Broadening the Scope of Impact

Defining, assessing and measuring impact of major public research programmes, with lessons from 6 small advanced economies.

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Ireland: Science Foundation Ireland

Denmark: Danish Agency for Science, Technology and Innovation (including the former Council for Strategic Research)

New Zealand: Tertiary Education Commission, Royal Society of New Zealand, Ministry of Business, Innovation and Employment

Finland: Academy of Finland

Israel: the Planning and Budgeting Committee of the Council for Higher Education

Caveat: References to current practices in a particular country are based on practices of the organisations listed above at the level of programmes in scope (unless otherwise specified).

Authors

Kate Harland, Small Advanced Economies Initiative (SAEI) Secretariat

Helen O'Connor, SFI Ireland

The material presented herein is based on discussions within the Small Advanced Economies Initiative and input from participating organisations listed above. Any errors or omissions are those of the authors and any comments or corrections should be addressed to the Small Advanced Economies Initiative (SAEI) Secretariat.

Contact: info@smalladvancedeconomies.org

Foreword

This report is prepared by the Science and Innovation group of the Small Advanced Economies Initiative (SAEI). The SAEI brings officials and experts from New Zealand, Israel, Singapore, Denmark, Finland, and Ireland together to consider policy issues of common interest where the perspective of small size influences policy choices. The initiative, which was started by New Zealand in 2012, operates under three broad streams: science and innovation, economics, and global issues affecting small advanced economies. The Secretariat for the science and innovation stream and for coordinating the entire initiative is housed in the Office of the Chief Science Advisor to the Prime Minister of New Zealand.

The work presented here has been jointly led by Science Foundation Ireland and the SAEI Secretariat and has the following aims and objectives:

- To provide a common language for the concepts surrounding impact and impact assessment across countries
- Sharing lessons in implementation of impact evaluation, particularly at the allocation stage
- Enabling improvements in the future analysis of impact through ideas for tools and metrics to gather better information across all impact areas
- Providing opportunity for the use of common metrics to enable cross-country comparisons in future analyses

NOTE: This document is written for those involved in allocation and distribution of funding for research and development in science and innovation systems. It is not designed to be prescriptive, but rather offers examples and guidance based on lessons from across the member economies.

It is expected that any given agency or funding team would need to tailor the work presented here to meet their own needs. Not all chapters will be applicable to all teams. This document therefore acts as a foundational resource for further work.

The Benefit of Considering Research Impact as a Group

Small advanced economies are acutely aware of the need for efficiency and efficacy of their science systems. With a smaller system, poor decision-making becomes apparent more quickly and success has greater impact on the country as a whole. The role of a science and innovation system is also slightly different in small countries, in which science and innovation activities may have significant impact on international reputation. In the case of the SAEI, which has sponsored this work, all of the countries have looked to their science and innovation systems to drive economic growth in recent years. This requires the ability not only to evaluate funding programmes and schemes, but to determine the wider impact of this research funding.

Considering this topic within a group of countries of similar scale offers an opportunity to share lessons learnt and to develop common metrics. In small systems, different approaches can be tested at a national level more quickly and data can be gathered in a variety of ways. It may also be that the best comparator for a centre or programme lies overseas in another small nation, and that through such work international parallels can be drawn about how best to achieve results in the future.

Context

The methods of impact assessment will vary according to whether the evaluation is at the project, programme or system level. The emphasis of this document is impact assessment at the centre or major programme level, where there is (i) sufficient scale and longevity for impact to be expected within the lifetime of the scheme, (ii) political interest in demonstrating this, and (iii) where attribution is often clearer than analysis of impact from the overall science and innovation ecosystem.

Impact assessment can also be considered at various stages in the lifetime of a programme.

This paper's focus is on (i) the value, and method, of assessing potential impact at the pre-award stage of major research grants, and (ii) developing frameworks and measures to assess progress towards achieving impact throughout the duration of the lifetime of the programmes or centres.

At the *ex-ante* stage of a grant or programme ("pre-award" stage), the potential for a research team to deliver impact is considered, taking into account the relevance of their work, knowledge and commitment of pathways to achieve impact (such as through early stakeholder engagement), the quality of the team, and governance structures designed to deliver this.

The document also focuses on collaboration between funders and research groups to define better ways to monitor the outcomes and eventual impact of the scheme concerned. Designing an approach to do so, including the development of appropriate metrics, requires understanding the various ways in which such research could contribute to society and the multiple pathways by which this can be achieved. Consideration of how impact could be measured early in the programme should enable better tracking and appropriate support for these processes, assisting in maximising the potential use of research for societal benefit. This is not to say that all impact can be determined before or during the execution of the research. We include some ideas for metrics to be used both during and *after* the completion of a programme.

Consultation and two-way engagement early in the process between funders and the research community are of key importance, particularly to avoid the generation of contradictory incentives, and as part of this process we would like to thank all those who have shared their ideas on the diverse range of potential impacts of their work.

This is a working paper and feedback via the SAEI Secretariat is welcome. Ideas on new metrics are of particular interest (see Chapter 4). The overall aims of this work are summarised in the foreword in this document.

The Appendix includes a list of related reports produced by the SAEI member economies. Some of these have informed the thinking in this document, while others provide a complementary emphasis with regards to impact (for example ex-post evaluation of impact at a system level) and may be of interest for further reading.

1. Defining Impact

1.1. Defining impact

Results from activities in the science and innovation space come in a variety of forms, from outputs such as scientific publications or patents, to the resulting development of new products, processes, or ideas which inspire behavioural/policy change. Dissemination and uptake, however, are necessary if outputs are to result in change. There is therefore a key distinction between scientific outputs and the resulting "impact" of research.

Impact in the context of this document may be considered as:

The direct and indirect 'influence' of research or its 'effect on' an individual, a community, or society as a whole, including benefits to our economic, social, human and natural capital.

Research Councils UK, for example, refers to *"the demonstrable contribution that excellent research makes to society and the economy"*[1].

Impact, as considered here, thus embraces all the diverse ways in which research-related knowledge and skills benefit individuals, organisations and nations. A broad definition has the benefit of inclusivity of all disciplines and multi-disciplinary research areas. It can encourage researchers and funders to think about the broader implications of the research from the outset, as priorities shift, or when research raises unexpected discoveries during the life of the programme.

In the context of this document, there is also a distinction between the terms 'relevance' and 'impact' with respect to research programmes. Impact considers both the relevance of the research to the challenges faced by stakeholders and society, AND implementation or use of the results.

Outcomes and Impacts

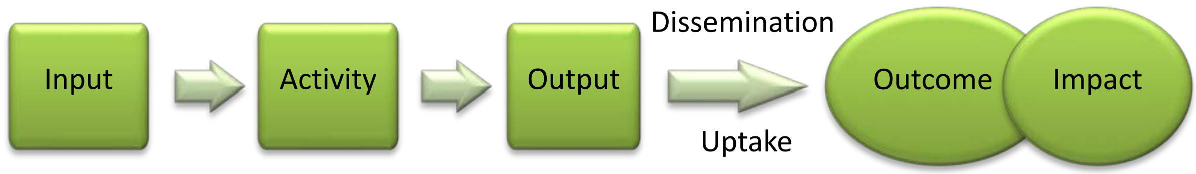
While the terms *outcome* and *impact* can sometimes be used interchangeably, there is an important difference between the two terms that can best be articulated in terms of timescale and relevance (or value).

Some outcomes can be considered as intermediate steps to longer-term impacts. In other cases, outcomes may be considered by some as impacts in their own right depending on the perspective, an example being improvements in science literacy and/or public engagement in science. Stakeholder perspectives on impact will be examined later in this section.

Impact is typically related to an end goal, and positive impact implicitly includes a value judgment as to what is considered important for society and relevant to stakeholders. An outcome without relevance may not be considered to have a meaningful impact. Identification of areas of relevance and priority is currently being examined in a separate SAEI study. Such areas of focus may be articulated for example in the long-term strategic aims of a science-funding agency or by the Ministry responsible for science system policy.

The following box and diagram summarise some key terms referred to throughout this document:

[1] http://www.rcuk.ac.uk/ke/impacts/meanbyimpact/



Box 1: Inputs, Outputs, Outcomes and Impact

- Input indicators: These refer to the resources (people, infrastructure and money) which a research funder or institution spends in the research process.
- Activity: Refers to the activities generated as a result of research inputs (for example awards granted, teams established, research undertaken).
- Output indicators: These indicators are typically described as the accomplishment or product of the activity (e.g. publications, conferences, workshops etc.).
- Outcomes: Refer to the knowledge transferred and/or the changes that occur as a result of a programme/project and tend to be more immediate than most forms of impact.
- Programme relevance: Work covering areas and issues as identified in the programme scope.
- Societal relevance: Research covering areas identified as important challenges for stakeholders and/or wider society.
- Impact: Considers both the relevance of the work and its implementation or influence. In other words, the direct and indirect 'influence' of research or its 'effect on' an individual, a community, or society as a whole, including benefits to our economic, social, human and natural capital.

Specific examples:

Publications and conferences are outputs that are important for the dissemination of research. Ways in which such outputs may become outcomes include the use of results as evidence in development of policy guidelines, or in improving the knowledge base of a particular discipline or research field. Impact can then be described as the development of these outcomes into, for example, improved health and/or wellbeing as a result of a policy change, or dramatic changes in our understanding of the world.

Invention disclosures or patent filings on their own are considered outputs of research until they are exploited, for example through a licence. The licence may be considered an intermediate outcome, with accrued economic benefits as the end goal or impact.

Discrepancy in the use of impact between academics and policymakers

It is worth noting that often there continues to be a discrepancy in use of terms between the academic community, funding agencies, policy makers and the political community. This in part stems from the different aims and objectives behind measuring impact, which will be discussed later in this section.

It is important to distinguish impact as described in this document from the bibliometric use of the term such as in the “impact factor” which is often referred to in academic settings – the latter is simply a measure of the citation rate of a journal and is not a measure of research impact in the sense referred to in this document.[2]

Much of the recent scholarly literature on impact is essentially focused on bibliometric proxies of research quality rather than on what society expects of the research it funds. This in part reflects today’s competitive academic environment, where universities need handy performance measures for recruitment and career advancement of faculty members. However, bibliometrics used within the science community tell us little about what Governments care most about: the visible societal impact of public investment in science.

It is therefore important to note that the term ‘impact’ as used in this document refers to the broader societal impact(s) of research. It does NOT refer to the ‘impact factor’ of scientific outputs (publications), as measured strictly by conventional bibliometric analysis and used primarily as a measure of scientific quality in the absence of a ‘relevance’ and ‘application’ lens.

1.2. Why we measure impact

A critical consideration of why we measure impact is important as the approach may differ depending on the context. The following describes some of the key reasons for measuring impact.

Accountability and advocacy

Each year nations spend significant amounts of public funds on scientific research, training, and development. As with all public spending it is both desirable and necessary to show value for money, and, within this, demonstrate and articulate the impact and benefits of scientific research. Measuring impact therefore helps offer accountability to taxpayers and donors, and enables advocacy for example for the continuation of programmes in times of budget constraints. Such analysis is often retrospective (or ex-post) and carried out long after the research has been performed.

There are, however, other key reasons for measuring impact that are of fundamental interest to those distributing funds.

Allocation and analysis

Those responsible for distributing funding must decide how best to do so. For competitive programmes, applicants are judged on the quality of the proposal and their ability to deliver

[2] For further discussion of the issue and misuse of the word ‘impact’ in science, see (http://www.pmcsa.org.nz/blog/impact-whats-in-a-word/)

this based for example on their CV, proposed team structure, and collaborators. In many cases agencies are also interested in assessing relevance of the programme to wider society, and the potential impact through *ex-ante* impact assessment. This may be used in the allocation of resources, ideally once the criteria for scientific quality have been met.

The charter of the funding agency may also influence the types of impact that are expected. A funding agency focused on technology transfer will expect a very different balance of impacts to one focused on health research. These expectations need to be made explicit in funding calls to avoid cynicism and scepticism about assessment processes.

Through identifying potential impact at the start of the programme, and actions proposed to help realise this, the opportunity also arises to gather data and evidence to understand what works in relation to uptake or translation of the research, whether the key stakeholders be policymakers, businesses, professionals, or society as a whole. This in turn allows improved assessment of potential impact as part of the selection process.

NOTE: Assessment of outputs may also be used in estimating the allocation of funds to institutions by a government, such as in university funding. There are a variety of algorithms used across the nations involved in the SAEI and this is a separate issue that will not be covered in detail here.

Altering behaviour and expectations

It is important to recognise that an *ex-ante* approach to assessing impact also offers the chance to change behaviour and expectations. This can be classed as a type of *formative evaluation*, designed to affect the conduct of researchers through its implementation.

If done well, there is opportunity to improve delivery of relevant research and increase translation of research through engagement between funders, key stakeholders and researchers:

- Researchers may be more aware or conscious of pathways for translation of their work.
- Early engagement of potential stakeholders enables improved understanding of potential relevance and, in return, increased interest and understanding of the final outcome.
- It also allows for an iterative negotiation of impact between funder and provider so that from the outset appropriate evidence of impact can be gained to mutual value.
- Any gaps in support for pathways or any critical points can be highlighted early on. This may feed into policy and practice of funding providers and Government.

Such engaged knowledge production (sometimes referred to as engaged scholarship[3] or 'integrated knowledge translation' in the health research sector) is supported by research highlighting the importance of collaboration and meaningful interaction as a critical factor in predicting research use[4]. Advocates of 'engaged scholarship' argue that the questions examined need to be of interest and relevance to the stakeholders and potential users, and framed in a way that takes into account the contextual setting, as communication post-research completion is too late. While in some disciplines such as the social sciences there

[3] From Knowledge Translation to Engaged Scholarship: Promoting Research Relevance and Utilization, Bowen et al., Archives of Physical Medicine and Rehabilitation, Volume 94 , Issue 1 , S3 - S8.

[4] Cargo, M. and Mercer, S.L. The value and challenges of participatory research: strengthening its practice. Annu Rev Public Health. 2008; 29: 325–350.

has been a long history of engaged knowledge production, to some fields this will be a new approach. This document suggests a systematic, consistent approach across the disciplines.

The following examples highlight some current uses of impact assessment by different stakeholders across the system.

In this document we focus on the use of impact assessment from the perspective of the funding agency.

Government

- Accountability to the taxpayer – to form a view on the value proposition of investment in R&D and benefit for the taxpayer
- Allocation – to identify needs for prioritisation and redistribution within the system, in an attempt to maximise benefit for society per dollar invested

Funding agencies

- Accountability to Government – and advocacy for future agency funding
- Allocation – to rate applications and make funding choices
- Altering behaviour – to encourage researchers to deliver impact through formative evaluation and selection processes

Academic institutions and research groups

- Advocacy for future institutional/group funding
- To replace or supplement performance assessment within an institution

1.3. Classification

While impacts of scientific research can be classified in many different ways, this document includes a framework for discussing impact (see Chapter 3). The idea behind this framework is to enable a holistic consideration of multiple aspects of impact beyond those traditionally considered, and to offer examples of metrics from the countries involved in this work. There is no single correct approach to classifying impact; however, we hope the ideas presented here provide a broad base and will facilitate your own discussion.

This framework is designed to recognise impact across many areas, including those that affect our economic, social, human and natural capital.

