A review of performance standards to monitor, evaluate and assess the impact of technology transfer offices

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ABSTRACT

The conversion of scientific discoveries to new products and processes and their launch onto the market can be a lengthy process. Similarly, it takes many years before the impact of scientific research on society and the economy is realised and a further length of time before its performance can be measured. Higher education and research institutions, and their governments, often make significant investments into intellectual property management and technology transfer activities through legislative and policy development, human resource development, financial allocation and infrastructure improvement. Since returns on such investments are not immediately apparent, it is important to establish a means by which the impact of their efforts can be determined. In this paper, I examined the measures and indicators that could be developed by institutions and their stakeholders in order to monitor, evaluate and determine the impact of research output and outcomes on the market.

INTRODUCTION

What's the use of running fast if you're not on the right road? – Old German Proverb[1]

South African higher education and research institutions are growing to appreciate the value of intellectual property (IP), which is evident in the establishment of in-house IP management and technology transfer offices (TTOs) to manage the various aspects related to IP and its transfer from the research environment to the market. The capacity to manage IP varies considerably across institutions; the Council for Scientific and Industrial Research, the Medical Research Council and the Universities of Cape Town, Pretoria, the North-West, Stellenbosch and the Witwatersrand all having relatively well-established and resourced TTOs,[2,3,4] while, at the other end of the spectrum, some institutions may have a single person who, in addition to other responsibilities, is expected to oversee the institution's entire IP management portfolio and its transfer to the market. As the level of awareness, experience and knowledge of IP and all its facets increases, TTOs are using more sophisticated methods to manage and transfer IP to the market, as is evident from the structures and policies being implemented for these activities. Furthermore, institutions are developing the capacity and capability to effectively exploit existing and newly generated IP.[3]

Figure 1 is an illustration of IP value as a function of the strategic use of IP.[5] As indicated in the figure, the most basic function is to create and maintain IP, which is now standard practice at the more research-intensive institutions in South Africa. On observation, the majority of local institutions operate between level 0 and level 2 of the illustration. As institutions graduate from the start-up phase, gaining more transactional experience and know-how, and as increasing resources are deployed to IP management and technology transfer activities, it becomes necessary to monitor and evaluate the performance of TTOs.

Several stakeholders have an interest in TTO operations. Scientists require reasonable turnaround times, good coordination, effective IP management and successful technology transfer of their ideas to the market. Institutional leaders are under increasing pressure to justify their spending on IP protection, human resources, training and technology transfer activities and would therefore want to evaluate the effectiveness and efficiency of TTOs. Government, on the other hand, is concerned with the contribution of science and technology to the application of various socio-economic solutions that result in the betterment of people's lives.

I have thus structured this paper in two parts: Part 1 discusses the importance of a monitoring and evaluation (M&E) system and the value that institutions could derive from implementing such a system, while Part 2 deals with common indicators to assess the performance of TTOs.

PART 1: THE IMPORTANCE OF A MONITORING AND EVALUATION SYSTEM

Definitions relating to monitoring, evaluation and impact assessment

An undefined M&E and impact assessment system is open to varying interpretations and, as a result, variable outcomes can be anticipated. For the purposes of this paper, the terms 'monitoring', 'evaluation' and 'impact' shall have the meanings set out below.

'Monitoring'[6] involves data recording, analysis, reporting and information storage. It is the continuous assessment of TTO activities against (predetermined?) expected deliverables. The outcome of monitoring should be a set of corrective actions at the operational level.

'Evaluation',[6] on the other hand, is a periodic assessment that involves the analysis of data generated during monitoring, as well as information gathered from other sources. The recommendations generated from the evaluation process are used to affirm or modify objectives, resources and processes.

'Impact'[6] is the intended and unintended effects of a given intervention on target beneficiaries. The resulting impact can include economic, sociocultural, environmental and institutional effects and

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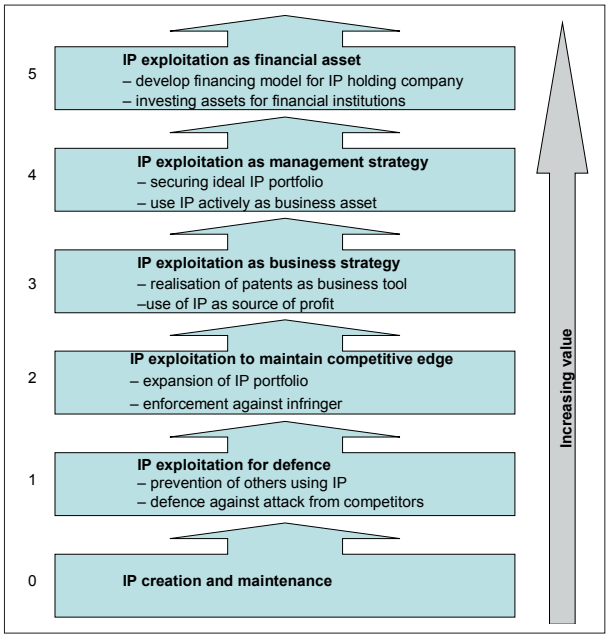

Source: Otsuyama[5]

FIGURE 1
Intellectual property (IP) value as a function of strategic use

can affect production. Depending on the result of the impact, behaviour, practice and/or circumstances could change.

