Subtheme 6.6 - New methods and analytical tools for technology transfer evaluation

The Value Scorecard – A Methodology For Evaluating The Impact Of Knowledge Transfer

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Abstract
The National Physical Laboratory provides technology transfer services for its own research outputs and on a contracted basis for other organisations. It is important to demonstrate the resulting outcomes to the funders of these activities. However, the outcomes required from this range of technology – or more precisely knowledge transfer cover the spectrum of commercial gain through to public good. This is a result of the mix of public and private financing and so adds complexity to evaluating this activity. This paper describes the development of the Value Scorecard methodology used to overcome this complexity.

The Challenge
The National Physical Laboratory (NPL) is a National Science and Technology Laboratory for business that is a key part of the UK's national innovation infrastructure. It is one of the UK's leading science and research facilities and is a world-leading centre of excellence in developing and applying the most accurate standards, science and technology available.

NPL occupies a unique position as the UK's National Measurement Institute, sitting at the intersection between scientific discovery and real world application. Its expertise and original research have underpinned quality of life, innovation and competitiveness for UK citizens and business for more than a century:

- NPL provides companies with access to world-leading support and technical expertise, inspiring the absolute confidence required to realise competitive advantage from new materials, techniques and technologies;
- NPL expertise and services are crucial in a wide range of social applications - helping to save lives, protect the environment and enable citizens to feel safe and secure. Support in areas such as the development of advanced medical treatments and environmental monitoring helps secure a better quality of life for all;
- NPL develops and maintains the nation's primary measurement standards, supporting an infrastructure of traceable measurement throughout the UK and the world, to ensure accuracy and consistency.

NPL operates as both a Public Sector Research Establishment through its mission as a custodian of national measurement standards as a national laboratory, and also more commercially in support of industry as a Research and Technology Organization. NPL is therefore firmly embedded in actively delivering the heart of the triple helix model [Etkowitz (2008)] through maximizing the transfer of knowledge across a range of government, academic and industry programmes [Cooper P et al (2009)].

This context brings with it distinct sets of stakeholders who must be included and engaged in developing and exchanging knowledge, especially when considering what is the desired impact that needs to be achieved from our work and how might those benefits be most effectively and efficiently achieved.

To fulfil this role, NPL draws on long history of successfully delivering R&D programmes that make a difference to competitiveness of industry and the well-being of the public in the UK as a result of measurement. But how do we go about ensuring that we make the difference that industry and others value - and are able to demonstrate that value using credible evidence to the satisfaction of this complex mix of stakeholders?

What is "Impact"?

The discussion of value and impact and in particular its assessment is an ongoing academic debate. A substantial amount of the literature highlights the difficulty in valuing an entity that is not tangible. For example, the difficulties cited include identifying and valuing relevant research inputs, accurately ascribing the impact of the research and appropriately valuing the attributed economic impact [POST (2002)]. The association of Universities and Colleges in Canada [AUCC (2006)] explains that there is often a confusion between the term impact and outcome.

The European Union uses impact assessment in policy decision making and defines it as:

> *"Impact assessment is a process aimed at structuring and supporting the development of policies. It identifies and assesses the problem at stake, and the objectives pursued. It identifies the main options for achieving the objective and analyses their likely impacts in the economic environmental and social fields. It outlines advantages and disadvantages of each option and examines possible synergies and trade-offs."*

For the purposes of this paper we will use the following definition of impact and impact assessment:

- *Impact* is a *measure* of the tangible and intangible effects (consequences) of one things or entity's action or influence upon another [Businessdictionary (2010)].
- Impact *assessment* is the *process* by which the outcomes of a programme of work are evaluated.

Based on our observations and experience, our hypothesis is that practitioners can have difficulties with these concepts in three key areas:

- The term impact is often confused with outcomes or outputs, so measures of impact can be inappropriately selected and used
- Issues of timing and proving causality complicate determining impact and again result in inappropriate use of measures and indicators
- The totality of the impact value chain is often overlooked, generally resulting in focusing on one or other of the ends instead of a more holistic view and gaps in actively managing impact across a programme lifecycle

The next sections of this paper aim to illustrate these difficulties and provide insights into why they might occur by reviewing impact assessment frameworks in general and setting out the approaches used to date by NPL.

Review of Impact assessment frameworks

The concept of measuring impact is not new but focus has been intensified as a result of the current economic climate. A significant number of studies have been done over the last fifteen years in the United Kingdom, as well as from Australia, USA and Canada. An extract of these studies were sampled in this review and the models most relevant to NPL's context were highlighted. These are:

- Economic Models
- Balanced Scorecard Model
- Knowledge Based Approaches

It should also be noted that while these frameworks are usually described as unique and separate in these studies, they could in fact form a continuum, measuring value in a qualitative to a quantitative way.

