MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

# The Impact of Research

## Position paper

October 2019

New Zealand Government

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# Executive summary

The Government has committed to significantly increasing economy-wide investment in research and development (R&D) to 2% of GDP by 2027 (from 1.37% in 2018). This increases the imperative to demonstrate the tangible benefits that public research has for society, in order to maintain the social licence for increases in research funding among other priorities for new spending.

A stronger research impact agenda will also help research organisations meet their social responsibilities, lead to research that is more relevant and more connected to end users, and ultimately support greater impact from research.

As well as being the largest public research funding agency, MBIE has a stewardship role for the science-system as a whole, both of which give it a keen interest in understanding and demonstrating impact from public research investment. The National Statement of Science Investment (NSSI) (MBIE 2015) introduced the joint pillars of excellence and impact for the research system, and requires that publicly-funded research should have a strong 'line-of-sight to impact'. There is currently some measurement and reporting of the impacts of public research, but it is not done consistently or systematically, which limits it usefulness.

The purpose of this paper is to progress the research impact agenda in New Zealand. It does this by presenting an impact measurement framework, and establishing principles, definitions and measurement approaches. It also sets out MBIE's expectations for public research funders, public research organisations and researchers.

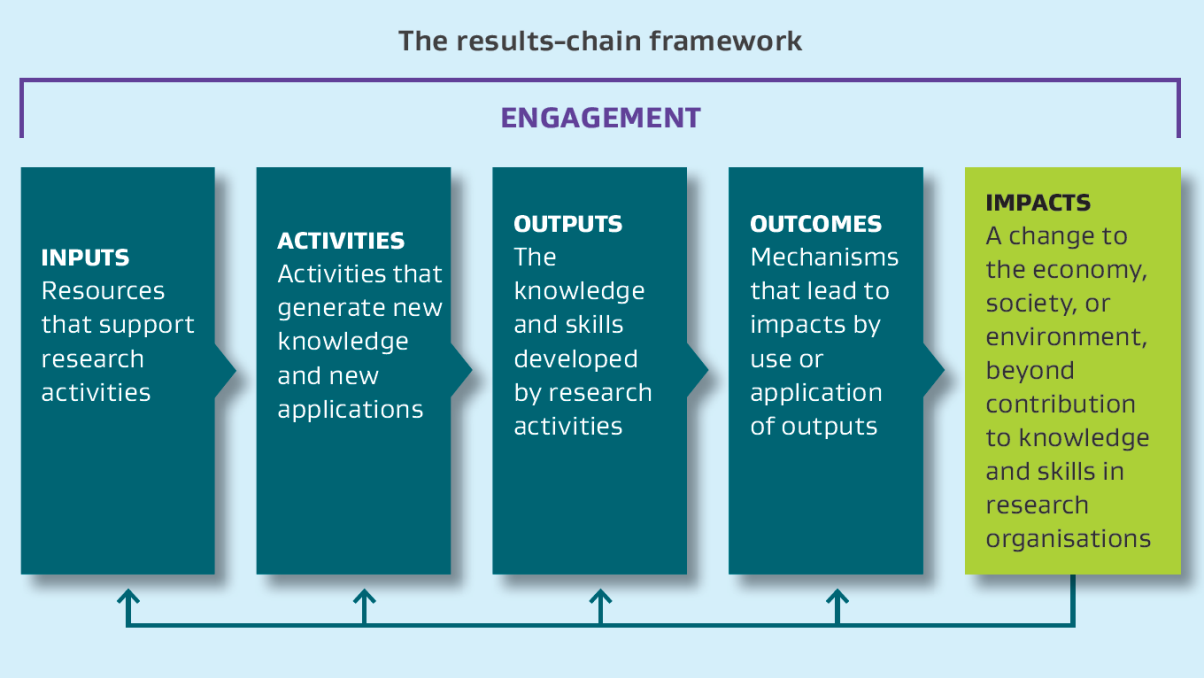
Research is a shared endeavour across many actors. **Having 'line-of-sight to impact' means that each researcher and institution understands their part in the bigger picture – how their activities have or could contribute, directly or indirectly, to the shared endeavour of impact for New Zealand**. Impacts are unpredictable and some may only become apparent in retrospect. As emphasised in the NSSI, a strong line of sight to impact does not mean an exclusive focus on applied research, but we need to work towards an understanding of how each part of the research system contributes to impact.

To properly understand line of sight to impact we need shared definitions, better data and robust methodologies. In this paper, MBIE introduces a new definition of research impact as:

> ***"A change to the economy, society or environment, beyond contribution to knowledge and skills in research organisations."***

This paper also presents a results-chain framework which defines the various stages leading to research impact. Pathways to impact may be long and convoluted. The results-chain is a simple representation of the key concepts along the pathway to impact to aid planning and reporting – it does not imply a predictable, linear pathway to impact.

**Figure 1** The results-chain for research impacts




Researchers, institutions and funders can demonstrate a line-of-sight to impact by putting their research in the results-chain. We propose the Living Standards Framework as a preferred method for categorising impacts, supplemented with the unique character of mātauranga Māori as expressed in the Vision Mātauranga policy.

Measuring impact robustly is challenging but significant steps are being made to systematically capture and link data on research inputs, people, organisations, outputs and real-world outcomes, including the New Zealand Research Information System (NZRIS). Such data-driven approaches form a powerful backbone for impact analysis, although they often stop at outputs. Extending measurement to actual impacts with meaningful narratives will require linking to other datasets and qualitative approaches, including talking to people who use research findings.

The technical challenges with measuring impact mean there is a risk of drawing incorrect conclusions or creating perverse incentives, such as encouraging applied research over basic research, rewarding good luck, or penalising researchers for factors beyond their control. To mitigate these risks, this paper presents principles for measuring research impact.

MBIE would like public research funders and research institutions to:

- Begin using the results-chain framework and language from this paper
- Be able to articulate the line-of-sight to impact for their research
- Continue working with MBIE to collect linkable data along the results-chain, following NZRIS common data standards.

In addition, MBIE would like public research institutions to renew their focus on supporting researchers to explicitly plan for and increase impact from their work. MBIE will complement these efforts by working with the sector to continue developing shared data infrastructure, to develop sector impact assessment capability, and to understand the sectoral resourcing needs of a stronger research impact agenda.

# Introduction

Researchers, governments, industry and communities all have an interest in better understanding and demonstrating the impacts of research. Researchers wish to demonstrate the benefits of their work to their field of research, institutions, stakeholders and society. Funding agencies seek to invest in projects and research areas that are most likely to generate impacts over time. Governments, industry and communities wish to gain value from new knowledge to address real-world challenges.