Why is M&E and impact assessment important?

Monitoring is a valuable management tool that can be used to improve technology transfer initiatives by identifying aspects that are working according to plan and yielding positive results, while also identifying those initiatives that require mid-course corrections.[6] Competence is required to develop relevant indicators for implemented initiatives and required interventions. At the same time, capacity is necessary for information collection, analysis, verification and reporting. Developing structures to carry out all of these activities requires management commitment, resources and time allocation. However, without appropriate robust incentives, whether monetary or non-monetary, institutions are unlikely to focus on the development of M&E systems.

Besides reporting on institutional performance, a good M&E system assists with decision-making, planning, strategy and policy development. Through self-monitoring and benchmarking, monitoring can help to increase the effectiveness of staff performance, identify staff development needs and facilitate the establishment of management standards, with the aim of improving working practices and efficiencies by identifying system, process and practice problems and opportunities. Furthermore, effective evaluations enable institutions to remedy problems timeously, thus managing risk. M&E systems offer accountability for resources invested.

Selecting an evaluation system

An effective M&E system needs to have a structured set of indicators, as well as a clear and simple approach to assessing the impact on beneficiaries. There needs to be provision for collecting data and managing records that enables the information to remain accessible. Systems for gathering, analysing and reporting information need to be sustainable and, for this, resources and capacity are required. When choosing an M&E system, institutions need to determine[6]:

- What should be measured?
- For whom it should be measured?
- For what purpose it should be measured, that is, what is the intended use of the results?
- How it should be measured?
- How the data will be collected and stored?
- When, and in what form, is the information needed?
- Who will collect, analyse and present the information?

The above issues will influence the type of evaluation chosen and, therefore, the time and resources allocated to this exercise.

Characteristics of a good evaluation system

South Africa needs to build a community of practice from which to learn, against which to benchmark and with which to monitor TTOs. Performance evaluation systems need to be balanced by ensuring that they are not driven solely by quantitative data, but also by an evaluation of qualitative information. Data should be used to ask questions and stimulate debate, but should not be the end in itself. For instance, poor results do not necessarily mean poor execution or negative impact, but could be a result of challenges that need to be addressed. Good performance evaluation systems should be transparent to ensure credibility; they must be simple for easy adoption and implementation, as well as cost-effective. These systems provide a valuable tool for management and continuous improvement; however, their use is valuable only for as long as the measures are a good approximation of reality and only to the extent that individuals have not tried to adjust the performance results.

Requirements of the Intellectual Property Rights Act of 2008

The *South African national research and development strategy*[7] (R&D strategy) refers to the need to develop a

> *clear approach to intellectual property that arises from publicly financed research, enhance national capacity to manage intellectual property (especially intellectual property derived from publicly financed research) and strengthen the initiatives for the commercialisation of intellectual property.*[7]

According to the R&D strategy,

> *there is an urgent need for the creation of a proper framework and enabling legislation for the management of intellectual property arising from publicly financed research. This* [*legislation*] *will define the 'playing field' for publicly financed research and research that is undertaken in parastatal institutions.*[7]

The *Intellectual Property Rights from Publicly Financed Research and Development Act* (IPR Act) was enacted in December 2008.[8] The objective of this Act is to make provision that intellectual property emanating from publicly financed research and development is identified, protected, utilised and commercialised for the benefit (whether social, economic, military, or any other) of the people of South Africa. The purpose of this Act is, therefore, to *inter alia*:

- Provide for a more effective use of IP emanating from publicly financed research and development.
- Establish the National Intellectual Property Management Office and the Intellectual Property Fund.
- Provide for the establishment of institutional TTOs and other related matters.

In order to fulfil the above requirements, higher education and research institutions will be expected to establish M&E systems to track their IP management and technology transfer activities, as they will have to report to the National IP Management Office. Data collection and reporting is only half the work, because analysis of the reported data is necessary to identify trends and assess actual performance against predetermined targets or external benchmarks.

Functions of a TTO

A typical TTO is responsible for a wide range of activities that include,[9] (1) vetting contracts for IP-related clauses and ensuring that they comply with the institution's policy and guidelines for IP management, (2) creating awareness of the importance of IP and the need for proper IP management within the research community, (3) implementing policies and processes to identify, protect, evaluate, commercialise and realise value from IP and technology for the benefit of society and industry, (4) ensuring

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that institutional research practices and operational activities are in line with IP management policies and guidelines, (5) ensuring that contracts are executed and monitored closely and that, overall, the IP portfolio is managed efficiently, (6) providing the research community with access to the relevant expertise and advisory services that are required, (7) facilitating the transfer of technologies to the market and society through licensing, donating or selling and (8) keeping up with current IP and technology transfer management trends and practices in the field. Furthermore, TTOs are often expected to regularly scan the market for commercialisation opportunities, infringement of the institution's IP, as well as developments by competitors and so on.