Economic Models

Economic based frameworks featured in a number of studies [Buxton et al (2004)] and appear to be a popular method of measuring the value of research driven by growth in global competition [RSC (2005)]. The economic frameworks identified contain many different metrics

used to assess value as part of econometric studies or microeconomic analysis. Financial metrics that are commonly employed include:

- Net Present Value
- Internal Rate of Return
- Benefit Cost Analysis
- Payback Period
- Accounting Rate of Return
- Profitability Index
- Benefit Cost Ratio
- Increase in tax base

Depending on the nature of the programme funded, other methods of analysing research contributions may also include metrics that are non-financial but are used as proxy indicators of things that contribute to economic development:

- Bibliometrics analysis
- Citations
- International co-authorship
- Patent citations
- Company spin offs
- Number of students educated

It is also contested that a more realistic measure of the value of research may be through considering how the research contributes to GDP [Allen Consulting Group (2005), such as:

- Formation of new companies exploiting publicly-funded research.
- Licensing revenues.
- Skill formation in research graduates.

Whilst the economic frameworks present many different metrics, the importance of data collection (a process that occurs before the metrics are applied) is also referred to in the literature. For example the US Department of Commerce in respect of NIST [Tassey G (2003)] draws upon the importance of obtaining the correct data and data collection strategies in general. This is seen as imperative to the quality of the data produced, decisions made and outcome of any type of assessment. Data collection is often noted as being time consuming and costly, therefore establishing the required and necessary data needed to enable an effective analysis is imperative [Tassey G (2003)].

The perceived strengths of economic frameworks are the simplicity of their use for monitoring and benchmarking. Economic frameworks also offer consistency because they are independent of people's opinions and bias. Despite these strengths they are only effective if the right data collection strategies have been put in place. An economic model depends on the data it receives. It the data lacks in quality and accuracy the result may suffer [Tassey G (2003).

To summarise, the options presented by economic frameworks are varied. There is no consensus on the best mix of metrics to evaluate research activities. However, it is agreed that data collection strategies are important and will affect the selection of the most appropriate mix of metrics for a particular context.

Balanced Scorecard Approach

This well known approach was developed by Kaplan and Norton and has evolved from being a simple performance measurement framework to a strategic planning and management system. It is used widely in business, industry, government and non-profit organisations to align business activities with organisational strategy [Kaplan R , Norton S (1992)]. This enables management to monitor the organisations performance against strategic goals.

The BSC foundation is based on four perspectives:

- Financial (costs, revenues, profitability).
- Customer (relationships, offerings).
- Internal Processes (considerations of innovation, efficiency and environmental impact).
- Learning and growth (underlying competencies and organisational culture).

Kaplan and Norton describe the BSC as being able to provide answers to following questions:

- How do customers see us? (Customer importance)
- What must we excel at? (Internal process)
- Can we continue to improve and create value? (Leveraging)
- How do we look to shareholders? (Finance)

Hence, this approach seeks to balance non-financial performance indicators with traditional financial indicators to give a 'balanced' view of organisational performance and explicitly link this to the strategic goals of the organisation. Stakeholders are limited to shareholders, customers and perhaps employees engaged in internal processes.

The BSC is often used in conjunction with organisation tools and frameworks, enabling them to tailor this model to suit the organisations specific activities [Allen Consulting Group (2003)]. For example, the Espida project (2006) at the University of Glasgow [Curral et al (2006)] investigated how intangible assets can be valued in ensure longevity of knowledge representations. The outcome of this project was a proposed principled dimension model, which resembles the Balanced Scorecard (BSC). This is because the University perceived the benefits of BSC as being able to 'explore all areas of value…presents the multiple dimensions of value to the decision makers. They no longer only see financial figures of cost income; they also see other, more intangible values'.

Another benefit of using the BSC includes its aid in decision-making and helping to establish a current snapshot of economic impact or work of organisations. However, the disadvantages of using the BSC may include that it is not a quick solution and considerable time and thought can be required to develop an appropriate scorecard and in deciding on the right metrics to use. Also the structure tends towards a limited view of stakeholders, which is perhaps less useful in the context of wider communities that are impacted by technological research.

In summary the BSC approach offers organisations the flexibility of adaptation to suit their own organisational context. However, it is important to consider the initial time and thought required to develop the BSC to suit the organisation and the potential limitations of relying solely on static strategic objectives and a limited view set of stakeholders.

Knowledge-based Approach

The *knowledge-based* approach is an integration of the preceding approaches with a *knowledge management* perspective.

The knowledge-based view is typified in the approach advocated by John Howard as a result of a study commissioned by the Department of Education, Employment and Workplace Relations of the Australian Government [Howard (2005)]. The approach proposed draws on earlier work undertaken in the UK by HMT and SPRU [Calvert D (2002), Salter et al (2001)], and other international organisations. The study identified four knowledge transfer processes that seek to address the plurality of mechanisms and stakeholder requirements of identifying, tracking and understanding the economic contribution of universities.