There are also consistent themes across all areas, and in particular:

- **Creating new** products, processes, policies or behaviours
- **Improving efficiency and efficacy** of existing practices/policies/processes
- **Building resilience**, sustainability and reducing risk (whether in relation to the economy, natural environment, health, or wider society)

The latter two themes are often underrepresented in reporting mechanisms, yet here are shown to cut across the six pillars of impact, as presented in Figure 1:

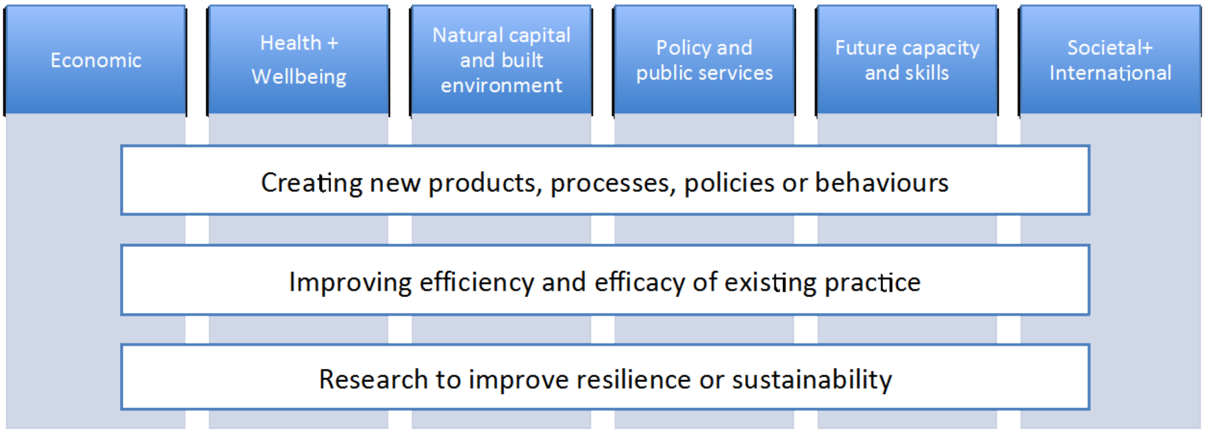


Figure 1: 6 pillars of impact used in this document, together with the cross-cutting themes

Building resilience may also include forming the foundational knowledge base on which to make decisions (e.g. through data collection and monitoring). Such data may not necessarily be 'applied' to a defined end-purpose other than to build understanding that will be drawn upon for preparedness and crisis.

The themes and the framework are discussed further in Chapter 3.

Depending on the funding agency, different impact areas may be weighted differently. An agency which primarily deals with health research funding, for example, would be expected to focus on this dimension but may still consider other broader aspects such as training future capacity, financial implications of healthcare, and community and societal issues.

The main objective of highlighting the wide variety of potential areas of impact from the start is to encourage researchers and those designing research programmes and funding mechanisms to consider the variety of ways in which the results may benefit or affect parts of society. There is *not* an expectation that researchers will have a perfect pathway and fixed process for delivering impact at the start of a project or centre, and during the programme new discoveries may result in unexpected outcomes; flexibility in the monitoring to accommodate this is therefore appropriate.

The choice of pillars here includes the dimension of 'future capacity and skills'. While from the perspectives of some stakeholders this may be seen as an intermediary outcome rather than impact, by including this as a pillar we are explicitly placing value on training and development of the current and next generation to enable future flexibility and establishment of strengths in the long term.

From an academic standpoint this is often considered a central form of impact, and by including such a pillar we also provide a bridge between the academic and policy use of the term. For those wishing to look across a portfolio of programmes together with the societal and international pillar, it enables inclusion of research that might traditionally be considered 'basic' research and recognises the long timescales of some academic research.

In the context of this document, *academic* impact can be considered and recognised alongside economic and societal impact in terms of:

Pillar 5 - building future capacity (e.g. through teaching and training of the next generation)

Pillar 6 - societal and reputational impacts including:

- establishment of reputation (for the group, and ultimately for the country as a whole)

- advancement of understanding of the world around us (advancing the forefront of knowledge, and enabling new avenues for future discovery)

As with other forms of impact, how such aspects are considered and weighted will depend on the aims and objectives of the funding agency, the programme and the country-specific context.

1.4. The broader challenges of measuring/evaluating impact

This section highlights at high level *some*[5] of the challenges in measuring and evaluating the impact arising from an investment in research.

Attribution

Any metrics selected to monitor progress along the way should be attributable to the proposed or funded programme as closely as possible.

Impact by its nature is harder to measure than direct outputs of scientific research; as such proxies are often required. To avoid confusion and unintended consequences (e.g. encouraging generation of certain outputs irrespective of relevance rather than progress towards the overall desired impact), it is important to distinguish when a metric is an indicator rather than an absolute measurement of impact. For example, measuring the number of spin-outs may be used as an indicator of growth of companies in the economy and the associated increased employment). Some metrics may be both indicators and absolute measurements in their own right, such as those which measure public engagement in science.

Long timescales and moving targets

Some research projects will have immediate impact whereas other projects may take much longer to achieve impact.

Impacts which relate to the development of the country's reputation, or attraction of talented people to build competitive human capacity, may materialise more rapidly than impacts which result from development and implementation of new technology, which typically develop over long timescales. An output such as a filed patent is unlikely to create an impact until the patent is licensed to develop a product that can then generate revenue and jobs.

In the medical field, the discovery of a new medical treatment or device ultimately has the potential for obvious health as well as economic benefits. However, achieving this requires multiple stages of testing and then uptake by healthcare centres and professionals. Mechanisms to consider and monitor the development stage (such as technology readiness levels) of outputs may be relevant to funders in this context as a tracking mechanism, but are not the focus of this document. In contrast, outputs from research in diagnostics such as publications in medical journals may have the potential to be used immediately. Experience has, however, shown that adoption can take longer than expected and lives could be improved or saved by accelerating this process.

[5] This is not intended to be an exclusive list of all issues, but is designed to highlight some major themes.

Non-linear process

Research, and especially research of a fundamental or basic nature, does not necessarily follow a linear process. Yet research is often portrayed as basic research transforming into applied research that then translates into technological development in forms such as devices, systems, drugs, and therapies that then exert an impact on the world. In reality the process is more complex and involves two-way exchange with multiple stakeholders. Longitudinal tracking requires a system of joined up thinking and reporting amongst these very stakeholders.

Many parties with different roles can be involved in the path from idea to impact and in conceptualising and articulating the potential impacts of research. Taking a broad view of where a project or research programme fits into the overall picture early on in the process can help to better understand how best a researcher can ensure his or her research makes a real difference in the world.

2. Current Practices in Programme Selection and ex-Ante Impact Assessment

In the current global climate of constrained public spending, there is an even greater focus on demonstrating the economic and social benefits of publicly-funded scientific research to the wider society if funding levels are to be maintained or increased.

In this section we consider lessons across the Small Advanced Economies regarding the evaluation of potential impact of research programmes at two points:

1. At the selection stage and during initial contract negotiations:

- How scientific quality and excellence is considered alongside impact
- What lines of evidence are used to assess potential impact, what guidelines are given and how these are communicated
- How the lines of evidence are reviewed and evaluated, and how conflicts of interest are avoided
- The transparency of the overall process

2. During the lifetime of the programme

- How programmes are evaluated for progress
- Maintaining flexibility for unforeseen outcomes

Processes for selection, *ex-ante* evaluation and monitoring will vary according to the scale of investment, as transaction costs should be to some extent proportional to the scale of the grant.

While some sections of this report are applicable more broadly, in this section we focus on awards:

- of substantial scale equivalent to the level of 1 million to 10 million euro for each centre/programme per annum (e.g. of the order of 10-50 million euro for a centre over its lifetime).
- with some degree of longevity (in the range of 4-10 years)
- with a multi-disciplinary component
- with a selection process which contains some degree of contestation
- with public funding (part or whole)
- involving public researchers (in some cases alongside private researchers)

This is to allow a more detailed discussion of the process involved. Such schemes have the timescales and scale for which a variety of impacts can be expected, and are likely to be the focus of political questions regarding the return for investment from the taxpayer. The general framework, however, is applicable to a wider context with different focus.

This includes schemes such as Centres of Excellence, National Challenge Programmes, Strategic Centres, and Research Centres. A detailed list of current programmes at this scale across the countries can be found in the Appendix. Some lessons are applicable more broadly but should be treated in context.

It is worth noting at this stage that there is not necessarily consistent terminology or nomenclature for the various schemes across the comparator countries. For example Centres of Excellence exist in all 6 of the countries in the SAEI, but there are significant differences in design and in the goals that they are expected to achieve; more detail can be found in the Appendix. The extent to which different potential impacts and their weightings are considered often depends on these critical objectives where the research programme or centre fits within the overall science system.

2.1. Selection

Consideration of potential impact in the selection process

The potential impact can be considered at various stages within the selection process.

1. In the selection of programme themes to which applicants can apply

In many cases research teams are provided with a list of themes to which they can apply. The development of the choice of these themes, and the call text surrounding them, may involve some degree of judgement as to what areas may have the greatest potential impact for a country. Several of the countries have reached out to their communities (scientific or general public) to help define where these areas might lie. The results have directly affected the design of the calls for proposals. Examples are provided below:

> **Israel:** the selection process for the establishment of centres of excellence engaged the wider scientific community. This was done in a different manner in each of the two rounds. In the first round, the pilot phase, the research institutions were asked to suggest research topics that would later be included in a call for proposals. A consortium of researchers from various institutions could then submit their proposals for the establishment of the centres. In the second round of establishing the centres, the whole research community was asked to submit research topics, receiving around 152 submissions involving more than 1200 researchers. Out of the large number of proposals that were received, 18 topics were chosen by designated committees. The International Scientific Advisory Committee was also involved in the process. Once the topics were announced, a call for proposals was issued inviting groups of researchers to submit proposals for the establishment of I-COREs in these topics. The potential impact and importance for Israel were considered as part of the topic selection by the Steering Committee. Applications were later assessed for their relevance to the particular theme but further impact consideration was not taken into account.
>
> **New Zealand:** engaged broader society to select National Science Challenges (NSCs) for the NSC Programme, with submissions from both the general public and the research community. A panel of experts reviewed the submissions; the final challenges selected would likely have been different without public engagement, which involved the opportunity to submit new ideas and to vote on those already submitted. The final challenge raised was one about science and society, to encourage two-way participation and to increase the impact and relevance of science conducted by and for New Zealanders.

Selection of themes may also be driven by priorities as defined by the funding agency and/or alignment with national priorities. National prioritisation strategies and consultations are a topic of a separate study under the SAEI, although it is worth noting here that several of the countries have undertaken such exercises. The Danish Agency for Science, Innovation and Technology, for example, engaged a wide group of representatives of businesses, the public sector, interest organisations and universities to identify the visions and needs for strategic research for Danish society as presented in the document *Research2020*. This was used by the parliament to guide policy on research and to prioritise specific research areas, and these in turn have historically been expressed through the Strategic Centres and Alliances.

Ireland carried out an exercise in top-down priority setting based on country needs. This work was informed by detailed analysis by a Research Prioritisation Group, which was tasked with recommending areas around which future public investment in Science, Technology and Innovation should be made. After consultation, the Group identified 14 Priority Areas, along with 6 Underpinning Technology Platforms and Research Infrastructures, that should be the focus of public investment in the coming years. Contributors included Government Departments and agencies who fund R&D, the research community, the enterprise sector and other stakeholders. The implementation of these 14 priority areas through the funding agencies is influencing the themes and allocations for different topics and encouraging discussion across agencies.

2. At the pre-proposal stage and/or full proposal stage
This will be discussed in detail in the next section in this chapter.

3. Post-selection, during the contract preparation

While impact may have been considered in the selection of the grants, some countries revisit impact statements and claims during contract preparation to define KPIs and assess how a programme or centre can be monitored appropriately.

Overview of the selection process

At the scale identified, all programmes in the SAEI countries typically involve two stages of selection. To avoid confusion of terminology, the following figures outline such a selection process (with an optional Stage 0), and roles of the different players within the system. There is variation in this process between countries and specific programmes, and therefore this diagram offers a base for discussion only. As a reminder we refer to programmes of substantial size and longevity, that is, of the order of 10-50 million euro per centre over their lifetime.

Some main points of variance are:

- To what extent and how initial submissions are filtered (if at all) prior to external review, and whether relevance is considered at this stage
- To what extent feedback is given during the process, and to what extent applicants are expected to revise their submissions from the initial proposal, including expansion of any statements of expected impact
- The composition of panels to review full proposals and how science and impact scores are combined
- Whether a board/committee has final decision-making rights based on rankings from the panel (or equivalent)

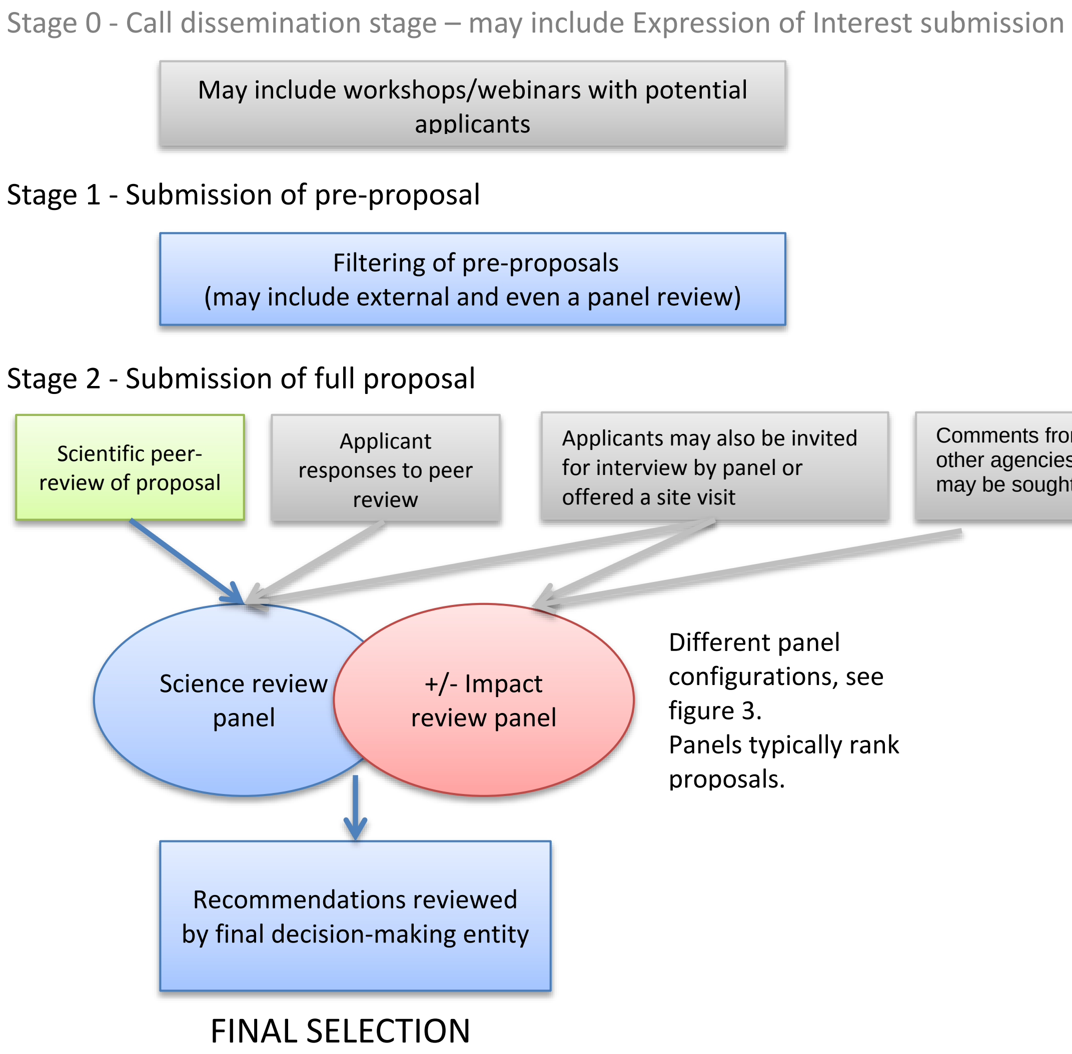


Figure 2: Stages in the selection process: A diagram to facilitate discussion across agencies with different terminologies. ***Items in grey in the diagram are optional, and show substantial variation between programmes and funders.***

Main considerations in detailed design of the processes include: transaction costs for funder, transaction costs for the research community, availability of reviewers and panel members with suitable expertise, avoidance of conflict of interest, and bias within committees/boards.