Relationship between the TTO and other organisational units

The TTO cannot operate in isolation of other administrative functions in an institution. For instance, a close working relationship is required between the IP management and research contract units to ensure that research agreements are in compliance with current IP management guidelines. The finance office often plays a role with regard to the financial aspects of a transaction, such as when to issue royalty payment invoices and providing information about when revenues will flow into the institution and the amounts of royalty and milestone payments expected. Furthermore, institutions need to budget for IP protection and technology transfer activities, such as market research analyses, business plan development and IP valuations. Human resource managers should play a role in ensuring that employee contracts are in line with institutional policies on IP ownership and in handling conflict of interest matters, disciplinary action and, in general, the rights of employees *vis-à-vis* the IP policy. Institutional leadership is interested in monitoring key performance, meeting targets and realising value from the investment in IP management and technology transfer activities. To this end, an M&E system needs to identify co-dependencies between the TTO and other units within an institution, to assign accountability to the appropriate group and, where necessary, provide appropriate weighting to the contributions of the various players.

Developing evaluation indicators

Evaluation approaches and indicators will differ according to the business model used by the TTO. Indicators used to measure a cost, as opposed to a profit centre, will be different and, as such, the model used to establish the TTO may differ from one institution to another, taking the form of[9]:

- an in-house TTO
- an independent company, wholly owned by the institution
- a function within a larger portfolio, such as the grants and contract research management office
- an external function, which is outsourced to a consulting or professional company
- a combination of the above.

Measures used to evaluate the performance of a TTO may be influenced by the operational model of the office and can be both quantitative and qualitative. Measures of performance comprise an evaluation of input measures, such as research expenditure, which is linked to the output of the TTO in the form of patents, licences, start-ups and so on. Measures of internal process efficiencies and performance would then be considered, followed by measures of the productivity of the research community in generating new IP and inventions. Measuring process efficiencies, whereby the speed with which cases received are cleared and the volume decreased, is a less developed area of IP management evaluation.

Inputs are resources required to initiate a programme of activity (e.g. people, funds and equipment), while activities are the actions required to achieve a given objective.[1] Certain IP management activities may take several years, for example, an application for an international patent may take a number of years to be granted. In such cases, it is sensible to develop in-process measures linked to the stages of the application process. Thus, as each examination stage is reached, the office is acknowledged for its accomplishment.

At the other end, one finds the immediate outputs, which are the observable products of the programme, such as the number of patents granted and licence agreements signed, as well as the outcomes – the long-term results of what a programme or process sets out to achieve. While an output could be the actual granting of a patent, an outcome would be the patenting success, based on the increased number of international patents granted or the extent to which a patent is successfully commercialised.

It is essential that performance measures promote appropriate behaviour among TTO staff and within the research community. Moreover, the objective of the implemented measures should support the institution's IP policy and strategy. For instance, if the objective is to increase the number of patents granted at the institution annually, it would be counter-productive if the measure used to reward researchers is limited solely to scholarly publications, to the exclusion of patents. Therefore, an institution needs to consider the drivers of research output, in relation to the use of incentive models, in order to assess how organisational behaviour can be managed.

Mary Sue Coleman, President of the University of Michigan, summarises the ultimate role of most institutions as follows:

> *Many people are often confused about why we are interested in technology commercialisation, in nurturing start-up companies, and in facilitating more patents and licence agreements. It's not about the promise of future revenues that might be generated from this activity. It is not about the money. Technology transfer must serve our core mission: sharing ideas and innovations in the service of society's well being.*[10]

It is therefore important for decision-makers not to focus solely on the potential monetary gains, but to look at the broader role of institutions in respect of knowledge transfer. Knowledge-sharing enables further research, leading to the development of new and improved processes, products and services. By facilitating this transfer, TTOs are instrumental in promoting innovation that ultimately benefits the public. TTOs provide a service to the academic community by creating, supporting and maintaining research partnerships with industry, as well as by promoting economic development and ensuring a fair compensation for institutional IP.[11] In essence, the role of the TTO is to expand the traditional knowledge that is generated and the publication-driven mission of the institution, to ensure that R&D results achieve at least one of the following outcomes:

- income generation for the institution
- service provision for the benefit of the research community
- economic development in relation to industry partnerships
- an increase in contract research and collaboration opportunities with industry and other institutions owing to perceived institutional strength
- jobs created through new start-up companies.

Challenges of applying the M&E system to IP management and technology transfer activities

The IP management and technology transfer environment presents its own unique set of challenges in terms of monitoring, evaluation and impact assessment. Firstly, there are long time lags associated with the different IP management and technology transfer processes. These raise the question of whether or not researchers should be rewarded for milestone achievements and what these milestone achievements should be.