- Knowledge *diffusion* – generating economic and social outcomes by encouraging industry-wide adoption of research findings (building capacity based on skills and standards).
- Knowledge *production* – generating economic and social outcomes through the sale of commoditised knowledge as per traditional view of knowledge transfer (predominantly IP).

- Knowledge *relationships* – generating economic outcomes through the provision of services that indirectly exploit IP, delivered through cooperation and partnerships (trade secrets and other tacit knowledge).
- Knowledge *engagement* – generating economic outputs as a by-product of shared interest.

This is one approach to framing what is essentially a knowledge management value chain. The outputs of such a value chain are commonly termed intellectual capital, which can be considered to comprise of human, structural and relational sub categories. The challenge to private and public sectors alike is how to account for and value this predominantly intangible asset.

Knowledge-based methods have been proposed as a response to the limitations of existing frameworks and models to create and realise value from these intellectual products and services, particularly when considering the commercialisation of research from organisations such as universities or Public Sector Research Establishments.

The performance measurement of research programmes should be considered in the wider context of knowledge exploitation, as appropriate to the purpose of the programme. Typical output measures for the four-knowledge commercialisation processes are summarised in Table 1 below.

Table 1: Performance measurement of the knowledge transfer aspects of research programmes

Process	**Possible measure / output indicator**
Knowledge diffusion	• Communication activities • Capacity building activities • Extension and education activities • Standard setting activities • Industry output data
Knowledge production	• Academic publication activities • Patenting and licensing activities • Income streams • Spin-off companies
Knowledge relationships	• Income streams • Staff and students working on interchange with industry • Industry research staff with sessional and adjunct appointments in universities • University appointed secondees
Knowledge engagement	• Participation in non-academic community and economic activities • Jointly owned and operated technology property infrastructure – technology and research parks, buildings, equipment, instruments etc. • University organised events for community and regional economic & social benefits • University facilities available for non-academic purposes

[Based on Howard (2005)]

The study also proposes that the economic benefits of publicly funded research should be considered at the four “levels” of:

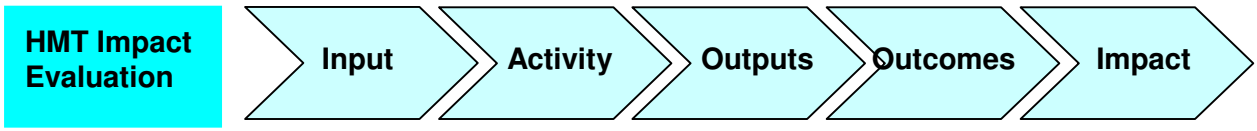
- The economy – contributions to wealth reflected in indicators such as national production, investment, contribution to research and economic performance.
- The industry – industry productivity and competitiveness.
- The enterprise – organisation specific commercial outcomes such as profitability, sustainability.

- The region – regional performance and consideration of clustering activities and networking.

The Knowledge Based View framework is a very complete treatment that deals with the complexities of knowledge markets and economies. This extensive nature means that it has generally been considered in relation to larger programmes but the generic concepts are also valid in respect to smaller scale ventures, subject to a pragmatic view of their application.

HM Treasury Guidelines

In line with other major public service procurers, HM Treasury in the UK provides guidelines as to the approach that needs to be taken in evaluating programmes that it has financed [HMT (2011)]. The approach follows assessment at five steps as depicted below:



This guidance is usefully illustrates that assessment should take place across the whole programme lifecycle and highlights some of the difficulties that need to be considered. However, it tends to be viewed as being focussed towards major expenditure programmes and its applicability to smaller programmes can be problematic due to the perception of cost.

Trends from the literature review

The following trends were identified as being prevalent throughout the literature considered in this review:

- Demonstrating impact is complicated by many factors but four key reasons are:
    1. Timescales – true impact often occurs many years after the initial outputs and outcomes of a project, so the measurement point may not accurately capture the totality, potential scale - or even an indication of - any anticipated impact.
    2. Causality - often difficult to determine as multiple factors can contribute to the ultimate impact of knowledge transfer. Time lag compounds this, making it less clear tracking back the factors that engendered the change.
    3. Access to data can be problematic if the final impact is not that originally envisaged, so data collection was not considered either internally or by the sources of the other contributing factors.
    4. Costs – increase with the complexity of impact factors, with impact assessment costs being in excess of any benefits from evaluation
- In practice, research impacts are often shown to be not easily quantifiable particularly due to the influence of the first three factors above. There is a time lag between when research is funded and when its benefits are realised and there are challenges in attributing an impact to a specific finding because there are often externalities and third party influences.
- There appears to be no consensus in identifying one best method in assessing and measuring the impact and value of the outputs of research-intensive organisations. The articles examined indicate that there are many different models attempting to value research. In reality many feel that these models can be adopted and tailored to a particular organisations own circumstances and context.