As a result, governments around the world are increasingly requiring that public investments in research demonstrate tangible impacts. New Zealand is no exception to this international trend. The Government has set a target of raising economy-wide investment in R&D to 2% of GDP by 2027 (from 1.37% in 2018). This increases the imperative to measure the benefits of this investment for society.

MBIE is advancing a stronger research impact agenda in its role as the largest public research funding agency and as steward of the broader research, science and innovation system.

The National Statement of Science Investment (NSSI, 2015) introduced *excellence* and *impact* as key guiding principles for the science system, and the draft Research, Science and Innovation Strategy (2018) proposes *connections* as a third principle.

> *It is vital that all parts of the system continue to strive for greater excellence and impact in the science undertaken, with our science being of the highest quality possible and* ***most public investment having a clear line of sight to eventual impact****. A focus on impact does not mean a focus solely on close-to-market or end user-driven research. (NSSI, 2015)*

Measuring and demonstrating impact from research presents a number of substantial challenges. The research system is highly distributed and many factors beyond the research system affect the achievement of impacts. In addition the impact agenda is just one of a number of imperatives faced by researchers and research institutions.

To date, measurement and reporting of research impacts across the system has not been done consistently or systematically. This limits the ability to convincingly demonstrate or understand how to promote impact from public research.

A focus on impact will need to be a system-wide endeavour and will require a common language, data infrastructure, resources and culture change. This document is a foundation for this work by providing a common and shared description of the concept of impact. It will serve as a reference guide for policy development, investment processes, planning and evaluation. The document sets out MBIE's priority work in this area, and its expectations of public research funders, research institutions and researchers with respect to impact. Together with other initiatives, it will enable the whole sector to move forward together and ultimately to understand and improve the impacts generated from public research in New Zealand.

In developing this document, MBIE has considered:

- Submissions received on the *Impact of Science Discussion Paper* in 2017
- International policies and assessment mechanisms for the impact of research
- Literature on science policy, co-innovation and knowledge mobilisation
- Literature on evaluation, results-chains and logic chains
- New Zealand public sector statutes and documents on results-based management and planning.

MBIE may update or supplement this document as the literature and thinking evolves, and as issues arise that require clarification. This will be done in consultation with interested stakeholders, such as the Crown Research Institute-led *Impact, Planning and Evaluation Network,* and the Universities New Zealand Research Committee.

# Drivers and benefits of an impact agenda

There is a broad international policy consensus that research, science and innovation are key drivers of economic development and social progress. They are critical to sustaining productivity growth, technological change and tackling social and environmental problems. However, how this process actually takes place is complex and highly debated.

There are four key drivers of a research impact agenda, as detailed below.

## Making the case for public research funding

Demonstrating impact enables governments to justify continued investment in research, alongside other policies, to achieve economic, social and environmental goals.

Communities and societies around the world increasingly expect research and innovation to respond to pressing societal challenges, such as food security, sustainable agriculture and forestry, clean energy, environmental degradation or climate change. At the same time, the rise of 'fake news' and rapid technological change make it important that science maintains its social license, credibility and perceived value in the eyes of the public.

In recent decades, government spending has become more transparent and open. Accountabilities have increased and focus has shifted from inputs, to outputs, and then to outcomes and impacts for society (refer to Appendix A for a list of research impact initiatives around the world).

## Helping research institutions meet social responsibilities and attract resources

Public research institutions and universities exist for the public good. Measuring and reporting on the tangible, societal benefits to which they have contributed helps these institutions demonstrate their social responsibilities. It is also likely to attract resources from researchers, students, and public and private funders interested in supporting particular impact areas in society.

## Informing research, science and innovation policy that supports greater impact

Those responsible for distributing funding must decide how best to do so. Like any investor, public research funders seek to maximise their return on investment (ie public-good impacts). Funding agencies must design funding mechanisms, assess the potential impact of research proposals, and understand the actual outputs and impacts of previous and current investments.

Gathering data on how impact is generated improves government understanding of how to support impact, through fund-level and system-wide settings. This does not imply an exclusive focus on impact, or on applied research that can more easily demonstrate impact. A system that can sustainably deliver impact in the long-term is likely to need excellent research across the full range of research horizons.

MBIE would like to understand how the different research horizons, funds and institutions come together to create knowledge and deliver impact in the long term, and the barriers and enablers for this process.

## Making research more relevant and more connected to end-user needs

An explicit focus on impact, including engaging with the end users of research, is likely to alter behaviour and expectations for researchers and end users. Enhanced engagement between researchers and stakeholders is believed to improve the quality and delivery of research (Harland and O'Connor 2015). This has been demonstrated for participatory research in public health (Cargo and Mercer 2008).

At the same time, researchers may have valid concerns about an explicit focus on impact and user-engagement, including taking resource away from the research itself, or reducing researchers' ability to pursue curiosity-led research directions.

MBIE would like to work with research institutions and funders to better understand the sectoral resourcing needs of better measurement and support for achieving impacts from research.

# A framework for impact

MBIE is proposing a 'results-chain' framework for thinking about impact across the sector (Figure 2). MBIE encourages all actors in New Zealand's research, science and innovation system to apply the framework when planning for and assessing the impacts of research.

## Why do we need a framework?

The framework elaborates on the NSSI by more closely defining impact and related concepts, and their high-level causal relationships within a results-chain[1].

We do not know in detail how research generates impact. We do know that the processes involved are distributed across a large number of actors, and therefore measuring and understanding impact properly must be a joint endeavour. A prerequisite is a shared understanding of the basic concepts to describe and capture information about impact and impact pathways.

## Where has the framework come from?

The framework proposed is based on the version which was distributed for public consultation in 2017, updated to reflect feedback received. It draws on the conceptual model in Australia's Commonwealth Scientific and Industrial Research Organisation's (CSIRO) Impact Evaluation Guide (CSIRO 2015) as well as work by Phipps et al (2016).

The proposed framework aligns the New Zealand usage of the word "impact" with common international usage, in which impacts follow outcomes (rather than the other way round). This aligns with the feedback from consultation and will allow evaluators to follow established international norms for constructing results chains.

## The MBIE definition of research impact

This paper presents MBIE's new definition of research impact as:

> ***"A change to the economy, society or environment, beyond contribution to knowledge and skills in research organisations."***

There are several important features to note about this definition:

- Impacts are changes to society, not the mechanisms by which those changes were made, such as adopting new knowledge, developing new products, commercialising intellectual property, or establishing new regulations or policies (these mechanisms are **outcomes**).