Some schemes have utilised a Stage 0 to influence and even filter or reduce the number of applications submitted (e.g. by encouraging research groups to collaborate), to minimise transaction costs and increase relevance of submissions.

Combining scientific excellence and impact at the selection stage

'Excellent science' is a term, like many others described in this document, which can have varying interpretations between different agencies. In the context of this document we make a general definition:

Excellent science: well designed, well performed, well reported research, recognised as such through peer-review

A hurdle of scientific excellence: can the scientists deliver?

In the previous chapter, we refer to the continued importance of evaluating the quality of science at the proposal stage. Scientific excellence is considered by most of the countries in this analysis to be a pre-requisite to achieving substantive impact, and hurdles for excellence are set in the selection process such that only proposals that meet this level are considered for impact evaluation.

Criteria for scientific excellence or quality evaluation typically include evaluation of:

- **The people:** The ***quality*** of the recent research record of the proposed research team and principal investigator(s), taking into account the career stage of the applicant(s), with particular focus on the proposed leader of the programme/centre or team.

- **The research idea:** The ***quality*** of the proposed research, including the potential to advance knowledge and understanding within its own field or across different fields.

- **The team structure:** The proposed organisational structure for the team/centre or programme and its ability to deliver ***quality*** research. Connections to the institutional environment in which it is set.

The latter is particularly important in medium-long term programmes (5 years +) where the research plans may evolve substantially through time.

Evaluators best placed to assess potential for the programme or centre are those with experience of running groups of similar scale elsewhere. Lessons from previous funding rounds within the SAEI countries show the importance of this, with some less experienced panellists focussing on the detail of the application at the expense of the larger picture.

Research that is not at the leading edge internationally is unlikely to generate science with significant increases in knowledge or technology, and the potential rewards that can follow. In several programmes and for some delivery agencies in the SAEI economies the excellence bar is therefore intentionally set high, from an international perspective, to maximise potential results for society and the economy.

Considering disruptive research

Research with potentially high impact can also be intellectually high risk, and in competitive and fast moving fields can have limited windows of opportunity. Ultimately when ambitious or potentially disruptive research options are presented, the judgement call as to whether or not this is achievable returns to the question of scientific excellence: do the individuals concerned have the track record and team capable of delivering the science suggested.

Combining assessment of excellence and impact during the process

Once proposals meet a minimum scientific threshold, there is then a diversity of approaches within the group regarding the process and balance of the consideration of excellence and impact.

The following schematic considers two different ways in which panels could be arranged.

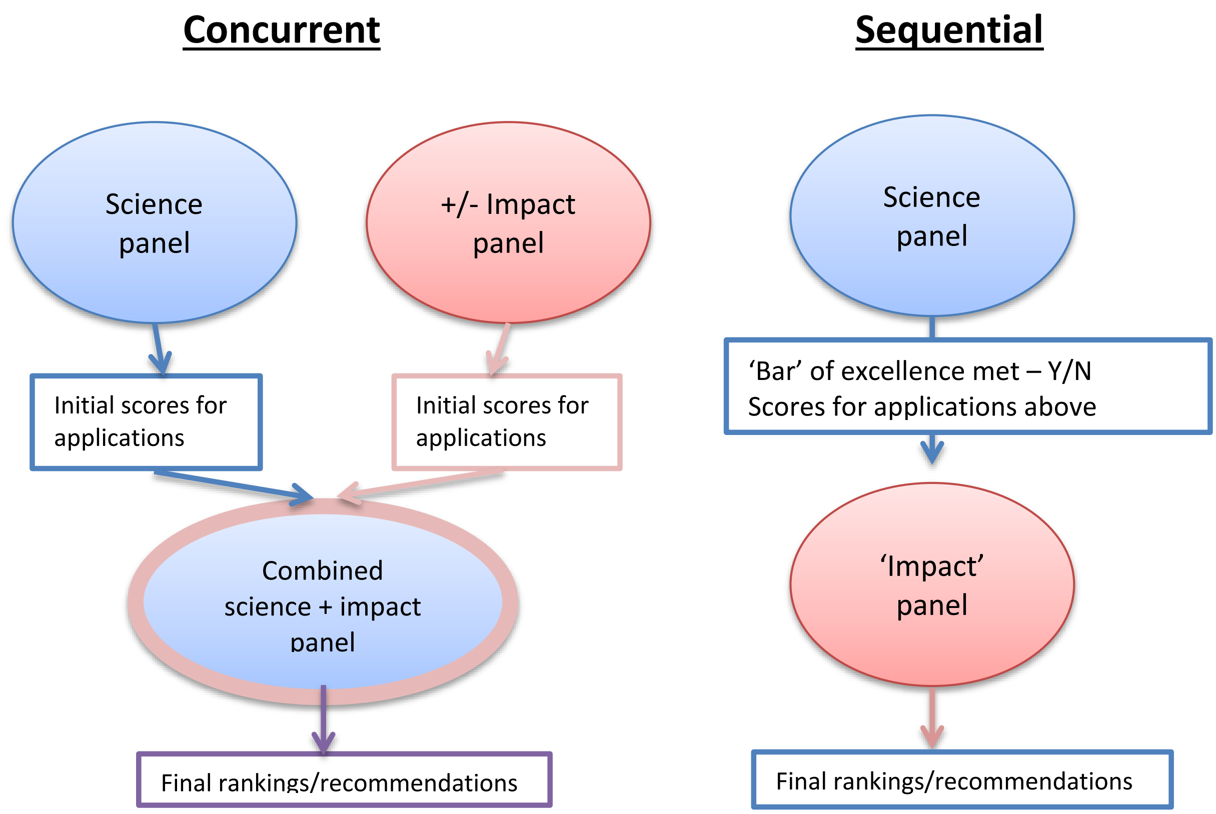


Figure 3: Two ways to arrange panels in the selection process, presenting two opposite cases. Hybrid versions are also present within the SAEI group.

There are also variations on the above and several agencies such as Science Foundation Ireland have been experimenting with different configurations.

Examples:
Science Foundation Ireland's Research Centres call in 2013-2014 followed a mix of both the combined and discrete approach. At the pre-proposal stage the panel was a combined international science & impact panel, with panellists assigned to comment on either the science or impact of the proposal. Proposals that were advanced to the full proposal stage were firstly reviewed by international scientific postal reviews and those that met the "excellence bar" were then reviewed by an international Impact panel.

In New Zealand's recent Centres of Research Excellence (CoREs) selection, the two-stage process involved expert selection panels comprising both local and international subject experts focussed on identifying research excellence and the proposed contribution to the tertiary education sector. The second stage was completed by an 'advisory committee' — in this context analogous to an impact panel. This panel has a wider understanding of the importance of research to New Zealand's social, economic or environmental success. The advisory committee assessed the proposed CoREs regarding their governance and management and the contribution it could make to New Zealand, and then delivered the final recommendations to the Tertiary Education Commission (TEC), which makes the actual decisions on funding.

Box 2: The process of evaluating scientific quality…

Peer-review

Postal peer-reviews of proposals are common amongst the group, and here experience indicates that a number of reviewers should be consulted (e.g. more than 4 reviews for grants to centres or programmes of similar scale with ideally the same number of reviews for each application in a given round. The peer review evidence is typically submitted to a panel/board or committee.

Panels, boards and committees

The small advanced economies frequently use panels and reviewers predominantly of international origin because the risks of bias and undeclared conflicts are so high, if not inevitable, in a small system. It also allows for evaluation by individuals with an appropriate level of expertise relevant to the application. **Finland** and **Ireland,** for example, only use international experts for their assessments, and at both the pre-proposal and full proposal stage.

The quality of scientists involved in the overseeing boards, committees, and in the international peer-review evaluation of the centres is extremely high in the small nations. Candidates for the review panels (or equivalent) in each country are typically selected by overseeing boards or committees who contain excellent senior-level scientists in their own right but are designed with breadth in mind.

In **Israel** for example, the Science Advisory Committee (SAC) for the I-CORE programme (Israeli Centers of Research Excellence) includes 12 members across a range of disciplines. The SAC includes 5 Nobel laureates, winners of the Godel prize and Clark Medal and the editor-in-chief of Science magazine. The SAC acts as a vital quality control on the process and directly helps compose the scientific evaluation panels. **Singapore** is another of the small nations which includes Nobel prize winners in their assessment process.

Denmark (Danish National Research Foundation) has utilised its network of Danish nationals to engage scientists of Danish nationality from top US universities in the selection and evaluation process for their Centres of Excellence programme. For example, a distinguished Professor of Economics from Princeton is one of their current nine board members. Five of the nine board members are international and are typically award-winning. Board members have significant ongoing engagement with the centres of excellence. Danish assessment procedures operate in English so that top international scientists can be engaged in the peer-review of the full proposals; again their suitability to act as a reviewer is assessed by the board.

In **Ireland**, Science Foundation Ireland (SFI) offers a range of funding schemes that support scientists and engineers to deliver both research excellence and impact. The use of international independent reviewers is an integral part of SFI's decision making process. The purpose of external review is to gather international expert evaluations from appropriate field experts so that SFI can make an informed decision regarding a proposal. Review panels comprise international reviewers with complementary knowledge who also possess broad knowledge of the science and engineering sub-fields relevant to the proposals. International reviewers assist in the process and make prioritised funding recommendations but do not make funding decisions. The final responsibility for evaluation and award decision lies with the Board of SFI.

Assessing potential impact at the selection stage: lines of evidence

This section looks at what applicants are asked to provide regarding the potential for impact of their work, both in their proposals and during the selection processes for programmes and centres. We consider this from the perspective of both current practice and future plans in this area amongst the Small Advanced Economies. Within the group there are key differences at the detailed level, such as how much information applicants are asked to provide, what guidance they are given to structure their input and whether they are prompted to directly answer certain questions or even asked to provide supporting documents (such as evidence of support from potential stakeholders).

With respect to assessment of scientific excellence, experience from the group suggests that the selection of individuals with appropriate experience to review potential impact is also key. We include commentary on the types of candidate for such a task.

Proposal submissions and Impact Statements

Researchers are often required to submit an Impact or Outcome Statement as part of their proposal. The expected length and detail of such a statement varies depending on the scope and nature of the programme of funding to which they are submitting their proposal and the country in question. Participants are often asked to provide a brief statement at the initial (pre) proposal phase and, following review, may then be provided with comments and asked to expand on this statement in their full proposal. The degree of guidance provided for such a statement varies significantly across the agencies and countries involved.

Historically, requests for such statements have not always been welcomed by the research community and submissions can often be vague or poorly informed. ‘Fluffy’ or grandiose statements of potential/expected impact are ultimately of little benefit and use either to the researchers or funding agencies, and both applicants and funders can quickly lose credibility as a result. Examples include over-ambitious goals for the scale and timeframe of the programme or centre (e.g. a ‘cure for cancer’).

Researchers’ and funders’ understanding of impact may vary widely. Therefore the first step in this process is often one of communication, so that all parties are on the same page and can communicate on how to construct a meaningful impact statement.

An impact statement will at a minimum demonstrate that applicants have awareness of a pathway to achieving impact, including the following:

- demonstrated understanding of the beneficiaries and users of their research
- understanding of how to engage with and transfer knowledge to these beneficiaries, or how to progress the research to the next stage of development
- commitment to maximising the impact of their proposed research for the benefit of the economy and society
- awareness of potential timescales at a high level

This highlights the importance of two-way exchange and dialogue between research and wider stakeholders and society. By considering these aspects at the start of the programme, facilitated by funding agencies, and showing recognition of its importance, such aspects can hopefully be appropriately resourced through the life of the centre or programme. Research often leads to unforeseen outcomes which would not have been predicted at proposal stage, and hence the emphasis here is on the understanding of the potential pathways and milestones rather than detailing events in year 10 of a programme.

Submissions on track record

While an impact statement can give some indication of the familiarity of the researchers with potential stakeholders and pathways to impact, the track record of the researchers, Scientific Director and Principal Investigators can give valuable evidence as to their ability to deliver not only from a scientific but also from an impact perspective.

Submissions of CVs and evidence of prior performance are therefore often a key piece of information taken into account by review panels.

Supporting evidence

Evidence such as letters of support from key stakeholders offer some demonstration that the researchers have not only identified those who may have interest in or be affected by the research but have also engaged with them.

For example in some cases where the research is close to commercial application, the research group or centre may even be asked to show some funding contribution from interested parties.

Oral interviews and site visits

In some of the countries, an oral interview forms part of the selection process in the evaluation of the final proposal. Applicants may be invited to present to a board or in some cases the proposed host institution may be required to host a potential site visit and interview (for example in selection of the Centres of Research Excellence, New Zealand; site visits were also used in the case of UNIK projects, Denmark).

Current practices across the SAEs:

The following section details how impact is currently evaluated at proposal stage in each of the six countries.

Ireland (SFI): Applicants to the SFI Research Centres programme are required to prepare impact statements both at pre- and full proposal stages of review. SFI has worked with the research community towards providing clear instructions and giving examples of ‘good’ and ‘bad’ statements, as well as providing case studies based on real world examples; more detail and links to this information can be found in the Appendix.

Applicants are encouraged to write their Impact Statements in lay, non-technical language and are requested to be as specific and comprehensive as possible and provide information that external reviewers will find helpful in assessing the potential impact of the proposed research activity. They are also asked to indicate appropriate plans, milestones and deliverables associated with their proposed impact. In this context, applicants are asked to consider the potential of the research centre to:

- Identify and exploit both scientific and commercial opportunities for synergistic collaboration, and implement linkages across areas in order to deliver significant economic and societal benefit
- Enhance the international competitiveness of Irish-based enterprises and attract large Foreign Direct Investment
- Enable high-tech start-up companies capable of raising investment (e.g. angel or venture capital funding) to be spun-out
- Deliver world-class educational, training and public outreach components

- Deliver societal impact, such as improving the health and well-being of the population, addressing food and energy security issues, enabling environmental protection, and supporting Government policies, initiatives and strategies

Evidence of stakeholder involvement is also taken into account in the selection process, in particular letters from industry regarding their participation in the research programme. These letters are scrutinised to assess their true commitment to the proposed programme of research including details of what will be provided by the stakeholder (e.g. staff, equipment donation, access to facilities/software tools, materials or components, or a direct cash contribution[6]).