In conclusion, the literature review has demonstrated that each of the presented frameworks comes with benefits and pitfalls as a result of being constructed for use in particular organisational context. This presents both opportunities from the rich knowledge base and challenges when transferring to other contexts. For application to the NPL context with relation to its knowledge transfer activities, an adaptation of the approaches described above is required to provide a pragmatic solution to complexity but provides a useful basis for supporting innovation in this task.

Review of NPL approach to assessing impact

NPL uses both public and private investments to develop and apply the UK's National Measurement System (NMS) in order to generate socioeconomic benefit to the UK. NPL has worked with the UK's National Measurement Office to develop a distinctive process for scoping and delivering R&D programmes that deliver impact based on the ability to make trustworthy measurements.

The purpose of the National Measurement System and the associated research programmes is to make socioeconomic impact for the UK based on the creation and application of measurement knowledge. Therefore, as shown in Figure 1, NPL has taken a distinctive approach to considering and assessing impact whereby it:

- Is considered throughout the NMS programme lifecycle (before, during and after)
- Takes the form of financial or social well being returns – or a combination across that spectrum
- Is generated by multiple impact mechanisms that are explicitly categorised and managed accordingly

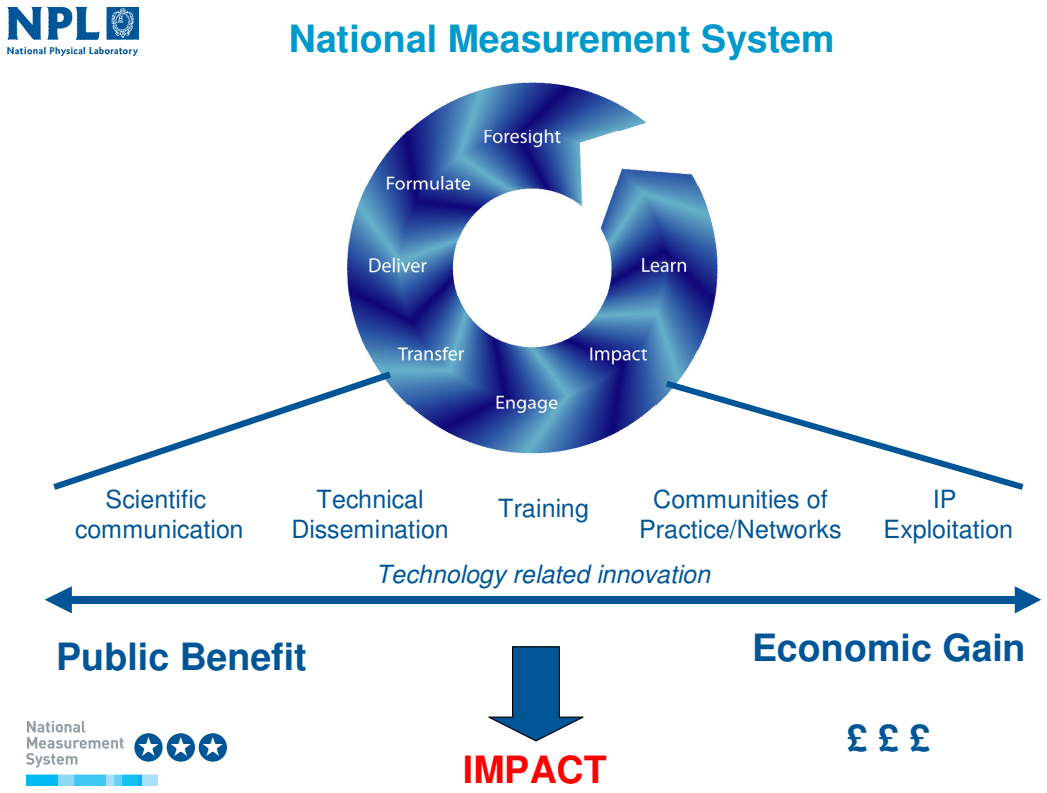


Figure 1: The NMS Programme Lifecycle and generation of impact

The distinctive aspect of this approach is that benefits i.e. impact is integral to the process and is considered at all stages of a programme's lifecycle eg :

- Scoping the programme of work to ensure that the outputs are able to make the difference that potential beneficiaries require – and provides an indicative pathway to achieving that impact
- Delivering the programme in such a way as to actively manage the pathway to impact to ensure resources are not wasted
- Post programme evaluation for demonstrating value to investors, beneficiaries – and to learn for the next time

The previous sections defined impact assessment is the process by which the outcomes of programmes are evaluated and showed that impact assessment can be challenging due to four key reasons:

- Timescales
- Causality
- Access to data
- Cost

These are considered in the context of NPL and providing evidence of the impact of the National Measurement System.