- Increases in **knowledge capital** or **human capital** that remain within research institutions or are only used in further research are not classified as impacts. However, both are important steps along the pathway to impact and are likely to be valued by many in their own right.

- All changes are impacts whether they are positive or negative (ie the definition is not restricted to positive changes). Furthermore, some may consider a change in a positive light, others not, depending on their values. The issues of impact trade-offs and differing values and worldviews are found throughout public policy, and should be acknowledged and explored in impact evaluations.

[1] "Results chain is the causal sequence…that stipulates the necessary sequence to achieve desired objectives – beginning with inputs, moving through activities and outputs, and culminating in outcomes, impacts, and feedback." (OECD 2002, p.33).

## The MBIE results-chain framework

The model in Figure 2 is a generic, conceptual framework for planning and measuring research to impact.

This framework is an abstract representation of what we believe to be the most important concepts related to impact. It is not intended to represent the full complexity or nuances of how impact happens in reality, or to imply that this is a predictable, linear process. It provides a useful, shared starting point for exploring how impacts happen.

### *Line-of-sight to impact*

The NSSI (MBIE 2015) introduced the joint pillars of excellence and impact for the research system, and requires that publicly-funded research should have a strong 'line-of-sight to impact'.

Research is a shared endeavour across many actors, each with potential direct or indirect contributions to research impact. **Having 'line-of-sight to impact' means that each researcher and institution understands their part in the bigger picture – how their activities have or could contribute, directly or indirectly, to the shared endeavour of impact for New Zealand**.

Presenting planned or completed research within the results-chain framework is a way to demonstrate a **line-of-sight to impact**. Any particular research project or programme may only address part of the results-chain.

### *Attribution and control*

The degree of control by the researcher(s) and research institution(s) decreases along the pathway and this is used as a key way of categorising things along the results-chain. For example, delivering **outputs** is normally considered the responsibility of researchers and institutions.

However, other people, organisations and institutions beyond research organisations have more influence on outcomes and impacts. This means that engagement outside the research organisation throughout the results-chain can help make research more relevant and increase awareness and uptake.

## Applying the framework

The framework is intended to be applicable to:

- Planning and assessing research proposals for public research funding
- Reporting on the impacts of public research and how the impact occurred
- Using research impact as part of performance evaluation.

### *Research is a distributed activity and impact is a joint endeavour*

The framework is intended to capture the direct or indirect contribution to impact of different types of research (from basic to applied). However, **any specific research project, programme, institution or fund may only address part of the results-chain.** For those assessing impact, this means choosing an appropriate unit of analysis and measurement approach.

### *Application to basic research*

Basic research pushes forwards fundamental knowledge and may only indirectly contribute to impact for society. For this type of research, impacts are particularly unpredictable and may often only become apparent in retrospect.

Nonetheless, this does not diminish the imperative to measure and articulate the contribution of basic research to impact. Figure 3 presents several approaches to better track and understand the contribution of New Zealand's basic research as well as other types of public research funding.

Appendix B includes examples of the results-chain framework applied to specific New Zealand research.

***Use of research impact in performance evaluation***

Assessing the impact of completed research as part of performance evaluation or funding allocation decisions is increasingly prominent in overseas funding systems. For example, it forms part of the Research Excellence Framework[2], which informs funding allocation to UK higher education institutions.

In New Zealand, several contestable funds assess the potential impact of research proposals, including the Endeavour Fund, and Health Research Council Projects and Programmes. New Zealand makes only limited use of impact assessment in performance evaluation, although the 2018 review of the National Science Challenges included an evaluation of each Challenge's delivery of its objective.

The 2019 review of the Performance Based Research Fund (PBRF) includes examining options, costs and benefits of introducing further impact measures into the PBRF[3].

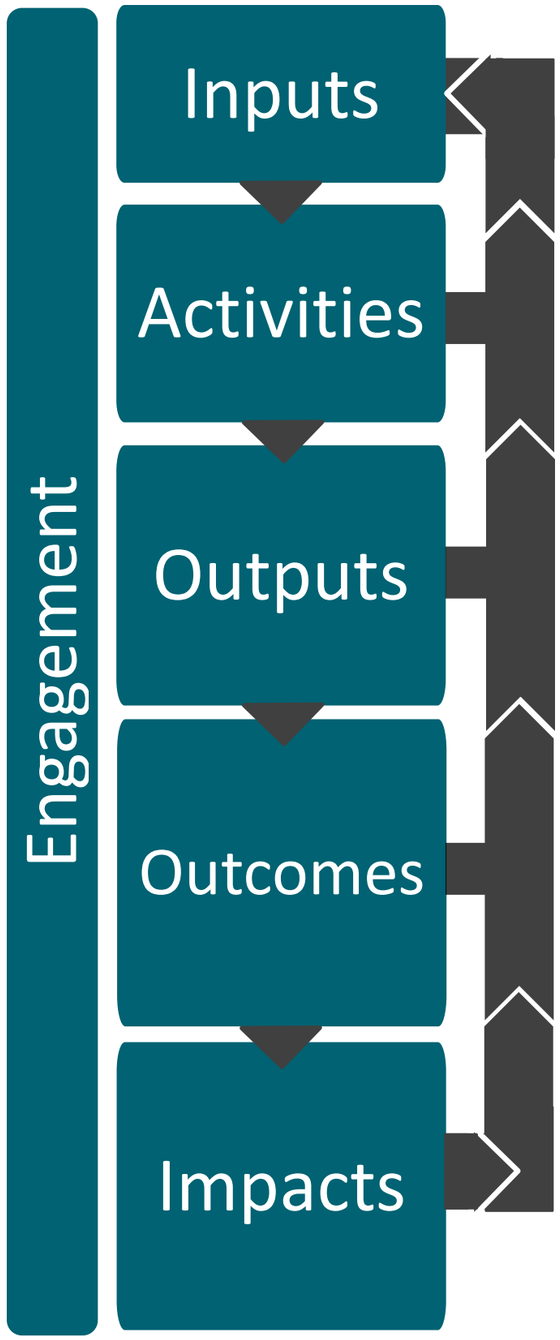
MBIE wants to understand the relative effectiveness, costs and limitations of including research impact in performance evaluation versus other options to increase the impact of research. This paper lays the groundwork for this by developing concepts used to gather data about research impact in New Zealand.

The difficulties of measuring research impact mean precautions are needed if it is to be applied to performance evaluation. The section on Measuring Impacts proposes some principles to safeguard against incorrect conclusions and perverse incentives of measuring research impacts for performance evaluation.