The SFI review process for Research Centres includes an invitation to groups that have excelled during the scientific review of their full proposal submission to make a presentation to an Impact Panel.

Denmark: Denmark has four major schemes relevant to this document: Centres of Excellence, Strategic research centres, Strategic research alliances, and UNIK. While the system is currently undergoing some change, recent processes are described here.

The Danish Council for Strategic Research has historically[7] run two schemes of the order of magnitude and duration discussed in this report, namely Strategic research centres and Strategic research alliances. Proposals to these schemes were assessed both at the application stage and in subsequent follow-up on the basis of:

1) Relevance: Relevance of research was assessed with respect to the extent to which it addresses the societal challenges that form the basis for the research theme in question.
2) Potential impact: Potential impact of the research was evaluated according to its anticipated positive impacts on public and private-sector stakeholders, including its potential to promote economic growth and the development of the welfare society from a global perspective.
3) Research quality: The quality of the research was evaluated on the basis of the originality of the application and projected achievements on an international scale.

Questions reflected upon in the applications and evaluations on the second criterion included:

- What and when are the potentials to increase value in the public and private sector?
- How can the project develop welfare society?
- What are the expected results in terms of improving decision-making and services in society?
- How will the project increase the level of knowledge in specific research areas?
- What is the expected outcome for education at master and PhD levels?
- What is the expected outcome for international collaborations and recruitment of researchers from Denmark and abroad?

The above criteria were assessed at a general level.

Applicants for the UNIK programme had only to meet a few criteria. Summarised, these were:

- Applications for research areas should be based on sound hypotheses and visions, and demonstrate excellence and originality.

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[6] A direct cash contribution from industry is a current requirement for applications for the SFI Research Centres programme

[7] The Council has recently been merged. Changes in terms of schemes and funding size remain to be seen.

- Applications are to have a strong, international dimension and capacity to play a leading role in an international context.
- Goals for the UNIK projects are to be ambitious and aimed at research breakthroughs.

A research educational element targeting national and international young researchers should be included.

New Zealand: New Zealand has two major schemes relevant to this document: Centres of Research Excellence (CoREs) and the National Science Challenges.

For the CoRE selection process, organisations are required to submit an outcome statement for their proposed CoRE. This statement details how the CoRE's activities and outputs lead to impacts that will deliver or contribute towards high-level outcomes for New Zealand's economy, society, and environment in alignment with the Government's CoRE mission statement. The outcome statement also links to the Performance Measurement Framework and is a condition for funding for any successful CoRE.

The CoRE selection process in New Zealand involves a site visit to shortlisted applicants at their proposed host institution. These site visits allow members of the Advisory Committee to ask questions and raise issues that are not readily addressed in the written proposal. The visits also allow the Advisory Committee to assess the suitability of the host organisation's provision of facilities, and to observe interactions between representatives of both host and partner organisations. This information forms part of the final assessment of the proposed CoRE against the selection criteria, from which recommendations are made to the Tertiary Education Commission board, who holds responsibility for the final selection.

Finland: Those who are selected to submit full proposals to the Academy of Finland's Centre of Excellence (CoE) Programme are asked to describe the expected societal impact in the proposal, in addition to the scientific quality. The impact is assessed in the evaluation process, and comments are sought from evaluators, but at the end no separate score is given.

The international evaluation panel interviews the CoE applicants during the evaluation process at the Academy. The aim of these interviews is to illustrate to the panel the scientific quality of the research of the proposed CoE. The representatives of the applicant are asked to give a short presentation with particular focus on the highlights of the unit's activities, on added value to be expected from a CoE status, on the international aspects of the CoE, and on how research careers of personnel are promoted. The presentation should not be a repetition of the research plan. The main focus of the interview is on questions of the evaluation panel.

The panel is asked to score on scientific quality, feasibility, competence and international competitiveness and to comment on the expected societal impact. Researcher training, the relationship with the host institution, and additional potential benefits of working as a centre are also considered.

Israel: In Israel the evaluation and assessment processes for the recent I-CORE programme were carried out on a competitive basis, in two stages: preliminary proposals and full proposals. The proposals were evaluated by a research field-specific panel. While potential impact was considered as part of the topic selection, applications were later assessed for excellence and merit of their contribution to the particular research theme, and further explicit impact consideration was not taken into account.

The applications are assessed by designated review committees in the different research fields based on: the scientific programme of the centre, new researchers that the centre is intending to recruit, compatibility with the programme's objectives, and the requested infrastructure.

Elements to be included in the applications and evaluations on the first criterion are:

- Scientific management of the centre
- Originality, innovation and implications of research
- Adequacy of methods, and suitability of researchers
- Overall scientific merit
- Significance and extent of possible synergy between the I-CORE members
- Whether the proposed collaboration combines all the forces required to accomplish the overall objective
- Expected contribution to the research topic in Israel

The committees both systematically assess the above criteria and also make a general judgement of the proposal's strengths and weaknesses. It is important to note that the focus of the I-CORE programme in Israel is on advancing academic research.

Who assesses lines of evidence

It is important to consider who assesses lines of evidence in the selection process, their levels of expertise, the number of viewpoints sought, how views of different assessors are combined and who oversees the whole system to check for bias, conflicts of interest, and issues of country or agency-specific context. We outline this here as experience from the SAE group suggests that this is an important factor not only for ensuring a fair selection process, but also for perception of the system by the wider research community.

	Role	**Examples of candidate types**
Overseeing board/ committee	• Responsible for selection of panellists • Role in overall design of process and briefing material for panellists and reviewers • May have final decision on award of funding based on recommendations of panel	
Scientific panellists	• Responsible for overall review of proposal for scientific quality and assessment of individuals' ability to deliver proposed scientific programme • Ranking or scoring proposals based on merit	Experience equal to or exceeding that of the principal applicant(s) in terms of running programmes or centres at equivalent scale. Free of conflict of interest
Impact panellists (if distinct from scientific panellists)	• Responsible for review of proposal in terms of relevance to society and demonstration by applicants of understanding of pathways to achieving impact	Experience of translating research Examples: a director of a Technology Transfer Office, a manager responsible for R&D in public or private company, a senior end-user/practitioner (e.g. from the health sector), an investor in a relevant high tech business, a director of a translational research institute (e.g. Fraunhofer Institute)
Scientific reviewers	• Peer-review of proposal to be used as supporting evidence by panellists	Recognised international experts in the fields concerned Free of conflict of interest

As consideration of impact is newer in many systems, we include additional detail on examples in the table and in the following section, to assist in clarifying the terminology used across countries, while recognising that in some countries or organisations these roles may be combined.

Impact panellists

While the use of international experts for scientific excellence evaluation is common amongst this group (and is described further in Box 2), evaluation of impact is more diverse. Not all programmes have separate individuals whose role is to consider potential impact of a submission.

Irrespective of whether separate expertise is brought in, it is important that panellists understand the local context and that this is dealt with in one of two ways: briefing international experts thoroughly on the objectives of the scheme and local setting, or including some local expertise in the panel.

In Science Foundation Ireland, review panels comprise international reviewers with complementary knowledge covering broad areas across science and engineering sub-fields relevant to the proposals under review. For the specific evaluation of potential impact, reviewers are identified with expertise in research translation, commercialisation, investment (e.g. venture capitalism) and with industry experience and/or experience in collaboration with industry. Only international experts are used in the impact panel as well as in the scientific assessment. Types of impact reviewer might include the head of a leading Technology Transfer Office from a US university. Local context is provided by asking relevant Government Agencies and Departments (e.g. Inward Investment, Indigenous company support, Health, Agriculture, Environment) to review the shortlisted proposals and to provide comments that are then made available to the international panel. Further, at the funding selection stage an SFI project manager provides an oral summary of the scientific research and feedback from the Government Agencies/Departments, together with any other constructive information.

Lessons from implementation

The selection of centres and equivalent programmes can affect the behaviour of the entire research system. A loss of trust in the organisations and agencies performing the selection, and unhealthy relations between research groups/institutions can develop when decisions are not seen to be transparent or fair. Clear guidelines are essential to managing expectations of the research community. Trust is also needed in the quality and expertise of those carrying out or overseeing the selection process.

Ireland: Communication is key

Significant time has been invested in Ireland to communicate with the research community, develop case studies of good and bad submissions, run workshops to highlight what is expected, and provide information on how the applications will be considered particularly when changes to the process of assessment are implemented. Work to change the assessment process began within the funding agency as it requires buy-in and understanding of all those who interact with the research community. Only proposals that achieve the requisite level of scientific excellence progress to the impact panel stage of evaluation. As part of the impact panel assessment, the panel rank proposals in priority order for funding having considered both the quality of scientific research proposed and their assessment of impact potential, with no tied positions, even if differences between them are slight. The use of explicit ranking of fundable projects together with expert recommendations of the amount to fund remains controversial. Research and experience shows that panels are more committed in their ranking of proposals than in their scoring of the same proposals.

Finland: Transparency

In the early 2000s resistance and criticism from the research community developed around a perceived lack of transparency. This in part was due to a general clustering of scores, resulting in an apparent lack of clarity over why the final list was selected. Significant input has been provided to remedy this.

New Zealand: refining the process

Additional funding to increase the range of CoRE activities has provided the opportunity to refine the selection process in 2014. The inclusion of chairs for the expert selection panels that feed into the initial assessment by the advisory committee ensures a greater level of consistency and clarity between the two groups of assessors. The more focussed selection process to identify a Māori research CoRE has also provided the opportunity to review and revise the way that proposals are developed and assessed.

Finland: Exit Strategy Planning

The funding for the Centres of Excellence is divided into two funding periods (3+3 years). For the second three-year period the CoEs must submit a short proposal, including a budget revised/updated from the original proposal; also all centres must describe an exit strategy for when the CoE period comes to an end. This has been very useful for helping the existing centres to plan their activities with the level on funding available after the CoE period (especially in case their CoE status is not renewed in a following call). Visibility and early planning for such eventualities help with any transition.

Israel: Transparency

Significant time has been invested in managing a bottom-up process through which the research topics were selected, so that they will reflect the genuine priorities and scientific interest of researchers in Israel.

Administration of the evaluation and assessment of proposals is carried out by the Israeli Science Foundation (ISF), Israel's predominant source of competitive grants and funding for basic research. The ISF utilises international evaluation committees to examine the proposals on a competitive basis. Criteria are published in advance as part of the call for proposals. Decisions are made by the steering committee based on review reports and recommendations. Assessments and full reviews, with evaluators' details omitted, are sent to the researchers who submitted the proposal.

2.2. Monitoring and management of impact arising during the term of an award

Once a research grant has been awarded, it is essential to monitor its progress, both in terms of meeting its scientific objectives and its impact aspirations. This section focuses on ways in which research funders monitor and manage impact during the lifetime of an award.

Researcher engagement

In several discussions within this group the idea of researcher engagement in determining appropriate evidence for monitoring was raised.

If researchers are engaged at the outset in considering what quantitative and qualitative evidence could be used to support claims of impact, the idea is that they are more likely:

- To consider the potential of the research in relation to societal expectations
- To ensure that such data is collected prospectively
- To support the overall process and offer suggestions for ideas for new metrics based on their in-depth knowledge of the research field

This also over time may enhance the compact between the research community, funder and other components of the system. An idea for gathering suggested metrics across a range of impacts can be found in the following chapter.

Quantitative and qualitative assessment

Given the inevitable varying timeframes and the various direct and indirect benefits that can be expected, singular quantitative measures of impact can only be proxies for what clearly has a large qualitative component.

These do not replace more formal external evaluations that involve site visits and assessment, and are a necessary part of evaluation of large programmes, particularly those under consideration for funding renewal.

Monitoring scientific outputs and scientific excellence

Monitoring the performance of teams and centres in terms of scientific excellence also provides valuable insights into understanding performance although this is not the focus of this report. Such information may provide insight into policy-relevant questions such as, what are the characteristics of a successful team? What types of collaboration improve science output for the centre and for the system as a whole? Is the knowledge being generated state-of-the-art and at the cutting-edge globally? What are the added benefits of such cutting-edge science and are these being maximised?

Even with excellent science, there may still be gaps in knowledge translation and this is the issue at the core of this document.

Current country practices

In **Ireland**, as part of their Impact Statement, the SFI Research Centre awardees are asked to set targets against a number of Key Performance Indicators (KPIs) that will guide progress and upon which they will be evaluated during the term of their award. These KPIs and the targets set are viewed to directly support delivery of impact across a number of areas. They are reviewed periodically by SFI staff, in addition to being used by review panels to gauge progress.

Mid-term/final reports: Many of SFI's awards, in particular awards 'of scale', are subject to a mid-term programme progress review. International experts in the relevant discipline, including those with expertise in relevant areas of industry, commercialisation and translation, are required to evaluate the progress being made against the original Impact Statement (and KPIs therein) as submitted in the funded proposal. Guidance is given to the reviewers to 'score' proposals with reference to indicators of impact, as defined by SFI, and not simply to 'rate' the outputs on the award, some of which may have little relevance to impact.

Annual reporting: In many of SFI's award reporting templates, a new section on impact has been introduced where researchers are asked to declare, by selecting from a list of ten statements, which areas of impact are most appropriate to their research across the range of impact categories.[8]

SFI uses this self-assessment type approach since it goes some way towards quantifying the types of impact arising from the awards it makes. This approach, however, may be subject to bias and so in addition to providing outputs in support of their chosen impact declarations, the researchers are required to provide a narrative/details justifying the options they have selected. A number of output and outcome metrics are also collected in support of the statements.

The impact declaration statements also facilitate semi-quantitative analysis from qualitative (narrative) statements. An example is identifying the percentage of programmes that are contributing to a particular area of potential socio-economic benefit.

In 2014, SFI collated and analysed the 'impact declaration' statements by award holders who submitted annual reports at the end of January 2014. The following observations were made in regard to this impact analysis.

- This self-assessment type of approach does not always guarantee that the awardee and funder are in agreement regarding a particular impact
- There are a substantial number of awardees who declared that 'The research conducted through my award has not yet realised any significant Impact'. This can be acceptable given the timeframe since the awards' inceptions. However, we would expect this to change with long term monitoring.
- There undoubtedly remains an opportunity to work with the research community on our collective understanding of 'impact'

In **New Zealand**, the new approach adopted by the TEC is that once a Centre of Research Excellence (CoRE) has been selected for funding, it develops its own strategic, operational and research Plan, and a succinct Outcome Statement, which are agreed with the TEC. The Plan and Outcome Statement describe at a high-level what the CoRE intends to achieve by

[8] e.g. *The research conducted through our award has resulted in a new policy being implemented and/or an improvement to the delivery of a public service (Y/N, if yes justify)*

the end of the six-year funding period, and how the CoRE's annual activities and outputs will contribute to these outcomes. CoREs will be required to tell their 'performance stories' by reporting against a Performance Management Framework (PMF) document, which has been jointly developed by TEC and the Ministry of Education. The PMF includes standard measures of performance, but in acknowledgement of the individuality of the CoREs, the CoRE may also select any additional performance measures that best demonstrate the value and impact of its contributions. In addition to annual reporting, the performance of the CoREs and their progress in delivering on their plans will be assessed in a formal mid-term review.

