National Research Infrastructure Evaluation

Submitted to

Science Foundation Ireland

Prepared by

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Indecon

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Executive Summary

Introduction

Indecon, following a competitive tendering process, was appointed by Science Foundation Ireland (SFI) to undertake an independent policy evaluation to: (a) retrospectively, evaluate the investment programmes implemented by SFI into Research Infrastructure 2015-2021 including an assessment of the programmes' performance and effectiveness with recommendations on potential opportunities for improvement; and (b) prospectively, give recommendations on national mechanisms involved in research infrastructure ('RI'), to include an overview RI landscape analysis on which to base potential investment scenario recommendations. While details of the 2021 call are discussed in this report, awards made under this call are not covered. The analysis has been informed by a detailed examination of SFI data and by new evidence from a survey of researchers and research institutions. Valuable inputs were also obtained from a range of departments, agencies and other stakeholders.

SECTION I: OVERVIEW OF RESEARCH INFRASTRUCTURE LANDSCAPE

Research infrastructure can be defined as equipment, facilities, infrastructure and personnel used for research. This can encompass physical research equipment, as well as facilities such as laboratories or office spaces. It can include IT infrastructure, database access and technology to facilitate research, as well as administrative supports. Research infrastructure can also include professional networks, such as networks of researchers and administrative supports.

Significant funding has been provided for Research Infrastructure in Ireland for a long period. As far back as 1998, the Irish Government launched the Programme for Research in Third Level Institutions (PRTLI), funded through the HEA. This was run on a competitive basis and open to publicly funded third-level institutions. Since 1998, €1,110 has been invested with the most recent cycle of PRTLI (Cycle 5) in 2010/11 investing exchequer expenditure of approximately €277 million with a further €59 million of private investment.[1] PRTLI focused on increasing the amount of transdisciplinary and interdisciplinary basic research, and supported personnel, infrastructure, and recurrent costs in third-level institutions.

International Comparator Analysis

As part of our international review, we examined RI infrastructure policies in Italy, the UK (including Scotland and Wales) and the Netherlands. The importance of funding for Research Infrastructure is recognised internationally and many comparator countries relevant to Ireland have developed mechanisms to support investment in this area.

In **Italy**, research and innovation had been a strategic objective for several decades. There is a multiannual framework, the National Programme for Research (NPR), which identifies strategies and priorities for Italy's research system. The NPR includes a specific plan (NPRI) to coordinate and prioritise investments in research infrastructures. Each source of financing follows the rules and criteria established by the authority responsible for its implementation. Sustainability of RIs is considered in the process, but this does not guarantee that operation and maintenance costs will be covered in the long term. The Italian RI landscape does not have a specific body responsible for supervising interoperability or coordinating access.

In the **UK** 'Research Infrastructure' refers to large-scale capital investment as well as other facilities, networks, and digital infrastructure. While significant investment in research infrastructure has been provided, the lack of funding for the maintenance and use of existing infrastructure has been raised as a potential weakness of the system. It has therefore been suggested[2] that funding decisions should be made contingent on sufficient

[1] https://www.oireachtas.ie/en/debates/question/2018-05-08/219/

[2] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/478125/BIS-15-625-ensuring-a-successful-UK-research-endeavour.pdf

resources being in place to ensure efficient operation of any proposed infrastructures or facilities. The UK has also placed significant emphasis on co-funding rates from industry and philanthropy sources. For example, the UK Research Partnership Investment Fund,[3] which supports investment in higher education research facilities, requires double match funding from non-public sources.

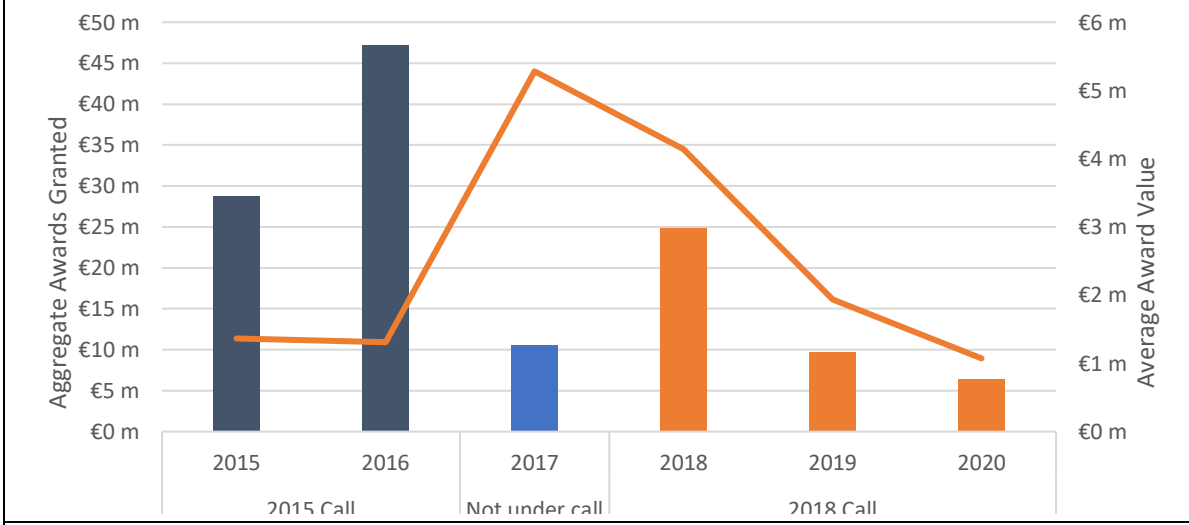
In the **Netherlands** the Dutch Research Council (NWO) provides funding of almost €1 billion annually in research and infrastructure by selecting proposals based on advice from specialists and experts.[4,5] The NWO aims to encourage national and international collaboration and investment in large research facilities. The Competition for Research Infrastructure funds wider infrastructure projects. The fund covers several types of infrastructure, from specialized devices (like large telescopes and cleanrooms) to 'virtual' facilities (like databases, scientific computer networks, and ICT support). In the Netherlands funding does not in general cover the total costs of maintenance and the NWO strategy 2019 – 2022 highlights a number of key issues including looking beyond equipment and facilities.

SECTION II: RETROSPECTIVE EVALUATION OF SFI RESEARCH INFRASTRUCTURE PROGRAMMES 2015-2021

Background to Programmes

The SFI Research Infrastructure Programme supports the research community in building and sustaining the infrastructural capacity required to accomplish high-quality, high-impact, and innovative research in areas of science, technology, engineering, and mathematics. The Programme identifies priority RIs through a combination of bottom-up (e.g., through an open application process) and top-down elements (e.g., focused on national priority areas). There were three calls over the period 2015-2021; due to the timing of this evaluation it was not possible to include the results of the 2021 call. As shown in the next graph, the main expenditure was allocated in the 2015 call. There was a total of 76 RI awardees over the period 2015-2020, with a total awarded of €127m and an average award value of €1.7m. Two strategic awards were made in 2017 which were not under call. There was a reserve list kept open for two years following the 2018 call and a number of awards were made from this in 2019 and 2020. In reviewing the SFI Research Infrastructure Programme it should be noted that funding of the Programme represents only a small element of total Irish Government R&D Spending.

Total Final Cumulative Cost and Average Cost per project, 2015 – 2020



Source: SFI

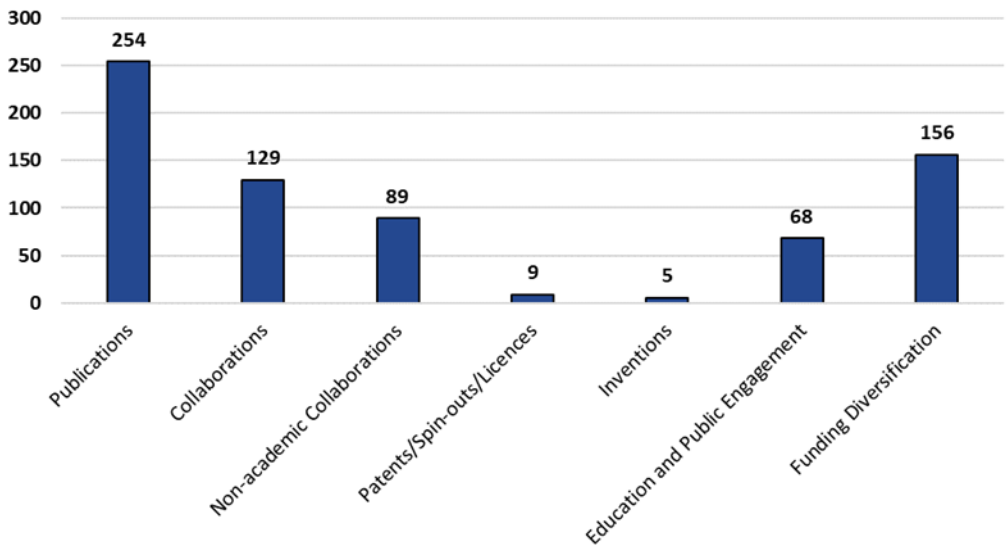
[3] More information: https://re.ukri.org/funding/our-funds-overview/uk-research-partnership-investment-fund/
[4] These experts are based both in the Netherlands and internationally.
[5] The exact figure for 2019 was €964 million. The breakdown of this figure is not available.

The latest SFI call was launched in May 2021 and had a minimum budget request from SFI of €500,000 in direct costs. An additional 10% cash cost share was mandatory. Broadly similar objectives applied to earlier calls but there was a shift towards higher value projects from 2018.

Performance & Effectiveness

There is strong evidence of a range of outputs which were supported by funding for RI provided through the SFI Programme, including publications made and education/public engagement. Key measures of outputs related to the Programme are shown below, and relate to the first two calls which commenced in 2015 and 2018. Also of note is the number of academic and non-academic collaborations. There is also some evidence of patents / spin outs / licences but we note that such impacts are likely to only take place after a lag.

Key Performance Indicators, 2015-2021



Source: Data based on SFI RI Survey 2021[6]

The same data from SFI shows that the total funding reported by respondents in receipt of SFI RI support amounted to €307m from 2015 – 2021, of which almost half is from EU Horizon 2020. The details are shown in the table below and highlight the extent of funding accessed by researchers who also benefit from SFI RI support.

[6] Data quoted in this study relating to the SFI RI Survey conducted in 2021 only relate to the calls made in 2015 and 2018, and do not include projects under earlier calls.

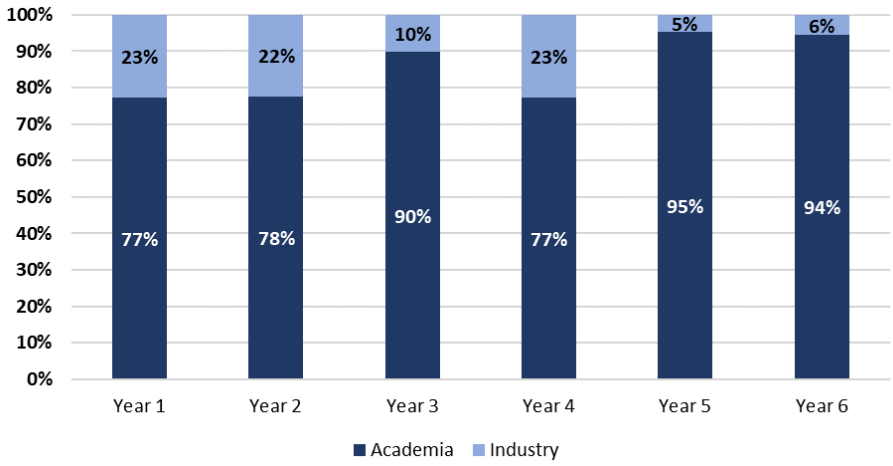
Amount of Leveraged National/International Funding by Funding Stream, 2015 – 2021		
Funding Stream	**Total Amount of Funding**	**% Of Total Funding**
European Union - Horizon 2020	€143m	46.6%
Enterprise Ireland - Non-Commercialisation Award	€89m	28.9%
European Union - Other	€26m	8.6%
European Union - Framework Programme	€24m	7.8%
Private Enterprise	€12m	3.8%
Other	€13m	4.2%
Total	**€307m**	**100%**
Source: Data based on SFI RI Survey 2021		

Indecon's survey of institutions and research bodies suggested that many viewed the SFI's RI Programme as being effective or very effective, but 28% of SFI Research Centres and 22% Technological Universities (TU)/Institutes of Technology (IOTs) suggested that the Programme was not effective. This is likely to reflect the fact that the Programme was viewed as being effective in meeting certain key objectives but did not address areas such as the renewal of existing infrastructure.

Views on Effectiveness of SFI RI Programme by Institution Type/Research Body						
	Very Effective	**Effective**	**Neither Effective nor Ineffective**	**Ineffective**	**Very Ineffective**	**No response**
Universities	0%	14%	71%	0%	0%	15%
SFI Research Centres	14%	29%	14%	14%	14%	15%
IOTs	11%	44%	11%	22%	0%	12%
Source: Indecon						

In reviewing the efficiencies of the Programme and the performance indicators it is useful to consider the views of institutions on its effectiveness. Feedback from institutions highlight the impact of the Programme but recognise that performance indicators do not fully capture all aspects. The views also highlight the issue of lack of funding to renew existing infrastructure or to fund maintenance costs. Researchers who use the Programme reported a range of views including the impact of the Programme. They also highlight issues such as the need to replace equipment and infrastructure. One of the important goals as set out in the SFI RI calls was to foster collaboration and partnership between researchers, while also encouraging partnership with industry. The evidence shows that income from both academic and industry users has been generated in each year of the Programme period. Larger projects (value >€0.5m) tend to attract a greater proportion of income from industry.

% of Income Generated by RI User Type and Year in Operation, 2015-2021



Source: Data based on SFI RI Survey 2021. Only includes data relating to 2015 and 2018 calls.

An issue in reviewing Programme performance and effectiveness is the extent to which infrastructure is utilised. Utilisation rates were found to range from 54% in projects <€499k up to 60% in projects >€1.5m. An issue for future programmes is whether a national approach to ownership and utilisation rather than an institutional approach would enhance levels of utilisation. This would involve the taking of steps to ensure that researchers from other national research intuitions have information on, and appropriate access to, RI. Rates of utilisation may also be enhanced by the provision of funding for maintenance and by the development of appropriate access plans. It may also be worth considering setting targets for utilisation levels.

SECTION III: PROSPECTIVE ANALYSIS OF NATIONAL NEEDS FOR RESEARCH INFRASTRUCTURE

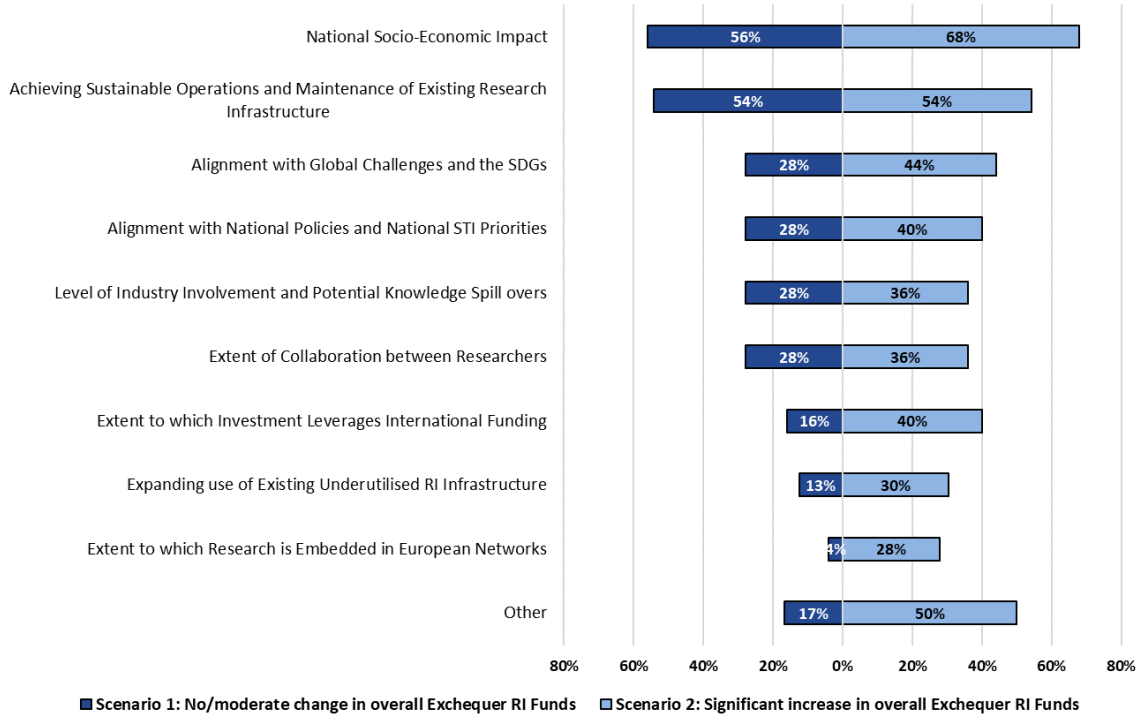
Any determination as to the 'need' for RI will be driven in the first instance by broader national research and innovation policy and prioritisation, given that RI expenditure represents only a small share of the overall research budget. SFI's Research Infrastructure Programme represents only 10% of its total programmatic expenditure by SFI,[7] and only around 2-3% of total governmental R&D spending annually. Indecon developed two scenarios for future investment in RI:

- Scenario 1: No change, or only a moderate change, in exchequer resources allocated to RI
- Scenario 2: A significant increase in exchequer resources allocated to RI

Feedback from key national stakeholders highlighted the importance of investing in Research Infrastructure. For example, Enterprise Ireland commented regarding the national need for research infrastructure "*Investment in new research equipment to grow Ireland's current and future strengths in areas of strategic importance and to keep up to date with new markets and developing*," while the EPA commented: "*Strong, relevant and strategically-coordinated investments in Research Infrastructure are key to a vibrant and successful research environment in Ireland*." The institutions surveyed rate achieving National / Social / Economic impact as a high priority and Indecon believes this should be a core objective of any future programmes. Maintaining existing infrastructure is also seen as a priority as is shown in the next figure.

[7] Spending Review 2019. Analysis of Science Foundation Ireland Research Grants.