[2] https://re.ukri.org/research/research-excellence-framework-ref/

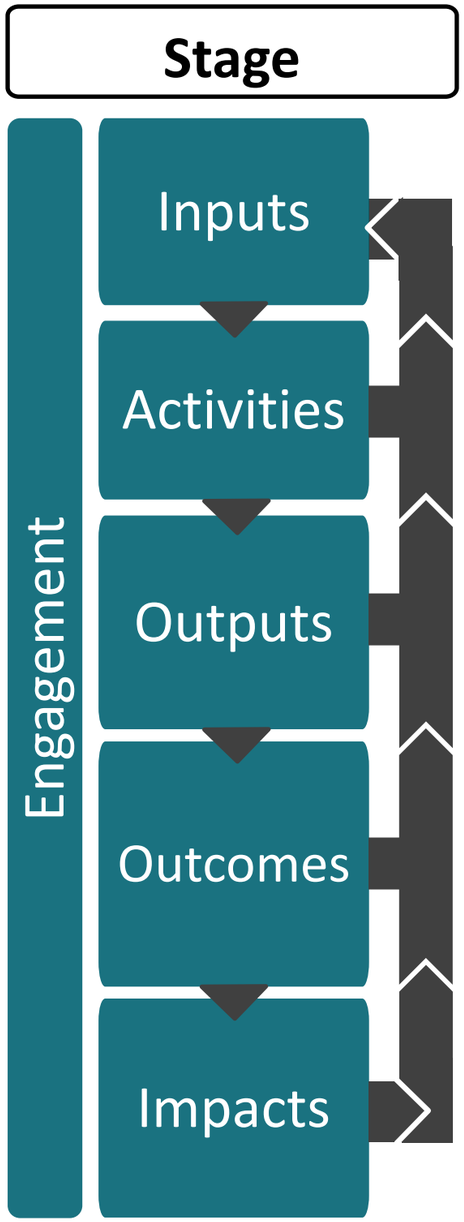
[3] http://education.govt.nz/assets/Documents/Further-education/Policies-and-strategies/Performance-based-research-fund/Terms-of-Reference-for-the-2019-Review-of-the-Performance-Based-Research-Fund.pdf

**Figure 2** The results-chain framework for the impact of research




| Stage | Definition | Examples |
|---|---|---|
| Inputs | Resources that support research activities | • Existing knowledge, including mātauranga Māori<br>• People, skills and relationships<br>• Infrastructure and facilities<br>• Cash and in-kind resources |
| Activities | Activities that, directly or indirectly, generate new knowledge and new applications of knowledge, including identifying research problems and opportunities | • Identification of new research problems or opportunities<br>• Research and training<br>• Organising and attending workshops/conferences<br>• Media interaction<br>• Engaging and collaborating with researchers and users |
| Outputs | • **The knowledge and skills that are developed by activities**<br>• Delivering outputs is normally considered the responsibility of the researcher(s) or institution(s) performing the activities | **Knowledge capital**<br>• **Publications** – eg book, article, manual, report, presentation, research thesis<br>• **Products and processes** – eg dataset, device, tool, software, standard, website<br>• **Intellectual property** – eg patent, plant variety<br><br>**Human capital**<br>• Research graduates and post-doctoral researchers trained<br>• Knowledge exchanged with users |
| Outcomes | • **Mechanisms that lead to impacts by use or application of outputs**<br>• Usually not under full control of the researcher(s) or institution(s) that developed the outputs<br>• There may be several consecutive or parallel outcomes preceding impact<br>• Specific funding may support some of these mechanisms (commercialisation funds, translation and extension funds, commercial co-funding) | • Skilled and knowledgeable people in higher education, govt. and private sectors<br>• Research findings inform further research<br>• Government policy, regulations and operations change to reflect evidence<br>• Iwi and hapū incorporate new knowledge in kaitiakitanga practices<br>• Spin-off company formed<br>• Public research informs better business products and processes<br>• General public make better-informed decisions for personal and community wellbeing and civic engagement |
| Impacts | **A change to the economy, society, or environment, beyond contribution to knowledge and skills in research organisations** | • Better environmental quality or sustainability of economic and cultural activities<br>• Reduced risks to natural, financial/physical, social or human capital<br>• More jobs and higher earnings<br>• Better physical and/or mental health<br>• Better personal safety<br>• Better material living standards<br>• New Zealanders are better able to express and preserve their cultures |

**Figure 3** Applying the results-chain framework to track and understand impact for different types of research and parts of the research system




| Stage | Basic research | Applied & mission-led | Research infrastructure | Business R&D support | System-wide (MBIE) |
|---|---|---|---|---|---|
| Inputs | | • Engage with end users on the value of possible research directions<br>• Plan for impact using the results-chain | • Plan and monitor how research infrastructure contributes to activities, outputs and outcomes of various researchers and institutions | • Track public research contribution to IP that underpins commercial innovation<br>• Track commercial contract research with public research institutions<br>• Track the movement of people between the public research sector and private sector | • Develop shared data infrastructure, capability and good practice<br>• Align research impact language and concepts across system<br>• Monitor impact at system level<br>• Develop understanding of how research impact happens, and how to support greater research impacts |
| Activities | • Look for opportunities for research and skills to solve problems in other academic and real-world domains | • Document significant interactions with end users | | | |
| Outputs | • Track citations to research by documents within and beyond academia | • Record links to prior research (NZRIS award, project or output ID) | | | |
| Outcomes | • Track movement of research alumni into the general workforce<br>• Measure and report on contributions to impact at a fund or institution level | • Gather evidence from end users about value provided by research<br>• Track outcomes of commercialisation, translation activities and use of IP<br>• Identify and monitor high-impact projects, during and after completion<br>• Measure and report on contributions to impact at work programme, fund or institution level | | | |
| **Research institutions** | • Articulate your institution's contribution in terms of the results-chain<br>• Work with MBIE towards systems that capture linkable data along the results-chain, following NZRIS common data standards<br>• Support researchers to plan for and increase impact from their work | | | | |