In **Denmark**, Strategic Centres, Strategic Research Alliances and UNIK projects were required to submit a yearly economic and short status report described at a general level. Strategic Centres and Strategic Research Alliances were also subject to a mid-term evaluation stated in general terms. If the Danish Council for Strategic Research found it necessary, it would invite project owners to an interview on the status of the project.

In **Finland**, mid-term negotiations are held in the follow up process of the Academy of Finland's Centres of Excellence period. One of the discussion points in the 2014 negotiations (for the Programme for the years 2012-2017) was the societal impact of the CoE work. The CoE representatives gave concrete examples from their work of both scientific impact and impact on the wider community.

In **Israel**, the Centers of Excellence are required to submit an annual budgetary report, annual budget request, and biennial scientific report that details, among other things, the research progress and further research plans. The centres are also required to report to the steering committee representatives in a designated meeting, or with a visit by the representatives to the centre, at the end of the year. The committee members bring to their attention factors which could affect the continued operation of their centre, and examine progress towards meeting the goals of the programme. The committee members try to assist the centres where possible by allowing more budgetary flexibility and by facilitating cooperation with international bodies.

3. Towards a Framework for Impact Assessment for Use at the Pre-Award Stage

Chapters 1 and 2 focussed on harmonising concepts of impact and sharing current processes and lessons on the evaluation of impact at pre- and post-award stage. The purpose of this chapter is to:

- Assist research funders in encouraging researchers and those involved in the science system to consider impact across all dimensions, beyond the expected primary area for the field in question
- Offer an idea of a proposed structure to allow researchers and those funding the work to discuss desired potential outcomes from the start, with recognition of a broad set of impacts
- Assist funders to convey to their researchers means of considering and communicating potential pathways to impact for their work

This framework and subsequent ideas are most appropriately applied at the centre or programme level.

The focus at this level offers a sufficient degree of granularity for issues surrounding cross-over and spillover between research teams to be identified, while enabling outputs and associated impact to be mapped more transparently than at the investment across an entire sector or even system. A causal relationship may still be difficult to establish in all areas, and this is markedly harder at larger scales.

3.1. Impact Areas

There are many different ways to categorise impact and this exercise has already been carried out by several of the countries in this group. We do not look to reinvent or repeat work, but rather to synthesise and offer some consistent categories that are based on previous work and on discussions within the group that build on experience of such assessments.

The suggestion for this framework is therefore to base it on six high-level impact areas, with three cross-cutting themes; the latter two highlight areas which are often less well represented. These themes were used to help formulate the sub-topic examples under each pillar, which can be found in Chapter 4. The aim was to try to encompass the range of research which might fall under each pillar.

This impact framework can be summarised as follows:

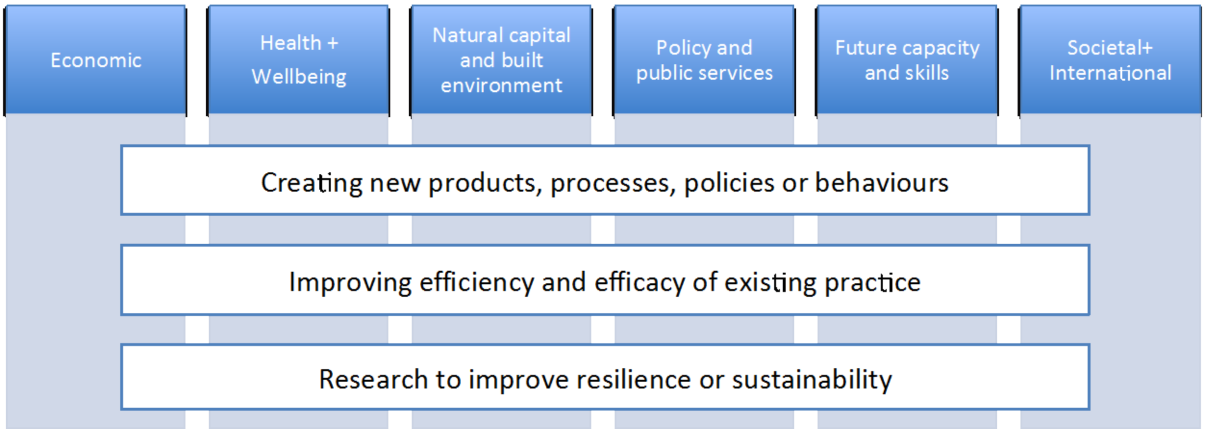

Figure 4: 6 pillars of impact used in this document, and cross-cutting themes. This is equivalent to Figrue 1 and is repeated for reference.

Pillar 1: Economic – including economic and employment-related impacts;

Pillar 2: Health – encompassing impacts on mental and physical health and wellbeing of individuals and populations;

Pillar 3: Environmental – including impacts on both the natural and built environment and surrounding ecosystems.

The remaining three areas include:

Pillar 4: Public policy, services and regulation – to inform public policy and decision-making within Government, the wider public service, non-governmental organisations, and charities, ultimately to benefit wider society and to improve delivery of public services (other than health services which are considered in pillar 2);

Pillar 5: Human capacity – considers improvements in skills and flexibility of the current and future workforce, as well as critical science literacy of the wider population;

Pillar 6: Societal and international engagement – science plays a specific role in a small nation in terms of cultural identity, foreign relationships, and diplomacy. This category includes these nuanced issues as well as risks to society not covered elsewhere.

As articulated in Chapter 1, depending on whether the perspective of the funder, academic, or policymaker is taken, aspects of these final three areas can be seen as intermediate outcomes rather than end goals in themselves. If excluded from the framework and matrix, however, the emphasis on these pillars is easily lost and the intrinsic value of building a flexible, highly-capable system with strong international connections is not fully captured. The inclusion of these areas also assists in engaging the full spectrum of researchers and takes into account different values and perspectives across countries. The structure itself places no differential value between the pillars as this is entirely dependent on the context in which an individual scheme is situated.

This work is not intended to be prescriptive but to encourage active consideration of impact and to present some new ideas for future development of impact assessment. Not all impact areas will be applicable to all funders.

3.2. Impact Matrix – concept idea

Not all of the six categories listed above will be applicable to all fields of research. Therefore, the first suggested step in this framework is for the organisation to specify the impact areas that are relevant to the research that they fund.

The weighting of the relative importance of the different areas may differ by country, through time, between centres/programmes, and between different funding agencies within countries. It therefore does not seem realistic or practicable to combine different impact areas to give an overall 'total impact' for a centre or programme. Mapping the different areas of expected impact onto a matrix, however, offers the potential to see the focus of different programmes or centres at a glance without imposing a value judgement of which impact areas are important.

Here we offer an example of how this might be done in practice across a range of centres, so that an agency could look across their portfolio of centres or programmes for strategic assessment.

The same technique could also be used to look at one centre in greater detail with a slight change in design (e.g. using the rows of the matrix to divide impact into near, medium and long term; see Figure 5).

The matrix offers an opportunity to map a portfolio of centres in terms of the six impact areas highlighted previously. This example covers a range of fictional centres from the biological/life sciences.

Fictional example centres
Centre 1: Biofuel institute
Centre 2: Molecular biology and bioengineering institute
Centre 3: Biodiversity institute
Centre 4: Microbiology institute

In this case, each centre is given 8 points to allocate across the six themes, to proactively look at where their research could deliver benefit to wider society during the lifetime of the centre.

The squares in Figure 5 are coloured based on a weighting given by the researchers to reflect where they believe their centre will have the greatest focus, and each theme can have a maximum of 3 points allocated. The idea of this maximum is to force applicants to allocate limited resources according to their plans for the centre or programme; by doing so more than one area must be selected, encouraging a broader consideration of the societal value of the work. There is still substantial flexibility in how the points can be allocated as evidenced by the example.

The second aspect of this matrix is the inclusion of a brief justification behind the choice of theme in the box by the applicants.

Funders could use the matrix presented in Figure 5 as a high level overview across selected centres/programmes to look at the balance of investments and consider the net effect at a system level.

Key:

(dark green)	3 points, core area/focus for impact
(medium green)	2 points, moderate potential impact
(light green)	1 point, some potential impact

	Economic	Environment	Health & Wellbeing	Policy + public services	Human capacity	Society + International
Centre 1: Biofuel institute "X"	Potential creation of new fuel product	Reduction in emissions per km Improved resilience for energy security		Understanding of lifecycle emissions, evidence for policy on use of fuel blends	Public awareness regarding appropriate use of biofuels and biofuel blends in vehicles	Contribution to global challenge of climate change
Centre 2: Molecular biology and bioengineering institute "Y"	Potential for development of new drug delivery devices		Modelling drug design/dosage to determine most effective treatments Guidelines for best practice for medical professionals		Public engagement around use of personalised medicine Clinical training	Positive impact on international relations-collaborations established with hospitals overseas.
Centre 3: Biodiversity institute "Z"		Increasing resilience of species at risk			Public engagement in prevention of spread of pests/foreign invasive species	Protecting National heritage + species of cultural importance
Centre 4: Microbiology "M"	Better food preservation for competitive edge	Reducing food waste	Reducing food poisoning	Guidelines for food labelling	Graduates for domestic industry	Reputational impact for exports

Figure 5: Example matrix to outline potential impact across the 6 pillars, for a portfolio of centres

A potential advantage of the matrix is that it allows other stakeholders of the research centre/programme (political, beneficiaries, potential partners) to clearly see the proposed impact, which would then help in understanding the landscape, for example when choosing centres/programmes with which to get involved.

A variation on the framework could be to colour code based on timescales of impact (near-medium-long term) rather than level of effort accorded to each area.

Implementation of concept for a centre/programme application

Applicants can quickly summarise where their proposed centre or programme could have impact in their submission through the matrix system, and additional rows can be added to collect information across additional dimensions (Figure 6).

Centre 1: Biofuel institute "X"	Economic	Environment	Health & Wellbeing	Policy + public services	Human capacity	Society + International
Potential Impact	Potential creation of new fuel product	Reduction in emissions per km Improved resilience for energy security		Understanding of lifecycle emissions, evidence for policy on use of fuel blends	Public awareness regarding appropriate use of biofuels and biofuel blends in vehicles	Contribution to global challenge of climate change
Timeframe	Long	Long		Short	Short-Medium	Long

Figure 6: Example of a submission from a centre on their planned focus across the potential impact areas

The idea is to combine this overview with a descriptive impact statement where applicants are expected to demonstrate knowledge of stakeholders, and commitment to engage with them through knowledge exchange and transfer.

Some initial ideas for metrics, that could be used to measure progress towards achieving the above, can also be requested from the researchers themselves before work commences. Research groups engaged from the outset in considering qualitative and quantitative evidence to support claims of impact, are more likely to ensure relevant data are collected over the lifetime of the programme. The groups can also provide valuable insight into what timelines are appropriate for measuring different forms of impact in the specific research area. Active consideration of potential impact early in the process is also likely to prompt consideration of the different ways in which the research may provide societal benefits in practice. This in turn influences both the researcher, the research programme, and the funder, and over time will enhance the compact between the research community and other components of society.

There is some debate about when is the optimum time for such engagement in the selection and award process. One idea is to finalise these post-selection, but before contract completion, on the basis that this:

- reduces the administrative burden for those not selected;
- provides an opportunity for those selected, where incentives for both applicant and agency are most closely aligned, to produce achievable goals. In this way applicants may be less inclined to over-exaggerate claims as their lack of ability to deliver the results may compromise future funding opportunities.

The counterargument to this is that researchers may be motivated to produce achievable rather than stretch goals, so this depends in part on the strength of interaction and relationship between funder and research community to achieve a reasonable balance.

The descriptive statement, matrix and metrics would need to be reviewed on a regular basis (e.g. annually). It is not intended that the research should only be confined to the direction indicated on the original statement. If unexpected avenues materialised, exploration of these should also be encouraged and the potential impact statement adjusted accordingly. This will be discussed further in the next section.

Potential further uses

This approach, or variations on it, can also provide opportunities in terms of the following:

- Cross-agency implementation
  Where funding systems are segregated between different agencies, one area of importance for a nation may 'fall between gaps', while other areas may be extensively supported. This can be exaggerated in small systems where the funding pot is reduced and the balance therefore more finely kept. If a high-level, cross-agency system is implemented which allows consideration of science across a range of areas and application stages, and across funders, then strategic oversight is facilitated.

- Facilitating decision-making
  Funders must make choices on which projects to fund, and occasionally several applications may demonstrate similar scientific merit and quality. If the choice of programme is made based on the perceived potential impact, tools that offer candidates a level playing field and an opportunity to demonstrate their knowledge of potential pathways could provide additional consistency and validity in the funding approach.

- Accelerating and assisting with knowledge translation
  By identifying pathways early, funders and research groups may be able to identify gaps or areas where additional resources are needed to aid knowledge translation and its eventual use. This could help increase the ultimate impact of the research by ensuring that such activities are properly resourced from the outset.

It may also be of interest to ask funded groups (especially recently funded groups) to 'retrospectively test' this process as though they were doing it prospectively. Some questions that could be asked are: At the time of your application, could you have foreseen the following types of impacts? How would you have rated the impact categories? This could provide some indication of the frequency with which an initial indication along these lines should be revisited.

It may be difficult, however, to assess one of the central ideas behind this work – notably that an earlier consideration of their potential pathway to impact could influence behaviour and results uptake.

4. Expanded Impact Areas – Monitoring and Retrospective Assessment

This chapter discusses how the researcher and funder could build on the framework to consider how impact can be proactively assessed during the course of the research (for long programmes) and after its completion.

One key aspect which has often been lacking is structured, consistent follow-up of outcomes of programmes after completion. Several funders in the SAEI countries have been looking at ways to encourage retrospective reporting to capture impact beyond the lifetime of the proposal. Science Foundation Ireland, for example, has asked researchers to report on previously received awards in order to maintain eligibility for future funding for new grants.

In any case, having a clear system, with low time requirement for reporting and some incentive to contribute maximises potential response rates.

The rest of this section expands on types of impact and takes an in-depth look into what types of evidence may be of interest.

Six pillars of impact

The following sections describe the variety of impacts that could be considered under each of the six pillars of impact discussed previously – economic, environmental, health, policy, human capacity, societal and international engagement.

The expanded impact areas presented here may be a useful resource that can be built upon to:

- emphasise and clearly articulate the desired end goals, so as to mitigate risks of employing monitoring mechanisms and rewards which encourage delivery of outputs without consideration of whether they add value;
- elaborate on the breadth of impact which is considered important, to provide reassurance earlier in the process that all types of potential are considered, and to help researchers and funders consider the variety of potential impacts throughout the programme;
- enable development of structured retrospective assessment. Here we use the example of a self-declaration statement applied to the expanded impact areas.

Different sub-headings may be developed under the high-level topics depending on the context and experience of the country or agency. The relative weighting and relevance of different impact areas will also change depending on the funder, programme, country context, and through time.

When generating your own sub-headings, we recommend considering the 3 cross-cutting themes to ensure a comprehensive approach: (i) creating new (ii) increasing efficiency and efficacy and (iii) increasing resilience.

Partners of the centre or programme, e.g. health practitioners, industry partners, and policy-makers, may provide evidence to justify statements where they are best placed to implement the results of the research to achieve the greatest impact for society. This evidence may be collected at various stages, including the mid-term and final evaluations.

The expectation, however, would be that such stakeholders are identified by the researchers in the application or early in the research to facilitate gathering of evidence, including understanding the 'business as usual' scenario (or counterfactual) without their involvement with the programme/centre.