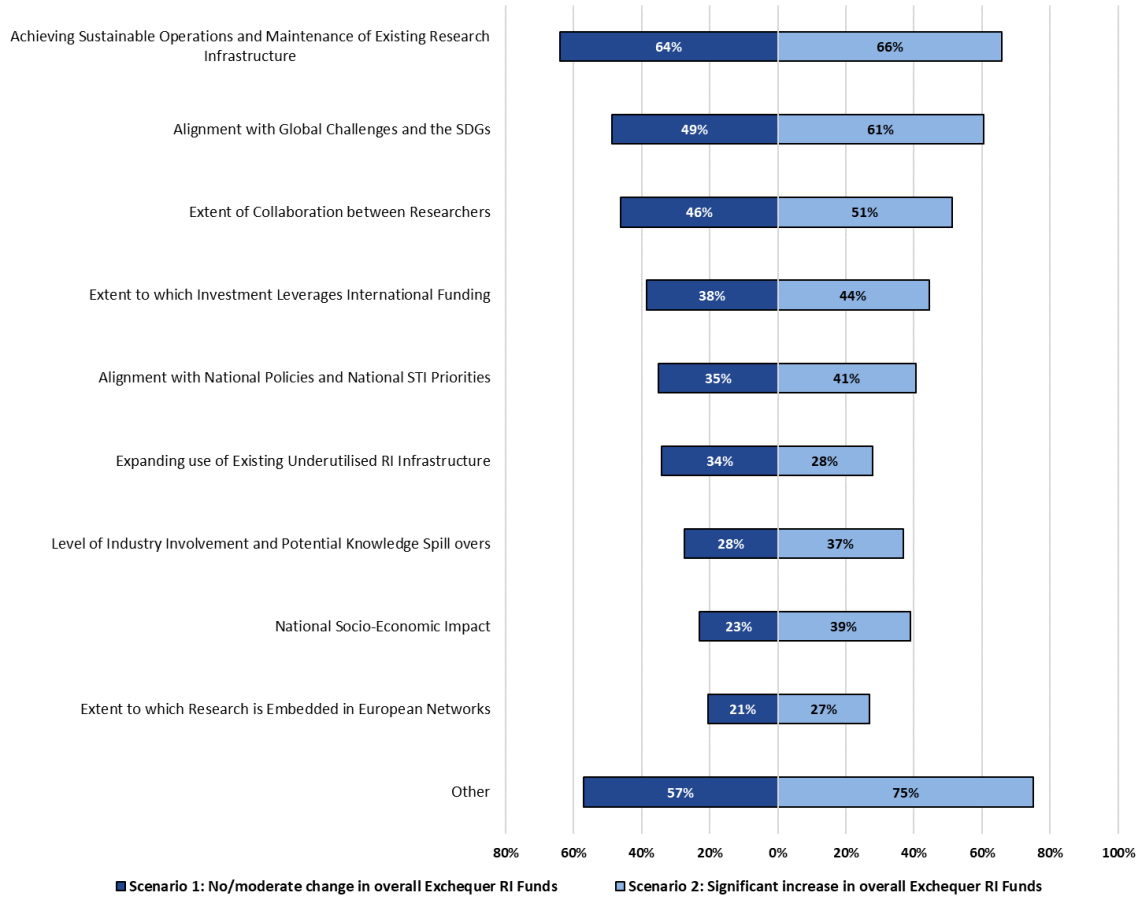
% Of Institutions that consider the following criteria as High Priority



Source: Indecon Survey

For both researchers and institutions, regardless of the funding scenario, a strong view was expressed of the need to achieve sustainable operations and maintenance of existing research infrastructure. Improving the extent of collaboration between researchers was also given a high priority by around half of all respondents in both funding scenarios. The evidence indicates that researchers suggested that investing in maintenance of existing infrastructure and achieving sustainable operations should be a high priority. The importance of alignment with global challenges and the SDGs was also noted.

% of Researchers that consider the following criteria as High Priority



Source: Indecon Survey

Indecon also asked stakeholders to suggest priority areas within a specific list of science, technology and innovation (STI) research areas. A number of submissions received by Indecon as part of this study highlighted specific research domains that merited additional investment, including environmental concerns and health, particularly in clinical trials. The new national research and innovation strategy (Impact 2030) will ultimately influence RI strategy, in particular by setting policy areas and priorities, and may also influence the resources available for investment in RI.

National needs are also reflected in other policy objectives. The IDA has identified several global megatrends that have potential to create new opportunities including: advanced manufacturing and integrated supply chain; a digitised industry; healthcare transformation; sustainable industries and technologies; and the future of work. Due to their cross-cutting nature, they are anticipated to require new hybrid infrastructure that involve multiple disciplines. Digital platforms are expected to be a prominent requirement to enable these future opportunities. Infrastructural investment and a variety of different financial supports to encourage and accelerate multi party business to business collaborations such as these will be required.

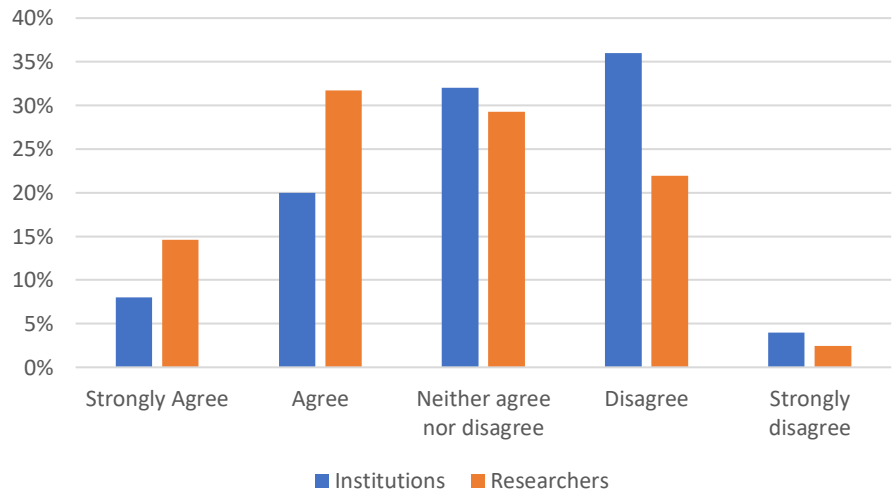
Operations and Maintenance Supports

Given that much of the national equipment stock was procured under previous PRTLI calls, a significant proportion of Ireland's RI stock is at least a decade old and in some instances 15-20 years old. National funding mechanisms in general do not account for the continued cost of ownership or depreciation of infrastructure which has led to a situation of key pieces of equipment being no longer viable due to an inability to fund maintenance contracts and support.[8] Further, much of the specialised investment in RI requires suitably qualified and experienced support staff to operate. These positions are not included as an allowable cost under many national funding instruments. There was a strong view among national stakeholders engaged by Indecon and the research community that Ireland should provide additional support for the ongoing operation and maintenance of RI.

Access to RI by Researchers and Industry

Given the significant investments made by the state in RI over the last 20 years, facilitating access to RI can help achieve a greater return on investment and value for money for the state and for the broader research community. Two aspects of access can be considered: first, visibility and the extent to which other researchers are aware of the availability of certain RI; and secondly, accessibility, to ensure that RI is made available in an appropriate manner to interested researchers from Ireland, including the setting of appropriate access charges. Respondents to Indecon's survey of the research community suggested that there were mixed views regarding the extent to which it was believed that investments in RI in Ireland were managed as a 'national asset', as opposed to a once-off investment, as shown in the next figure. Assets considered a 'national asset' can be considered as being available for other researchers, in terms of being both visible and available.

% Who believe Investments made in RI are managed as a national asset as opposed to a once-off investment



Source: Indecon Survey

Access by industry users is also important. Companies accessing infrastructure in the HEIs can result in a range of benefits including improved technological knowledge; an improvement in developing a culture of innovation;

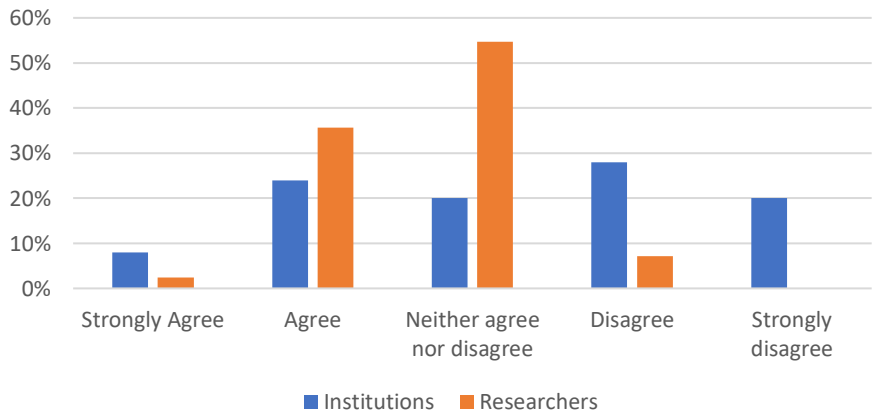
[8] IUA submisison to Indecon, 2021

securing access to further capital; and development of new products and processes.[9] Ireland's research programme has already achieved a significant level of partnership and collaboration between academia and enterprise. However, not all RI is necessarily suitable for open access, given the nature of the technology and the level of expertise required to operate it.

The HEA has usefully developed national guidelines for access to research infrastructures hosted by higher education institutions or other research bodies in Ireland.[10] The guidelines state that access would be facilitated by the Large Items of Research Equipment database ('LIRE') to provide relevant contact information. The LIRE database, maintained by the HEA, was compiled following the completion of a national inventory of all significant publicly funded research infrastructure and equipment. Indecon understands that the LIRE database has not been accessible for a period and as a result few respondents to Indecon's survey believed that the LIRE database was being used optimally. Stakeholders consulted as part of this study reported that a national database could impact on supporting access to RI (see selected comments below). The 2018 report by the Royal Irish Academy recommended the creation of a National Database of Research Infrastructures to avoid duplication and improve accessibility.[11]

In addition to the provision of a centralised database of RIs, there are different aspects of digital needs which are relevant to researchers. The research community, comprising institutions, research bodies and individual researchers, reported mixed views when asked whether they believe that there was good access to digital RI as shown in the next figure.

% who believe Irish researchers have very good access to digital RI



Source: Indecon Survey

[9] Enterprise Ireland Submission to Indecon,2021.
[10] HEA, "National Principles for Access to Research Infrastructure."
[11] Royal Irish Academy,2018, "*Future- Proofing and Improving Research Infrastructures in Ireland*."

Conclusions

The evidence presented in this report shows the importance of the current funding for Research Infrastructure to the conduct of advanced research in Ireland. The SFI RI programme plays a critical role. There is evidence of a range of outputs which were supported by funding for RI provided through the SFI Programme, including publications, education/public engagement and collaborations, including with industry. Indecon believes that a continued focus on large-scale investments in areas of national priority is necessary to maximise additionality and collaboration. Indecon's analysis also identifies a number of ways that RI investment in Ireland could be further improved, to optimise the impact of the investment. This is important in order to maximise the effectiveness of scarce Exchequer resources. These focus on adjustments to SFI future programme calls, as well as changes that can be made at a national level. These are designed to build on the success of previous funding rounds. Indecon's independent assessment is that the SFI's RI programme can continue to play a critical element in Ireland's overall national effort to support excellence in advanced research.

Indecon believe that an important way that the effectiveness of future funding could be enhanced is to have funding mechanisms to support the operation, maintenance and repair of equipment. This issue was raised as one of the most important recommendations by national stakeholders engaged by Indecon as part of this study. It was also a major theme in previous reports on RI funding in Ireland. Ireland is not alone in facing this challenge, with the Chair of the House of Lords Science and Technology Committee in the UK referring to it as the 'batteries not included' syndrome. Reforms are needed to ensure that both existing and future investments in RI funded by the Irish Government have the resources available to ensure that they can be maintained and used optimally. This would enhance the utilisation of the infrastructure.

Another key area is to ensure that RI in Ireland is treated as a national asset, accessible where appropriate to leading researchers regardless of their institutional affiliation. Many of the mechanisms needed are already in place, though further measures are needed to ensure that they are used to their fullest extent. Most notably, we believe that it is important that Access Charge Plans are published online and made publicly available. Indecon's review of international experience, however, confirms that Ireland is more advanced than other countries in requiring Access Charge Plans. This is due to policy in Ireland as reflected in the HEA's national guidelines for access to research infrastructures, as well as the requirements of SFI RI calls.

There are other ways that greater access to RI could be enhanced. Indeed, Indecon note that the most recent SFI RI programme call in 2021 has already done much to promote greater collaboration among researchers by further strengthening the need to collaborate to the selection criteria. Work to promote greater collaboration should continue and be a key feature of future programme calls.

Access to infrastructure is also about visibility, the extent to which other researchers are aware of the availability of certain RI. In this regard, the development of a fully functioning searchable central equipment/infrastructure database accessible to all is very important. This was seen as important not only for researchers in other higher education institutions, but also to promote visibility of RI for private industry. The Large Items of Research Equipment (LIRE) database was intended to contain items of research equipment items with a value of at least €100,000 and was compiled following the completion of a national inventory of all significant publicly funded research infrastructure and equipment. However, the LIRE database has not been updated, and is not currently in active use. The development of a central database of RI to replace LIRE which is accessible to public and private sector would facilitate the realisation of the full benefits of publicly funded infrastructure.

Indecon believes that the SFI RI Programme has been effective but that a greater co-ordination of national strategy for research infrastructures is needed. An oversight and coordination group could help in guiding many aspects of national policy in a way that reflects the evolving changes in society, the economy, and in the research community itself. Such a group could help inform the national prioritisation for RI, promote greater collaboration and usage of RI, and identify emerging issues faced by the research community and industry. We also note that the research needs of Technological Universities are likely to change rapidly in the coming years, as reflected in the research and innovation metrics set in legislation for TUs/TU consortia to achieve. Indecon believes that greater tracking of TUs use of RI should be carried out.

Indecon's analysis suggests that the wider economic and research impact of RI infrastructure is significant. With the adjustments proposed the full benefits of this important investment will be realised.

Recommendations for Future SFI RI Programmes

In the table below we summarise recommendations for improvement in the SFI RI Programme, which are discussed in the subsequent text. These are designed to build on the achievements of the current Programme and to enhance its impact. These are consistent with our recommendations for a national approach to research infrastructure which follow subsequently.

Summary of Recommendations for Future SFI RI Programmes
1.1: All future applications for new SFI RI supports to take account of maintenance/upkeep costs.
1.2. Dedicated funding for upkeep/maintenance of existing and new RI
1.3. Continue current focus on large-scale investments
1.4. Access plans should be published online and made publicly available
1.5. Additional weight to projects which leverage external sources of funding and joint projects
Source: Indecon

1.1: All future applications for new RI SFI supports to take account of maintenance/upkeep costs: As noted in Recommendation 2.4 below, the maintenance, upgrading and operation of research infrastructure is a key element of ensuring that public investment in Ireland's national stock of research infrastructure is optimised. The SFI's RI Programme can support this by requiring that future Programmes which fund new RI require, as one of the selection criteria, provide sufficient evidence showing the sustainability of that RI in the medium to long term. This would include allowing applicants to apply for funding through the Programme for service contract, maintenance costs and other upkeep costs (e.g., software upgrades) for the lifetime of the equipment, or applicants setting how maintenance and upkeep would otherwise be achieved.

1.2. Dedicated funding for upkeep/maintenance of existing and new RI: While the implementation of Recommendation 1.1 above would help in funding the support and maintenance required for new RI, there exists a significant stock of RI in need of investment, including investments made as part of historical PRTLI calls dating back to 2000. As part of the next call of the RI Programme, SFI should consider dedicating a portion of funds for the upkeep and maintenance of existing and new RI or ensure co-ordination with other government departments and agencies to ensure funding is provided. Depending on the quantity and quality of applications received, this could be repeated in future Programme rounds.

1.3. Continue current focus on large-scale investments: Over the course of the period from 2015 to 2021, there was a change in emphasis within the SFI Programme towards larger calls. This is reflected in both the minimum size of SFI budget request as set out in the call documentation, as well as the average larger size of award in 2018 compared to 2015. Larger calls are more associated with collaboration, are more likely to have published access plans, and show a greater time in use. Further, it is likely that a focus on higher cost RI increases the additionality of the Programme by supporting investments which may not have been otherwise made in the absence of SFI funding. As such, we recommend that the SFI Programme continues to focus on large-scale investments in areas of national priority but includes provision for targeted small-scale projects.

1.4. Access plans should be published online and made publicly available: Research Infrastructure should be viewed as 'national assets' and not solely institutional ones. A culture of collaboration, sharing, and accessibility

must be fostered to ensure they are utilised effectively. This study shows that for many projects, including many large projects, access plans are not published online and made publicly available. The process for ensuring that access plans are published should be strengthened. For example, this could be done by tracking and reporting the percentage of RI awardees by institution that have published up to date access plans. Any request for funding to support the upkeep/maintenance of existing and new RI should also be made contingent on access plans being published online and made publicly available.

1.5. Additional weight to projects which leverage external sources of funding and joint projects: The SFI Programmes make mention of a number of important aspects as part of the call process. These include setting out recommended cost shares to leverage funding, facilitating a more rapid commercialisation of research, encouraging strategic infrastructural planning by research bodies, and the fostering of collaboration and partnership between researchers, including in Northern Ireland. Indecon believes that significant weight should be given to projects which leverage external sources of funding, and to joint projects involving a number of institutions. Indecon note the 2021 call was developed to place emphasis on broad collaboration and usage in Ireland, and this emphasis should continue. In terms of leveraging of income, as well as public funds (whether Irish or European) and industry contributions, consideration should be given to the potential role of philanthropy in developing the RI in Ireland. In terms of joint projects, large scale investments which are applied for jointly by more than one higher education institution should be given particular consideration in the evaluation process.

Recommendations for National Approach to Research Infrastructure

We set out below the recommendations regarding the national approach to RI and discuss them subsequently. These are designed to build on the success of the investment made in Research Infrastructure.

Summary of Recommendations re. National Approach to Research Infrastructure
2.1. Consider the establishment of an RI oversight group
2.2. Develop a RI roadmap
2.3. Track access by TUs to RI in other institutions
2.4: Develop supports for the sustainable operations and maintenance of RI
2.5: Develop and maintain a national centralised database of RI and its utilisation
Source: Indecon

2.1. Consider the Establishment of a National RI oversight group: Indecon believes there is merit in the Government considering setting up an oversight and coordination group to establish the national prioritisation for RI investment. This would build on existing initiatives which have been taken and could involve mechanisms to facilitate sharing of infrastructure among institutions and industry users. This group might also consider establishing a common evaluation framework to guide the allocation of resources available from different funds, and include key metrics to measure the impact of RI investment. This group could also suggest initiatives to enhance interoperability among RIs; and engagement by research-and-innovation communities.

2.2. Develop a RI roadmap: A greater co-ordination of national strategy for research infrastructures could be achieved through the development of a roadmap for RI investment in Ireland. Securing the appropriate long-term structures, processes and principles, combined with a multi-annual strategy, should be a priority for RI in

Ireland. The process of developing a roadmap could involve the RI oversight group and co-ordinate views from Government departments and agencies, the higher education sector, representatives of industry, and other important stakeholders. This roadmap could build on and be guided by the new national strategy for research and innovation, *Impact 2030*.