Secondly, TTO managers often have limited direct control over certain activities, because the completion of these activities may be dependent on other collaborative or research partners. In

addition, certain activities do not take place by design and are not always subject to pre-determined schedules. Under such circumstances, it is not easy to determine the contribution of the TTO.

Thirdly, institutions need to develop the appropriate capacity to develop M&E systems and processes, the expertise to carry out M&E functions correctly, the financial resources to support M&E activities, and representation throughout the institution in order to implement a robust M&E and impact assessment system.

Fourthly, it is not always possible to link cause and effect in the context of IP management, due to diverse external factors that influence management and technology transfer processes, for example, institutional and national policies and legislation that facilitate the transfer of knowledge and technologies to the market, thus contributing to the transfer outcomes and impact achieved.

Fifthly, it is a continual challenge to implement an M&E and impact assessment system that satisfies the needs of, and is relevant to, the wider group of IP stakeholders. The government or investors (both local and international) often want to be informed of the outcome and impact of the interventions they have funded and thus require, as a part of the funding conditions, that institutions implement an M&E assessment and reporting framework that reveals such outcomes and impacts when they occur. The results of a technology programme and its implementation thus impact:

- the organisation conducting the research
- the client or the organisation funding the work
- industry and society
- the country and region to which the technology has been transferred.

Finally, M&E frameworks need to adequately address data quality and evaluation methodology shortfalls that exist with all assessment methods.[12] The assessment methods used need to be appropriate and aligned with the objectives of the TTO being assessed. Qualitative assessment methods are generally more complex because they are subjective and focus on descriptions to describe symbols or experiences, which means that they are difficult to validate and, therefore, they can compromise credibility.

PART 2: PERFORMANCE MEASURES

Understanding performance measures

This section is intended to assist TTOs with designing performance measures. As mentioned in Part 1, dynamics, such as legislation, national and institutional policies and strategies, have a bearing on the performance measures used. Broad performance measures include the different forms of technology and knowledge transfer within a research institution; or they could focus exclusively on IP and technology transfer activities. Figure 2 provides an illustration of a typical performance assessment cycle.[1] Planning processes should be inclusive to ensure that users are familiar with the assessment tools that will be used to determine performance. An understanding of the targets, goals and standards against which performance will be evaluated will ensure that assessment outcomes are not disputed or rejected. While performance targets should have a degree of flexibility, they should also be realistic, with certain actions being implemented in response to performance results. In this way, M&E becomes a continuous activity of the TTO.

Elements of M&E and impact assessment

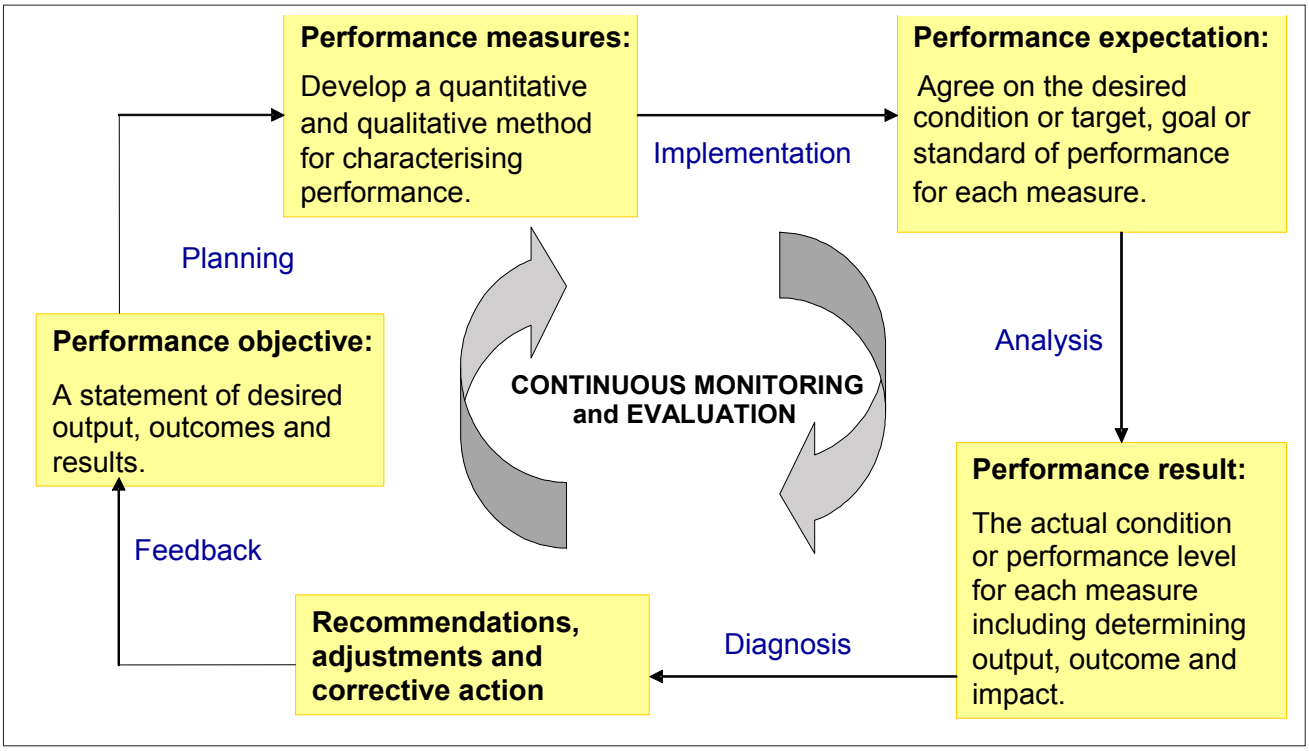
To implement an M&E and impact assessment system successfully, the following elements are necessary[1]:

Leadership support and commitment

M&E and impact assessments will not be properly done unless institutional leaders demonstrate a sustained level of support by committing resources to an assessment system, as well as by calling for assessments to be carried out and advocating their importance to the organisation.

A desire and culture for accountability

Institutions must be held accountable for the use of public funds.



Source: US Department of Energy, Office of Policy and Office of Human Resource and Administration[1]

FIGURE 2
Performance measurement cycle

To this end, M&E and impact assessments should form an integral part of the research process and should not be viewed as an onerous responsibility in the daily research activities, but rather as one that fosters a culture of accountability.

A conceptual framework

It is important to realise that M&E and impact assessment is a process and not an event. Therefore, such a process must be structured in a way that all parties understand what is required of them and how they can use the outputs to benefit the institution.

Strategic alignment

An assessment framework must be linked to the goals and objectives of the TTO, which, in turn, are linked to the objectives of the overall research programme and, ultimately, the institution. Therefore, assessment indicators should generate a report that will enable evaluators to determine how well a given intervention is achieving strategic objectives.

Commitment to excellence

It is important that assessment processes and procedures are of the highest quality so as not to compromise the credibility of results; this requires a sustained commitment to excellence by all parties involved in these processes.

Knowledgeable and trained staff

Staff involved in M&E must be knowledgeable in M&E processes. They need to be trained to ensure that procedures are carried out correctly and that information transfer is effective.

Effective internal and external communication

In order for stakeholders to buy into a new M&E system, the benefits of, and the need for, such a system must be communicated to all relevant stakeholders through a well-prepared awareness campaign.

A reward-oriented culture

Using a punitive approach to ensure adherence to policies and procedures is less effective than encouraging and promoting innovation and performance through an incentive-based reward system.

Integrated data-processing systems

Integration of the data-processing systems used in M&E and impact assessment helps to ensure that those involved in M&E are able to carry out, record and report on any progress made in an efficient and effective manner.

Reasonable timeframes and adequate resources

It needs to be realised that assessments of any nature take time and require resources to perform; quality output can only come from quality input, particularly in terms of time and resources, and so these elements must remain integral to M&E and impact assessments.

Commitment to acting on recommendations

The purpose of any assessment is to determine whether a given intervention has the potential to succeed. If the recommendations of an assessment are not going to be considered at all, then the exercise and resources will have been for nought.

The practical use of M&E and impact assessments

An example of a well-established M&E process is the *AUTM licensing survey*. Each year, the Association of University Technology Managers (AUTM) conducts a survey of technology licensing and related activities among American and Canadian academic, non-profit technology investment firms. The purpose of the survey is to demonstrate how technology transfer professionals assist researchers in bringing new products and services to market for the benefit of society and the economy.[10] The survey assesses the following components, (1) the level of research expenditure, (2) new products introduced to the market, (3) the number of start-up companies launched, (4) the number of disclosures received by organisations, (5) the number of licences and options signed and patents issued and (6) the number of start-up companies still in operation. Similar surveys have been established in South Africa, the United Kingdom, Australia and Switzerland.[13,14]

The use of quantitative indicators is common when determining the performance of a TTO. Other approaches that have been used in this area include:

- peer review by an expert panel of assessors
- economic methods such as ratio and cost benefit analyses
- customer and beneficiary surveys
- case studies that provide qualitative information.

Table 1 provides a summary of common M&E methods and their strengths and weaknesses.[15,16]

IP management and technology transfer measures

IP management indicators

The number of invention disclosures registered: An invention disclosure is the point where a researcher begins to share information on a potential discovery with a TTO, which, effectively, is the start of the technology transfer process. Typically, an invention disclosure will entail an evaluation of the technology, which will possibly lead to its protection and commercialisation. Measuring the number of disclosures is particularly important in situations where IP protection is not possible, or a decision is made not to protect the invention. Furthermore, this could indicate the extent of awareness of IP within an institution. In addition to counting the number of patents, the number of disclosures will reveal serial inventors and creators of IP. A well-structured invention disclosure process will not only capture patentable inventions, but non-patentable discoveries as well and can be used to track the participation of researchers in the technology transfer process. It is also useful to monitor performance by tracking the number of disclosures that are not only converted to patent applications or patents, but also those that are 'converted' into successful technology transfer opportunities and ultimately applied in industry and society.