- The timescales of when impact occurs can often be many years after the initial outputs and outcomes of a project, which is particularly in the technology domain. E.g. the laser that was the result of applied research in the 1960's but has only become ubiquitous throughout our lives in the last 10 years. This means that a measurement point may not accurately capture the totality, potential scale - or even an indication of - any anticipated impact.
- Demonstrating the causality of a financial or social difference in the context of technological research is difficult. For example, as measurement is often an underpinning or cross-cutting capability, other factors will contribute to creating that impact making it complicated to explicitly quantify the contribution arising from the NMS. This is compounded by the time lag factor, which makes it less clear when tracking back from an impact to the factors that engendered the change.
- Another consequence of timescales and causality is that the data required for an evaluation may not be accessible. For example, if the final impact was not that originally envisaged, so data collection was not considered either internally or by the sources of the other contributing factors.
- Ultimately the consequences of this complexity means that the costs of performing an impact assessment can be considerable and in excess of any benefits that would accrue, notwithstanding the obligations of public accountability.

Therefore, the impact assessment to underpin this process can be time consuming, expensive and above all just difficult. However, we have reviewed a number of impact assessment techniques previously applied to the evaluation of the NMS and developed a pragmatic approach, the Value Scorecard methodology, to support delivering research for innovation and impact.

The next sections review approaches used to quantify the impact of the NMS and then presents the Value Scorecard methodology.

Approaches to Quantifying Impact of the NMS

Both knowledge transfer activities and the resulting impact are complex concepts for the National Physical Laboratory especially when factoring in its complex operating environment. Impact is demonstrated in different ways and so impact assessment is carried out using a variety of frameworks akin to the knowledge based view.

For the NMS research a portfolio approach to impact assessment is taken to build up evidence from a variety of approaches [Lambert R (2010)]. Examples include macroeconomic and microeconomic modelling, supplemented by surveys and case studies that focus on the individual company receiving benefits through engagement with the NMS through the knowledge transfer channels.

Macroeconomic Impact – models and surveys

Macro economic models, in particular growth accounting, which are valuable to draw out the overall contribution of the programmes to the UK economy.
Surveys are used to define the impact of NPL's facilities and expertise to business and industry. A market research consultancy is periodically commissioned to survey as many as 1200 businesses, including 800 customers of the NMS laboratories, to establish how they gain economic benefit from interacting with the NMS and to quantify the magnitude of that benefit in terms of increased profit.

Microeconomic Impact – economic models and case studies
Prof Swann of Nottingham University has developed a microeconomic impact model to analyse the benefit mechanisms of the NMS. This model describes the micro-economy through three processes - production, market and consumption – and includes the inputs and outputs of these processes. The model traces the delivery of benefit through the economic process to identify the beneficiaries.

Case studies were used to identify NMS benefit mechanisms and these were then mapped onto the microeconomic model to populate matrices that link the inputs, outputs and processes. The model was designed to analyse the benefits delivered by a R&D project, and to assign the proportion received by producers, wholesalers, consumers and through externalities. Externalities describe those receiving benefits from the project but not contributing to its cost through the purchase of products or services [King MJ (2005)].

This model has been combined with other data to provide a quantitative assessment of the economic impact of proposed R&D projects for NMS Programmes. This information is provided to support the prioritisation of project proposals submitted to NMS Programmes. It has also been possible to collate this data for funded projects across the NMS programme portfolio, and provide an overview of the breakdown of intended impact by industrial sector.

In summary, the impact assessment of the NMS has used four common frameworks:

- Economic modelling (macro and micro) [Tasey (2003), Ruegg (2003), King (2005)] – simple and easy to use but complex to build and a one-sided view
- Balanced scorecards [Kaplan & Norton (2001)] – Include financial and non-financial performance indicators linked to strategy but do not incorporate the complexity of the environment
- Industry surveys and production of case studies – useful evidence and examples but care needed with survey design and statistical interpretation, case studies are a single example
- Knowledge based view [Howard, 2005] – very complete treatment of management of knowledge as an intangible asset and across the knowledge value chain but complex and time consuming

The revised approach

The benefits and challenges outlined above have been present to varying degrees across these techniques. Learning from these experiences and to address these challenges, the impact assessment methodology is revised to include the concepts of impact pathways [Smutyo (2001)] and an innovative tool called the Value Scorecard.

The concept is based on the fact that there is a chain of influence that connects the activity from a programme of work to an impact. As Figure 2 depicts, whilst there is some central linear pathway, it acknowledges that there are other pathways that are difficult to track.