2.3. Track access by TUs to RI in other institutions: TUs will require significant increases in research and innovation capacity in the coming years to meet targets set down in legislation. In the short to medium term, it will be important that researchers in TUs have access to existing RI investments where appropriate. This could be supported by ensuring that a national centralised database of RI is created (see Recommendation 2.5 below), and also that access plans are in place setting out terms of usage.

2.4: Develop supports for the sustainable operations and maintenance of RI: The maintenance, upgrading and operation of research infrastructure is a key element of ensuring that public investment in Ireland's national stock of research infrastructure is optimised. Outdated equipment, or the lack of personnel with the right skillsets to operate it effectively, would undermine Ireland's ability to deliver world class research in a globally and highly competitive environment. The continuous support and maintenance of equipment requires the development of a funding model that can ensure equipment remains effective over its lifetime. Whether as part of the SFI RI Programme or otherwise, Ireland needs to consider funding mechanisms to provide sustainable operations and maintenance of existing and new RI.

2.5: Develop and maintain a national centralised database of RI and its utilisation: The development of a central database of RI which is accessible to the public and private sector could facilitate the realisation of the full benefits of publicly funded infrastructure. Innovation 2020, the Irish Government's strategy for research, development, science and technology, states that in making future investment decisions, system efficiencies must be continuously sought, for instance through the provision to industry of access to infrastructure promoted through online resources. The existing LIRE database is currently not accessible to researchers. A new national database should be created providing details of RI investments including access plans, indicating what RI is available to other researchers and industry, and who the contact point is. To ensure high levels of take-up and use, this database needs to be maintained online, made easily searchable by research area, and the status of the RI in question should be updated on a regular basis (e.g., regarding availability, contact details, whether it is fully functioning, etc.). This new database could replace the current LIRE database.

Section I: Introduction and Overview

1 Introduction

1.1 Introduction

Indecon, following a competitive tendering process, was appointed by Science Foundation Ireland (SFI) to undertake an independent policy evaluation to, retrospectively, evaluate the investment Programmes implemented by SFI into Research Infrastructure 2015-2021; and, prospectively, give recommendations on national mechanisms involved in research infrastructure ('RI'). The analysis has been informed by a detailed examination of SFI data and by new evidence from a survey of research institutes and individual researchers. Valuable inputs were also obtained from a range of departments, agencies and other external stakeholders.

1.2 Scope of Study

The objective of this research is to: (a) retrospectively, evaluate the investment programmes implemented by SFI into Research Infrastructure 2015-2021 including an assessment of the Programmes' performance and effectiveness with recommendations on potential opportunities for improvement; and (b) prospectively, give recommendations on national mechanisms involved in research infrastructure, to include an overview RI landscape analysis on which to base potential investment scenario recommendations. While details of the 2021 call are discussed in this report, awards made under this call are not covered. Within the framework of Ireland's future economic projections, the report sets out different courses of action for funding levels to determine optimisation of investment in RI. The following are particular issues that are considered as part of this research:

a) Update national needs for RI investment, prioritise these needs, and relate the needs to scenarios of various funding levels provided;

b) Achieving sustainable operations and maintenance supports for existing and new RI;

c) Optimising access to RI for all of Ireland's researchers, including the use of access charge plans;

d) Optimising State Aid compliant access for industry;

e) Emerging needs of the Technological Universities (TUs) for RI;

f) Digital RI needs;

g) Optimising use of the LIRE database;

h) Assessing the national mix between competitive & call-based RI versus non-competitive or core-grant funded RI;

i) Identifying where technology transfer and knowledge spill overs from RI could be increased;

j) Assessing national asset management versus one-off investment approaches to RI;

k) Identifying coherent national mechanisms for RI oversight; and

l) Assessing the interoperability of RI in Ireland.

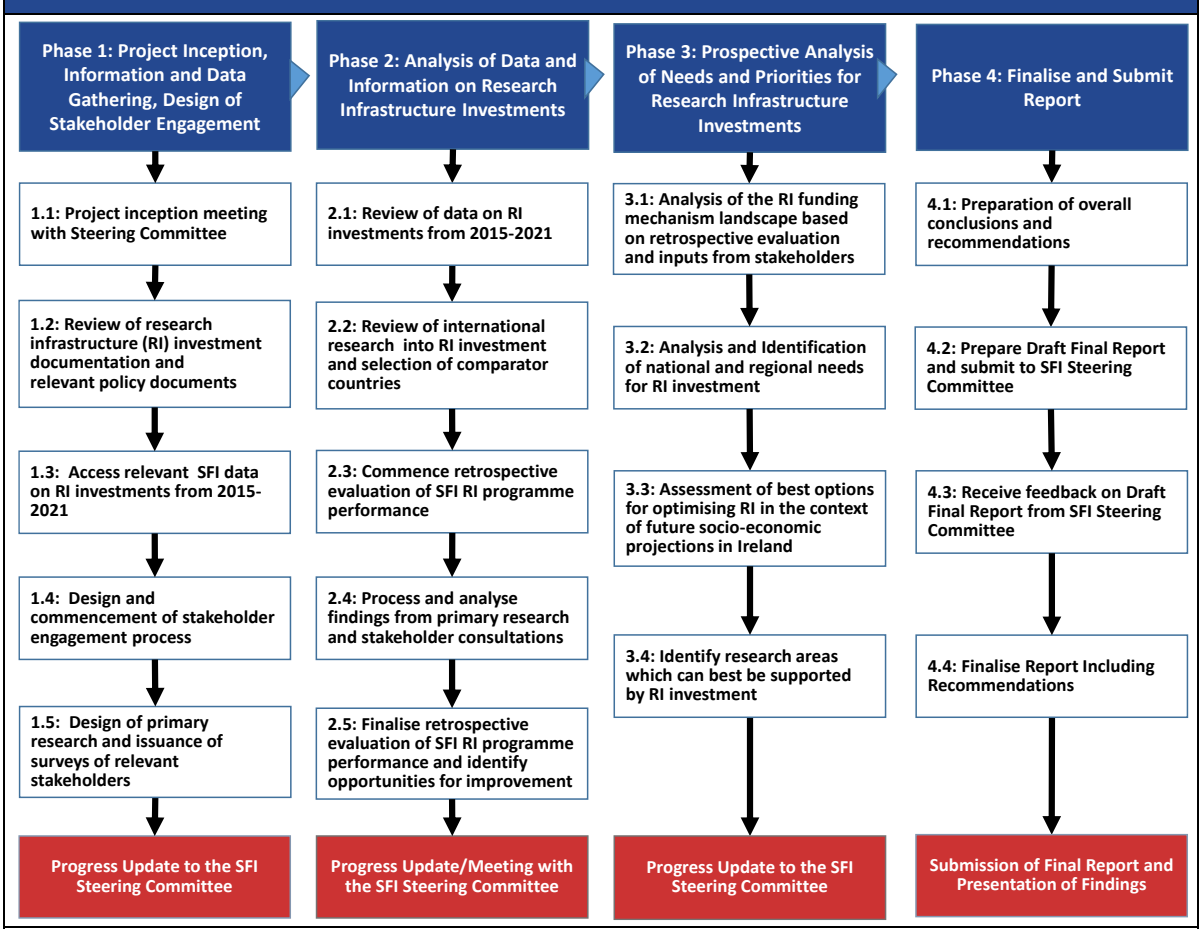
The evaluation does not include analysis of the application process and peer-review process associated with SFI, or other funding calls. While other organisations invest in RI nationally, it is not

within the scope of this project to conduct in-depth analysis into those other agencies. This evaluation does not consider High Powered Computing under its scope, due to the separate needs of HPC. Nor does it review membership of international research organisations, as they have been recently reviewed separately. The physical sites of research infrastructure were not generally within the scope of the study.

1.3 Approach and Methodology

A rigorous methodology was applied in completing this evaluation. An overview of the methodological approach to completing the evaluation is presented in the next figure.

Figure 1.1: Description of Methodological Approach to Assessment



Source: Indecon

1.4 Consultation Process

As part of the methodological approach to complete this study, Indecon conducted a widescale consultation exercise involving national bodies and agencies; research institutions and Higher Education Institutes (HEIs); and individual researchers. The latter survey of individual researchers targeted applicants to the various SFI RI Programmes and included both successful and unsuccessful applicants. The survey of research institutions/research bodies was aimed at research offices/vice-president's of research. As part of this consultation process, Indecon invited written submissions from state bodies and agencies, and bodies representing HEIs. In all, nine submissions were received from the bodies as shown in Figure 1.2 below. In addition to these formal submissions, HEIs, research bodies, and researchers were also given the opportunity to comment on a range of issues of relevance to this study. As well as the primary research conducted by Indecon as part of this evaluation, Indecon also had access to a 2021 survey of successful applicants conducted by SFI. In using this latter survey, which included data on SFI calls from 2012-2020, Indecon only included projects funded under the 2015 and 2018 calls.

Figure 1.2: Written Submissions Received
Department of the Environment, Climate & Communications
Enterprise Ireland
Environmental Protection Agency
Geological Survey Ireland
HSE
IDA Ireland
Irish Research Council
Irish Universities Association
Technological Higher Education Authority
Source: Indecon

1.5 Report Structure

This report is subdivided into four sections. Section I gives an introduction and overview of the landscape for RI investment in Ireland; Section II reports on Indecon's retrospective evaluation of SFI Research Infrastructure Programmes 2015-2021; Section III reports on the prospective analysis of national needs for research infrastructure; and Section IV sets out the recommendations of the report. An outline of the structure of the report is as follows:

Section I

- Chapter 1 sets out the introduction and background to the study
- Chapter 2 provides an overview of the RI landscape, including a review of how RI is defined and the national funding landscape

- Chapter 3 reviews international experience in a number of relevant comparator countries

Section II

- Chapter 4 provides an overview of SFI RI Programmes from 2015-2021, including a review of awards by subject domain and institution
- Chapter 5 assesses various aspects of the outputs and impacts of the SFI Programmes, including with respect to access by other researchers and industry

Section III

- Chapter 6 sets out an assessment of the national need for RI based on a number of criteria, including priority areas, research domain and the needs of the TUs
- Chapter 7 focuses on access to RI by other researchers and industry, including a review of the operation of the LIRE database

Section IV

- Chapter 8 sets out two sets of recommendations, the first regarding the national approach to RI, while the second sets out potential opportunities for improvement in the SFI RI Programme

1.6 Acknowledgements

The Indecon Research team wish to acknowledge the valuable inputs provided by a range of state bodies, HEIs, research organisations and individual researchers. We would particularly like to thank staff in the SFI for their invaluable inputs and support during this project, in particular Peter Clifford, Mary Teehan, Ciarán Seoighe, Nicola McGillicuddy and Roisin Cheshire. We would also like to thank members of the Steering Committee, in particular Paddy Howard of the Department of Further and Higher Education, Research, Innovation and Science, and Tim Conlon of the Higher Education Authority. We would also like to thank all stakeholders who took the time to fill out information requests or issued submissions. We would particularly like to thank the following: Gerry Clabby and Beatrix Aigner (Department of the Environment, Climate & Communications); Garret Murray, Gearoid Mooney, Kevin Burke, Alison Campbell, Deirdre Glenn, Neil Kerrigan and Imelda Lambkin (Enterprise Ireland); Alice Wemaere (Environmental Protection Agency); Aoife Braiden (Geological Survey Ireland); Ana Terres and Declan O'Hanlon (HSE); Breda O'Toole (IDA Ireland); Peter Brown (Irish Research Council); Lisa Keating (Irish Universities Association); and Jennifer Brennan (Technological Higher Education Authority). We would also like to thank our academic advisors on this project, in particular Professor Graeme Reid (University College London); Professor Massimo Florio (Università degli Studi di Milano); and Silvia Vignetti (Centre for Industrial Studies). **The usual disclaimer applies and the views and analysis in this independent report are the sole responsibility of Indecon International Economic Consultants.**

2 Overview of RI landscape

2.1 Introduction

This chapter discusses the definition of Research Infrastructure (RI) and presents an overview of the funding landscape in Ireland. The provision and funding of adequate RI has been recognised as an important National priority. Ireland's innovation 2020 document noted the objective to *"ensure that our researchers have access to the best possible equipment and facilities."* This was confirmed in Ireland's National Research and Innovation Strategy (2021-2027) consultation paper, which aims to *"Build a world class environment for research and innovation"* using modern and adequate research infrastructure.

2.2 Definition of Research Infrastructure

Research infrastructure can be defined as equipment, facilities, infrastructure and personnel used for research. This can encompass physical research equipment, and facilities, such as laboratories or office spaces. It can include IT infrastructure, database access and technology to facilitate research, as well as administrative supports. Research infrastructure can also include professional networks, such as networks of researchers and administrative supports.

Significant funding has been provided for Research infrastructure in Ireland for a long period. As far back as 1998, the Irish Government launched the Programme for Research in Third Level Institutions (PRTLI), funded through the HEA. This was run on a competitive basis and open to publicly funded third-level institutions. Since 1998, €1,110 million has been invested with the most recent cycle of PRTLI (Cycle 5) in 2010/11 investing exchequer expenditure of approximately €277 million with a further €59 million of private investment.[12] PRTLI focused on increasing the amount of transdisciplinary and interdisciplinary basic research, and supported personnel, infrastructure, and recurrent costs in third-level institutions.

Table 2.1: Total funding allocated for PRTLI (Cycles 1-5)

	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5
Total Allocated Funding	€206m	€78m	€319m	€230m	€277m

Source: Indecon analysis of HEA and Oireachtas data

SFI takes a broad view of the definition on Research Infrastructure:[13]

> "*Research Infrastructures, including the associated human resources, covers major equipment or smaller individual items of equipment, in addition to knowledge-containing resources such as collections, archives, data banks, e-infrastructure and test beds. Research Infrastructures may be "single-sited", "distributed", or "virtual"*

[12] https://www.oireachtas.ie/en/debates/question/2018-05-08/219/

[13] See SFI Research Infrastructure Call 2015

including technology-based infrastructures such as Grid, computing, software and middleware."

This SFI definition includes IT support and IT resources for research purposes but does not consider administrative support for research purposes. Further, it does not consider a monetary value behind research infrastructure, suggesting it is a widely encompassing definition.

The Higher Education Authority (HEA) uses a similar definition of RI in a wider policy document,[14] defining RI as:

"a wide variety of physical items of research equipment, including individual and collections of such equipment, as well as dedicated research facilities that provide centralised access to suites of specialised items… It has deliberately been decided not to define the term Research Infrastructure more precisely (for example by using arbitrary monetary threshold values). The Large Item of Research Equipment database has a €100,000 threshold which may be considered as a general rule of thumb. However, this is not to suggest that only those items of research equipment listed on this database fall under the scope of these access guidelines."

Here too, there is no monetary value behind the definition of RI, although it is acknowledged that a separate definition exists which focuses on the €100,000 value. Further, administrative support is not considered a part of the definition. In broad terms, the HEA sees research equipment, and facilities to use that equipment, as RI. In a similar vein, the Royal Irish Academy notes:

"There are many varying definitions of research infrastructures. This report takes a broad view of what a 'research infrastructure' is and includes equipment, facilities (including library resources), buildings, research institutes, research support systems, virtual infrastructure, and personnel. It examines research infrastructures related to Arts, Humanities and Social Sciences (AHSS) disciplines as well as Science, Technology, Engineering and Maths (STEM) related infrastructures. The definition adopted is that of the Directorate-General for Research, European Commission."

The official definition of the Directorate General for Research, European Commission is broad, encompassing equipment in a single site or multiple sites. Again, administrative support for such sites is not considered infrastructure, while facilities for special equipment are considered infrastructure. Their definition of the term RI covers:

"…facilities, resources and related services that are used by the scientific community to conduct top-level research in their respective fields and covers major scientific equipment or sets of instruments; knowledge-based resources such as collections, archives or structures for scientific information; enabling Information and Communications Technology-based infrastructures such as Grid, computing, software and communication, or any other entity of a unique nature essential to achieve excellence in research. Such infrastructures may be 'single-sited' or 'distributed'."

There are other definitions of RI. For example, organisations can take the above definitions but focus on the cost of equipment used, as shown in Table 2.1. Based on the value of the equipment, infrastructure can be split into five categories ranging from least to most expensive. Infrastructure

[14] See National Guidelines for Access by Researchers To Research Infrastructure Hosted By Higher Education Institutions Or Other Research Bodies In Ireland

can also be split by discipline and department, although many projects call for a multi-departmental or multi-discipline approach in the use of such facilities.

Table 2.2: Categories of Research Infrastructure by monetary value		
	Category	**Value**
1	Basic Equipment	<€ 20,000
2	Analytical/Specialised Equipment	€20,000 to €50,000
3	Advanced/Specialised/ Unique Equipment	€50,000 to €250,000
4	Core Technologies / Core Facilities	€250,000 to €1M
5	National Infrastructure	> €1M
Source: IUA Submission to Indecon, 2021		

In Section II of this report (retrospective analysis of SFI RI Programme), the implicit definition of RI followed will be based on that used for that Programme. In Section III covering a discussion of RI nationally, a broader definition based on stakeholder feedback will be employed.

2.3 National Funding Landscape

A range of organisations have played an important role in the funding of research infrastructure. More recently, Ireland's Programme for Government recognised the high-quality research emerging through a range of funding agencies and Programmes. Apart from Science Foundation Ireland, examples of these include the HEA, as well as Enterprise Ireland, IDA (Ireland), the Department of Agriculture and Food, and the Environmental Protection Agency (EPA). Other funders have included the Irish Research Council for the Humanities and Social Sciences (IRCHSS), the Irish Research Council for Science, Engineering and Technology (IRCSET), the Health Research Board (HRB), the Marine Institute, Teagasc, and COFORD. GSI supports a number of important Research Infrastructures, including for example directly providing data and maps. Funding has also been provided by the European Commission's Horizon 2020 and from philanthropic sources.