# Categorising impacts

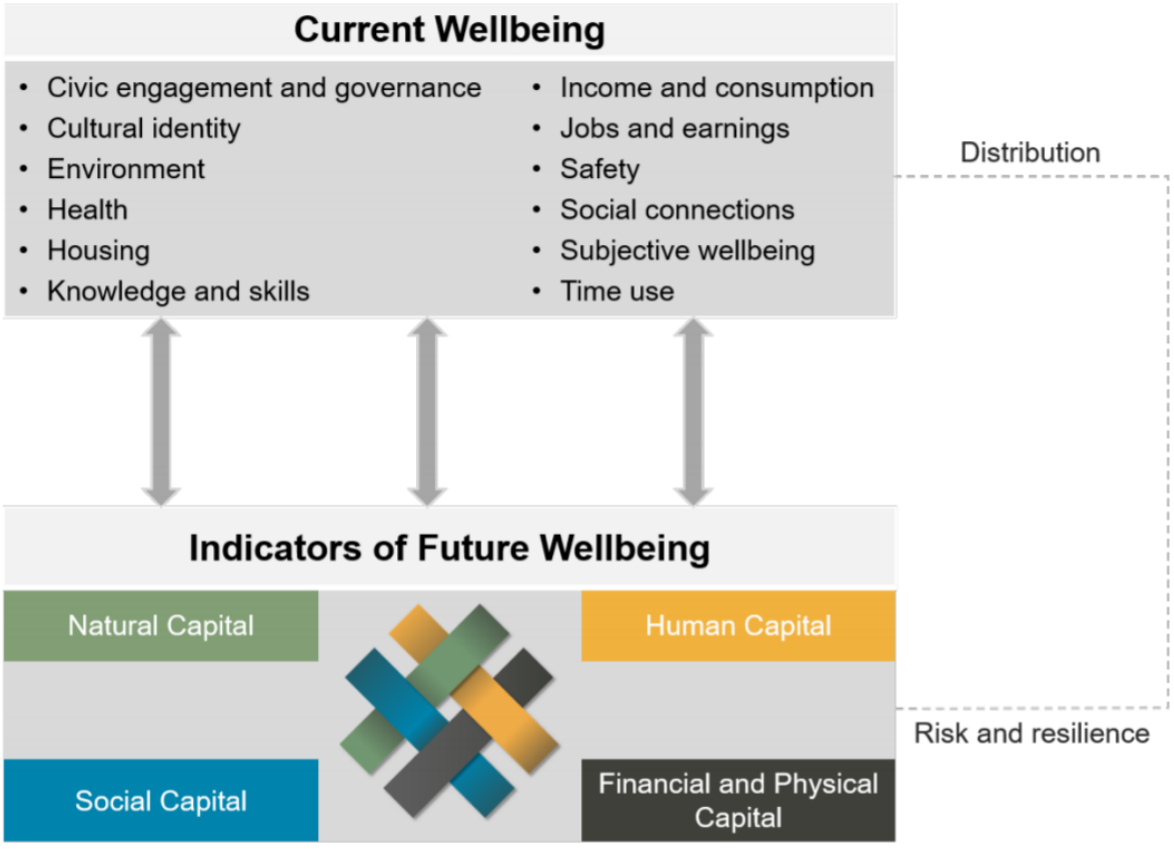
Categorising impacts consistently is important for measuring and analysing them. The submissions on the discussion paper highlighted that there is no optimum categorisation framework.

MBIE proposes the Treasury Living Standards Framework (LSF) (Figure 4) (New Zealand Treasury 2018) as a preferred, generic basis for categorising impacts.

The LSF has been developed based on robust, internationally accepted concepts of intergenerational wellbeing, put into a New Zealand context. It is being rolled out across public sector agencies so that policy analysis and decisions explicitly take a much broader view of impacts than traditional economic cost benefit analysis.

There are various other ways to categorise impacts which are already embedded in funding mechanisms and generally capture elements of the LSF. We do not propose replacing these with the LSF. However we suggest checking existing frameworks against the LSF for completeness and exploring the materials that the Treasury and Statistics New Zealand have developed to support measurement of wellbeing (Appendix C).

**Figure 4** The Treasury Living Standards Framework



## Applying the Living Standards Framework to research impacts

### General application

The LSF takes sustainable, intergenerational wellbeing as the overarching public policy goal. It unpacks this concept into 12 domains of current wellbeing, the distribution of these across the population, and four types of capital stock (natural, human, social and financial/physical) that support wellbeing for present and future generations.

Within this framework, 'research impact' is conceived as a change in current wellbeing and/or its distribution, or something which adds to or protects capital stocks. This includes improving resilience through technology, knowledge or skills with a credible 'option value' (such as knowledge or technology which increases the ability to respond to a potential biosecurity incursion or public health emergency).

### Treatment of knowledge and human capital

Knowledge and human capital appear in the LSF under current wellbeing and capital stocks. Analysis of research impact should explore the benefits of those knowledge and skills beyond their intrinsic value for those individuals[4].

## Vision Mātauranga

Categorising research impacts within the LSF does not supersede or diminish the importance of the approach presented in the Vision Mātauranga policy. MBIE believes that these frameworks are complementary and compatible.

The Vision Mātauranga policy is designed to assist research funders, researchers and research users when they consider research of relevance to Māori – particularly its distinctive aspects – and how this might be supported through public funding.

The policy includes some broad research impact areas as follows:

- **Indigenous Innovation**: Contributing to economic growth through distinctive R&D
- **Taiao**: Achieving environmental sustainability through iwi and hapū relationships with land and sea
- **Hauora/Oranga**: Improving health and social wellbeing.

[4] This treatment also fits with the distributional aspect of the LSF. Knowledge and skills which accrue only to some people are by definition narrowly distributed.

# Measuring impacts

## Methodologies and datasets

A variety of different methodologies and datasets and sources are useful to measure the impacts of research (Appendix D). The choice of method may depend on the type of research and research impact, data availability and intended purpose of the measurement. For example:

- For applied research which targets a particular economic sector, it may be feasible to perform a **cost benefit analysis** or **econometric study**
- An '**indicator framework**' approach may be useful for measuring the contribution of research to public delivery of health, education or social services
- **Case studies** are widely used to describe research impacts in an accessible and engaging way to a non-technical audience
- **Citation analysis** of research publications, patents and public documents may be more appropriate for discovering the knowledge flows from basic research.

MBIE would like to work with the sector to build and share joint capability and understanding of these approaches and their application in the New Zealand context.

## Data-driven approaches

Significant steps have been made in recent years to tackle some of the data issues associated with impact measurement. Data infrastructure is becoming available which allows systematic capture and analysis of knowledge artefacts and other elements in the results-chain.

Such databases and systems provide powerful ways to discover and link together pathways to impact across time and across research organisations. However, because they are generally limited to research activities and outputs, they are only a starting point. They need to be complemented with qualitative approaches, including talking to researchers and end users to explore the full range of impact categories, and to construct meaningful impact narratives.