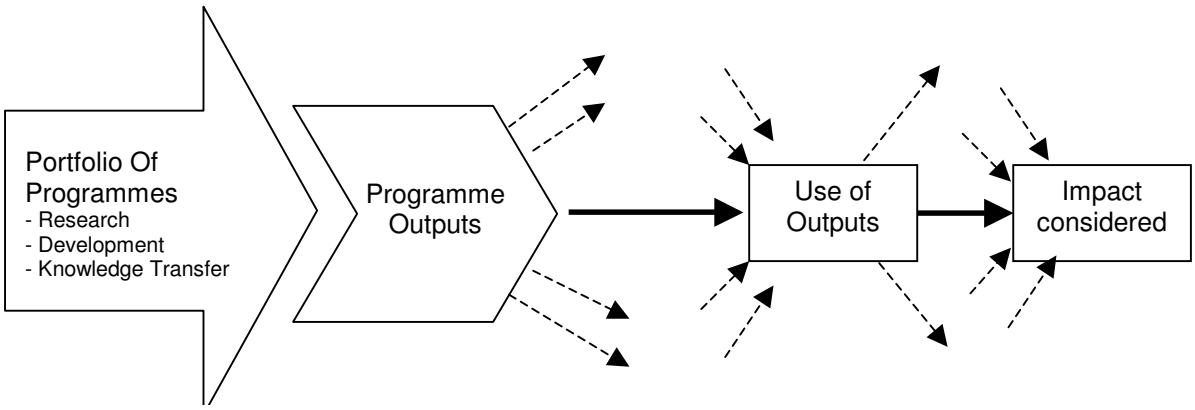


Figure 2: Pathways to impact **[Based on Smutyo (2001)]**

It is also clear that different dimensions need to be taken into account when developing methodologies for measuring impact including:

- Objective: Public good versus private gain
    - What is the purpose of the programme? (e.g. behavioural change, pure financial gain or some other combination etc)
- Type: Positive versus negative or inverse impact, intended or unintended
    - Is the impact beneficial or detrimental to the situation - or the positive of something not occurring (e.g. cost savings from a flood defence system that avoids a disaster)
- Nature of occurrence: intended or unintended consequence?
- Participant versus beneficiaries
    - Especially in a Knowledge Transfer context, beneficiaries can often turn into enabler of impact. It is important to make a distinction and recognise these peculiarities
- Frameworks, indicators, measures and metrics
    - There is a myriad of frameworks that can be used in different contexts as described previously. Consideration also needs to be given to the difference between indicators, measures and metrics – as well as acknowledging different meanings of these to different people e.g. one definition is that indicators are measurable variables used as representation of an associated factor, which is different from metrics, which are standards of measurements[Businessdirectory (2010)].

The Value Scorecard Approach

The Value Scorecard is an innovative methodology developed by NPL that provides the means of tracking progress along the pathways to impact throughout a programme (or project) lifecycle. It does this in such a way as to draw together the strategic objectives with due acknowledgement of what key stakeholders in the programme value, along with combining quantitative and qualitative measures. In essence it is a continuous innovation based on adopting elements from the frameworks above to provide a pragmatic solution.

The process broadly follows:

- Determining the strategic objectives driving the investment in a programme
- Identifying the key stakeholders in the programme and establishing what they *value*
- Defining value windows through which the programme can be viewed from the different perspectives that are relevant to those key stakeholders
- Establishing indicators measures and metrics that describe performance towards those objectives

This process for this context is summarised in figure 3. It shows an example of how the contents of the value scorecard could encompass the strategic objectives and communicates those in a way that is understandable to the key stakeholders.