Programme for Research in Third Level Institutions (PRTLI) (1998-2010)

In the mid-1990s, deficits in the quantum of research being conducted in Ireland were noted. Expenditure on research and development, as well as the total number of personnel working in the sector, was below that of comparable countries. In 1996 a Circa Group study identified undercapitalisation of higher education research as a significant problem in Ireland's research sector. It also found weaknesses in the organisation and management of research activities. The Irish government launched the Programme for Research in Third Level Institutions (PRTLI) in 1998. It was hosted by the HEA on behalf of the Minister for Education and Science and the Government, providing financial support for third-level institutions. This support was made up of funding for infrastructure, staff, and other research resources through a series of rounds (PRTLI 1- PRTLI 5). The Programme was run on a competitive basis and open to all publicly funded third-level institutions. The last cycle of

PRTLI (Cycle 5) was announced in 2010 and has involved exchequer expenditure of approximately €277m with a further €59m of private investment.[15]

PRTLI focused on increasing the amount of transdisciplinary and interdisciplinary basic research, and supported personnel, infrastructure, and recurrent Programme costs in third-level institutions. The original Programme was funded under Ireland's National Development Plan 2000-2006, with assistance from the European Regional Development Fund and with private funding through a public/private financial framework. PRTLI Cycles 1-3 invested € 605 million (€403 million for capital spend, plus €202 million for recurrent spend) into 23 of 35 eligible higher education institutions. A total of 62 research Programmes, covering science and engineering, social sciences, humanities, and library services were supported by these cycles. This funding occurred between 1999 and 2004. During this time institutions secured 97,000m^2 of new research space, including almost 20,000 m^2 of library space. Within that, universities secured 5,800 new research spaces and 1,600 new library spaces. They also secured new capital equipment for advanced research costing approximately €135m, as well as €260m for new research buildings, among other investments related to teaching and staffing.

In August 2007, the Minister for Education and Science announced the launch of PRTLI Cycle 4. Approximately €230 million was allocated for major research initiatives in 15 higher education institutions. Here too, the funding provided workspace and researcher funding, including 200 postgraduates, 100 postdocs, 50 principal investigators, and 60 support staff. Shortly after, Cycle 5 of PRTLI was announced in 2010. This call allocated €277 million with a further €59 million of private investment. This cycle of projects and funding finished in 2018.

Since 2018, subsequent cycles have not been launched. Ireland's Innovation 2020 strategic plan had a number of objectives tied to research and development. One of these was to create a system of funding to replace the PRTLI. More recently, Ireland's Programme for Government recognised the high-quality research emerging through a range of funding agencies and Programmes. The government is now looking to fund infrastructure, equipment, and structured PhD Programmes using a new scheme. Although future cycles of PRTLI were referenced in the National Development Plan, Project Ireland 2040, its status remains under review. Subsequent national strategies and policy initiatives consistently emphasized the importance of sustained investment in research infrastructure to achieve Ireland's national ambitions.[16,17] In 2015, as the final funding of PRTLI came to an end, the Irish Government commissioned a study by Technopolis[18] to identify any future investment needs in the period to 2020 (and beyond) that may be strategically required for the achievement of national R&I priorities. The report, "Ireland's Future Research Infrastructure needs" stated**:**

> "*One of the main risks is that the pendulum swings from large, systemic programs such as PRTLI to isolated, uncoordinated investments in Research Infrastructures, research centres, PhD education, etc*."

There is a risk that the absence of a successor to PRTLI may result in increasingly outdated equipment, which may undermine Ireland's ability to deliver world class research.

[15] https://www.oireachtas.ie/en/debates/question/2018-05-08/219/
[16] https://dbei.gov.ie/en/Publications/Publication-files/Innovation-2020.pdf
[17] https://www.gov.ie/en/policy/project-ireland-2040-policy/
[18] https://www.technopolis-group.com/wp-content/uploads/2015/12/Irelands-Future-Research-Infrastructure-Needs-Study.pdf

Funding of Research Infrastructure after the PRTLI scheme

While there has not been a successor announced to PRTLI, organisations like the SFI have targeted investment in Research infrastructure. SFI was established on a statutory basis in July 2003. It funds fellowships and research programmes in response to applications from researchers in targeted areas of economic importance, currently focused on the areas of biotechnology and ICT. SFI is also engaged with industry in some joint funding, specifically tied to infrastructure spending. An important distinction between SFI and PRTLI funding is that the former is geared towards funding individual researchers as well as institutions. SFI's budget rose from €49 million in its first year of operation to €208 million in 2021. This funding is broken down to €167.9 million in allocation for grants awarded in previous years (81%) and €40.4 million for in-year expenditure on new awards (19%).

Within the context of the wider research infrastructure landscape, Science Foundation Ireland's Infrastructure 2015-2021 Programme has played an important role in targeting investment in research infrastructure. This has provided funding for meeting the capital cost of equipment.

Another source for RI funding for certain institutes is the Capital Equipment Calls, which have run between 2019 and 2021. These calls are run by Enterprise Ireland (EI) and are open to members of the Technology Gateways (exclusively hosted by TUs and IOTs) and Technology Centres (which many Technological Universities and Institutes of Technology are members of). The Capital Equipment Call was put in place to renew or upgrade existing RI and source new state-of-the-art RI. Further, the Capital Equipment Call was designed to improve interaction between Technology Gateway or Technology Centre participants with private industry in Ireland. Applications for well-established equipment where there is a clear industrial need were especially sought after. The calls funded between €25,000 to €250,000 per application, although larger applications were also considered on an exceptional basis. This represents a lower price band than for the SFI RI Programme, which in its 2018 and 2021 calls was focussed on grants for RI which cost in excess of €500,000. The total value of the calls was €6 million in 2021. Only members of the Technology Gateway Programme are allowed to apply, and so funding is only available to a small fraction of Ireland's total research infrastructure. Further, the value of the call is far lower than the amount of capital investment in the PRTLI scheme.

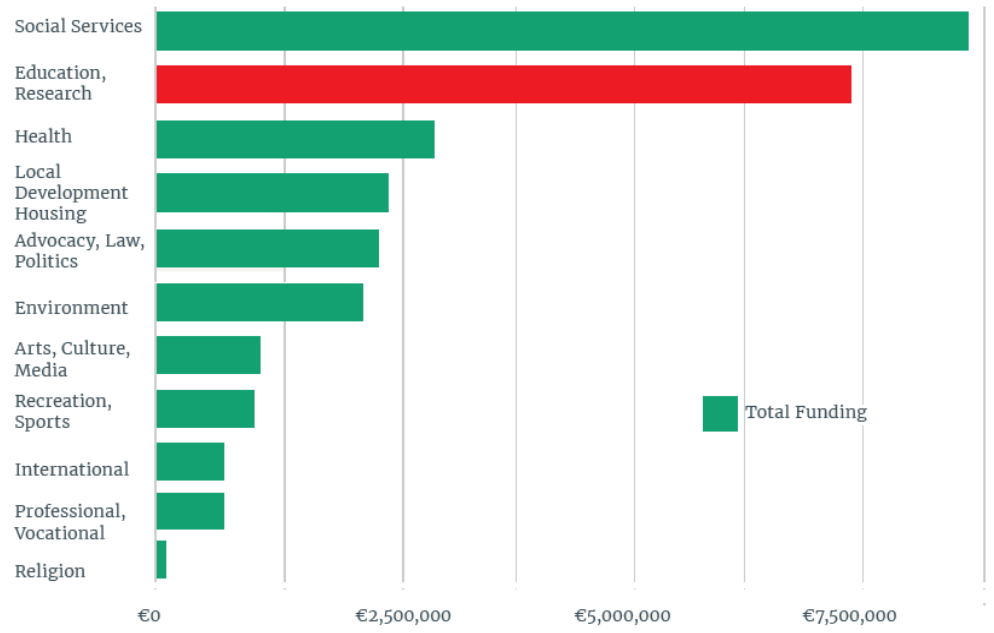
Beyond this, Irish researchers have secured funding for infrastructure through the Horizon 2020 funding stream. In 2020, Ireland's Marine Institute was awarded funding for five projects, totalling €2.1 million. The projects were: (i) JERICO-S3 (Joint European Research Infrastructure of Coastal Observatories: Science, Service, Sustainability); (ii) MISSION ATLANTIC (mapping and assessing the present and future status of Atlantic marine ecosystems under the influence of climate change and exploitation); (iii) ASTRAL (All Atlantic Ocean Sustainable, Profitable and Resilient Aquaculture); (iv) GROOM II (Gliders for Research, Ocean Observations and Management: Infrastructure and Innovation); and (v) JERICO-DS (Joint European Research Infrastructure of Coastal Observatories Design Study). This funding is an important contribution to Ireland's climate infrastructure.

There are other examples of smaller scale sectoral-level funding for research infrastructure. For example, the Health Research Board (HRB) (established in 1986) promotes, funds, commissions, and conducts medical, epidemiological and health services research in Ireland. It does not fund infrastructure such as buildings, although it does provide some funding for equipment for researchers working in the health sector. The HRB's budget rose from €21 million in 2002 to €45 million for 2021. Another example of sector-specific funding for research, including for RI, is the agriculture and food research conducted by Teagasc, which includes animal and grassland research and innovation; crops, environment, and land use; food; and rural economy and development.

Philanthropic Giving

Philanthropic donations are another important source of income for investment in RI by some HEIs. Atlantic Philanthropies was one of the largest philanthropic organisations in Ireland and made significant donations to Irish universities, before ceasing Irish operations in 2018. However, a number of institutions have continued to attract philanthropic donations, which can be used to support research activities. For example, Trinity College Dublin received a donation of €30m in 2021 for the development of Trinity East, which will be modelled on innovation districts such as Kendall Square in Boston and similar districts in cities such as Toronto, Rotterdam and Barcelona. Figure 2.1 shows that education and research was one of the most successful sectors for attracting philanthropic investment in 2020.

Figure 2.1: Breakdown of Philanthropic Investments, 2020

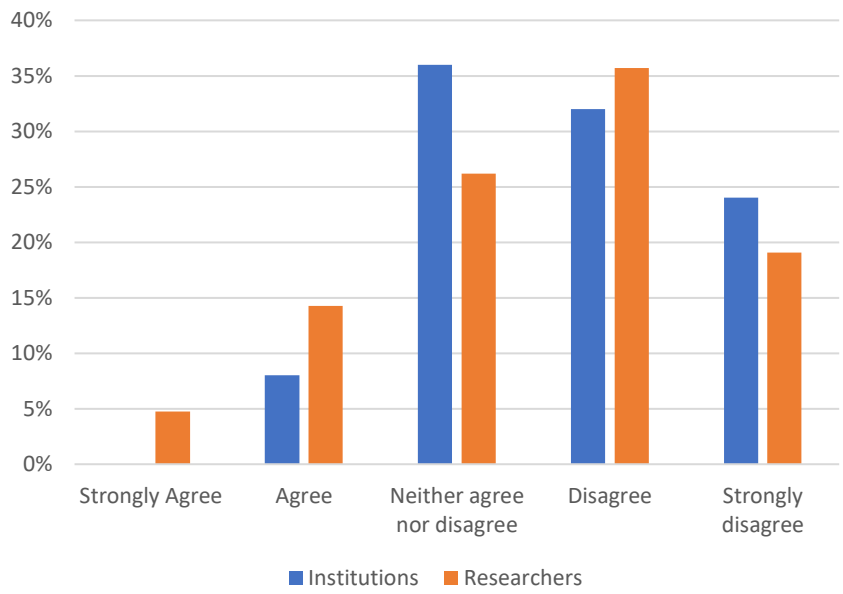


Source: Benefacts

2.4 National mechanisms for RI

In an Indecon survey comprised of institutions and researchers, respondents were asked whether they believed that the current mechanisms for oversight of RI investment in Ireland were coherent, with the results illustrated in Figure 2.2 below. This shows that more than half of respondent institutions and researchers did not feel that systems were coherent, with one in five strongly disagreeing with this view. This suggests a potential need for greater oversight and coordination at national level across departments and agencies.

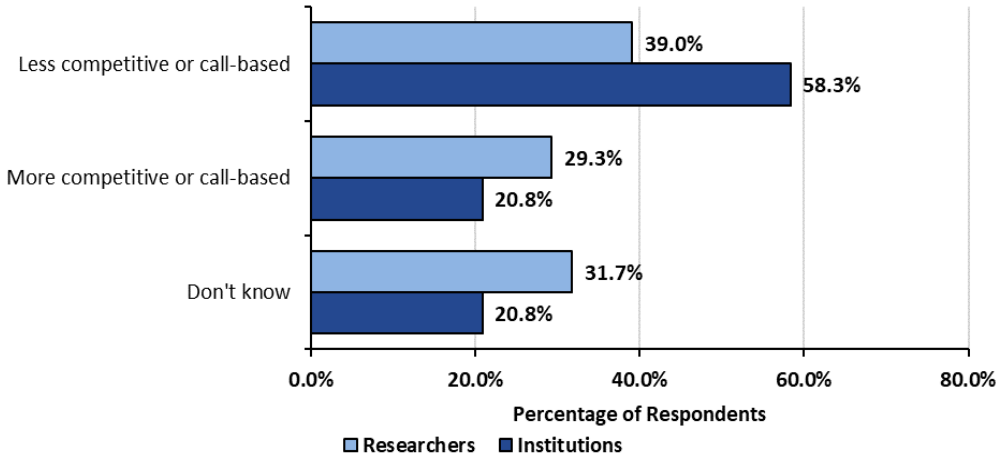
Figure 2.2: % who believe National mechanisms for RI oversight are coherent



Source: Indecon Survey

Indecon also surveyed institutions and individual researchers on the most appropriate balance between competitive, call-based funding (such as the SFI RI Programme) and non-competitive, core grant-based funding. This is illustrated in Figure 2.3 below. Institutions in particular show a strong preference for core grant-based funding as opposed to competitive funding, which can be less predictable.

Figure 2.3: % who think there should be any change in the national mix between competitive and call-based RI versus non-competitive or core-grant funded RI



Source: Indecon Survey

2.5 Summary of Findings

A summary of the findings of the findings of the section are as follows:

- Research infrastructure can be defined as equipment, facilities, infrastructure and personnel used for research. This can encompass physical research equipment, and facilities, such as laboratories or office spaces. It can include IT infrastructure, database access and technology to facilitate research. Research infrastructure can also include professional networks, such as networks of researchers and administrative supports.
- Significant funding has been provided for Research infrastructure in Ireland for a long period. As far back as 1998 the Irish Government launched the PRTLI. This was run on a competitive basis and open to publicly funded third-level institutions. The last cycle of PRTLI (Cycle 5) involved exchequer expenditure of approximately €277m with a further €59m of private investment.[19] PRTLI focused on increasing the amount of transdisciplinary and interdisciplinary basic research, and supported personnel, infrastructure, and recurrent costs in third-level institutions.
- More recently, Ireland's Programme for Government recognised the high-quality research emerging through a range of funding agencies. Apart from SFI these include the HEA, as well as Enterprise Ireland, IDA (Ireland), the Department of Agriculture and Food, and the Environmental Protection Agency (EPA). Other funders have included the Irish Research Council for the Humanities and Social Sciences (IRCHSS), the Irish Research Council for Science, Engineering and Technology (IRCSET), the Health Research Board (HRB), the Marine Institute, Teagasc, and COFORD. Funding has also been provided by the European Commission's Horizon 2020 and from philanthropic sources.

[19] https://www.oireachtas.ie/en/debates/question/2018-05-08/219/

3 International Comparator Analysis

3.1 Introduction

As part of our international review, we examined RI infrastructure policies in Italy, the UK (including Scotland and Wales) and the Netherlands. The importance of funding for Research Infrastructure is recognised internationally and many of comparator countries relevant to Ireland have developed mechanisms to support investment in this area.

In **Italy**, research and innovation had been a strategic objective for a number of decades. There is a multiannual framework, the National Programme for Research (NPR), which identifies strategies and priorities for Italy's research system. The NPR includes a specific plan (NPRI) to coordinate and prioritise investments in research infrastructures. Each source of financing follows the rules and criteria established by the authority responsible for its implementation. Sustainability of RIs is taken into account in the prioritisation process, but this does not guarantee that operation and maintenance costs will be covered in the long term. The Italian RI landscape does not have a specific body responsible for supervising interoperability coordinating access. In **the UK** 'Research Infrastructure' refers to large-scale capital facilities, as well as less specific large-scale facilities, networks, and digital infrastructure. While significant investment in research infrastructure has been provided, the lack of funding for the maintenance and use of existing infrastructure has been raised as a potential weakness of the UK system. It has therefore been suggested[20] that funding decisions should be made contingent on sufficient resources being in place to ensure efficient operation of any proposed infrastructures or facilities. For example, the UK has also placed significant emphasis on co-funding rates from industry and philanthropy sources. The UK Research Partnership Investment Fund,[21] which supports investment in higher education research facilities, requires double match funding from non-public sources.

In the **Netherlands** the Dutch Research Council (NWO) provides funding of almost €1 billion annually in research and infrastructure by selecting proposals based on advice from specialists and experts.[22,23] The NWO aims to encourage national and international collaboration and investment in large research facilities. The Competition for Research Infrastructure funds wider infrastructure projects in the Netherlands. The fund covers several types of infrastructure, from specialized devices (like large telescopes and cleanrooms) to 'virtual' facilities (like databases, scientific computer networks, and ICT support). In the Netherlands funding does not in general cover the total costs of maintenance and the NWO strategy 2019 – 2022 highlights a number of issues including looking beyond equipment and facilities.

3.2 Comparator Analysis: Italy

Research and innovation had become a strategic objective in Italy towards the end of the 1990s, at the time that the Lisbon strategy at European level in 2000 was to improve the EU's competitiveness through an increased investment in the knowledge-based economy. A similar shift in industrial strategy was also evident in Ireland at this time.

[20] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/478125/BIS-15-625-ensuring-a-successful-UK-research-endeavour.pdf

[21] Formore information: https://re.ukri.org/funding/our-funds-overview/uk-research-partnership-investment-fund/

[22] These experts are based both in the Netherlands and internationally.

[23] The exact figure for 2019 was €964 million. The breakdown of this figure is not available.

The importance of giving a higher priority to R&D investments in Italy was reflected in the adoption of new legislative acts, which developed a framework for research and innovation policies. The most significant of these was the reform of the National Research System in 1998, which introduced a programmatic coordination of research activities and initiatives. This included a multiannual framework programming tool, the so-called National Programme for Research (NPR). Since 2014, this Programme has spanned seven years to align with the multiannual programming of Cohesion Policy and ESIF Funds, as well as with the relevant EU Research Programmes (Horizon 2020 for 2014-2020, and Horizon Europe for 2021-2027).[24]

The NPR is the instrument that identifies strategies and priorities for Italy's research system. The key goal is to ensure the coordination of research with other national policies and to align the country with the pertinent strategic vision at the European level. A related goal is to promote progressive integration between public and private research. The policy was drawn up by the Italian Government through broad consultation with the scientific and academic community, various economic actors, and the relevant administrations. It is divided into sections addressing system priorities, major research and innovation areas, related areas of intervention, national plans, and missions. The latest NPR was approved on 15th December 2020 and refers to the 2021-2027 programming period. It is designed to contribute to the United Nations' Sustainable Development Goals (SDGs), the European Commission's priorities, the 2021-27 Cohesion Policy Objectives, and the Next Generation EU initiative. It articulates nine system priorities, and includes six major research and innovation areas, which in turn reflect the six clusters of Horizon Europe and the European Research and Innovation Framework Programme, 2021-27. It also considers the various National Smart Specialisation Strategy areas. These research and innovation areas are structured at a more refined, granular level (28 areas), and they are broken down in line with the specific features of the national context, as highlighted by the respective administrations' consultations and contributions.