The number of provisional patent applications: This measure could be a proxy for future patenting potential. A provisional patent application allows for patent filing without any formal patent claim, oath or declaration, or any information disclosure (prior art) statement. This measure provides the means to establish an early, effective filing date in a non-provisional patent application and allows the term 'patent pending' to be applied.

The number of South African patent applications granted: The South African patent registration office does not subject patent applications to substantive examination in respect of novelty, inventiveness or utility and, therefore, the weighting placed on this measure needs to be contextualised. Institutions interested in promoting a culture of registering and protecting IP may want to use this measure to encourage and educate the research community. Once researchers are familiar with the processes and practices of IP protection, institutions may decide to apply measures that hold greater value, such as patents granted by examining countries.

The number of international patents, trademarks, registered designs and plant-breeders' rights granted: These are universal measures used as an indication of the productivity of the private and public sector research environment.

TABLE 1
Summary of evaluation methods

Methods	Description	Strengths	Weaknesses
Modified peer review	Screening of projects	• Relatively easy to organise • Can provide valuable information on potential impacts • Cost is low to medium	• Relies on the opinions of a small number of people • Qualitative information only
User surveys	Assessing the use of a product or service for the person for whom it has been designed	• Overcomes the problem of a small number of respondents • Possible to develop quantitative indices • Relative cost is medium	• Structuring the survey and analysing the results can be tricky • Often requires considerable time to identify users, develop survey methodology and analyse results
Cost-benefit methods	Measures marketable outputs and commercial resources	• Can provide reasonable defensible estimates of potential benefits • Provides a structure and a framework for assessing projects which ensures that the right questions are asked	• Can be very time-consuming and labour-intensive • Results are critically dependent on assumptions, which can be highly uncertain • Because of cost and time requirements, can only be used for a limited number of projects • Relative cost is high; data collection requirements are demanding
Cost-effectiveness analysis	A method for measuring the benefits and effectiveness of a particular item of expenditure	• Simple • Does not require benefit information • Relative cost is medium	• Nothing to prove that any of the alternatives compared can yield benefits over and above costs • If one of the alternatives costs less, but produces a low quality product or has a different impact, then the assessment becomes more complicated
Case studies	A collection and presentation of detailed information about a particular intervention and its effect on a participant group or social or economic situation	• Can provide good illustrations of the relationship between technology transfer initiatives and their impacts • Relative cost is medium	• Generally there is no way to summate the results of a group of case studies to obtain a measure of the total impact of the group • The results cannot be extrapolated to other projects that are not in the group
Partial indicators	The partial indicators of the impact method involve the collection of information (generally readily available) for a number of items, each of which provides some insight into the extent of the socio-economic impacts resulting from an intervention	• The information required to specify the indicators is relatively easy to collect • Probably the best method for on-going monitoring • Relative cost is low	• The individual indicators can generally only be summated on a judgmental basis, making overall impact assessment more difficult • Provides only a partial picture of impacts
Integrated partial indicators / Weighted multiple criteria analysis / Scoring analysis	This method is used to assess R&D being considered for the future. The common approach is to summate the partial indicators and to arrive at a 'bottom line score' for each potential project or project area under consideration. Each project is evaluated with reference to a specific set of criteria/questions (partial indicators). Each criterion is then assigned a numerical weight, which enables the array of projects, or projects under consideration to be ranked in order of priority, according to the sum of the numerical values assigned to the various criteria	• An easy but structured way to identify research priorities • Forces the decision-makers to explicitly consider the key determinants of impacts • Relative cost is low	• Totally relies on the judgement of (usually a few) individuals • Potential for bias in assigning weights to different criteria
Mathematical programming	The mathematical programming method provides a more powerful and sophisticated priority setting technique in that it relies on a mathematical optimisation of a multiple goal objective function, subject to resource constraints (available funding and human resources) to select a portfolio of research projects	• More powerful and sophisticated • Enables one to select an 'optimal' portfolio • Can handle simultaneous change in many variables	• Demanding in terms of data requirements • Relative cost is high • Not particularly useful for evaluating too diverse a set of projects • If either the criteria or constraints are not well defined, there is a risk of arriving at a nonsensical 'optimal' solution
Production function approach	The production function relates the output of an institution to the amount of inputs such as financial resources and human capital. The production function describes technology, not economic behaviour	• Offers a more rigorous analysis of the impact • Estimates marginal rates of return • Statistically isolates the effects of technology transfer from other complementary inputs and services	• Uncertainty in projecting past rates of return to the future • Demanding in terms of data • Selection of suitable functional form • Serious econometric problems • Relative cost is high

Sources: Adapted from International Service for National Agricultural Research[15] and Capron et al.[16]

The number of Patent Cooperation Treaty applications submitted: Given that it may take 18 months or longer from the earliest priority date to publication of a patent application, it is often useful to include in-process measures that will enable evaluators to track progress and identify problem areas well in advance. Measuring the number of Patent Cooperation Treaty (PCT) applications thus enables evaluators to track the number of patent applications and assess how many of these are eventually granted.