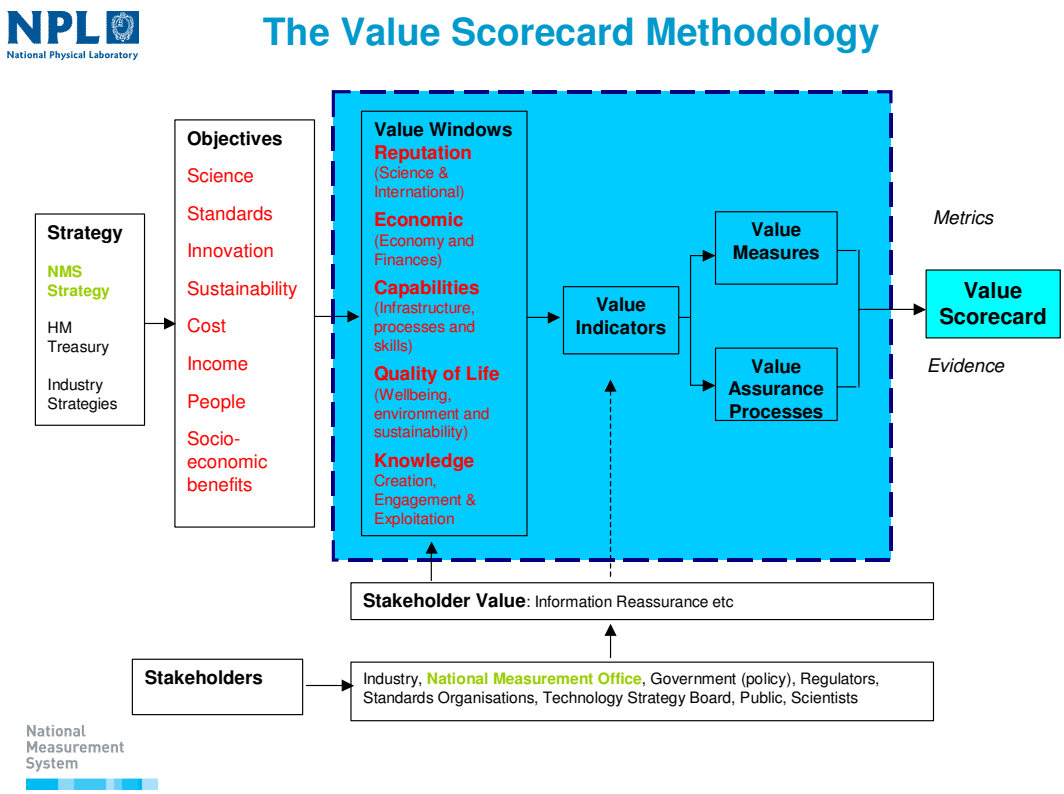


Figure 3: The Value Scorecard Methodology summarised

It also shows that metrics on their own are not sufficient, with inclusion of the value assurance processes (procedures, systems, processes and practices) that are required to generate credible, evidence-based metrics for the scorecard. In the same way the VS is not the only mechanism for demonstrating impact and should be supported with case studies and narrative as appropriate for the target audience.

The Value Scorecard process makes use of metrics, measures and indicators. Different people often interpret these terms differently, so for the purposes of clarity they are defined here as follows:

Value Window	This is a perspective that captures an aggregated aspect of what key stakeholders value in the context of the strategic objectives. Value is demonstrated to stakeholders using this lens or filter through value indicators, measures and metrics.
Value Metric	A value metric is a base unit of performance measurement data. Multiple metrics are available that can contribute to one or more value measures The value metric can be leading or lagging: Leading measures are considered to be an input into the pathway to impact or the outputs from that project; A lagging measure would reflect the difference those inputs and outputs made
Value Measure	A value measure is the aggregation of multiple value metrics into a single key measure, or a key value metric. The value measure maybe direct or indirect. A direct measure requires a clear route to impact e.g. the co-funding revenue obtained is a direct measure of leveraging the programme budget. Indirect measures give insight into the quality and effectiveness of the outcomes, capabilities, processes and culture. In other words they are proxy indicators where other information is not available, subject to credible assumptions of causal linkages. They can be quantitative e.g. number of downloads of good practice guides published on the web or qualitative e.g. customer satisfaction. The value measure can be leading or lagging in the same way as described for the value metrics.
Value Indicator	A value indicator shows the trend from comparison of a value measure relative to another e.g. a baseline, previous period or a benchmarking measure. Ideally it would be linked to a target from a strategic objective.

The value windows provide a means of structuring a summary of the key perspectives of value that arise from consideration of the multiple stakeholders involved in the receipt or supply of the appropriate benefits of the NMS.

The categories of key stakeholder groups identified and examples of members of those groups are:

- Funders – e.g. NMO on behalf of BIS, other collaborative research project contributors, UK Tax Payers
- Suppliers of research programmes e.g. NPL, scientists delivering projects
- Beneficiaries – UK Industry, UK Citizens, Government Departments

BIS are the sponsoring body of the National Measurement Office, who are the primary source of funding for the NMS. They are focussing efforts on delivering the policies of increasing economic performance with current businesses and define successful impact as:

- Creating new businesses
- Attracting R&D investment from global businesses
- Delivering skilled labour
- Improving public policy and public services

In this example, five key perspectives can be used to capture the majority of the requirements of these key stakeholder groups:

1. ***Reputation*** – UK perspectives need to be fairly acknowledge in standards and policies that underpin trading and legislation. In addition, the emergence of the innovation ecosystem means that businesses only seek out the best providers of science and technology. Therefore, the UK needs to maintain adequate representation within the measurement, standards and science communities at a national, European and global level. The NMS is a key component of this representation and can only engage in influential science diplomacy and the innovation market if it has a demonstrably credible reputation in metrology. Equally, scientists also have an interest in reputation as scientists operate in a global system of peer review, where reputation and standing are both enablers of their work and personal motivation factors.