Investments in research infrastructures are cited as an important pillar for the achievement of NPR objectives. Since 2014, the NPR has included a specific national plan, namely, the National Plan for Research Infrastructures (NPRI), to coordinate and prioritise investments in research infrastructures. The NPRI identifies priority RIs through a combination of bottom-up (e.g., consultation of national and regional stakeholders) and top-down elements (e.g., the definition of criteria based on European and national priorities, alignment with regional strategies, classification based on ESFRI domains and inclusion in the roadmap, etc.). It relies on five steps as illustrated in Figure 3.1.

Figure 3.1: Steps for prioritising RI in Italy

Source: SFI

[24] For more details on the NPR see https://www.istruzione.it/archivio/web/ricerca/pnr_precedenti.html

Different sources of financing contribute to ensuring the sustainability of the priority RIs included in the NPRI. In this regard, it is worth distinguishing between the previous programming period and its current counterpart. During the 2014-2020 programming period, the NPRI introduced a 'virtual common pot', the so-called FUIR, which was to be updated annually and managed by an ad-hoc Committee. It included resources from the following funds:

- National funds, such as the FOE - Ordinary fund for the financing of research bodies and institutes (managed by the relevant ministry), and the FFO - Ordinary Financing Fund (managed by the Universities)
- Regional funds
- ESIF Funds, earmarked to finance research infrastructures under the national and regional operational programmes

Currently, there are no common guidelines and there is no coordination body specifically responsible for supervising the allocation of resources to RIs. Each source of financing follows the rules and criteria established by the authority responsible for its implementation. The FOE (managed by the Ministry) is the main source of financing for the RIs. Resources from this fund are allocated annually to RIs, along with indications of expected resources for the following two years. Moreover, these resources are not strictly bound to financing a specific activity or purpose, although they are mostly employed to cover RIs' memberships and operating costs (including human capital).

Resources are not equally distributed to all priority RIs identified in the NPRI. Criteria for their allocation were established by the Legislative Decree No. 218/2016 and include the following: (i) prioritise those RIs for which the country has already undertaken a financial commitment (e.g. CERN); (ii) prioritise those RIs that have acquired (or applied for) ERIC status ; (iii) prioritise those RIs that are part of the ESFRI roadmap; and (iv) prioritise those RIs that - according to their plan of activities - are in need of financing (e.g., to cover the cost of human capital).

Despite being allocated annually, the FOE has provided financial support to RIs since 1998. A significant increase of resources has been made available since 2010, which reflects the increasing attention paid by the country to RIs, as well as Italy's international commitment to pan-European RIs and ERIC. Conversely, resources from other funds (e.g., from ESIF, regional or other national funds) are mostly allocated on a competitive and call basis. To provide an example, criteria for the allocation of resources from the National Operational Programme on Research and Innovation, 2014-2020, included: (i) RIs being entirely publicly owned; (ii) RIs being able to ensure their sustainability in the medium-long term; (iii) RIs promoting interventions in the eight regions covered by the Programme; and (vi) RIs being distributed or strategically connected to other RIs located in regions not covered by the Programme.

Despite funds being allocated to ensure the sustainability of priority RIs, some weaknesses have been detected in the latest approved NPRI, such as: (i) the lack of multi-year financing for the RIs (indeed, resources from FOE are approved on an annual basis, although some indications are provided for the following two years); and (ii) the lack of a common evaluation framework (to take into account, moreover, the wide range of impacts produced by RIs, and not merely scientific ones), designed to guide the allocation of available resources to RIs. Although the sustainability of RIs is taken into account in the prioritisation process, this is no guarantee that operation and maintenance costs will be covered in the long term. Indeed, the NPRI provides a 'picture' of the financial status of an RI at the moment of its drafting, but it does not include a dynamic mechanism capable of providing updated information on an RI's status.

Unlike Ireland, there are no national guidelines in place governing the access to RI of third parties such as researchers or industries. It is the responsibility of the host institutions to determine which items of the research infrastructure should or should not be accessible to external users, and under what conditions. Some RI requires the payment of an access fee by private users carrying out market-driven research to help cover operating costs. A practice which has evolved in recent years is resources from the so-called 'research projects of national interest' (annually financed by the relevant ministry on a call basis since 1996) to cover the costs of access to research infrastructures, or to provide financial resources to those RIs that make their facilities available for the purpose of research.

Different measures, embedded in the national strategic documents, contribute to the optimisation of RI-related impacts - in particular, with regard to technological transfer and knowledge spillovers. Among these measures, there is a specific line of intervention included in the current national recovery-and-resilience plan (NPRR, Mission 4, second component), which looks at basic, applied research and technology transfer. The line in question focuses on enhancing technology-transfer mechanisms, while also encouraging innovation through the systemic use of research results by the productive system (e.g., through partnership between public and private actors). In this context, investments are intended to strengthen research structures, create “national R&D networks” in certain key enabling technologies, and create “innovation ecosystems” around “local R&D systems”. Attention to technological and knowledge transfer is also provided for during the definition of priority RIs. Indeed, one of the criteria included in the process concerns the capacity of RIs to offer high-quality related services, which means the capacity to create relations with third parties (largely within industry) and foster knowledge transfer.

The interoperability of the research infrastructures in Italy is largely addressed via bottom-up initiatives. A relevant example is provided by the Italian Computing and Data Infrastructure (ICDI), which is a forum created by representatives of major Italian Research Infrastructures and e-Infrastructures, with the aim of promoting synergies at the national level and optimising Italian participation in responses to the European and global challenges in this field. Forums for such participation include the European Open Science Cloud (EOSC), the European Data Infrastructure (EDI), and High-Performance Computing (HPC). In the long term, the ambition of ICDI is to create a national coordinating body that is representative of the Italian infrastructures, and which interacts with national and European institutions on their behalf. In addition to ICDI, some attempts have been made, on an individual basis, by research infrastructures to ensure the interoperability of their facilities. For instance, the Nanoscience Foundries and Fine Analysis (NFFA) Trieste offers its users transnational open access to tools at two different research infrastructures. In future, the interoperability of RIs is expected to be fostered via approval from the National Plan for Open Science, currently under discussion, which is expected to be included in the NPR for 2021-2027. The aim of the plan is to stimulate the interoperability of data or digital services provided by the different RIs.

In terms of mechanisms adopted in Italy to ensure the oversight of RIs, a key role is played by the Italian Ministry of Universities and Research, which is in charge of drafting the NPR and NPRI, supported by other bodies. An example is the ERIC Coordination Technical Table, which is responsible for coordinating the participation of Italy in the increasing number of ERICs, while fostering the exchange of information and best practices. The Joint Research Unit (JRU) is a further example of measures taken to ensure coordination at the national level, in particular with regard to the human resources or tools employed in the framework of a scientific project. It is primarily utilised by RIs to set up national consortia. Nonetheless, the Italian RI landscape still lacks a specific body responsible for supervising interoperability for, and between, RIs, and for coordinating their access.

3.3 Comparator Analysis: Scotland

Capital investment in research in Scotland comes from both the Scottish Funding Council which provides several sources of capital funding[25] and funding for industry partnerships, and from Research England (via the UK Research Partnership Investment Fund). The Scottish Funding Council has invested heavily in innovation centres which allow for collaboration between businesses, research bodies, and universities, making scientific infrastructure more accessible. It committed £120 million for programmes supporting university infrastructure between 2013 and 2018.[26]

Scottish researchers rely on infrastructure both from inside and outside Scotland, e.g., Diamond Light Source in Oxfordshire; astronomical telescopes in Chile; and CERN in Switzerland. These facilities are funded at UK and international levels. Scottish universities are members of UK-wide (and often international) institutes that can be considered part of UK research infrastructure (e.g., the Alan Turing Institute in London).

Previously, the UK Government allocated funds for research infrastructure across the four nations of the UK through the Strategic Research Investment Fund. Money went directly to Funding Councils so that it could be ring-fenced for R&D investment without breaching the devolution legislation. Government involvement in research funding increased from 2007, after the banking crisis all but removed private investment in research funding. These maintained levels of funding and encouraged confidence from private investors.

There is no consensus on the use of the term 'Research Infrastructure' in Scotland or the UK. It is used to refer to large-scale capital facilities such as astronomical telescopes, as well as less specific large-scale facilities, laboratories, and buildings within which research is carried out. It is also used to refer to networks, such as networks of organisations that promote collaborations between researchers, and between research and business. Digital infrastructure is usually included in the definition. Importantly, the term sometimes also includes administrative supports for such facilities.

The Scottish Funding Council sees administrative costs as one of their biggest costs in terms of support. In contrast, the Royal Irish Academy does not count administrative costs as a source of costs for Scientific Infrastructure. For the UK more broadly, the Economic and Social Research Council states:[27]

> *"Research infrastructure refers to the facilities, resources and services that are used by the research and innovation community to conduct research and foster innovation in their fields."*

This includes major research equipment, resources like collections, archives, and data, and wider e-infrastructure such as data and computing systems and communication networks.

The lack of funding for the maintenance and use of existing infrastructure has been raised as a weakness of the UK system. This issue was summarised by Chair of the House of Lords Science and Technology Committee Lord Krebs, who said:[28]

[25] https://www.sfc.ac.uk/funding/capital-funding/capital-funding-guidance/capital-resources.aspx

[26] More information is available here https://www.sfc.ac.uk/innovation/innovation-centres/innovation-centres.aspx. A recommendation tied to the importance of such collaboration appears in the SFC's annual review, located here https://www.sfc.ac.uk/review/review.aspx

[27] More information is available here https://esrc.ukri.org/research/future-of-social-science-insights-opportunities-and-expectations/research-infrastructure/

[28]https://old.parliament.uk/business/committees/committees-a-z/lords-select/science-and-technology-committee/news/scientific-infra-report-published/

> *"The UK has an enviable reputation internationally for the range and quality of its large-scale scientific facilities. But …. we are concerned about the "batteries not included" syndrome – very expensive, large scale scientific equipment has been built, but there is not enough money to keep it running. This lack of provision for operational costs has seen facilities not being used to a maximum capacity, with severe research consequences."*

The risk is that existing RI may fall into disrepair in the time that it takes for new infrastructure to be built. This point was also articulated in the report "Ensuring a Successful UK Research Endeavour"[29] which argued that funding decisions should be made contingent on sufficient resources being in place to ensure efficient operation of any proposed infrastructures or facilities:

> *"Similarly, with the balance between infrastructure spending and resource spending for operations, there is no precise optimum but there are upper and lower boundaries. If infrastructure is allowed to decay too much, then the delivery of research and the effective utilisation of resource spending is damaged. …. Equipment needs to be refreshed and replaced regularly, and laboratory and science infrastructure facilities require renewal to remain effective."*

Importantly, there is no public data available on the landscape of scientific infrastructure in the UK or Scotland. Further, there is no estimate for the cost of maintaining collective infrastructure. In this way, although grants exist and are targeted towards universities and infrastructure projects, there are no figures available on the scale of infrastructure and the cost tied to its maintenance.

The UK has also been successful in increasing co-funding rates from industry and philanthropy sources. In 2012 the UK government launched the UK Research Partnership Investment Fund,[30] a competitive grant designed to support investment in higher education research facilities. A unique feature of the scheme is the double match funding that is required from non-public investors - for every £1 awarded through UKRPIF, universities must attract £2 from other sources, usually in the private sector. To date, UKRPIF projects have secured commitments of over £2 billion of co-investment from industry partners, charitable organisations, and philanthropic donors. This fund has funded several infrastructure projects in Scotland. However, the reliance on co-funding may result in the fund favouring infrastructure which attracts private sector investment and leave less attractive, or long-term infrastructure projects, at a disadvantage.

3.4 Comparator Analysis: The Netherlands

The Dutch Research Council (NWO) provides funding for researchers based in the Netherlands, investing almost €1 billion annually in research and infrastructure by selecting proposals based on advice from specialists and experts.[31,32] The NWO aims to encourage national and international collaboration, invests in large research facilities, promote knowledge utilisation, and manage research institutes. In this section we provide an overview of the Dutch Research Council's approach to funding, the number of grants awarded, and its approach to funding Research Infrastructure more

[29]https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/478125/BIS-15-625-ensuring-a-successful-UK-research-endeavour.pdf

[30] More information is available here https://re.ukri.org/funding/our-funds-overview/uk-research-partnership-investment-fund/

[31] These experts are based both in the Netherlands and internationally.

[32] The exact figure for 2019 was €964 million. The breakdown of this figure is not available.

specifically, with reference to its National Roadmap for Large-Scale Research Facilities. There are five ambitions to Dutch research laid out in the NWO's strategy 2019-2022.

- Nexus: Connecting agendas, science, and society. Since the NWO is a central and independent organisation, it connects researchers with government funding, and the output of that funding with wider society. This ambition is about expanding this role.
- People: Perspective for researchers. The council aims to empower researchers to work on their own topic and gives them independence in how they do this research. It launched a talent programme, a distinct funding stream specifically designed to attract top researchers who specialise in their field, and other more targeted programmes for established researchers looking for funding.
- Research: Collaboration for excellent innovation. Informed by the advice of council members and other experts, the NWO targets curiosity-driven research with long funding periods. There is also an emphasis on international collaboration and collaboration between disciplines to produce high quality research which is also relevant to society.
- Infrastructure: Accessible and sustainable scientific infrastructure. This definition does not apply only to 'hard equipment' and facilities, but also to promote a professional environment for researchers to work and meet. It also includes high grade ICT infrastructure, where data can be stored, accessed, and analysed.
- Knowledge utilisation: Effective use of knowledge through co-design and co-creation. The council hopes to fund research that has an impact not only for the scientific community but also for wider society. Further, knowledge sharing should also be encouraged between disciplines, with researchers from the humanities drawing on work developed in the natural sciences and vice versa.

In order to achieve the ambitions as set out above, the council has developed streams of funding and expanded existing streams. These are outlined below. The council allocates money for research and infrastructure through six competitive streams of funding. These are:

- A talent programme (for individual researchers)
- An open competition programme
- The Dutch Research Agenda (NWA) and the Knowledge and Innovation Covenant (KIC), intended for research into societal issues
- A Competition for temporary taskforces
- Competition for research infrastructure (outlined in the Roadmap Large-Scale Scientific Infrastructure) (discussed in greater detail below)
- Other research programmes

In total, it received over 7,000 competitive proposals in 2020. It awarded funding to 25% of all proposals received, although there are differences in this rate between streams. Application success rates range from 15% (open competition) to 90% (proposals tied to scientific infrastructure). As with Ireland, demand for RI far outstrips available funding. Most of this funding was spent on salary costs for scientific staff. Combining this funding with ongoing projects, granted in previous years, the council is funding 7,133 projects in total.

The Competition for Research Infrastructure (mentioned above) funds wider infrastructure projects in the Netherlands. The fund covers several types of infrastructure, from specialized devices (like large telescopes and cleanrooms) to 'virtual' facilities (like databases, scientific computer networks,

and ICT support). These can be monodisciplinary or multidisciplinary. This funding is not expected to cover the total costs of maintaining the country's research infrastructure.

Because of the way that funding is structured, infrastructures must lie in recognised facilities. A facility may hold one large device or several connected devices in a specialised building (a cleanroom, for example). In order to qualify for funding, facilities must be recognised as qualifying facilities. In all cases, a core group of technical experts and scientists must be associated with a given facility. Specific targets and aspirations for research infrastructure are laid out in the National Roadmap for Large-Scale Research Facilities. This roadmap explains the allocation of funds in more detail.

The first national roadmap was published in 2016. It was created by the Permanent Committee for Large-scale Scientific Infrastructure who were tasked with developing a national strategy for such investments. The committee's first task was to determine all existing large-scale research facilities in The Netherlands which fit the committee's criteria. This meant considering both physical equipment – such as telescopes, particle accelerators and biobanks – and less tangible facilities such as databases and ICT facilities. The committee then made an inventory of new investments that would be needed for existing and new facilities. This was implemented across the entire research landscape, including institutes and government organisations.

Regarding the inventory, the committee has a number of criteria for the distribution of resources. Facilities must meet the definition of large-scale infrastructure and the type of infrastructure it involves; have cohesion between the various facilities; be affiliated with strategic developments; provide participation and use; be of significance to science and society; and hold status/maturity of facility.

The committee identified 164 facilities from 54 institutions, which had a combined investment need of over €3 billion over five years. Of these, 113 facilities were recognised as being part of the infrastructure "landscape" as outlined above, but only 100 wanted to be recognised in the said roadmap[33]. In total, these 100 facilities had an investment need of roughly €2 billion according to the committee. At the same time, the National Roadmap's budget for this period was €200 million over five years, highlighting the gap between the total demand for infrastructure investment and the available funds for such investment. The committee noted that *"Many infrastructures that are highly important to science in the Netherlands may… never see the light of day."*

One way to address the gap between the demand and supply of funding noted above was to examine the use of existing research infrastructure. For example, the committee noted that many institutions were in the process of investing in new facilities while existing facilities had significant capacity. Further, they noticed that several institutions were ordering and building on similar infrastructures with wide capacity. This prompted increased collaborative work between institutions on infrastructure proposals and funding applications.

Despite this cooperation, there was still a need for investment in the maintenance and expansion of research infrastructure. In allocating funding, the committee built a framework and a set of conditions for calls for proposals tied to research infrastructure. In order to ensure that science, humanities, and other disciplines were included, the committee devised discipline-specific caps. Out of the total amount of approximately €200 million made available, €20 million was reserved for the humanities or social sciences, €90 million for science or technology, and €90 for the life sciences. This constituted a breakdown of 10%, 45% and 45% of the available resources, respectively.

[33] The other 13 declined to be influded in the roadmap.

A subsequent roadmap was published in 2021, where nine groups of experts made cases for prioritising investment in large-scale scientific infrastructure over the next ten years. As before, the Dutch government granted €40 million to the NWO to spend on large-scale research infrastructure. The newest roadmap (2021-2025) once again commits a total of €200 million to be invested over the period in two separate calls.

3.5 Summary of Findings

This section reviewed the systems in place to manage RI nationally in three comparator countries, namely Italy, the UK (including Scotland and Wales) and the Netherlands. The importance of funding for Research Infrastructure is recognised internationally and many comparator countries relevant to Ireland have developed mechanisms to support investment in this area.