The number of international preliminary reports on patentability issued by the International Bureau: The objective of the international preliminary reports on patentability is to formulate a preliminary and non-binding opinion on the patentability of an invention. The report is issued after a search and analysis of the claims covering the invention and provides a preliminary opinion on the novelty, non-obviousness and industrial applicability of the invention. A positive response could be considered an early indicator for patentability;

however, a considerable number of negative reports must be investigated, as this could suggest a problem with the quality of the specifications or claim drafting of the PCT applications submitted. A negative response could also provide a basis for the amendment of claims to remove the objections by the examiners.

The number of publications, conference papers and the like that are accepted: Traditionally, TTOs are not responsible for tracking the number of publications published, even though they fall within the broader sphere of knowledge output. Publications are an important output measure, especially for academic institutions, and their inclusion in a measuring framework is an important element in assessing transfer of knowledge to society and increases the scope of IP measures.[17,18,19,20] This calculation, though, is quite complex, with weightings assigned to different types of publication. For example, an entire book will receive a different weighting in relation to a book chapter or a journal paper. Generally, only peer-reviewed publications or a paper published in the approved list of journals are considered.

Patent citations: These are references to prior technology, either in the form of patent applications, patents or other scientific literature, which the current patent builds upon or uses.[21] Patent citations are increasingly used as a measure of patent quality and innovation performance. When filing a patent in the United States of America, it is a legal requirement for applicants to supply a complete list of prior articles and, so rather than run the risk of having their patent revoked, applicants quote every reference, even if it is only remotely related to what is being patented.[22] For this reason, the US Patent and Trademark Office has significantly more patent citations than any other patenting office, including the European Patent Office. While, patent citations are used to indicate the relative strength of a patent, this measure does not take into account the fact that citations originate from patents of different qualities.

Technology transfer and commercialisation indicators

Financial indicators: The amount of money generated by a TTO is a common indicator of commercialisation performance. This is income obtained from royalty payments or other licence fees (e.g. upfront and milestone payments), sale of intellectual property, research contracts secured as a result of a licensing agreement or linked to existing IP within the institution. This is an output measure used to determine investment into research, development and commercialisation. It also provides an indication of the value of the technology in the market and the level of success with respect to knowledge flow. When assessing financial indicators, the following factors need to be taken into account:

- Revenues received as a result of IP-induced research contracts; there is a correlation between the quality and quantity of an institution's knowledge output and the funding it receives in the form of sponsored research.[23] A strong IP portfolio in a given domain will attract the attention and interest of industry and other researchers. At the same time, it is also important to note that the conditions placed on sponsored research can influence the institution's ability to patent and publish knowledge generated through such contracts. Such conditions may limit patenting opportunities and therefore influence performance results.
- Revenues received from the sale, licensing and/or assignment of IP rights.
- The source/s of revenue, because, in certain cases, revenues from highly regarded sources raise the profile of the institution and can be a sign that the quality of research and innovation is of a high calibre.

Non-financial indicators: The actual outputs and outcomes of technology transfer activities are equally important and should be reviewed regularly. The non-financial indicators selected to measure productivity in terms of knowledge and technology transfer should be in line with the general strategies and policies set by the institution. If licensing is of strategic importance to an institution, one would ensure that a count of the number of licenses signed in a given period is included in the performance review of that TTO. Therefore, a pragmatic approach is needed when selecting outputs and outcomes to be included in an M&E system, taking into account the following:

- The number of new licences, assignments, donations and options signed; each indicator in this group is a measure on its own and could be divided according to the number of signed and non-income yielding agreements.
- The number of new start-up companies (new companies) and spin-out companies (those formed from an existing parent company).
- The number of new products, processes or services introduced into the market for both industrial and social good applications.
- The number of technology transfer opportunities under negotiation.
- The deal flow or stream of technology transfer projects, which provide an indication of the size, sector, complexity and quantity of projects managed by the TTO. An analysis of this information should reveal which resource and capacity issues need attention.
- The number of new collaboration programmes and contract research opportunities as a result of IP generated by the institution.

Internal processes: It is not often that institutions use measures of internal process performance in M&E systems. The main reason for this is that internal performance measurement is the least developed area in IP management. Thus said, institutions are beginning to take notice of aspects of internal performance measurement and, in an informal way, estimate how well or badly the TTO is doing in some of the following areas:

- The case elimination[9] process requires that a well-resourced TTO should demonstrate efficiency in terms of eliminating the number of projects or negotiations to which it is attending. A stage-gate process can be applied where unpromising cases can be abandoned early in the technology transfer process in favour of more promising opportunities, before the office wastes critical resources or incurs excessive costs. This approach enables evaluators to assess the number of cases that pass and fail the technology transfer process.
- Measuring the number of iterations with respect to drafting and reviewing of contracts and key documentation considers the number of revisions required for documents and the time spent on each revision. However, the value of this measure, in terms of efficiency, is questionable due to the complexities of each case being assessed.
- Assessing case load queue times refers to an evaluation of the number of projects a TTO is handling at a given point in time. The turnaround time of documents submitted to the TTO is important in order to identify blockages in the process, capacity problems and inefficiencies.