2. ***Economic*** - The provision of an effective measurement system contributes to the UK economy. BIS, along with the other funders and suppliers need to demonstrate to their individual stakeholders the return on investment in the provision of the NMS. BIS also have a specific need to demonstrate the financial benefits from leveraging their public investment to secure funding from other areas, showing that they are contributing to delivering policy drivers to do more with less

3. ***Capabilities*** – This is about ensuring that world-class measurement capabilities and skills are available in the UK. This is required at two distinct levels:
    - The NMI to ensure that the capabilities and skills are available to underpin traceability for current and future measurement requirements.
    - Equally that businesses and public services have the knowledge and skills to effectively apply that know how to their operations

4. ***Knowledge*** – This recognises the fact that the importance of the knowledge associated with the NMS. Knowledge has to be identified, captured in a codified format, transferred between engaged beneficiaries and ultimately adopted in their practices to realise the value from the NMS portfolio. Therefore, this needs to be demonstrably managed as befits such a key asset.

5. ***Well Being*** – all stakeholders have an interest in ensuring the “well-being” (quality of life experienced by) of citizens arising from health, the environment, sustainable practices and security. The NMS has a part to play in supporting policy, legislative and moral/ethical obligations of stakeholders in this perspective.

Table 2 below summarises examples of the attributes of the potential five value windows and what demonstrates that value to the key stakeholders.

Value	Value demonstrated by
Reputation (Science & International) • Delivering high quality science • Visible leadership in measurement • International influence in measurement matters	• Contribution to the metrology science base and the use by others • Contribution to and take-up by international metrology community & metrology related committees, both invited by others and proposed by the NMS • Independent recognition of NMS achievements
Economic (Economy & Financial) • Contribution to UK economic growth • Financial benefits from leveraging investment and offsetting NMS running costs – more with less • Financial return on investment for BIS, other funders and suppliers	• Contribution of measurement to the UK economy in monetary terms • Finances secured by NMS suppliers beyond core NMS funding (private & public sectors) • Financial benefits accrued by organisations (cost savings, increased profits, investments secured etc)
Capabilities (Skills and Facilities) • World class metrology capabilities and skills available in the UK • The provision of traceable measurements • Capability of the NMS to deliver current and future measurement requirements of UK	• Provision and take-up of metrology skills training and education • Provision and take up of traceable measurement services • Level of response to measurement challenges identified in portfolio of NMS programmes
Knowledge (Creation, dissemination & engagement) • Availability of high quality knowledge, relevant to consumers at the right time • Reach, engage and serve more organisations and individuals	• Level of members actively engaged in multidirectional NMS knowledge transfer activities • Flow of people between organisations (sharing tacit knowledge and improving absorptive capacity) • Increase in average technology readiness level of the NMS portfolio • Provision and take up of science communications, patents and licences
Well Being (Quality of Life) • "Well-being" of citizens arising from Health, The Environment, Sustainable practices (and Security)	• Contributions made by NMS to health, environmental, sustainability and security challenges • Contributions to patient well-being • Contribution to WB related standards • Provision and take up of WB related measurement services

Table 2: Example of the Value Scorecard Framework based on the NMS

Value measures and metrics

The value measures and metrics provide the evidence of what value we want to measure as shown in table 1 and informs the answer to “what should we measure to demonstrate that that value?”

It should be noted that value measures (or metrics) are used to represent the current status of the programme and as such are more output orientated. They are often combined to provide information in the form akin to an indicator that reports progress towards a specified goal. Often metrics are used as proxy indicators when other information is not available, though obviously caution must be exercised with regard to assumptions of causal linkages

Selection of suitable measures is constrained by:

- What measures and metrics are readily available from the programme participants
- What measures and metrics are readily available from other sources (eg government statistics)
- Evidence of the credibility of the correlation of the measure to impact value
- Budgetary considerations in respect to the cost of obtaining the information

Key Findings from practice

This approach has been applied to research programmes that share similar attributes of complexity of stakeholder interests, a mix of public and private funding and collaborative working. The key benefits realised from this approach are:

- Includes setting and defining aspirations for impact at the start of a programme
- Identifies how that impact might be achieved
- Provides a way of actively monitoring progress (and active management if appropriate)
- Pragmatic solution to addressing the generic challenges of impact assessment present in technology and knowledge management environments
- A core set of measures will give a consistent reporting over medium to long term time frames
- Flexibility to address more immediate drivers through tailored narrative and case studies

Conclusions

The findings to date show that:

- The methodology can be successfully applied to a range of organisations and contexts described by the triple helix model, including public sector research establishments, universities and RTOs.
- Engagement of the full range of stakeholders in the development process is critical to the success of implementation
- Selection of metrics, measures and indicators must focus on balancing what should be measured against what can and could be measured within resource constraints

The challenges currently being explored further include:

- The potential for extending this approach to a wider range of contexts beyond the technology research and exploitation domain, such as social enterprises
- Investigating how to improve the inclusion of the wider context of the sustainability agenda that is coming to the fore in organisational practices.
- Seeking pragmatic ways of developing the scope of the well being perspective, including appropriate measures

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