Structure of the following sections

Each impact area can be read in isolation and is structured as follows:

1. Examples of sub-headings under each impact category to expand on the theme
2. Examples of self-declaration statements using the sub-headings (using the example centres described in the previous chapter).
3. Examples of general metrics under each sub-heading, for use as a prompt.

We recommend reading the notes in Pillar 1 for further context.

The example themes and metrics presented under each area are ideas gathered from the countries involved in this work, and offer ideas for research groups and funders to consider and build upon.

We welcome other suggestions and recommend consultation with the research community and individual research groups to define appropriate metrics for monitoring and reporting.

Submissions to the authors of this report are welcome for future updates.

A note on the impact self-declaration examples

Research centres/programmes can be asked to self-declare whether they have had impact that contributes towards specific areas as a result of the research conducted through the funding, and justify these accordingly. This self-reporting approach, which can then be verified by external players during a more substantial review, has been implemented by Science Foundation Ireland. This can be a relatively low time requirement process depending on the design of the system, and is an essential requirement for follow-up during and particularly after the programme. In an ideal response, statements would be justified through a mixture of descriptive text and some supporting quantitative evidence.

Having a consistent framework or list of questions to which groups are asked to respond also enables semi-quantitative analysis of qualitative results (e.g. recognising the percentage of awards with impacts in certain areas).

The self-declaration examples in each section follow this process, where the research group identifies sub-headings where they believe impact has been achieved, and justifies the choices accordingly.

It is important that an overall objective or end goal for a research programme or centre is clearly articulated and that the pathway to achieving impact has been outlined. However, consideration should also be made for externalities beyond the control of the research group, which may affect the realisation of this goal. An example of this could be a change in the political landscape or failed uptake of research findings due to political will.

PILLAR 1 : ECONOMIC IMPACT

This theme can best be described as encompassing:

Impacts where the beneficiaries may include businesses, either new or established, or other types of organisation which undertake activity that may create jobs and societal prosperity. Impacts which have a direct effect on the wider economy and employment (e.g. attraction of a major company from overseas).

This section lists ideas for potential sub-categories that describe some of the types of economic impact that could be of interest from the perspective of society. Examples of the mechanisms through which research and innovation can contribute towards the desired outcome are provided.

This list and those in subsequent sections are intended to encourage consideration of the impact area in the broadest sense and to separate out different aspects of societal importance under the theme (such as growing business revenues, and increasing employment), which depending on the country context and time may be weighted with differing levels of importance. Other sub-divisions may be formulated, depending on your country or agency context and emphasis.

While these impacts may not arise during the lifetime of the programme or centre of greater duration (5–10+ years) and scale, research groups and their partners, such as industry contributors, may articulate progress towards this end goal.

In the case of economic impact, as for other areas presented, consideration of the system-wide effects and wider context is encouraged both in the near and longer term.[9]

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[9] Example: Where capacity constraints exist, highly skilled graduates may be diverted to a new and emerging industry area but away from other sectors that may contribute significantly to GDP, particularly in the short term if immigration and education policy cannot fill the gap. This may increase risk of some shorter-term negative economic effects. Here country context becomes important, as depending on the existing level of diversity or economic complexity present in the economy such risks may be justified to reduce future exposure.

Ideas for sub-divisions, with examples for each heading

1.1. Growing businesses (existing or new) through new or improved products/services

- The performance of an existing business has been improved through the introduction of new, or the improvement of existing, products or services.
- A business or sector has adopted a new or significantly improved technology or process, including through acquisition and/or joint venture.
- Access to new resources has been enabled through a new process or technique.
- A start-up has been established around a new product, service or licence and has demonstrated its viability (e.g. generated revenue or profits).

1.2. Improving the performance of an existing business (or businesses) through increasing efficiency, productivity and/or reducing commercial risk

- Adoption of updated or enhanced technical standards and/or protocols, or the enhancement of strategy, processes, operations or management practices.
- Highly skilled people have taken up specialist roles or provided consultancy or training drawing on their research.

1.3. Attracting and retaining businesses

- Research has attracted and nurtured developing businesses, for example, through the licensing of technologies.

1.4. Building opportunities in the economy (increasing economic resilience)

- A new business sector or activity has been created or expanded (e.g. development of start-ups in new sector)
- A spin-out or new business has been created in an emerging sector.

1.5. Improving employment opportunities (including job creation and increase in job value)

- Employment has been created or value of employment has been increased through the production of a highly educated and relevant workforce in demand by industry and academia.

1.6 Enabling access to new markets and state-of-the art knowledge for businesses

- New connections to expertise overseas have been developed.

Impact self-declaration examples

In the following examples, each centre selects from the sub-categories above and justifies their choice accordingly. In an ideal response the selected statements would be justified through a mixture of descriptive text and some supporting quantitative evidence.

Centre X: Biofuel institute – New start-up (biofuel)

The centre's research conducted through the funding award/programme has now resulted in:

1.1. A new start-up business based around a new biofuel product
1.4 New economic opportunities through establishment of a company in an emerging sector

Justification: A qualitative description of the company (including number of employees) and its product, evidence of any uptake/use of the product. Relevant financial information (e.g whether there has been private investment, and whether any revenue has been generated).

Centre Z: Microbiology institute – improved understanding of pathogens in dairy

The centre's research conducted through the funding award/programme has now resulted in:

1.2. Reduced commercial risk for dairy companies by establishing better testing for pathogens
1.3 Enabled company to compete with overseas incumbents on cost basis and maintain jobs by reducing cost of compliance with food standards
1.5. Employment – generated graduates in an area of industry shortage
1.6. Enabled access to new markets by establishing quality brand

Justification: Evidence of uptake of testing by industry (funding of test facilities, frequency of use, number of users), evidence of cost/efficacy of new testing relative to incumbent, evidence of employment of graduates by industry collaborators.

Ideas for metrics - evidence of progress towards identified end goals

Metrics need to be considered carefully on a case by case basis so that they are realistic and useful proxies of impact, with the caveat that impact cannot always be measured directly and over the timeframe of the grant itself. Traditional measures of research output may provide some information about research quality and productivity, but in themselves generally do not directly inform on impact.

In the following table, we explicitly state the 'ultimate desired impact' in an attempt to avoid generating metrics which reinforce themselves rather than the end goal (such as filing patents which are never utilised to achieve KPI targets). Intermediate outcomes/trackers represent areas in which funding agencies or ministries may wish to track overall system performance. Primary and secondary output metrics are those most likely to be available from researchers.

The table represents a first attempt at this work, and we expect it to improve over time as suggestions are provided by the wider community. Comments and new ideas are welcome for future iterations of this working paper.

Topic	Ultimate desired impact e.g.	Intermediate outcomes/trackers e.g	METRICS: Ideas for proxies to measure progress
			Primary and secondary outputs
1.1. Growing businesses (existing and new) through products/services	Increased value of exports Increase in GDP value added from companies involved in RD&I	Increase in number and scale of indigenous companies Growth in revenue of individual company or group of companies directly engaged with research/researchers	Number + value of collaborations with industry partners, number of repeat collaborations, duration of collaboration. Proxies for new technologies/services and their value (see also 1.4): • Number of Invention Disclosures that are a) under active commercialisation b) licenced • Number of/revenue generated from licenced technologies • Duration of licencing contract and identification of any continuation of industry contracts once initial contracts lapse. • Sales of IP
1.2. Efficiency, productivity, risk	Improvement in economic productivity (e.g. GDP per hour worked)	Productivity of company(ies) or unit directly engaged with research/ researchers	Number + value of collaborations with industry partners where rationale is training or improving capacity in industry.
1.3.Attracting / retaining business	Job and/or value retention/ creation Increase in FDI		Licences to new customers overseas Contracts with overseas companies for research
1.4. Increasing resilience/ building opportunities	Export growth (new/emerging sectors) Employment in new/emerging sectors	Number of spin-outs/ businesses created, time to 1st private investment, 1st revenue or profits Survival rates of new spin-outs	Number of spin-out or new companies formed (by sector) Number of patents exploited to form spin-out or new companies Number of new hires within spin-out/start-up company
1.5. Improved employment opportunities	Increase in number of high end jobs created Job retention	Increase in number of jobs created in RD&I (split by business + public sector)	Number of collaborations with industry partners, where rationale is to identify possible new recruits and/or support and influence the supply of relevant skills
1.6. Enabling access to new markets + overseas knowledge	State-of-the art companies at forefront internationally Exports to new markets	Increase in absorptive capacity of industry.	Number of non-academic collaborations with industry with rationale as “sharing of knowledge, material and equipment” or “to develop networks with academics and access to global academic network” Co-funded international awards received. Leverage of funding from overseas.

PILLAR 2 :HEALTH & WELLBEING IMPACT

Impacts where the beneficiaries may include individuals and groups of individuals whose health outcomes have been improved, or whose quality of life has been enhanced (or potential harm mitigated) through the application of enhanced healthcare for individuals or public health activities.

Ideas for sub-divisions, with examples:

This section lists ideas for potential sub-categories that describe some of the types of health and wellbeing impact that could be of interest from the perspective of society. This list and those in subsequent sections are intended to encourage consideration of the impact area in the broadest sense and to separate out different aspects of societal importance under the theme. Other sub-divisions may be formulated based on similar principles, depending on your country or agency context.

2.1. Improvement in physical health of population - morbidity, quality of life and mortality

- A new drug, treatment or therapy, diagnostic or medical technology has been developed or adopted
- Patient health outcomes have improved through, for example, the availability of new drug, treatment or therapy, diagnostic or medical technology, improvements to patient care practices or processes, or improvements to clinical or healthcare guidelines

2.2. Improvement in mental and social health and wellbeing

- Understanding of risk factors for mental illness have been improved
- Improved recovery rate in relation to misuse of licit and illicit substances

2.3. Increased efficiency of delivery of public health services

- Decisions by a health service or regulatory authority have been informed by research
- Reduction in cost for equivalent treatment for an equivalent outcome through a new drug, device, improved diagnosis or shift in behaviour of practitioner

2.4. Mitigation of risks to public health - avoidance of future costs e.g. through preventative measures for communicable and non-communicable diseases

- Disease prevention or markers of health have been enhanced by research
- Public awareness of a health risk or benefit has been raised
- Improved nutrition and food security

Impact Declaration examples

In these examples, each centre selects from the sub-categories above and justifies their choice accordingly. In an ideal response the selected statements would be justified through a mixture of descriptive text and some supporting quantitative evidence.

Centre Y:

The centre's research conducted through the funding award/programme has resulted in:

2.1 Improvements in physical health – improved efficacy of drug treatment by determining most effective delivery mechanism
2.3 Increased efficiency of delivery – drug dosage levels can be reduced for same level of efficacy in most patient groups, reducing costs and side-effects for patients

Justification: Evidence of efficacy/costs. Evidence of collaboration with hospitals/health practitioners to encourage uptake.

Centre M:

The centre's research conducted through the funding award/programme has resulted in:

2.4 Reduced risk to public health – reduction in potential food poisoning cases through intelligent labelling of food and better hygiene regulations in food production

Justification: Evidence of potential to reduce food poisoning, evidence of uptake of new system in supermarkets etc., evidence of change of guidelines in food manufacturing industry etc.

Ideas for metrics to measure health impact

See Pillar 1: Economic Impact, for an explanation of the structure of the table below Comments and new ideas for metrics are welcome for any future iterations of this working paper.

	Desired outcomes	Intermediate outcomes	METRICS: Ideas for proxies to measure progress Primary and secondary outputs
2.1. Improvement in physical health	Public physical health has been improved (lower incidence and prevalence of chronic and acute illnesses, improved recovery rates) Improvement in quality adjusted life years (QALYs)	Evidence of adoption of new technology/treatment Adoption of improvements to patient care practices or processes, or improvements to clinical or healthcare guidelines Evidence of collaboration with hospitals and health care centres	A new drug, treatment or therapy, diagnostic or medical technology has been developed. Drug/treatment passed for use. Improvements or development of theoretical frameworks/models of disease Use of research in clinical and service guidelines, and health profession educational material
2.2. Improvement in mental/ social health	Public mental health and wellbeing has been improved	Adoption of improvements to patient care practices Improved accessibility to healthcare	Publications providing evidence on impact factors on mental health Evidence of engagement with mental health services
2.3. Increased efficiency of delivery of public health services	Health care cost savings	Decisions by a health service or regulatory authority have been informed by research Best practice guidelines and/or professional health education has been informed by research	Number of collaborations with health sector bodies, hospitals, charities, and NGOs Publications identifying potential improvements in healthcare efficiency and efficacy
2.4. Mitigation of risks to public health	Fewer incidents of public health outbreaks Improved lifestyles (preventing future costs) Reduced prevalence of modifiable risk factors (e.g. obesity, smoking, alcohol consumption)	Use of disease prevention or markers in health policy/practice Public awareness of a health risk or benefit has been raised (e.g. evidence of health prevention/promotion programme)	Disease prevention or markers of health have been enhanced by research Improved understanding of health determinants (human behaviour, environmental determinants) and preventative intervention

PILLAR 3 : ENVIRONMENTAL IMPACT (NATURAL + BUILT)

Impacts where the key beneficiaries are the natural environment with its ecosystem services, together with societies, individuals or groups who benefit from such services.

Impacts which relate to the built environment and infrastructure in terms of its longevity, function and impact on the natural environment.

Below is a list of potential sub-categories, which describe some of the types of impact on the natural and built environment that could be of interest from the perspective of society.

Sub-divisions here recognise a distinction between improving the use of resources (e.g. through new technologies and processes) and reducing pollutants and preserving overall biodiversity. If demand is increasing, for example, the use of resources may be improving while the overall pollution/emissions output may still be increasing. This encourages consideration of lifecycle costs and system-wide effects. Other sub-divisions may be formulated based on similar principles, depending on your country or agency context and emphasis.

Ideas for sub-divisions:

3.1. New/improved technology or process has led to a direct reduction in pollution and/or reduction of impact of pollutants on ecosystems and humans

- Direct intervention, based on research evidence, has led to reduction in carbon dioxide or other environmentally damaging emissions and pollutants
- Improved renewable energy technology; increase in renewable energy capability
- Technology or management process which reduces pollutants or the impact of pollutants released per unit of resource utilised. Includes technology such as filters, converters, and processes and procedures which affect pollutant output.

3.2. Improvement in sustainable use of resources and reduced overall consumption of constrained resources

- The operations of a business or sector have been improved to reduce the use of resources per unit of output
- Energy efficiency measures have been adopted by organisations/individuals
- Sustainability of infrastructure and homes has been improved (e.g. lower embodied energy of materials, lower emissions from construction and during lifetime)
- Transport emissions and/or congestion have been reduced through increasing use of high-occupancy vehicles (e.g. bus, train, car-sharing), increasing alternative means of

transport (e.g. walking, cycling) or through improvements in urban and transport network planning and design.

3.3. Increased understanding of the dynamics of ecosystem services, to enable their protection and/or sustainable management.

- Increased understanding of crop pollination, soil absorption and filtration of minerals, erosion control and sediment retention, climate regulation and nutrient cycling.