Indicators that measure process efficiency focus mainly on managing disclosed technologies and IP and thus can be challenging to implement, unless the TTO has an effective administration system for processing large volumes of documents. Where multiple people are involved in reviewing and processing information, a system is required that allows each participant to register their input and be held accountable for their component of the work.

Institutions need to determine the relevance of the various indicators for their own particular use. They can then substitute, add or discard indicators accordingly.[24] In this regard, benchmarking can be most useful in cases where institutions use common indicators. However, benchmarking needs to be approached with caution because one of its common shortcomings is when institutions assume that there are pre-existing benchmarks for everything they wish to measure. It is therefore necessary to investigate and verify the measures being benchmarked. The greatest advantage of a benchmarking exercise is that it gives an institution a reference

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on the possibilities available in respect to IP management and technology transfer performance. In addition, benchmarking assists leaders in assessing exactly how much improvement is required to achieve superior performance.

Monitoring and evaluation tools

There is a wide selection of software packages available on the market for collecting, analysing and reporting on IP management and technology transfer performance results.[25,26] An IP management database should enable users to manage the entire IP and technology transfer value chain. This includes managing projects, IP, contracts and technology transfer. As a result of implementing an information management system, agreements, invention disclosures and patent prosecutions can be managed more effectively. Furthermore, contact with researchers is more efficient because information can be shared easily and automated invoicing capabilities improve revenue collection. Finally, data can be stored in a secure environment and reports on performance and progress can be produced at the press of a button. These tools ensure efficient and effective tracking and monitoring of IP management and technology transfer processes and improve productivity and overall management.

Assessing the impact of technology transfer

Impact studies assess the extent of use, or application of, a technology and knowledge by targeted beneficiaries. Ideally, institutions should be involved in constant monitoring of technology transfer activities. Thus said, it is important to perform assessments at key stages of the transfer processes, with the type and timing of the assessment depending on the purpose of the study.[6] A survey, whether formal or informal, is a convenient way of assessing impact; however, before embarking on a survey, evaluators should agree on the definition of technology and knowledge transfer. Possible parameters here include:

- The use of a new technology as a product, process, service, et cetera.
- Widespread diffusion of a new technology, such that it is accessible and available to a large number of beneficiaries
- Application of the technology, whether at a test site or in actual practice.

In developing an impact assessment survey, it is important to define the nature of the technology and changes that are to be analysed. It is also essential to identify the audience for the assessment. The resources, capacity, geographical spread and available time will determine the design, size and intensity of the survey, thus, during the planning phase, evaluators should determine how and what type of impact will be measured. The greatest challenge when assessing impact is to demonstrate a link between changes in society and industry and the technology and knowledge transfer intervention. In the long term, evaluators should work towards building quality into the performance system and process. As such, key steps in developing an impact assessment plan are to:

- Identify the need or problem.
- Define the objectives for the assessment.
- Develop the impact measures.
- Analyse and interpret the results.
- Report on findings and develop policy or strategic options.[27]

Case studies, as an impact assessment method, provide an opportunity to 'tell the story' and, in so doing, communicate qualitative information, in addition to the quantitative facts and figures. Qualitative and in-depth case studies can thus be used to share economic achievements and entrepreneurial successes on technical and scientific innovations.[28] Well-crafted case studies add the human element to technology transfer activities and demonstrate commitment to making an impact. An example of the use of case studies is the AUTM Better World Project, which shares inspiring stories behind the innovations that have changed the way we live. The initiative draws from years of case studies and news from AUTM members.[29]

Social impact assessments

There is increasing interest in social impact assessments as stand-alone studies. Social impact assessments measure the impact of technology and knowledge on people and their quality of life. The International Association for Impact Assessment (IAIA) defines social impact as follows:

> *Social impact assessment should not be understood only as the task of predicting social impacts in an assessment process. It includes the processes of analysing, monitoring and managing the intended and unintended social consequences, both positive and negative of planned interventions (policies, plans, projects) and any social change processes invoked by those interventions. Its primary purpose is to bring about a more sustainable and equitable biophysical and human environment.*[30]

Useful guides on social impact assessment have been developed by the IAIA and other institutions, such as the World Bank, the Asian Development Bank, the African Development Bank and the European Commission.[31,32,33,34]

CONCLUSION

M&E and impact assessment are complex activities that need to be planned and implemented well to benefit an institution, its members and stakeholders. When M&E and impact assessment processes, procedures and systems have been well established, they can be highly effective in assisting institutions to perform more efficiently and make better decisions. No single best practice exists in this regard; however, as institutions develop their IP management and technology transfer capacities to the next level, they need to engage in M&E and impact assessment practices to ensure that they are achieving the desired objectives for investment in an area that, in itself, is complex, multidimensional and characterised by long-term activity.

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