- In Italy, research and innovation had been a strategic objective for a number of decades. There is a multiannual framework (NPR), which identifies strategies and priorities for Italy's research system. The NPR includes a specific plan (NPRI) to coordinate and prioritise investments in research infrastructures. Each source of financing follows the rules and criteria established by the authority responsible for its implementation. Sustainability of RIs is taken into account in the prioritisation process, but this does not guarantee that operation and maintenance costs will be covered in the long term. The Italian RI landscape does not have a specific body responsible for supervising interoperability or coordinating access.
- In the UK 'Research Infrastructure' refers to large-scale capital investment as well as other facilities, networks, and digital infrastructure. While significant investment in research infrastructure has been provided, the lack of funding for the maintenance and use of existing infrastructure has been raised as a potential weakness of the UK system. It has therefore been suggested that funding decisions should be made contingent on sufficient resources being in place to ensure efficient operation of any proposed infrastructures or facilities. The UK has also placed significant emphasis on co-funding rates from industry and philanthropy sources. For example, the UK Research Partnership Investment Fund, which supports investment in higher education research facilities, requires double-match funding from non-public sources.
- In the Netherlands the Dutch Research Council (NWO) provides funding of almost €1 billion annually in research and infrastructure by selecting proposals based on advice from specialists and experts. The NWO aims to encourage national and international collaboration and investment in large research facilities. The Competition for Research Infrastructure funds wider infrastructure projects in the Netherlands. The fund covers several types of infrastructure, from specialized devices (like large telescopes and cleanrooms) to 'virtual' facilities (like databases, scientific computer networks, and ICT support). In the Netherlands funding does not in general cover the total costs of maintenance and the NWO strategy 2019 – 2022 highlights a number of key issues including looking beyond equipment and facilities.

Section II: Retrospective Evaluation of SFI Research Infrastructure Programmes 2015-2021

4 SFI RI investment Programmes 2015-2021

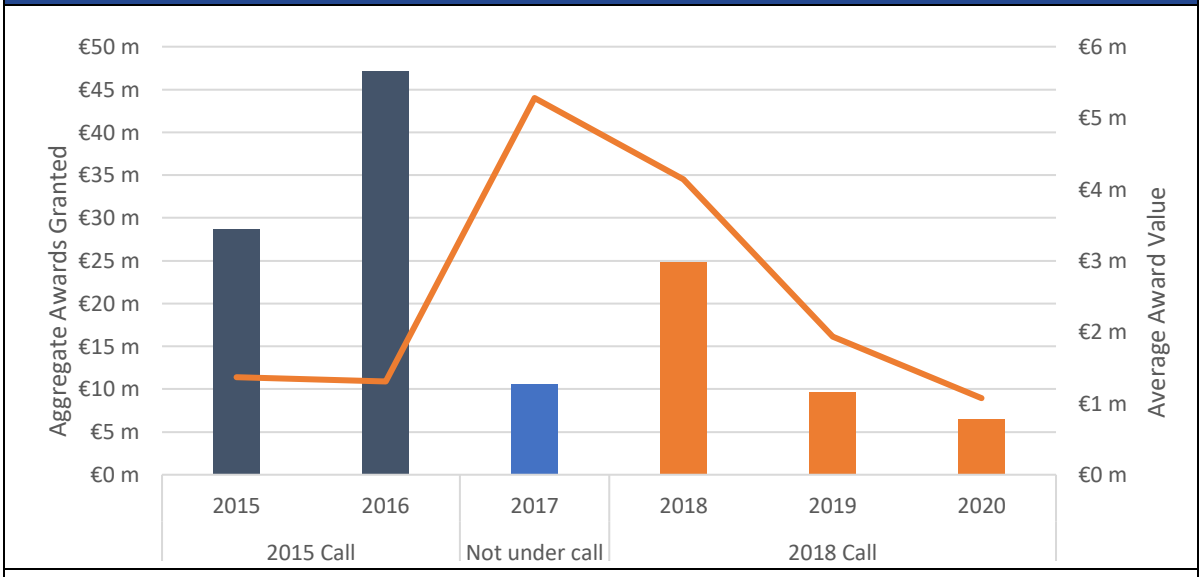
4.1 Introduction

The SFI Research Infrastructure Programme supports the research community in building and sustaining the infrastructural capacity required to accomplish high-quality, high-impact, and innovative research in areas of science, technology, engineering, and mathematics. The Programme identifies priority RI through a combination of bottom-up (e.g., through an open application process without pre-defined limits as to which areas will get specific areas of funding) and top-down elements (e.g., focused on national priority areas). In this chapter we set out the activities and outputs of these funding Programmes over this period.

4.2 RI Programme Calls 2015-2021

There were three calls over the period 2015-2021, namely in 2015, 2018 and 2021; due to the timing of this evaluation it was not possible to include the results of the 2021 call. The total final cumulative cost for the 2015 and 2018 calls, along with the average cost per project, is shown in Figure 4.1 below. It shows that the level of expenditure was highest in the 2015 call, though the average size per project was higher in subsequent calls, reflecting changes in the value limits as set out in the calls. Total grants awarded in this period was €127m, with an average award value of €1.7m. Two strategic awards were made in 2017 which were not under call. There was a reserve list kept open for two years following the 2018 call and a number of awards were made from this in 2019 and 2020. SFI running costs for RI since 2015 are approximately €264,000, which is equivalent to €38,000 per annum.[34]

Figure 4.1: Total Final Cumulative Cost and Average Cost per project, 2015 – 2020



Source: SFI

[34] Internal SFI estimate provided to Indecon.

2015 Call

The 2015 call was launched in mid-2015 and was structured in two phases, the first covering Categories A and B below, the second covering Categories C and D. Deadlines for some of the calls were in 2016:

- Category A: H2020 Research Infrastructure Integrating Activities – Advanced Communities aligned bids.
- Category B: Large Scale Research Infrastructures for SFI Research Centres.
- Category C: Large Scale Research Infrastructure for Research Bodies that focuses on applications for infrastructure requests in areas of national priority and other areas of strategic opportunity that are aligned with the strategic research objectives of eligible research bodies.
- Category D: Opportunistic Funding for bids representing smaller infrastructure needs that can be purchased through a value-for-money opportunity.

Individual items of infrastructure requested had to cost a minimum of €50,000; however, different conditions in relation to cost share for items of infrastructure costing above or below €200,000 were applied. Infrastructure costing from €50,000 to €200,000 required a minimum of 40% cost share. For investments in excess of €200,000, a minimum cost share of 10% from the research body was mandatory (cash or restricted in-kind). Applicants were guided that significant (~30%) cost share should be obtained from industry and could take the form of in-kind contributions. All infrastructure requests were to be required to align with one of the 14 National Research Priority (NRP report) areas, or any area under SFI's legal remit where strong evidence could be provided of significant industrial relevance and strong economic impact. Since SFI's 2015 call, maintenance or service contracts for up to 2 years from purchase date were eligible costs; following this time it is expected that the access charges (especially industry charges at market rate) would cover future maintenance of the infrastructure. A summary of the call objectives is set out in Figure 4.2.

Figure 4.2: SFI Research Infrastructure Call 2015[35]- Summary of Objectives
Objectives ❑ Build, enhance and maintain national capacity by supporting acquisition of infrastructure. ❑ Enhance activities and outputs of SFI researchers and other research groups. ❑ Facilitate a more rapid commercialisation of research. ❑ Encourage strategic infrastructural planning by research bodies. ❑ Foster collaboration and partnership between researchers (including Northern Ireland). ❑ Encourage partnership with industry. ❑ Encourage good negotiation with equipment vendors resulting in cost-effectiveness. ❑ Promote future sustainability through the development of access charge plans. ❑ Enable Irish researchers to compete for Horizon 2020 research funding calls. ❑ Encouraging bids that fund large infrastructures including testbeds. Other Important aspects referenced: ❑ Partnership ❑ Industry links ❑ Access charge plans ❑ International links
Source: Indecon summary of SFI Research Infrastructure Programme 2015 Call for Submission of Proposals

Call II: 2018

Applications for the 2018 call were to be made by mid-2018. They were accepted for the following two categories of infrastructure request:

- Category A: H2020 Research Infrastructure Integrating Activities – Advanced Communities aligned bids
- Category B: Strategic Research Infrastructures that focus on applications for large-scale infrastructure requests in areas of national priority and other areas of strategic opportunity

This differs from the 2015 call, excluding the distinct categories covering large scale RIs for SFI Research Centres, and for opportunistic bids representing smaller infrastructure needs that can be purchased through a value-for-money opportunity. Other major differences from the 2015 call were that individual items of infrastructure requested had to cost a minimum of €500,000 in direct costs, and lower-cost infrastructures were not supported under this Programme. As before, a cost share was made mandatory for all infrastructure requests. Applicants were asked to select which one of the 14 NRP areas their application related to. A summary of the objectives of this call are set out in Figure 4.3.

[35] SFI Research Infrastructure Call 2015, Call for Submission of Proposals.

Figure 4.3: SFI Research Infrastructure Call 2018[36]- Summary of Objectives

Objectives

- Give Irish researchers access to cutting-edge research infrastructure that will enhance high quality research activities and innovation in areas of strategic priority
- Facilitate inter-institutional sharing of national research infrastructure, especially with IOTs
- Support the strategic development and growth of the SFI Research Centres
- Encourage effective research partnership with industry through collaborative initiatives involving provision of industry access to infrastructure, with particular focus on growing multi-national companies and/or small and medium-sized enterprise partnerships
- To provide outstanding research infrastructure that will enable Irish researchers to compete for Horizon 2020 research funding calls
- Make Ireland an attractive location for recruitment of world-leading scientists and engineers
- Support national and European Open Science policies and principles and ensure access to an effective digital research infrastructure ecosystem
- Optimise utilisation and promote future sustainability of research infrastructures through the development of management and access charge plans

Other Important aspects referenced:

- Partnership
- Industry links
- International links
- Recruitment
- Open Science Infrastructure
- Access charge plans

Source: Indecon summary of SFI Research Infrastructure Programme 2018 Call for Submission of Proposals

Call III: 2021

The third call was launched in May 2021, with applications to be received in July. One of the main objectives of the 2021 call was to promote collaboration, used as a tiebreaker for ranking of the awards. Broad usage and access across Ireland was a scoring criteria, and was also used as a tiebreaker for ranking of the awards. As with the 2018 call, the 2021 call had to have a minimum budget request from SFI of €500,000 in direct costs. An additional 10% cash cost share was mandatory, therefore the total infrastructure cost had to be at least €550,000. There was no maximum budget request. Multiple items of equipment could be grouped together to reach the €500,000 cost threshold, if they were to contribute to a single, shared infrastructure request (e.g., a testbed or distributed cluster). The 2021 Programme included a co-funding partnership with the Sustainable Energy Authority of Ireland (SEAI). A summary of the objectives of this call are set out in Figure 4.4.

[36] SFI Research Infrastructure Call 2015, Call for Submission of Proposals.

Figure 4.4: SFI Research Infrastructure Call 2021[37]- Summary of Objectives

Objectives

- Give Ireland's researchers access to cutting-edge research infrastructure that will enhance high-quality research activities and innovation in areas of strategic priority
- Make Ireland an attractive location for the recruitment of world-leading scientists and engineers
- Provide outstanding research infrastructure that will enable Ireland's researchers to compete in future Horizon Europe research funding calls
- Facilitate broad usage across Ireland and to encourage partnerships and collaboration between different cohorts of researchers in Ireland, for example, between Universities, Technological Universities, Institutes of Technology, other Eligible Research Bodies, researchers in the Republic of Ireland and Northern Ireland, and between different cohorts of researchers in Ireland
- Encourage research partnership with industry through collaborative initiatives that involve industry access to infrastructure.
- Support the strategic development and growth of the SFI Research Centres
- Support national and European Open Science policies and principles and ensure access to an effective digital research infrastructure ecosystem
- Optimise utilisation and promote future sustainability of research infrastructures through the development of management and access charge plans

Other Important aspects referenced:

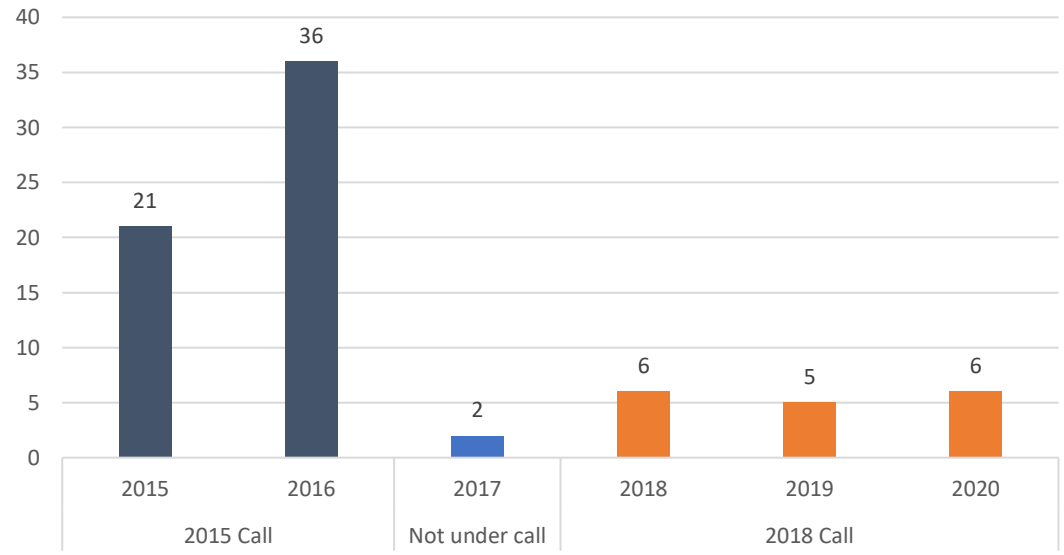
- ❑ Partnership (applications from Institute of Technologies or Technological Universities 'strongly encouraged')
- ❑ Industry participation
- ❑ International programmes
- ❑ Driving recruitment
- ❑ Open Science Infrastructure
- ❑ Access charge plans

Source: Indecon summary of SFI Research Infrastructure Programme 2021 Call for Submission of Proposals

The number of awards each year during the 2015-21 period is shown in Figure 4.5. As can be seen, there were 57 awards as a result of 2015 call, with 17 during the 2018 call (which included awards made in 2019 and 2020). This is linked to the change in the Programme criteria in the 2018 and 2021 calls, which required a minimum grant contribution of €500,000, while the 2015 call had a lower minimum of €50,000.

[37] SFI Research Infrastructure Call 2015, Call for Submission of Proposals.

Figure 4.5: Number of RI Awardees, 2015-2020

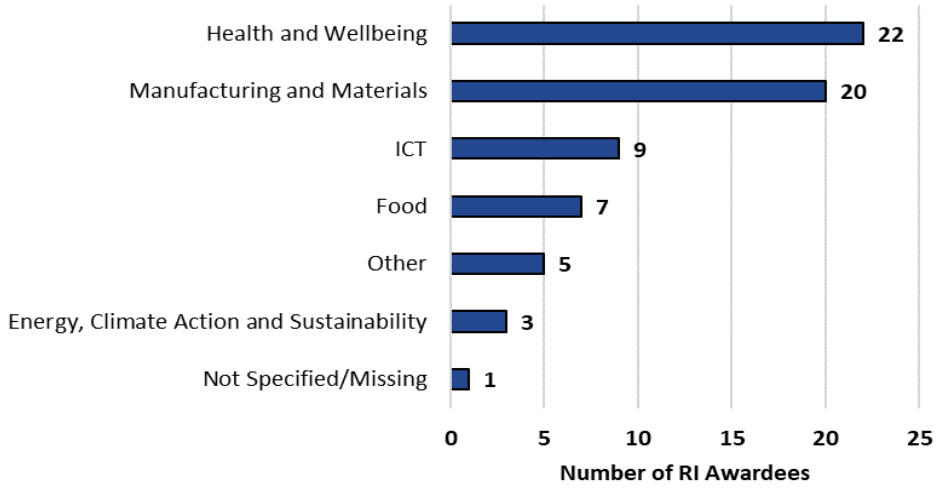


Source: Indecon

4.3 Awards by subject domain

Awards issued during the 2015-2020 period can also be broken down by subject domain. This is illustrated in Figure 4.6. Approximately one-third of projects are in 'Health and Wellbeing' and 'Manufacturing and Material', while the remaining one-third is accounted for by the other subject domains.

Figure 4.6: RI Awards by Subject Domain, 2015-2020



Source: Indecon

4.4 Awards by Institution

The activity of the three programme calls can also be examined in terms of institution of awardees, as shown in the table below**Error! Reference source not found.**. This shows that while Trinity College, University of Limerick, NUIG UCD, UCC and Tyndall were significant beneficiaries, a wide range of other institutions were also supported. The table also shows the extent of matched funding, whether in the form of cash or in-kind contributions. The average reported cash contribution represented 11% of project cost, while the average in-kind contribution represented 9% of project cost. In-kind contributions can take the form of the salary costs of dedicated personnel to operate infrastructure; supplier discounts; maintenance/service contracts; technical support; cost of materials and consumables essential to the operation of the equipment; software; training for key personnel required to operate instruments; installation costs; and the cost of industry scientists, engineers or technicians assigned to work on instrument development or to provide ongoing technical support.

