. Although these metrics do not have an obvious impact on revenues, they are able to indicate the effective transfer of knowledge resulting from TRIUMF activities.

Limitations of Metrics

Measuring the effectiveness of knowledge transfer solely within one's own organization is already a complicated, time-consuming process. Without a clear requirement outlined in the objectives of PROs to perform thorough measurement on a regular basis, the task can easily find itself a low priority.

The emphasis on the ability to quantify measures is not conducive to sharing anecdotal responses that may be useful in broadly assessing performance and in creating more relevant measures. Currently, the use of inconsistent metrics across organizations makes direct comparison essentially impossible. Although some measures use the number of employees or amount of research funding in dollars as denominators to create comparable ratios, there is still not one standard measure. Additionally, some metrics, including royalty income, are used despite their being a more accurate indicator of past successes than of current activities.

To further complicate the process of creating a standard set of metrics, broad measures are inherently biased. One issue is that there are often differences between organizations in their definitions of the measures, since there is much room for interpretation. For example, there may be an ambiguity in the counting of patents; if patent applications are filed or granted in multiple countries, the question exists if they should be counted for each instance. Measures may fail to distinguish between slight modifications of existing technologies and radical innovations. Furthermore, surveys are commonly distributed in English, although not all respondents have equal fluency.

Incentives play a key role in the decision of which measures will be employed; naturally, if the objective of an organization is to prove to its funding bodies that it is maximizing their return on investment, then the measures used will reflect the financial aspect of technology transfer rather than the process by which knowledge is disseminated in society. Consequently, the goal of PROs to conduct basic research often conflicts with the goal of their commercial partners to maximize profits. This results in a dichotomy between short-term and long-term focus; PROs strive to balance immediate commercialization—and in doing so, being accountable to their funding bodies—with advances in science that have the potential to benefit society.

The Organization for Economic Co-operation and Development (OECD) is an assembly of the governments of 30 member countries dedicated to democracy and the market economy. OECD's mission includes the promotion of policies to facilitate academia-industry collaborations. Membership comprises some of the world's most important economies, but with notable omissions; China, which OECD predicts will surpass Japan by the end of 2006 to become the world's second largest investor in R&D behind the United States, is not a member.

OECD identifies four fundamental problems encountered by organizations when attempting to measure the effectiveness of knowledge transfer activity:

1. Timing: the lapse between the completion of research and the effects on society
2. Attribution: crediting some portion of impact to the sources used in developing a new innovation
3. Appropriability: the difficulty in identifying all parties affected by the research
4. Inequality: skewed results from the lack of attention to contrasts in project size; most effects are ascribed to large-scale research[5]

These are significant impediments to the accurate, timely, and relevant evaluation of knowledge transfer activity and its impact on the economy and society.

RECOMMENDATIONS

When measuring the effectiveness of knowledge transfer activity, it is important to consider these distinctions:

1. Inputs vs. outputs

Inputs are easier to measure than outputs and are therefore frequently used, but they show little indication of the production of tangible benefits for the economy and society. Whereas input measures, such as number of invention disclosures, prove that activity has occurred, output measures are more meaningful in that they evaluate the results of the TTO's efforts.

2. Quality vs. quantity
   Output measures are not without their flaws, however. Currently, there is no mechanism to distinguish between the quality and quantity of the results being measured. Since these metrics evaluate effectiveness and may in turn affect funding and other considerations, there is an incentive for TTOs to overstate their numbers. This raises an issue with accuracy. The number of spin-offs can be taken as an example. This metric does not explicitly take into account how successful the venture becomes; indeed, the spin-offs included in the measurement may not even be commercially viable. Without controlling for this, PROs with an abundance of financial and human resources may be able to incorporate a higher number of companies to inflate their results. Hence, they could be considered more successful than a smaller PRO whose few spin-offs create more positive economic and social benefits for the community.
3. Subjectivity vs. objectivity
   Subjective measures of knowledge transfer effectiveness are naturally biased and therefore may not provide useful evaluations. These measures, such as the quality and potential of an invention, or the significance of a transferred technology to a company or institution, not surprisingly lend themselves to exaggeration. While anecdotal evidence and other subjective evaluations may provide an opportunity to elaborate on less concrete aspects of knowledge transfer effort, opinions are not useful for comparison and benchmarking.
   Conversely, objective measures could be considered more practical because they allow TTOs to directly compare results with their own from previous years or with those of other organizations. For example, an objective measure would be number of "technically unique patents," terminology used to avoid multiple counting of patents issued in different countries for the same invention.[6] These results are observable, measurable, and unbiased.
4. Time series vs. cross-sectional analysis
   TTOs have the option of either comparing the results of knowledge transfer activity within their organization or with those of other organizations in the industry, over time or at one moment.
   The first method, known as time series analysis, can accurately demonstrate the underlying cause of changes and predict trends. For instance, the licensing of a technology in one year may lead to a marked increase in license revenues in subsequent years. This will be reflected in time series analysis. It also controls for the difference in resources at the disposal of each TTO, since it compares an organization with its own results in previous years. To be more effective, however, the data should be compared with the progress of other organizations.
   On the other hand, cross-sectional analysis provides a snapshot of results at a single point in time. This type of analysis is used by many of the technology transfer industry associations, primarily because of the ease with which data can be collected and recorded. However, it is not necessarily the best indicator of effectiveness because it compares TTOs of varying sizes, which may not give an accurate picture of performance.

In deciding which knowledge transfer metrics to use, PROs must examine their underlying motivations for measuring effectiveness. TTOs should adopt innovative measures to gauge the intangible effects of knowledge transfer activity on the economy and society. The non-traditional metrics used by TRIUMF and those advocated by ProTon could serve as a framework. Furthermore, TTOs should focus on measuring outputs rather than inputs if their objective is to measure the success of knowledge transfer practices, as these results would be more useful to its stakeholders, particularly industry and policy makers.

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