Examples of relevant data infrastructure include:

- **The New Zealand Research Information System (NZRIS)**
  MBIE is leading the development of NZRIS, with other research funders and research organisations. By introducing agreed data standards, this will allow systematic capture of data on research inputs, activities, people, organisations and outputs, for publicly-funded research.
- **Bibliometric databases** allow tracking of academic knowledge flows through citation analysis. New tools are becoming available which link academic publications to patents (eg lens.org) and to public policy documents (eg 'Dimensions' from Digital Science[5]).
- The **ORCID** system introduces unique, persistent researcher identifiers to allow unambiguous linking of researchers to outputs and funding data.
- The New Zealand **Integrated Data Infrastructure** (IDI) and **Longitudinal Business Database** include de-identified, linked micro-data about people, households and businesses. They are used by researchers to answer research, policy and evaluation questions across many subject areas, and have the potential to track human capital flows between the research sector and broader society.

[5] https://www.digital-science.com/products/dimensions/

## Addressing the difficulties of impact measurement

Measuring and attributing impacts to research is challenging and complex. Specific issues include:

- Long lags between research activities and impacts
- Convoluted impact pathways which may be distributed across several research organisations
- Missing or ambiguous data
- Contributions from multiple streams of research and factors beyond researchers' control
- Difficulties quantifying the magnitude and value of impacts.

These challenges do not reduce the imperative to attempt measurement of impacts, but mean precautions are needed, especially if research impact is used as part of performance evaluation. These precautions are summarised in the principles below.

## Principles for impact measurement

- Acknowledge the multiple factors that contribute to impact, and:
    - note the influence of researchers diminishes along the results-chain
    - use caution when attributing impacts to research
- Corroborate the value of research by talking to end users and collecting evidence
- Use a unit of analysis that is large enough to allow for failures, risk-taking and distributed impact pathways (eg research institution, large research programme, portfolio or fund)
- Acknowledge lags, data gaps and data biases towards large or easily-measured impacts
- Recognise the diverse contributions to impact across disciplines, horizons and wellbeing domains.

# Next steps

Researchers, governments, industry and communities all have an interest in better understanding and demonstrating the impacts of science and research.

As a steward of the research system, MBIE would like funders, researchers and research institutions to be able to confidently assess and convincingly articulate the contribution their research has made to New Zealand. This will result in end users who are confident the system is delivering value, and increase the ability to design a funding environment that supports impact and excellence in research.

## Priority areas for MBIE

MBIE will focus in the following areas to advance the research impact agenda:

1) **Use consistent language:** Implement the results-chain framework and language in our fund documents and impact assessment exercises; work with the sector to encourage uptake of the framework
2) **Monitor impact at system level:** Continue to collect, create and publish impact case studies at the system level
3) **Develop sector capability:** Work with research institutions to continue to develop impact measurement methodologies appropriate for New Zealand, including Vision Mātauranga
4) **Develop data infrastructure:** Continue to build NZRIS and explore how it can be linked to other datasets across the results-chain
5) **Better understand how New Zealand research organisations are supporting research impacts:** Carry out a research project on research knowledge exchange in New Zealand and how it can be enhanced
6) **Better understand resourcing needs and incentives:** Work with research institutions to understand the resourcing requirements for impact assessment and what incentives support research impact.

## Expectations for other parts of the system

The research impact agenda is a shared endeavour. MBIE would like to see other parts of the research system making the following contributions:

**Public research funders**

- Use the results-chain framework and language in your fund documents and impact assessment exercises
- Be able to articulate the line-of-sight to impact of each fund or contract in terms of the results-chain framework
- Perform impact assessment exercises, with an appropriate unit of analysis
- Strive to collect and maintain linkable data along the results-chain for your funded research, including following NZRIS common data standards.

**Researchers**

- Use the results-chain framework to plan for impact and to increase the impact of your research

- Talk to your research office about impact assessment and end user engagement.

**Public research institutions**

- Support researchers to plan for and increase impact from their work
- Be able to articulate your institution's contribution to research impact in terms of the results-chain
- Work with MBIE towards systems that capture linkable data along the results-chain, following NZRIS common data standards.

# Appendix A – International examples of impact initiatives

1. The United States (US) has developed a repository of data and tools for assessing the impact of federal R&D investments – *Science and Technology for America's Reinvestment: Measuring the Effects of Research on Innovation, Competitiveness and Science* (STAR METRICS).

2. The US National Science Foundation uses the concept of "broader impacts", ie, "the potential to intellectual merit (the potential to advance knowledge) to assess proposals.

3. The United Kingdom's (UK) Research Excellence Framework now includes an assessment of the impact of research outside of academia.

4. Research Councils UK requires applicants to provide 'pathways to impact' statements.

5. The Australian Research Council (2015, 2016, 2018) has introduced a national engagement and impact assessment, which examines how universities are translating their research into economic, social and other benefits.

6. Ireland's science strategy Agenda 2020 places impact at its core and Science Foundation Ireland has developed an impact framework to help implement the strategy (2013).

7. The Canadian Academy of Health Sciences (2009) and the Canadian Institutes of Health Research (CIHR) (2005) have developed an impact framework for health research to evaluate the returns on investment in health research.

8. The UK National Institute for Health Research (NIHR) (Jones et al., 2016) has produced an impact synthesis of 100 case studies showing how NIHR-supported research is improving public health and the healthcare system.

9. The European Union (EU) has set up a High Level Group of Experts to advise on how to maximise the impact of the EU's investment in research and innovation (European Commission 2015 & 2016).

# Appendix B – Example results-chains

## 1) More birds in the bush

- **Manaaki Whenua**
- **Funded under Endeavour Research Programmes by MBIE in 2018**

The public statement provided by the research team is given below. The table on the next page puts this information into the results-chain framework.

### Public statement

Native bird populations in large NZ native forests are still rapidly declining, mostly due to predation by pest mammals, including rats, stoats and possums. The government's goal is to eradicate these predators by 2050, but we must act quickly to preserve remaining native bird populations in large forests now if we are to have viable bird populations in 2050.

NZ has learned to prevent catastrophic bird declines in cold beech forests by coinciding predator control with rodent and stoat plagues following 'beech masts'. But we don't yet know when and how to intervene to save birds at large scales in the remaining 84% of NZ's warmer, more productive native forests, which potentially support our most diverse bird communities.

Our research will develop the capability to predict both predator threats and bird responses across all native forests so that we can successfully suppress multiple predators in them and birds can recover, at large scales. This will require new field studies and building on very large, long-term monitoring datasets. Advanced integrated modelling will be used to link forest environments and fluctuating resources ('productivity'), predators, management regimes, and bird outcomes. These are fundamental interim steps towards a predator-free NZ.