3.4. Improvement in resource security (including in water and energy security) and/or mitigation of or reduction of potential impact from environmental risks (including risks in waste management, water/air quality, biodiversity and climate change)

- The management of natural resources, including issues around global competition for energy, water and food resources, has been improved

- Understanding of health risks to livestock and disease risks to crops have improved, enabling improved health and increased security in food production

- The management of an environmental risk or hazard has been improved (e.g. risk to stakeholders/community has been decreased and/or resilience of community has been increased)

3.5. Built environment - infrastructure or housing quality and/or longevity has been increased

- Suitability for purpose has improved or lifetime of infrastructure has been extended

Impact Declaration examples

In these examples, each centre selects from the sub-categories above and justifies their choice accordingly. In an ideal response the selected statements would be justified through a mixture of descriptive text and some supporting quantitative evidence.

Centre X: Biofuel Institute

The centre's research conducted through the funding award/programme has resulted in:

3.1 Creation of a new product for aircraft that has the potential to reduce emissions by X% per km travelled compared to the incumbent on a full life cycle basis.
3.4 Improved energy security through diversification of fuel mix available for air transport.

Justification: Certified testing of product to demonstrate potential emissions reduction, testing by potential end users (e.g. by aircraft manufacturers).

Centre Z: Biodiversity Institute

The centre's research conducted through the funding award/programme has resulted in:

3.3 Improved understanding of the importance of native plant species in providing coastal defences against storms
3.4 Increased resilience of species X through breeding programme to diversify gene pool, reduced risk to species through protection of coastal habitat

Justification: Use of native plant species in coastal defences by local council, evidence of genetic diversity of species X following programme

Ideas for metrics to measure environmental impact

See Pillar 1: Economic Impact, for an explanation of the structure of the table below Comments and new ideas for metrics are welcome for any future iterations of this working paper.

	Desired impact/ outcomes	**Intermediate outcomes**	**METRICS: Ideas for proxies to measure progress** **Primary and secondary outputs**
3.1. New/improved tech, to reduce pollution	Overall reduction in CO_2 emissions per unit of energy produced/per km travelled Overall reduction in other pollution per unit of production Overall reduced impact of pollutants per unit produced (e.g. through capture, filtration, management processes)	Uptake of technology and/or process	Technology or process demonstrates potential for reduction in pollution and/or emissions (e.g. CO_2 emissions per unit of energy produced/per km travelled)
3.2. Improved sustainable use of resources	Reduction in energy/water consumption (or other resource) Increase in use of sustainable transport, sustainable building practice etc.	Uptake of shift in behaviour or management practice Change in local Government policy or urban planning	Evidence that a realisable shift in behaviour or practice could cause significant reduction in consumption of resources. Evidence that change could result in increased uptake of sustainable practices (e.g. increased use of public transport).
3.3. Understanding ecosystem services	Evidence of importance of ecosystem service X enables policy or best practice guidelines to ensure its protection	Change in local Government policy or agricultural industry best practice	Evidence of dynamics and importance of ecosystem services and best opportunities to protect them

3.4. Resource security, Risks and resilience	Diversification of supply Improved load management (e.g. prevention of blackouts, water shortages) Reduced risk to humans, species, ecosystems Improved resilience in response to hazard	Evidence of increased redundancy in system Introduction or expansion of use of state-of art technologies Evidence used in local planning processes to reduce potential risk of natural hazards to population and key infrastructure Evidence used to improve resilience in the event of a crisis (e.g. improving reaction plans and backup systems) Deployment of processes, systems or regulations to protect biodiversity and vital ecosystem services	Reduced demand, increased diversity of supply options Advancement of knowledge with respect to likelihood and potential implications of local natural hazards (e.g. earthquakes, floods, storms) Identification of risks to species and ecosystem services
3.5. Built environment (quality/ use)	Policy of best practice guidelines on construction, maintenance or repair Improved quality and functionality of infrastructure	Change in policy/codes/standards or best practice in construction industry	Evidence of collaboration with planners/engineering professionals/construction industry Evidence of contribution of research towards development of building codes and standards Production of tools for industry to enable improvements in quality/functionality/resilient design and construction

PILLAR 4 : IMPACT ON PUBLIC POLICY, SERVICES AND REGULATION

Impacts where the beneficiaries may include government, non-governmental organisations (NGOs), charities and public sector organisations, groups of individuals in society and/or society as a whole. Impact can occur top-down through policy and also through changing behaviours at the delivery level.

Note health policy and health risk specifically is considered separately under Pillar 2.

Ideas for sub-divisions: Below is a list of potential sub-categories, which describe some of the types of impact on policy which could be of interest from the perspective of society, and some examples of the mechanisms through which research and innovation can contribute towards the desired outcome. Other sub-divisions may be formulated based on similar principles, depending on your country or agency context and emphasis.

4.1. Implementation, revision or verification of policy to improve efficiency, efficacy and responsiveness of public services and/or Government regulation

- Policy decisions or changes to legislation or regulations have been informed by research evidence
- Changes to the school curriculum have been informed by research
- The public has benefitted from public service improvements
- Policy debate has been stimulated or informed by research evidence
- Cost savings to the public purse have been demonstrated, with no loss in level of service

4.2. Improvements in best practice of those delivering public services

- Changes in recommended practice and guidelines for those delivering services (e.g. teachers, police)

4.3. Improvements in risk management in public services/public sector

- Improved identification of risks and improved management processes
- Improved community preparedness and resilience to risk

Impact Declaration examples

In these examples, each centre selects from the sub-categories above and justifies their choice accordingly. In an ideal response the selected statements would be justified through a mixture of descriptive text and some supporting quantitative evidence.

Centre X: Biofuels

The centre's research conducted through the funding award/programme has resulted in:

4.1 Changes to Government policy on the use of biofuels and blends, enabling and prioritising use in aviation sector based on potential impact

Justification: Citation of research in policy documentation

Centre M: Microbiology

The centre's research conducted through the funding award/programme has resulted in:

4.1 Changes to Government regulation on the food industry, with decreased cost to public sector of monitoring compliance

4.3. Improved management processes and procedures, including roles and responsibilities in relation to discovery of food contaminants

Justification: Evidence of implementation of change to regulatory process

Ideas for metrics to measure policy and delivery impact

See Pillar 1: Economic Impact, for an explanation of the structure of the table below Comments and new ideas for metrics are welcome for any future iterations of this working paper.

	Desired impact/ outcomes	**Intermediate outcomes**	**METRICS: Ideas for proxies to measure progress** **Primary and secondary outputs**
4.1. Affecting policy to improve efficiency and efficacy of services	Policy decisions or changes to legislation, regulations or guidelines have been informed by research evidence The public have benefitted from public service improvements	Policy debate has been stimulated or informed by research evidence (records of references to research)	The number of collaborations with public bodies/government departments Co-funding received from public bodies/government departments Number of Technical Reports authored Number of Standards contributed to Number of Consultancy Agreements signed between public bodies and the research group/centre
4.2. Affecting best practice delivery	Adoption of new practice by professional community	Practice has been informed by research (citations of research)	Publications in professional journals on the topic of best practice Direct dissemination to professionals and/or professional bodies Training programmes delivered Collaborations with professional bodies/groups
4.3. Improvement of risk management in public sector	Improved awareness and preparedness of Government in relation to risk. Increased resilience of society and groups of society to risks.	Research used in establishing appropriate risk management structures and procedures (national and local Government).	Collaborations with local and/or national Government and other stakeholders to identify risks Contract research for Government/NGOs related to risk and resilience and their management

PILLAR 5 : HUMAN CAPACITY IMPACT

Impacts involving enhanced scientific and technical capabilities of the population (including the workforce, and those in education and training), future-proofing and enabling the current workforce, and enabling informed public discussions on complex issues involving science.

Ideas for sub-divisions:

Below is a list of potential sub-categories, which describe some of the types of impact on human capacity which could be of interest from the perspective of society, and some examples of the mechanisms through which research and innovation can contribute towards the desired outcome. Other sub-divisions may be formulated based on similar principles, depending on your country or agency context and emphasis.

5.1. Improved scientific and technical skills of current and future workforce and/or increased awareness and engagement in science

5.2. Increased public engagement in science and science literacy (eg. changes to education or the school curriculum have been informed by research)

- Public debate has been stimulated or informed by research
- Public interest and engagement in science, engineering and mathematics (STEM) has been stimulated, including through the enhancement of STEM related education in schools
- The awareness, attitudes, education and understanding of the public have been enhanced by engaging them with research of social or cultural significance

5.3 Increased productivity of the workforce through improvements in health, work environment etc.

Impact Declaration examples

In these examples, each centre selects from the sub-categories above and justifies their choice accordingly. In an ideal response the selected statements would be justified through a mixture of descriptive text and some supporting quantitative evidence.

Centre X: Biofuel Institute

The centre's research conducted through the funding award/programme has resulted in:

5.1. Improved scientific skills of workforce – attracted top scientists from overseas to work in the country and train next generation of researchers

5.2. Stimulated debate around appropriate use of biofuels, and how to manage their use to avoid adverse consequences on e.g. food production

Justification: Articles in print media debating issues and citing research. Blogs, social media. Nobel laureate scientist attracted to country, indicators of outputs for emerging young scientists improved (e.g. highly cited publications produced more quickly in career).

The centre's research conducted through the funding award/programme has resulted in:

Centre Y: Molecular biology + bioengineering

5.2. Stimulated public interest around personalised medicine and two-way engagement about how to avoid misuse of information and handle psychological effects on patients

Justification: Formal steering group has been established to look at ethical issues for the centre, with a range of panellists. Issues gathered and discussed in public workshops and lectures.

Centre Z: Biodiversity

5.2 Increased public participation in prevention of spread of pests and monitoring of native species

Justification: Public submissions to website (citizen science project – monitoring native birds)

Centre M: Microbiology Institute

5.1. Improved scientific skills of workforce – trainees from institute moving to industry as next destination

Justification: Evidence of trainees gaining employment in company involved in collaboration.

Ideas for metrics to measure human capacity impact

See Pillar 1: Economic Impact, for an explanation of the structure of the table below Comments and new ideas for metrics are welcome for any future iterations of this working paper.

	Desired impact/ outcomes	**Intermediate outcomes**	**METRICS: Ideas for proxies to measure progress** **Primary and secondary outputs**
5.1. Improved scientific and technical skills of workforce	Improved absorptive capacity in companies, improved knowledge of international state-of-the art research Improved academic capability for the future	Increased number of researchers in industry/increased training level of researchers Attracted international scientists and talented people to work in the country	The percentage of trainees that move to industry as a first destination Uptake of STEM subjects by students. Enhancement of STEM-related education in schools
5.2. Increased public engagement in science and science literacy	Awareness, attitudes, education and understanding of the public have been enhanced by engaging them with research of social or cultural significance	Public debate has been stimulated or informed by research Public interest and engagement in science, engineering and mathematics has been stimulated	Outreach – number of events and/or estimation of number of participants Social media data/ altmetrics and references to research in print media
5.3. Increased productivity of the workforce	Increased productivity of workforce (improved quantity and quality of output per hour worked)	Research has led to change of policy in relation to rehabilitation of people to reenter the workforce	

PILLAR 6 : SOCIETAL IMPACT AND INTERNATIONAL ENGAGEMENT

Impacts where the beneficiaries may include individuals, groups of individuals, organisations or communities whose quality of life, knowledge, behaviours, creative practices and other activity have been influenced positively.

Ideas for sub-divisions: Below is a list of potential sub-categories under Pillar 6, and some examples of the mechanisms through which research and innovation can contribute towards the desired outcome. Other sub-divisions may be formulated based on similar principles.

6.1. Positive impact on cultural life of population and/or national identity

- Research increases cultural understanding and nurtures relationships across all sectors of society, including indigenous peoples and minority groups
- Research supports creativity and increases appreciation of cultural services (e.g. museums, galleries, libraries), through improving cultural awareness or improving design, relevance and accessibility of public facilities

6.2. Contributes to community development/regeneration

- Research base supports and attracts local businesses in area with identified need for regeneration
- Research provides evidence-base for appropriate planning policy
- Research provides evidence-base for efficacy and responsiveness of community services and engagement programmes (e.g. in relation to lower socio-economic families with specific needs)

6.3. Positive impact on international relations, profile/reputation of country

- Reputation of country as a global leader in field has been established/increased
- Diplomatic relations have increased/improved as a result of scientific collaboration

6.4. Significant contribution to global challenges (health, poverty reduction, etc.)

- Quality of life in another country/globally has been improved by new products or processes through, for example, improved water quality or access to healthcare

6.5. Reduction in societal risk not considered elsewhere (e.g. risks in terms of information security)

- This may include research to improve protection against virtual threats such as: identity fraud, business fraud, information and data security as well as protection against physical threats including terrorism

Impact Declaration examples

In these examples, each centre selects from the sub-categories above and justifies their choice accordingly. In an ideal response the selected statements would be justified through a mixture of descriptive text and some supporting quantitative evidence.

Centre Z: Biodiversity

The centre's research conducted through the funding award/programme has resulted in..

6.1. Positive impact in area relating to national identity

Justification: Protection of species with national cultural significance, engagement of youth in such protection through 'citizen science' (% participants under 18).

Centre M: Microbiology Institute

The centre's research conducted through the funding award/programme has resulted in..

6.3 Positive impact in reputation of country for food safety expertise

Justification: Downloads of science publications by other countries, citations and new collaborations established, awards and international recognition by others, new talent attracted to country (evidenced by their track record)

Centre X: Biofuel institute

The centre's research conducted through the funding award/programme has resulted in..

6.4. Contribution to global challenges - climate change

Justification: Contribution to EU assessment of biofuel policy (research cited)

Centre Y: Molecular biology + bioengineering institute

The centre's research conducted through the funding award/programme has resulted in..

6.5. Societal risk – new protocols for management of personal medical information to mitigate potential risks arising

Justification: New guideline for management of data and evidence of use.

Ideas for metrics to measure societal impact and international engagement

See Pillar 1: Economic Impact, for an explanation of the structure of the table below Comments and new ideas for metrics are welcome for any future iterations of this working paper.

	Desired impact/outcomes	Intermediate outcomes	**METRICS: Ideas for proxies to measure progress** Primary and secondary outputs
6.1. Cultural life and/or national identity	Protection of areas/items/practices of cultural and national importance	Evidence used to propose or strengthen regulatory protections of tangible and intangible cultural resources Better public understanding and interest in tangible and intangible cultural resources	
6.2. Community development/ regeneration	Improved outcomes (e.g. employment rates, social outcomes) for regional areas		
6.3. International relations, profile/ reputation of country	Improved profile of country in relation to science and technology capabilities Diplomatic benefits from collaborative work		Number of international conferences organised in country Number of international collaborations Number of international co-publications Evidence of leadership in international fora (including joint projects, panels, commissions)
6.4. Contribution to global challenges	Quality of life in a developed or developing country has been improved through e.g. improved water quality or access to healthcare		Coordination of/participation in European or International Consortia targeted at global challenges (such as health, climate change)
6.5. Reduction in societal risk (not considered elsewhere)	Risks to national security have been reduced (e.g. information security)		

5. Monitoring Scientific Quality and Advancement of Knowledge

While previous chapters have focussed primarily on monitoring and metrics for socio-economic impacts of science, this chapter looks at measurement of scientific excellence and advancement of knowledge in its own right, focussing on outputs from the perspective of the academic community.

The quantity and quality of outputs are typically measured as a minimum on an ongoing basis. This includes:

1. **Evidence of scientific and technological workforce development** through research-based teaching. It is important not to discount the value imparted by emerging researchers and the knowledge they carry with them to the organisations that employ them both within and outside academia. Data on destinations of leaving trainees and/or attraction of any new staff from overseas are highly valued.