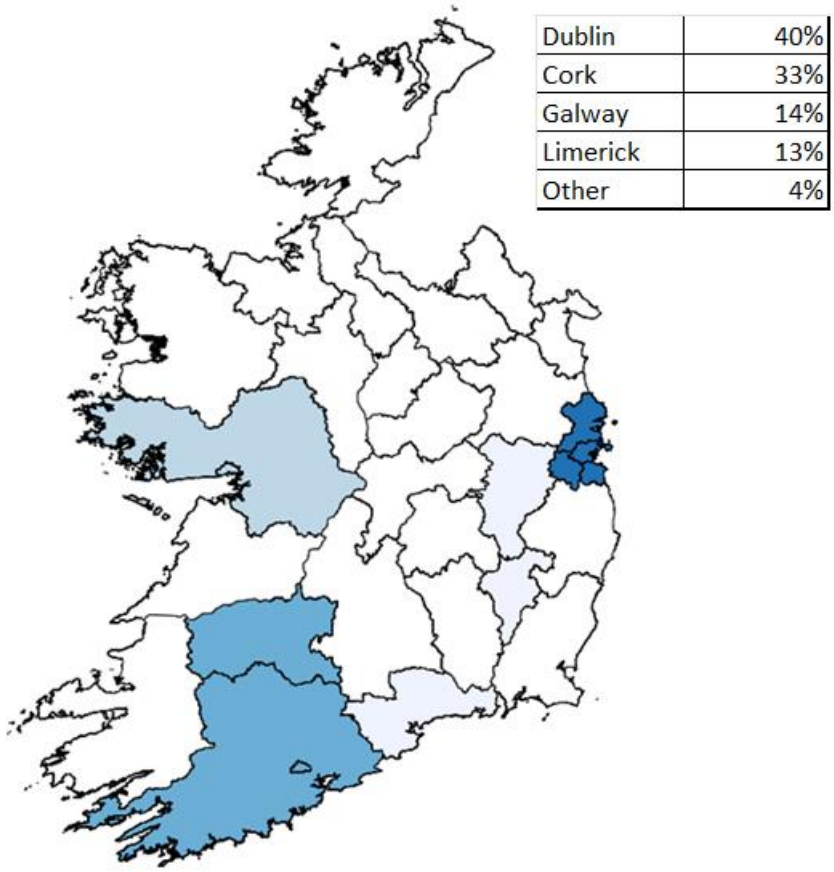
Table 4.1: Total RI Investments by Research Body (RB),2015-2020

Research Body	Number of RI Projects Awarded	Total Amount Awarded	% Cash contribution from RB	% in-kind contribution from RB
Trinity College Dublin	13	€22 m	7.5%	11.3%
University of Limerick	10	€16 m	11.3%	3.3%
University College Dublin	10	€11 m	14.2%	19.5%
NUIG	7	€16 m	22.8%	7.8%
University College Cork	7	€14 m	5.2%	9.5%
Dublin City University	6	€5 m	10.2%	4.7%
Tyndall National Institute	5	€26 m	25.5%	4.0%
Royal College of Surgeons	5	€7 m	5.5%	8.7%
Maynooth University	5	€4 m	10.4%	8.9%
Teagasc	4	€2 m	44.9%	11.7%
Waterford Institute of Tech.	2	€1 m	0.0%	8.8%
DIAS	1	€3 m	0.0%	13.4%
Marine Institute	1	€2 m	-	-
Total	**76**	**€127.5m**	***11.1%***	***8.9%***

Source: Indecon analysis of SFI Data. *Note that a number of awards were under the 2015 call "Category D - Opportunistic Funding" which did not require cost share. Figures for cash contribution and in-kind contribution are based on actual draw-downs, and therefore do not include all projects.*

Awards can also be aggregated across research bodies to give an indication of the geographic distribution of research funding. As can be seen, significant share of funding is won by Dublin-based institutions, followed by 33% in Cork, 14% in Galway and 13% in Limerick. Four other counties account for the remainder of the funding, though other regions will also have benefited through access by researchers and industry from outside these institutions.

Figure 4.7:Geographic Distribution of RI Awards, 2015-2020



Source: SFI.

4.5 Summary of Findings

This section set out the activities and outputs of these funding programmes over this period. A summary of the findings of this section are set out below.

- The SFI Research Infrastructure Programme supports the research community in building and sustaining the infrastructural capacity required to accomplish high-quality, high-impact, and innovative research in areas of science, technology, engineering, and mathematics. The Programme identifies priority RIs through a combination of bottom-up (e.g., through an open application process) and top-down elements (e.g., focused on national priority areas).
- There were three calls over the period 2015-2021, though the main expenditure was allocated through the 2015 call. There was a total of 76 RI awardees over the period 2015-2020. The latest SFI call was launched in May 2021 and had a minimum budget requirement of €500,000 in direct costs. An additional 10% cash cost share was mandatory.
- In reviewing the SFI Research Infrastructure Programme it should be noted that funding of the Programme represents only a small element of total Irish Government R&D Spending.

- Almost half of investments were made in Dublin reflecting the location of Trinity College, UCD, DCU and other national institutions. However, the evidence also shows that institutions in other regions and counties also benefitted including Cork, Galway Limerick and Waterford.

5 SFI RI Programme Performance & Effectiveness

5.1 Introduction

In this chapter, we discuss the performance and effectiveness of the Science Foundation Ireland RI Programme over the period 2015-2021. While the Programme's output and impact cover a period during which there were three calls, these outputs and impacts will relate largely to the calls run in 2015 and 2018.

5.2 Overall Effectiveness

Indecon's survey of institutions suggested that many viewed the SFI RI Programme as being effective or very effective, but 28% of SFI Research Centres and 22% TUs/IOTs suggested that the Programme was not effective. This is likely to reflect the fact that the Programme was viewed as being effective in meeting certain key objectives but did not address areas such as the renewal of existing infrastructure.

Table 5.1: Views on Effectiveness of SFI RI Programme by Institution Type/Research Body

	Very Effective	Effective	Neither Effective nor Ineffective	Ineffective	Very Ineffective	No response
Universities	0%	14%	71%	0%	0%	15%
SFI Research Centres	14%	29%	14%	14%	14%	15%
IOTs	11%	44%	11%	22%	0%	12%

Source: Indecon

A selection of comments made by institutions as to the effectiveness of the SFI Research Infrastructure Programme are summarised in Table 5.1 overleaf. These highlight the impact of the Programme but recognise that performance indicators do not fully capture all aspects. The views also highlight the issue of lack of funding to renew existing infrastructure or to fund maintenance costs.

Table 5.2: Institutions views on Impact and Effectiveness
"The impact and effectiveness of SFI Research Infrastructure is not fully captured under current metrics. Research communities and networks are forming as a result of SFI investment and infrastructure that is not fully captured under current reporting mechanisms."
"The SFI RI Programme has been largely effective in meeting its primary aim, which is to support significant new items of infrastructure aligned with the SFI research protocol."
"Infrastructure needs to be determined at a national level than at a local level. Most of the time the proposal is around- what we don't have in the University than what is needed in the system."
"Infrastructure was highly used and supported over 50 publications despite only being operationalised from 2016 and through little use during COVID."
"Too small in scale… No depreciation costs… No maintenance costs available."
"The SFI Infrastructure program has been very good at funding specific pieces of high-end infrastructure… have been really enabling for PI in achieving high impact publications and in securing National, International and Industry funding. Where the approach fails is that of funding to support the ongoing maintenance and specialist technical staff for keeping this infrastructure running is not covered under any funding scheme."
"The SFI Research Infrastructure Programme has been more effective for large equipment items whereas Smaller equipment/infrastructure has not been really catered for in this Programme."
Source: Indecon Survey. *Question: "Please provide any views you might have on the impact and effectiveness of the SFI Research Infrastructure Programme from 2015-2021."*

Researchers who use the Programme reported a range of views, including the impact of the Programme. They also highlight issues such as the need to replace equipment and infrastructure, as summarised in the next table.

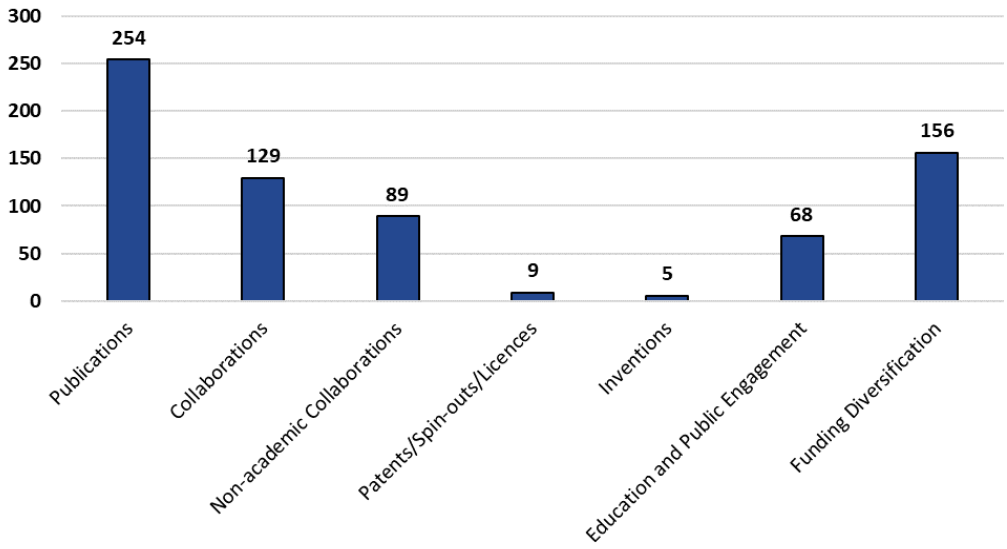
Table 5.3: Researcher views on Impact and Effectiveness
"The SFI RI Programme has been of fundamental[…] in growing national and international partnerships. Infrastructure supported has directly enabled successful European funding applications and industry collaboration."
"The impact has been welcome and positive when set against the outcomes had SFI not made these investments."
"Funding options are needed to replace ageing infrastructure."
Source: Indecon

5.3 Programme Outputs and Impacts

There is strong evidence of a range of outputs which were supported by funding for RI provided through the SFI Programme, including publications made and education/public engagement. Also of

note is the number of academic and non-academic collaborations. There is also some evidence of patents / spin outs / licences but we note that such impacts are likely to only take place after a lag. Key measures of outputs related to 2015 and 2018 calls are shown in Figure 5.1.

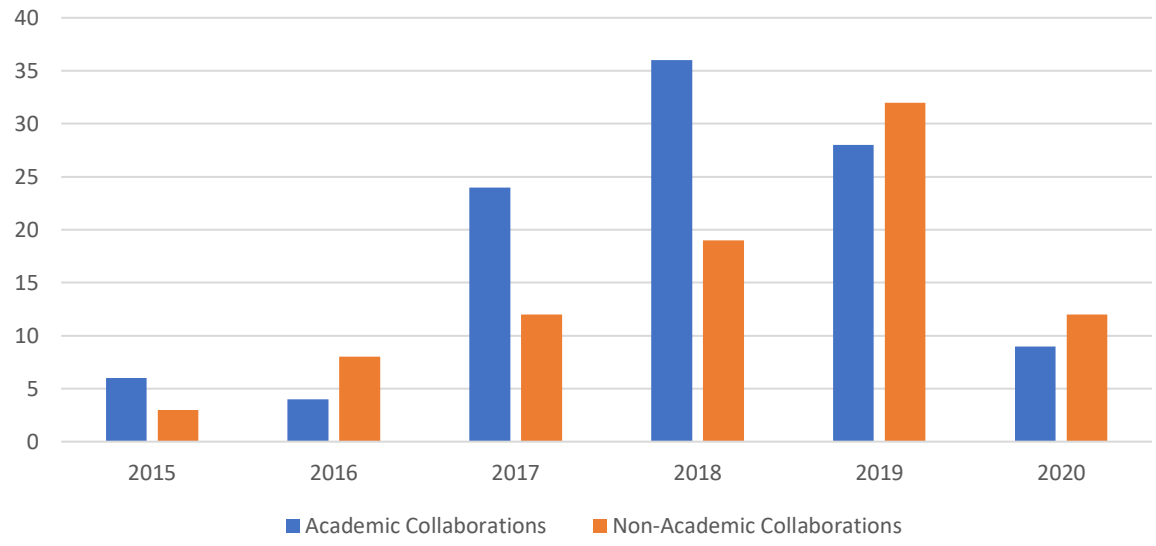
Figure 5.1: Key Performance Indicators, 2015-2021



Source: Data based on SFI RI Survey 2021

The number of academic collaborations peaked in 2018 and 2019. It is possible that collaborations peaked in 2018/2019 as a larger number infrastructure funded under the 2015 call became operational. There is some evidence of a fall in the number of collaborations in 2020, though this may have been affected by the public health restrictions introduced early in that year with the emergence of the COVID-19 pandemic or a range of other reasons. There was also a number of pre-existing collaborations which made use of RI, collaborations which were initiated prior to the award of funding.

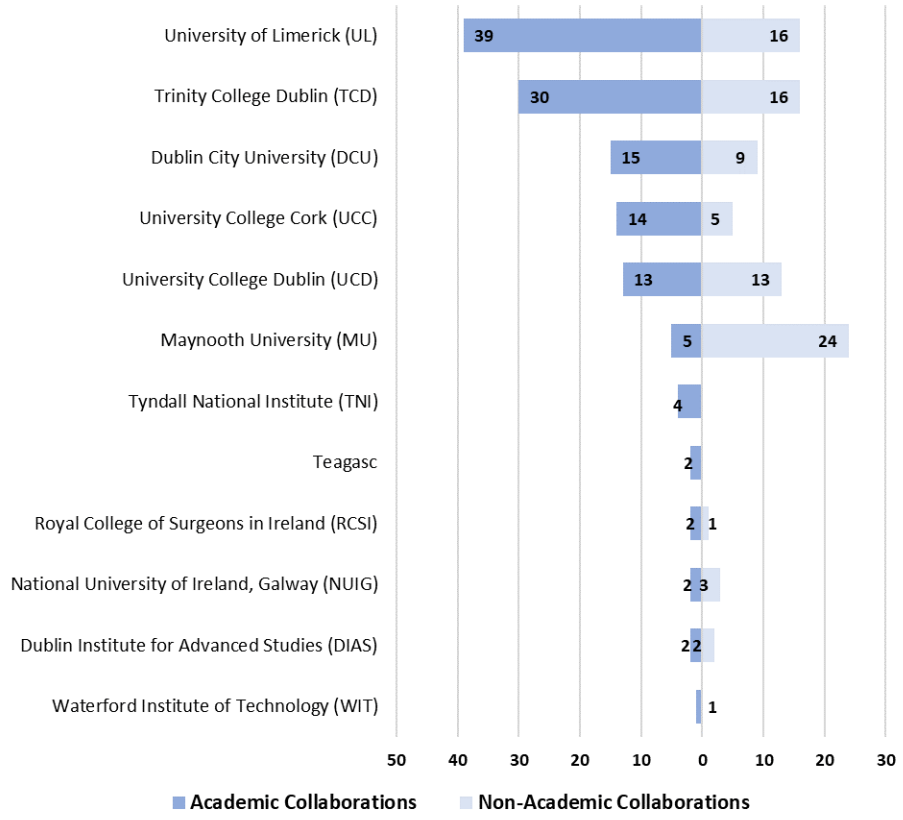
Figure 5.2: Number of Academic and Non-academic Collaborations, 2015-2021



Source: Data based on SFI RI Survey 2021

Collaborations supported by the SFI RI Programme were both academic and non-academic in nature. The type of collaboration broken down by institution is shown in Figure 5.3.

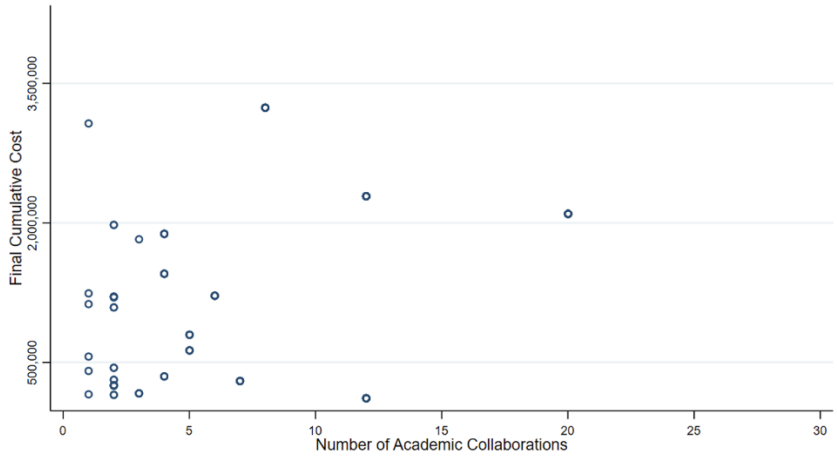
Figure 5.3: Number of Academic & Non-academic Collaborations by Research Body, 2015-2021



Source: Data based on SFI RI Survey 2021, relates to 2015 and 2018 calls.

There appears to be a positive relationship between the level of RI investment and the number of academic collaborations per project. This is illustrated in Figure 5.4. Each of the markers in the diagram represent a separate investment in RI made with the support of the SFI Programme.

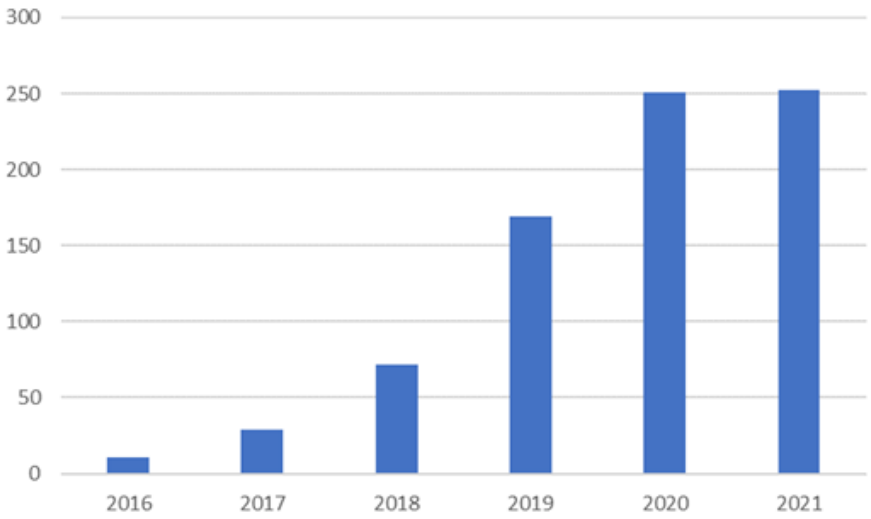
Figure 5.4: Number of Academic Collaborations by RI Final Project Cost, 2015 - 2021



Source: Data based on SFI RI Survey 2021

Data shows the cumulative number of publications associated with RI reached 250 over the period 2015 - 2020. This is illustrated in Figure 5.5.

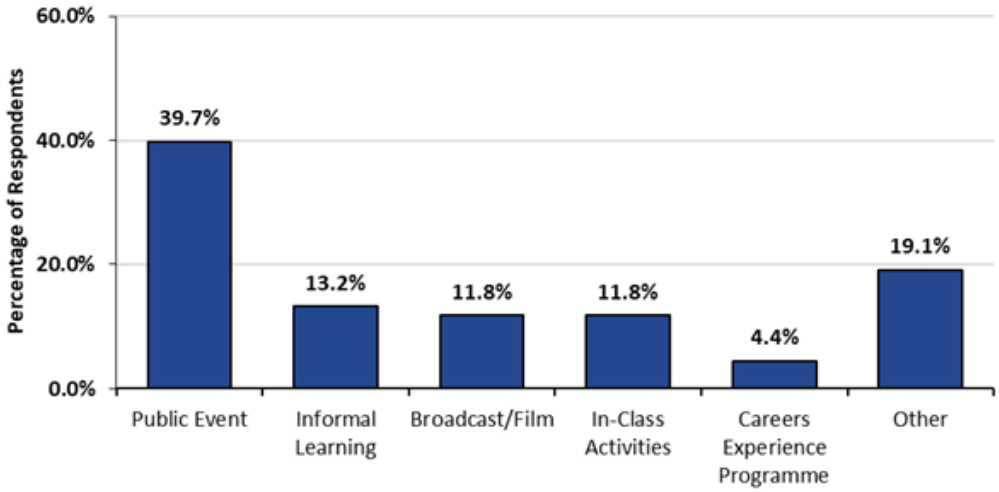
Figure 5.5: Cumulative Number of publications, 2015-2021



Source: Data based on SFI RI Survey 2021

There is also a range of public engagement linked with research supported by the SFI RI Programme. The most common type of education and public engagement are public events (39.7%), followed by informal learning (13.2%). The most frequent forms of public engagement are shown in Figure 5.6.