Our team will develop this new knowledge, and the tools to use it, in partnership with iwi and large organisations who undertake large-scale forest restoration and predator management. They and future innovators will apply it to develop new predator-control strategies, approaches and devices that are better for birds and meet iwi aspirations. Our goal is that NZ will be able to halt forest bird declines and then reverse them. We will have more birds, not just fewer predators.

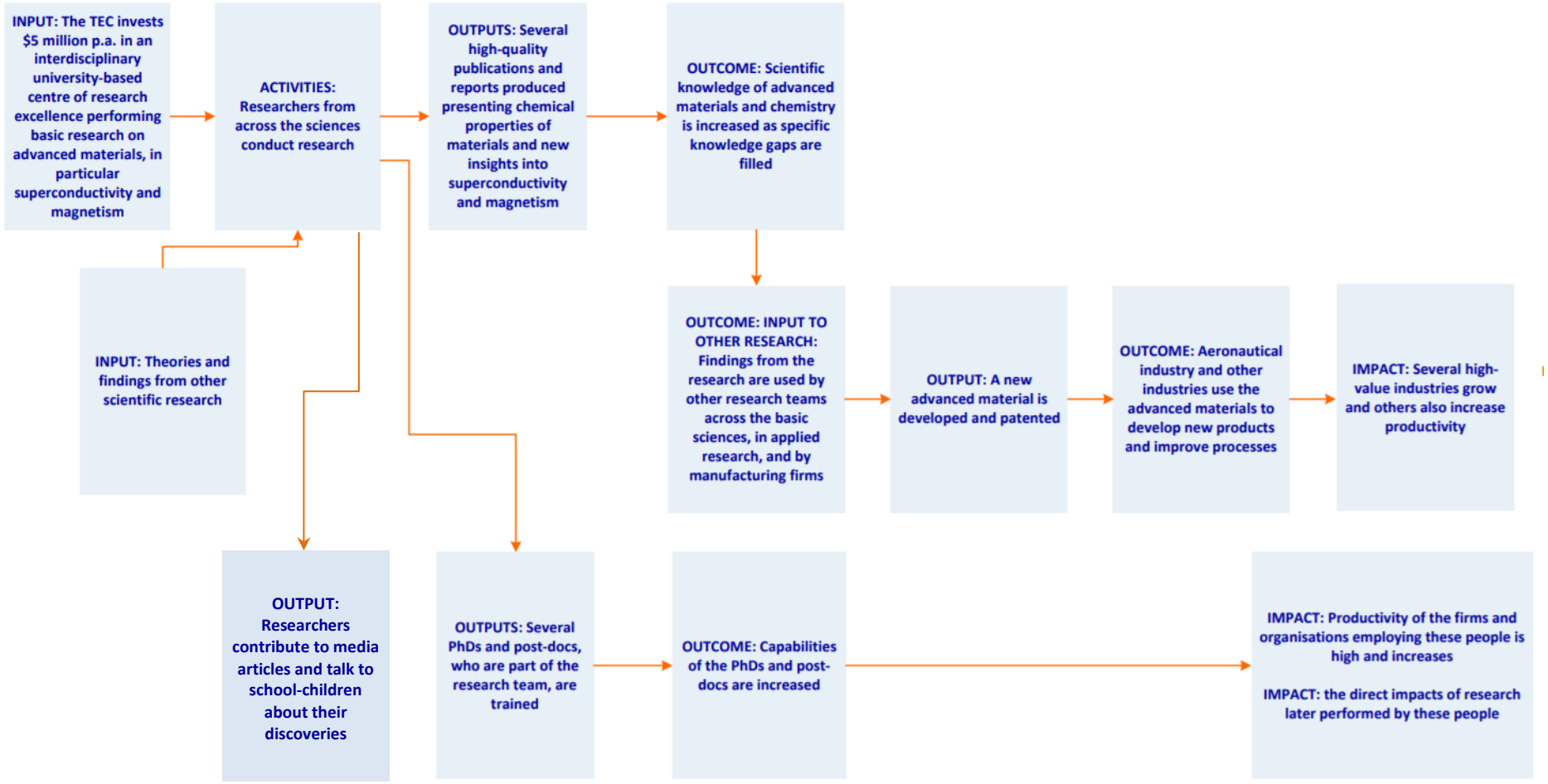
**Table 1** Results-chain for the Manaaki Whenua *'More Birds in the Bush*' research proposal

| **Stage** | **Definition** | **Example** | **Engagement** |
|---|---|---|---|
| Inputs | *Resources that support Research Activities* | • Funding from Endeavour<br>• In-kind support from DOC, OSPRI, regional councils and NEXT foundation<br>• Existing relationships with conservation organisations and iwi<br>• Existing data | • Guidance from conservation groups and Māori on research goals and design |
| Research activities | *Activities that, directly or indirectly, generate new knowledge and new applications of knowledge, including identifying research problems and opportunities* | • Identify opportunity to build on new, national rodent tracking dataset to understand and model ecosystem processes to inform pest management approaches in NZ's warm forests<br>• Conversations and relationship-building with iwi and hapū on iwi aspirations, tikanga and perspectives<br>• Field measurement and remote sensing of rodent numbers, other ecosystem variables, management methods and their interaction<br>• Tracking outcomes of experimental bird re-introductions<br>• Development of proxies of ecosystem productivity for use in predictive models<br>• Development of temporal forecasting models for predator and bird numbers based on existing and new data<br>• Demonstrate use of the models in specific cases | • Collect pest management data from conservation organisations<br>• Select case-studies for model with iwi and other stakeholders<br>• Joint, on-site research collaboration with iwi and hapū |
| Outputs | *The knowledge and skills that are developed by Research Activities* | • Integrated forest ecosystem forecasting models<br>• Publications<br>• Data layers<br>• Technical advice on pest management techniques<br>• Early-career Māori ecological research capability<br>• Wānanga and hui | • Co-author publications and co-develop models<br>• Co-develop tools and guides with iwi and hapū |

| | | | |
|---|---|---|---|
| Outcomes | *Mechanisms that lead to impacts by use or application of research outputs* | **More effective and efficient site-based management for birds:**<br>• DOC and regional councils demonstrate improve effectiveness and efficiency of large-scale, warm-forest predator suppression initiatives<br>• New mātauranga-based forest restoration approaches are applied<br>• New large-scale management strategies and tactics in non-beech North Island 'warm forests' are designed by partner agencies to benefit birds.<br>• Councils and DOC deliver and drive management practice change through advisory and extension roles. | |
| Impacts | *A change to the economy, society, or environment, beyond contribution to knowledge and skills in research organisations* | **Forest bird declines are halted and reversed across complex forests at large scales, eg:**<br>• The threat status of rifleman in the North Island and mohua in the South Island has improved through downslope population expansions in large forests<br>• North Island kōkako populations are growing in unfenced forest areas in three South Island regions<br><br>**A distinctive forest conservation character has emerged that gives effect to Māori, Pākehā, and international conservation aspirations and strengthens New Zealand's global reputation.** | |

## 2) Advanced materials

A hypothetical example illustrating some possible pathways to impacts for basic research in advanced materials, via both knowledge and skills-based routes.