2. **Evidence of scientific outputs (publications, patents, conferences, contracts for research)**

3. **Evidence of awards or proxies for recognition of excellence (e.g. leverage of funding from other competitive funding sources)**

A note on bibliometrics and altmetrics

Records of publication outputs and their use can be used in innovative ways to give some quantitative evidence of performance. Measures such as citations are only proxies for quality and reach of a publication, but in many cases are the best indicator presently available.

Some measures such as citations and downloads can be field-weighted to adjust for different usage and citation patterns in different disciplines, as well as the age of the publication.

One important point is to ensure that the information provided on a publication is complete and comprehensive and can be connected to the centre or programme with which the researchers are affiliated. If this is the case then publications can also provide evidence of:

- Collaboration between groups, institutions, countries, and industry and academia
- Movement of publishing scientists (by virtue of the address provided on the publication)
- Which are the main countries or groups domestic scientists look to in terms of publications (derived from download data)
- Who around the world is looking up publications from your country, institution or group (derived from download data)
- Multi-disciplinary strengths and emerging areas (through the associated keywords)
- Counter-evidence such as the number of publications which have not generated traction (e.g. received no citations)

Examples of use of metrics:

Note: *The metrics outlined below apply to both this section and to the 'human capacity development' theme as described in the impact section. Ideas have been gathered from across the group and as with the previous section, this is an evolving process – new ideas for future versions are always welcome.*

	Quantity	Quality proxy	Proxies for dissemination and relevance
Creating & transferring knowledge (all)	Lists and numbers of publications (per FTE) Number and type (national, international) of academic collaborations	Field-weighted citations per paper Publications in top 10% of world publications by citation Publications in A-rated (or equivalent) journals % of researchers with h-index above threshold	Presentations at relevant conferences Downloads of articles
	Number of patents (applications, grants) Number of licences	Patent citations Value of licence income	
Creating and transferring knowledge (to industry)	Number of collaborations Number of consultancy contracts	Duration and activity covered by collaboration Repeat clients Value of contracts	Leverage of funding from industry
Attracting talent	Number of people from abroad over time and country of origin	Quality of recruits (h-indices, awards, previous institution)	
Nurturing talent	Number of PhDs awarded	Awards received Publication and citation data of emerging scientists compared to counterparts	Destination of graduates (e.g. to industry, academic position etc.)

6. Conclusion

This is a working document which has provided a basis on which impact assessment may be defined and assessed pre-award, and during the monitoring and measurement of progress towards achieving impact for major research grants or programmes.

There are many other questions and topics which this report has not had opportunity to address, but which may be of interest for further work or updates to this paper. We summarise these here:

Topics relating to monitoring of grants:

1. Poor performance particularly at the mid-term review stage or at the time of funding renewal. In this case care should be taken to differentiate between lack of quality of scientific output, poor training of research personnel, lack of engagement of researchers with stakeholders/end-users, and lack of uptake by the latter. Depending on the field and length of time which has passed, impacts may appear over longer time horizons. However, it is worth considering whether (i) the group remains state-of-the art in an international context; (ii) the research question is still of high relevance; and (iii) whether the translational pathways require alteration/support. This issue affects all research funders and would be an interesting discussion topic.

2. Incentivising strong performance: Are there elements such as additional funding for successful groups which can be used as positive reinforcement? Does such policy leverage greater benefits or not? Does it change behaviour of groups due to awareness that such a scheme is available?

3. Transitional planning: What happens at the termination of funding for the group or centre? How long do the team have to prepare? What options are available and how can public resources best be leveraged? Do research funders engage in planning “exit strategies” for research centres?

4. How can new programmes/schemes be supported, and how is their performance assessed alongside older centres?

Topics relating to system improvements:

Ideas on how systems could be improved have developed through discussion within the SAEI group and include the following steps:

1) Reviewing the aims and objectives of different schemes within an agency and funders across a system, to understand the overall portfolio of current programmes and identify any gaps. Clarifying which aspects of potential impact are important to which funder/scheme. Providing clarity on this to the research community, while recognising that in some cases priorities at a national or funder level may change through time.

2) Engaging researchers in identifying and justifying at high-level, what types of impact the centre or programme might deliver from the outset as part of the selection process. The matrix concept presented in Chapter 3 provides a possible tool for this.

3) Involving programme leaders in determining how such impact may be assessed and over what timescales, e.g. during and 3, 5 and 10 years after completion of work. As

work proceeds, this may be developed iteratively through 2-way discussion between the researchers and funders.

4) Utilising a system which allows both quantitative and qualitative assessment so that aspects which cannot easily be counted can still be considered. This could involve (in order of time requirement): self-declaration statements (where researchers declare whether or not they have had impact in certain areas and justify these), submission of corroborative evidence (e.g. from stakeholders), and case studies.

5) Developing a system which positively promotes feedback on former projects. This requires better tracking of those receiving grants, and motivation for these individuals/groups to update the funder as to results of former awards (e.g. by requiring this for future funding applications, or offering awards or other incentives).

6) Iterative time frames for monitoring and accommodating adjustments to the program and expectations based on lessons learned and unforeseen discoveries.

7. Appendix

Further Reading – from SAEI Economies

The following reports and references from the SAEI economies have informed the background thinking in this document:

SFI Ireland: Research impact (http://www.sfi.ie/funding/sfi-research-impact/)

Tekes & Academy of Finland: Better Results, More Value: A framework for analysing the societal impact of Research and Innovation (2011), Finland.

Reports covering complementary aspects of impact assessment (such as assessment at a system level) include:

The Short-run Impact on Total Factor Productivity Growth of the Danish Innovation and Research Support System (2014), http://ufm.dk/en/publications/2014/the-short-run-impact-on-total-factor-productivity-growth

Compendium of Analysis of the Danish Research and Innovation System (2014), http://ufm.dk/publikationer/2014/analysis-of-the-danish-research-and-innovation-system

Current Country Programmes

The following table outlines schemes which are (i) multidisciplinary (ii) of medium-long duration (5 years +), and of substantial scale (e.g. 50 million euro over their lifetime) in each of the SAEI countries. This table does not include permanent institutions (such as research institutes) to which some but not all sections of this report may also be relevant.

Country	Schemes	Descriptions
Ireland	SFI Research Centres	SFI Research Centres consolidate research activities across higher education institutes to create a critical mass of internationally leading researchers in strategic areas which become a key attractant to industry and lay the foundation for effective and productive academic and industrial partnerships. Additionally, these centres will be excellent, relevant, sustainable, and will serve as international beacons for attracting talent and leveraging non-Exchequer funding. SFI currently funds 12 Research Centres, each for 6 years in duration at a cost of €1-5 million per annum. SFI funds up to 70% of the overall budget. A minimum of 30% of the Centre budget must be secured from industry, at least one-third of which must be cash.
Denmark	Centres of Excellence Strategic Alliances	Grant size: Total fund $51m USD per annum, average of $1.2m USD per centre per annum. Provider: Danish National Research Foundation Grant size: From 2.5 to 3.5 million USD Duration: 5 years Provider: The Danish Council for Strategic Research

	Strategic Centres UNIK	Grant size: From 5 million USD Duration: 5-7 years Provider: The Danish Council for Strategic Research Content: Big, long-term projects to develop ground breaking and excellent research areas at an international level of importance for the applicant and Danish research in general. Applicant: Universities (not individuals). Grant follows the project and not the researcher. 2-5 applications for each university depending on university size. Grant size: Total fund: 88 million USD. For each project: 1.8-3.6 million USD per year. Duration: 5 years Research areas: All research areas included (basic or strategic) Conditions: Applicants apply in competition. No *a priori* distribution of research areas. No co-finance needed Provider: Danish Agency for Science, Technology and Innovation Running time: From 2008-2009 to 2013-2014
New Zealand	Centres of Research Excellence National Science Challenges	The CoRE Fund (established in 2001) supports inter-institutional research networks, with researchers working together on a joint work programme and with one institution acting as the main host. Contestable grants initially for 6 years, which may be renewed. Up to 10 CoREs to be funded from 2015. CoRE funding is in the order of 4 million USD per CoRE per year. 11 National Science Challenges were identified, with the first launching in 2014. The challenges each have a strategic goal and vision, and require multi-disciplinary collaboration across institutions bringing together the best across the country. Each has a defined governance model. Total fund over 10 years: 1.2 billion USD (including new and reallocated funds). For each challenge: 26 – 80 million USD each over 10 years.
Finland	Centre of Excellence Programme (Academy of Finland)	The Academy of Finland's Centres of Excellence (CoE) are flagships of Finnish research. A CoE is a research and training network with clearly defined sets of research objectives and is run under a joint management. Funding is provided for a six-year term and CoEs are jointly funded by the Academy of Finland, universities, research institutes, the private business sector and other sources. Examples from Finland in this document are based on experience with the CoEs. There are other major funding instruments in Finland of the scale mentioned in this document, to which some aspects of this work may be applicable.[10]The funding instrument for Strategic Research, with

[10] A second programme, the Strategic Centres for Science, Technology and Innovation (SHOK in Finnish) is of similar scale but was selected through a one-off process quite different to the descriptions in this document. It is a public-private-partnership scheme with major funding from the Finnish Funding Agency for Innovation (Tekes).

		the Strategic Research Council located at the Academy of Finland, was introduced in 2014 as part of the Comprehensive Reform of State Research Institutes and Research Funding (2013).
Israel	Israeli Centers of Excellence (I-CORE)	The I-CORE program provides 5 years of funding for each centre. The total budget for 5 years of the program was 450 million NIS (around 115 million USD). The centres' budget differs based on whether they perform theoretical or experimental research, and ranges between 20-70 million NIS (5-18 million USD). An I-CORE is an association of researchers in a specific research field, who are current faculty members of different higher education institutions, for the purpose of promoting ground-breaking and innovative research. The center serves as an anchor for shared research infrastructure and research groups in this field. The programme encourages academic innovation, including integration between different fields of multi-disciplinary knowledge.

A note on Research Centres of Excellence

If we take, for example, Centres of Excellence or schemes with similar titles, the extent to which these are mission-oriented varies across the group.

In situations where there is another fund, council or programme targeting mission-oriented science the Centres of Excellence may be focussed almost entirely on delivering advancement in scientific knowledge and training of new capacity. These outcomes can be considered impact in their own right, and potential to achieve this can be evaluated based on the scientific proposal, track record of researchers and proposed management and training structures of the centre or programme. Secondary benefits may also accrue, as the result of talent development (such as the attraction of businesses and others to work with the centre or research group). The Danish centres, for example, would fall under such a model.

In some other countries, Centres of Excellence are aligned under specific themes with different mission-oriented goals and objectives from the outset. As a result, the prevalence of assessment of potential impact in the selection process is more explicit. The Science Foundation Ireland Research Centres are an example here.

Key objectives for Centres of Research Excellence (CoREs) or schemes with similar titles across the 6 countries:

Objectives	Singapore	Israel	Finland
Reputational		Strengthen scientific research in Israel and establish Israel's standing as a world leader in scientific research Promote collaboration with leading researchers and research institutions worldwide	Develop and support research collaboration with the best international researchers and research teams Raise the quality, international competitiveness, visibility and esteem of Finnish research
Human capacity development and retention	Attract, retain and support world-class academic investigators Enhance graduate education in the universities and train quality research manpower	"Brain Return": return excellent researchers to Israel, as a central means of fortifying the research capabilities and the academic staffs of the institutions of higher education Maintain and promote advanced programs of instruction and training in select fields	
Critical mass, national collaboration, innovation		Create a critical mass and intensify the relative advantages in select fields in the different institutions Encourage research collaboration between institutions of higher education, both universities and colleges	Create favourable operating conditions for consortia of research teams Create potential for scientific breakthroughs at the interfaces of disciplines and fields Network Centres of Excellence nationally and internationally

			Have a positive impact on the Finnish research and innovation system
Promote research in areas of strategic/ societal importance	World-class investigator-led research aligned with the long-term strategic interests of Singapore	Strengthen the scientific research in Israel in disciplines of system-wide and national importance	Promote the societal impact of research
Infrastructure		Improving and upgrading the research infrastructure in the universities	Reinforce the use of research infrastructures
Other			Promote the compatibility of the strategies of a CoE with its host organisations

	Ireland	New Zealand
Reputational	Achieve, maintain and enhance research excellence and leadership	Build wide networks within national and international research, strengthening engagement and influence Operate as a showcase for NZ
Human capacity development and retention	Train and educate a cohort of engineers and scientists at MSc/MEng, PhD and post-doctoral level that will take up employment in MNCs and SMEs based in Ireland	Support development of world class researchers in areas of existing excellence that are important to NZ's future development
Critical mass, national collaboration, innovation	Undertake joint research projects with industry Transfer knowledge, expertise and know-how to MNCs and SMEs based in Ireland	Perform pioneering research, commonly multi-dimensional and/or multidisciplinary Facilitate collaborative and inter-institutional participation hosted by a TEI
Promote research in areas of strategic/ societal importance	Deliver significant economic and societal impact – i.e. research excellence with impact – which will be aligned with areas of strategic opportunity for Ireland, including but not limited to the 14 National Research Priority areas	Support growth in research excellence and the development of world class researchers in areas of existing excellence that are important to New Zealand's future development
Infrastructure		
Other	Attract additional non-Exchequer funding through industry sources and external research-funding organisations with particular emphasis on European funding sources Increase the level of industrial and commercial investment in R&D activities with existing	Active and outward facing engagement with next-stage and potential end-users

	Ireland-based companies, and furthermore to attract large Foreign Direct Investments Transfer technology, through licences, to companies based in Ireland to spin out new, high-technology start-up companies	

Denmark:
The Centres of Excellence scheme is the flagship programme of the Danish National Research Foundation, and accounts for the bulk of their expenditure. DNRF's mission is described as follows:

"Our core mission is to fund innovative research by the best people in optimal surroundings. By recognizing and trusting their talent, we expect top researchers to deliver potentially ground-breaking results, thereby boosting the international competitiveness and impact of Danish research."(Danmarks Grundforskningsfond 2010).

For further information:

Israel: I-CORE Guidelines for submitting a full application, 2012-13
Finland: Programme for Centres of Excellence in Research 2012-17, Evaluation criteria for panel
Singapore: Research Centres of Excellence factsheet
http://www.nrf.gov.sg/about-nrf/programmes/research-centres-of-excellence
(Singapore also has Centres for Innovation, managed by SPRING)
New Zealand: Mission Statement for CoREs, 2014/15
Ireland: SFI Research Centre Call document 2012
Denmark: DNRF (http://dg.dk/en/centers-of-excellence-2)

Criteria for reviewers of centre proposals – an Irish example

In Ireland, the reviewers for Science Foundation Ireland's recent Call for Research Centres were required to evaluate proposals based on the following criteria:

- Quality, significance, and relevance of the recent research record of the lead and co-applicants and the strength and cohesiveness of the applicant group, including likely synergy in delivering research and potential for international leadership

- Quality, significance, and relevance of the proposed research, including value for money and the potential to advance knowledge and understanding within its own field or across different fields

- Quality, significance, and relevance of the proposed research's potential contribution to demonstrably support and underpin enterprise competitiveness and societal development in Ireland

- Quality of plans for execution and delivery of the research programme and Centre goals, including the appropriateness of the proposed milestones and deliverables *(specific to evaluation of full proposal applications)*