# Appendix C – Resources for using the Living Standards Framework

**Living Standards Framework**

New Zealand Treasury (2018), *Living Standards Framework: Background and Future work*
https://treasury.govt.nz/publications/tp/living-standards-framework-background-and-future-work

**The Treasury's CBAx Tool**

A spreadsheet model that contains a database of values to help agencies monetise impacts and do cost benefit and wellbeing analysis
https://treasury.govt.nz/information-and-services/state-sector-leadership/investment-management/plan-investment-choices/cost-benefit-analysis-including-public-sector-discount-rates/treasurys-cbax-tool

**Indicators Aotearoa New Zealand – Ngā Tūtohu Aotearoa**

A suite of measures for New Zealand's wellbeing

https://www.stats.govt.nz/indicators-and-snapshots/indicators-aotearoa-new-zealand-nga-tutohu-aotearoa/

# Appendix D – Impact measurement methods

## Citation analysis

Bibliometrics is the quantitative analysis of the codified output of science, predominantly journal articles. Citations between papers are a quantitative indicator of links between different bodies of research and are also often taken as an indicator of the quality of scientific output (OECD 2013). Patent analysis is similar to bibliometrics in many ways but focuses on patents rather than publications.

Bibliometrics and patent analysis are widely used in research impact measurement. Jaffe (1989) conducted a patent analysis study that has been highly-cited. He estimated that R&D conducted in universities in the US had a positive effect on firm R&D and innovation (using patenting rates as a proxy) in related technological fields.

## Case studies

A case study is a descriptive, exploratory or explanatory analysis of a person, group or event. It can be based on any mix of quantitative and qualitative evidence. Case studies provide an in-depth examination of the subject of interest, in particular the context.

Case studies are widely used in research impact assessment. One of the most famous case studies was the retrospective tracing of key events that led to five major technological innovations, including the oral contraceptive "the Pill". The study was conducted by the Illinois Institute of Technology Research Institute in the 1960s, and was entitled "Technology in Retrospect And Critical Events in Science" (TRACES). The study found that: more than 340 significant R&D events were important to the five major innovations; around 90% of the non-mission research relevant to the innovations had been accomplished ten years prior to innovation; and the bulk of non-mission research was completed without insight into the innovation to which it would ultimately contribute (Mosaic 1970).

## Cost Benefit Analysis (CBA)

CBA is a systematic process for identifying and measuring all (both direct and indirect) costs and benefits of a proposal or intervention. All costs and benefits are assigned a monetary value, allowing the calculation of the net benefit of different proposals as a basis for evaluating alternatives.

CBA is sometimes used in research impact measurement, mainly *ex-post*. Alston et al (2000) conducted a comprehensive meta-analysis of 292 studies (including a small number of New Zealand studies) of the returns to agricultural R&D. The estimated rates of return were 81% per annum overall, ranging from –7.4% to 5,645% per annum. The authors considered that there is much noise relative to signal across the estimates.

The Treasury LSF builds on traditional CBA to include a much broader conception of benefits for current and future wellbeing.

## Econometric techniques

Econometrics is the application of mathematical and statistical techniques to economics in the study of problems, the analysis of data, and the development and testing of theories and models. Econometric techniques are designed to measure the impact of research investment both at the economy-wide level, and at lower levels of aggregation. They essentially use existing data to examine relationships between key variables.

A key problem for econometric techniques is selection bias i.e. that treated firms or individuals differ in important ways to untreated ones. In particular, firms that seek government assistance are

already growing faster and performing better than the average firm (Ministry of Economic Development 2011). Specific approaches have been developed to overcome selection bias (Crepin et al 2011):

- **Difference-in-difference** uses data before and after the intervention to compare the performance of two groups of firms/individuals.
- **Matching estimation** compares the performance of participating firms/individuals with other firms/individuals that are statistically similar.
- **Regression discontinuity design** applies to ranked proposals and compares the performance of projects/firms/individuals just above and below the participation threshold.
- **Instrumental variables** use a variable that affects the probability of participation, but is not related to other variables affecting the outcome in any way.

In New Zealand, econometric techniques have been used in a range of areas. For example, Hall and Scobie (2006) examined the contribution that R&D has made to agricultural productivity over the period 1927 to 2001, using a production function approach. The authors estimate that investment in domestic R&D has generated an annual rate of return of 17%, and that foreign knowledge is consistently an important factor in explaining agricultural productivity growth. The Ministry of Economic Development (2011) assessed the impact of public R&D funding on the economic performance of firms that have received assistance, using a combined propensity score matching and difference-in-difference approach. It found additional impacts of the funding for capability building assistance for small firms and for firms that had not recently (two years) undertaken R&D.

## Indicator frameworks/contribution analysis

An indicator is a set of facts or observations that tells us something meaningful about the underlying phenomenon of interest. The foundation of an indicator is a set of data. Indicator frameworks combine a set of indicators to cover a whole ecosystem or programme, and are usually organised around a conceptual framework (abstract representation of the world) such as an intervention logic model.

Contribution analysis is a related concept. It aims to explore and demonstrate 'plausible associations' across a programme's intervention logic, usually based on a series of indicators. It involves acknowledging the attribution problem, analysing the logic of a programme, measuring expected behaviour change, using discriminating indicators, tracking performance over time, testing alternative explanations and gathering additional and multiple lines of evidence (Mayne 1999).

Indicator frameworks are widely used in research impact measurement. Significant examples include those developed by the OECD (see for example OECD 2010), Tekes in Finland (Luoma et al 2011) and STAR METRICS in the US.

Statistics New Zealand is developing wellbeing indicators for the Treasury Living Standards Framework through the Indicators Aoteaora initiative. It will develop wellbeing and sustainable development indicators tailored to New Zealanders, including incorporating te ao Māori perspectives.

## Systems dynamics models

A systems dynamics model seeks to understand the behaviour of complex systems over time, including internal feedback loops and time delays that affect the behaviour of the entire system. This may become possible with more extensive linking of comprehensive funding, bibliometric, patent and researcher databases.

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