Figure 5.6: % of Education and Public Engagement Activity by Type, 2015-2021



Source: Data based on SFI RI Survey 2021

5.4 Funding Diversification

The total funding reported from survey respondents amounted to €307m from 2015 – 2021, of which over one-third is from EU Horizon 2020. This figure excludes other sources of funding from the Irish Government. The details are shown in the table below and highlights the extent of funding leverage particularly in accessing EU funding.

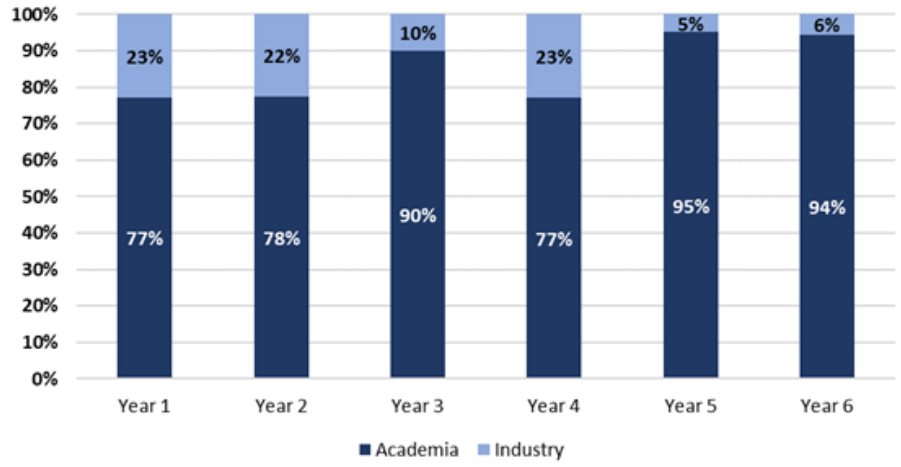
Table 5.4: Amount of Leveraged National/International Funding by Funding Stream, 2015 – 2021		
Funding Stream	**Total Amount of Funding**	**% Of Total Funding**
European Union - Horizon 2020	€143m	46.6%
Enterprise Ireland - Non-Commercialisation Award	€89m	28.9%
European Union - Other	€26m	8.6%
European Union - Framework Programme	€24m	7.8%
Private Enterprise	€12m	3.8%
Other	€13m	4.2%
Total	**€307m**	**100%**
Source: Data based on SFI RI Survey 2021		

5.5 Access to researchers and industry

One of the important goals as set out in the SFI RI calls was to foster collaboration and partnership between researchers, while also encouraging partnership with industry. The more general issue of the access to researchers and industry to all relevant national Research Infrastructure is discussed in Section 6, including issues relating to 'discovery' of the existence of, and access conditions associated with, relevant RI, including relating to the LIRE database. This section focuses on measures of the extent to which the RI Programme was associated with increased 'sharing' of resources, whether through formal collaboration or otherwise.

The evidence shows that income from both academic and industry has been generated in each year of the Programme period. This is illustrated in Figure 5.7. The periods relate to the number of years the infrastructure has been in operation, and not to a particular calendar year. It shows that industry engagement appears stronger in the early life of the RI in question (accounting for nearly one quarter of income generated in Years 1 and 2), though this falls as the RI gets older.

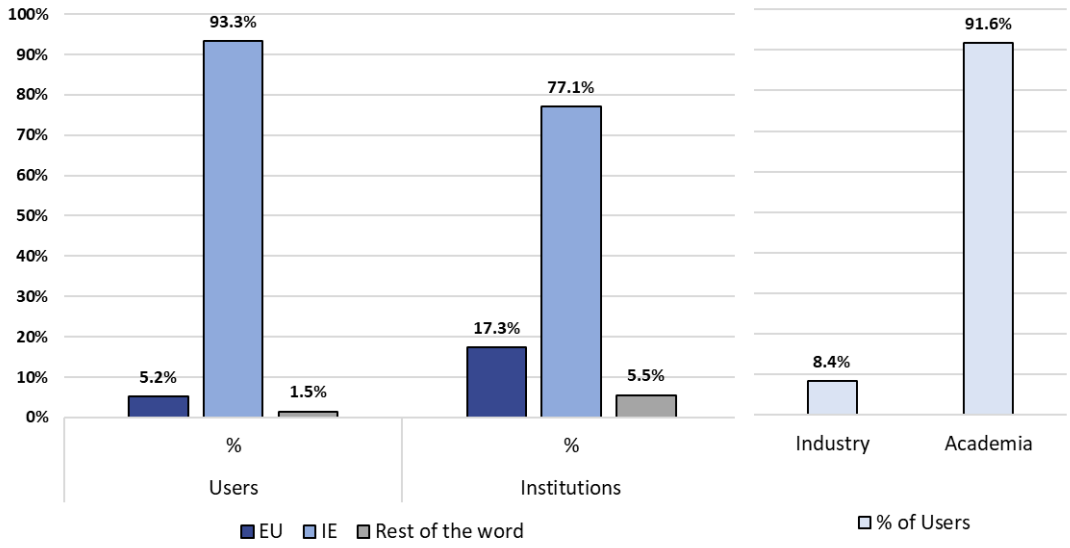
Figure 5.7: % of Income Generated by RI User Type and Year in Operation, 2015-2021



Source: Data based on SFI RI Survey 2021

Most users of RI were based in Ireland, whether measured by the location of users themselves, or the institutions they were connected to. This is illustrated in Figure 5.8. Most overseas use was by EU-based users/institutions.

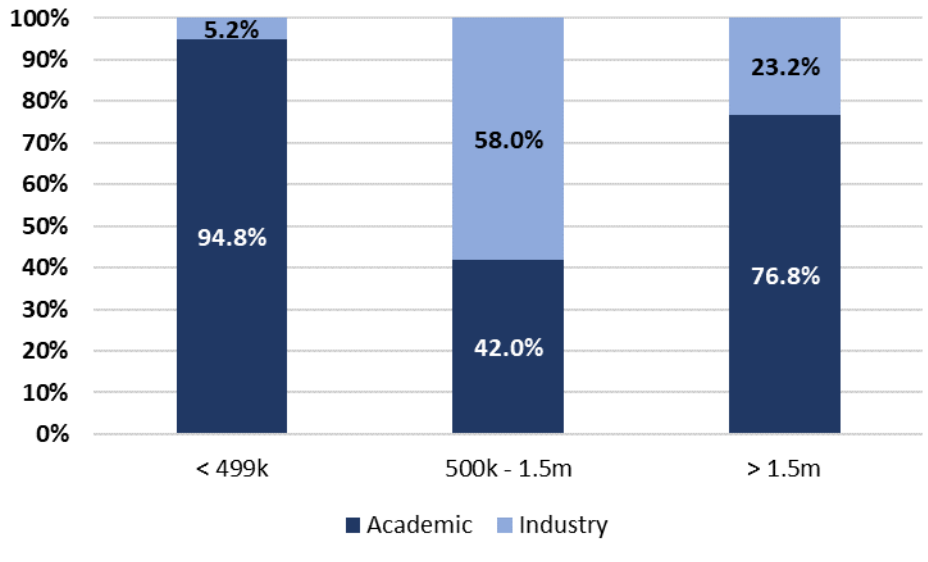
Figure 5.8: % of Users of RI by User Type, 2015-2021



Source: Data based on SFI RI Survey 2021

Larger projects (value >€0.5m) tends to attract a greater proportion of income from industry, as shown in Figure 5.9.

Figure 5.9: Share of Academic and Industry Income generated by Project Size, 20–5 - 2021



Source: Data based on SFI RI Survey 2021

An issue in reviewing Programme performance and effectiveness is the extent to which infrastructure is utilised. The figures in Table 5.5 show utilisation rates above 50% across all project sizes with rates of utilisation higher on larger projects. An issue for future programmes is whether a national approach to ownership and utilisation rather than an institutional approach would enhance levels of utilisation. This would involve the taking of steps to ensure that researchers from other national research intuitions have information on, and appropriate access to, RI. Rates of utilisation may also be enhanced by the provision of funding for maintenance and by the development of appropriate access plans. It may also be worth considering setting targets for utilisation levels either at national, institution or individual project level, the meeting of which could be made a requirement for the drawdown of further funding.

Table 5.5: What proportion of the total available time is the infrastructure in use

Project Size	Time Used
<€499k	54%
€500k-€1.5m	58%
>€1.5m	60%

Source: 2021 SFI Survey of RI Researchers

The calls for the SFI RI Programme highlight that the development of suitable and auditable access charge plans was an important element of applications. However, less than one in two SFI-funded RI projects surveyed actually have SFI-approved access charge plans in place, though they may have other access charge plans. The percentage of RI Projects with access charge plans by research body is shown in Table 5.6. Indecon note that Access Charge plans are mandatory, though may not have been published online, and therefore respondent institutions may have answered "no" to the existence of such plans even where they are in place. SFI are currently working towards ensuring that all plans are published online and publicly available.

Table 5.6: % of RI Projects with SFI-approved Access Charge Plans by Research Body

Research Body	% Of Access Charge Plans
Trinity College Dublin	42.9%
NUIG	61.5%
University College Cork	7.7%
University of Limerick	46.2%
Maynooth University	40.0%
University College Dublin	62.5%
Dublin City University	66.7%
Royal College of Surgeons in Ireland	50.0%
Tyndall National Institute	75.0%
Teagasc	50.0%
Waterford Institute of Technology	0.0%
Dublin Institute for Advanced Studies	100.0%
Marine Institute	0.0%
Total	**44.9%**

Source: Data based on SFI RI Survey 2021

Larger projects were more likely to state they have access charge plans in place compared to smaller projects. This is illustrated in Table 5.7, which shows the percentage projects which have received RI funding from the SFI which have SFI-approved access charge plans. It shows that less than one in three of smaller projects[38] had an access charge plan in place, though around three in four of larger projects did. However, a significant minority (31.3%) of very large projects (defined as >€1.5m) stated that they did not have an access charge plan in place, which may have limited access by other users and potentially reduced the extent of use of the RI in question. It may be the case that giving access to other researchers for some technologies is not feasible, or it might only be possible to give such access under very specific circumstances.

[38] As measured as projects with a value of less than €0.5m.

Table 5.7: % of RI projects with SFI-approved Access Charge Plans in place by Project Size, 2015 - 2020		
Project Size	**Access Charge Plans in place**	**No Access Charge Plan**
<€499k	*31.9%*	*68.1%*
€500k-€1.5m	*81.8%*	*18.2%*
>€1.5m	*68.8%*	*31.3%*
Source: 2021 SFI Survey of RI Researchers		

Stakeholders consulted by Indecon as part of this study were supportive of the role that access charge plans can have, as shown in Figure 5.10. Additional comments from institutions and individual researchers commented on specific aspects of existing arrangements, including for example the need to ensure that the pricing model chosen is appropriate.

Figure 5.10: Selected comments from national stakeholders on access charge plans
IUA: *An access plan should be in place to explain how it will be available to more than the hosting institute. This should include a plan for (and permission to cost) technical/support staff.*
Knowledge Transfer Ireland: *Access terms for users – and in particular companies, that are simple and transparent including how to access, T&Cs, contracting, pricing*.
Technological Higher Education Association: *Access to RI at other HEIs is generally dependent on having a relationship with the researcher or research team responsible for the RI. 'Access for all', with an access charging model where appropriate, should be the ultimate goal.*
Enterprise Ireland: *National need…… for accessing research infrastructure including the facilitation of use by enterprise, and partnerships in, research infrastructure for national and international researchers.*
Source: Indecon Consultation

5.6 Summary of Findings

In this section, we assessed the performance and effectiveness of the Science Foundation Ireland RI Programme over the period 2015-2021. Some of the key findings of this section are as follows:

- There is strong evidence of a range of outputs which were supported by funding for RI provided through the SFI Programme, including publications made and education/public engagement. Also of note is the number of academic and non-academic collaborations. There is also some evidence of patents / spin outs / licences but we note that such impacts are likely to only take place after a lag.

- Indecon's survey of institutions suggested that many viewed the SFI RI Programme as being effective or very effective, but 28% of SFI Research Centres and 22% TUs/IOTs suggested that the Programme was not effective. This is likely to reflect the fact that the Programme was viewed as being effective in meeting certain key objectives but did not address areas such as the renewal of existing infrastructure.
- In reviewing the efficiencies of the Programme and the performance indicators it is useful to consider the individual views of institutions on its effectiveness. These highlight the impact of the Programme but recognise that performance indicators do not fully capture all aspects. The views also highlight the issue of lack of funding to renew existing infrastructure or to fund maintenance costs.
- One of the important goals as set out in the SFI RI calls was to foster collaboration and partnership between researchers, while also encouraging partnership with industry. The evidence shows that income from both academic and industry users has been generated in each year of the Programme period. Larger projects (value >€0.5m) tend to attract a greater proportion of income from industry.
- An issue for future programmes is whether a national approach to ownership and utilisation rather than an institutional approach would enhance levels of utilisation. Rates of utilisation may also be enhanced by the provision of funding for maintenance and by the development of appropriate access plans. It may also be worth considering setting targets for utilisation levels.

Section III: Prospective Analysis of National Needs for Research Infrastructure

6 National Needs Assessment

6.1 Introduction

In this section we discuss the prioritisation of needs for investment in RI. It should be noted that the SFI's Research Infrastructure Programme represents only 10% of its total programmatic expenditure,[39] and only around 2-3% of total governmental R&D spending annually. As such, investment in RI is only one element of the broader investment in research capability in Ireland, and any determination as to the 'need' for RI will be driven in the first instance by broader national research and innovation policy and prioritisation. For example, the establishment of a new SFI research centre in a particular field is likely to increase demand for RI relevant to that field of study.

There is considerable uncertainty as to Ireland's capacity to fund RI and research in the future, which will likely be constrained by the availability of public resources. The Irish and global economies are currently emerging from the impact of the global pandemic, which had a significant effect on government borrowing. The economic lockdown due to COVID-19 marked another sharp increase in spending and a decrease in revenue, brought about by increased unemployment and a significant fall in economic activity, as the Government sought to limit the risk of case numbers and infection. The Central Bank has forecasted that the budget will likely remain in deficit for the foreseeable future,[40] and that additional shocks could cause debt and deficits to start rising. In the medium term the Irish Fiscal Advisory council also suggest that the budget balance is not set to reach a surplus of 0.3% of GNI* until 2025. They also identify risks to the Irish economy[41] including additional pandemic restrictions, risks to foreign direct investment from international tax developments, and continued uncertainties around Brexit. The current Russian invasion of Ukraine and the responses of other countries also creates additional unexpected uncertainty.

Indecon has considered two scenarios for future investment in RI in Ireland as follows:

- Scenario 1: No change, or only a moderate change, in exchequer resources allocated to RI
- Scenario 2: A significant increase in exchequer resources allocated to RI

6.2 Priority Criterion

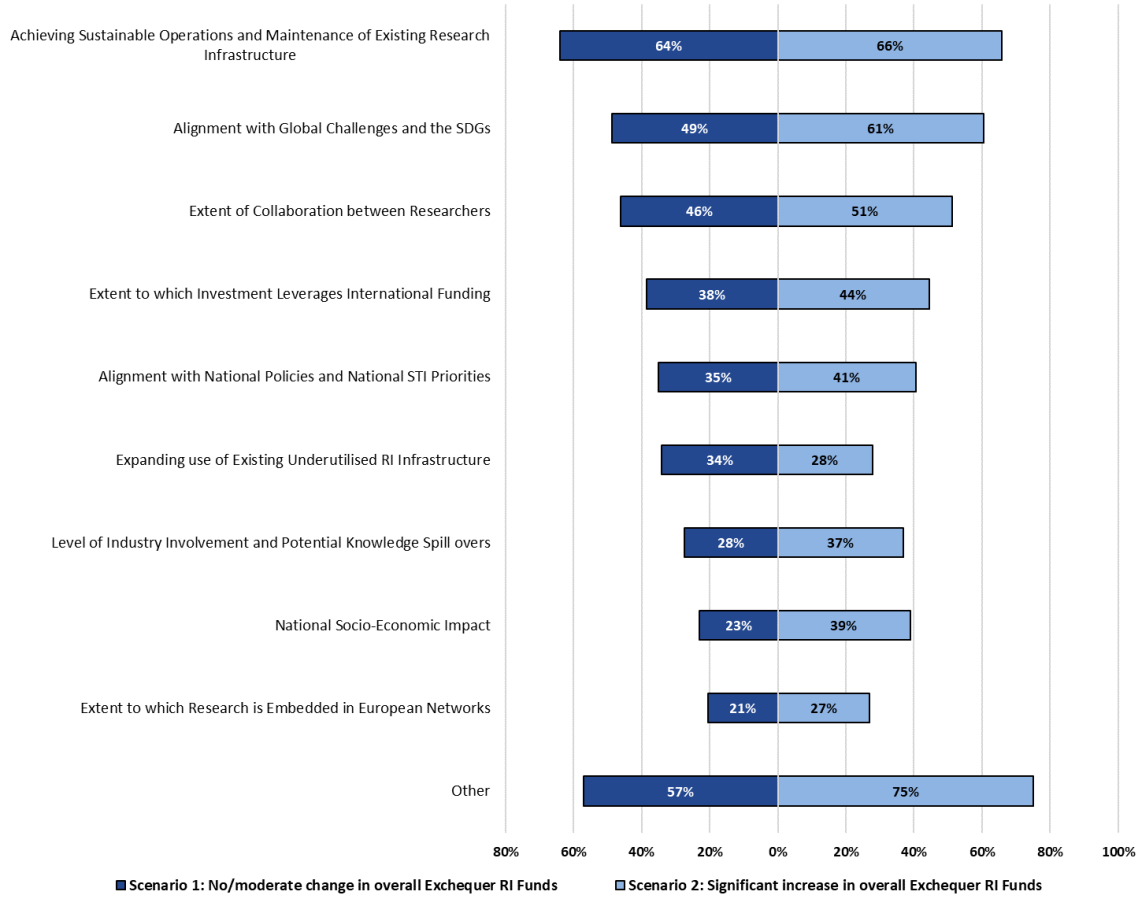
The importance of ensuring that RI investments are in line with national and international policy priorities is reflected in the views of researchers, with around half of respondents indicating that "alignment with global challenges and the SDGs" was a high priority. The evidence indicates that researchers suggested that investing in maintenance of existing infrastructure and achieving sustainable operations should also be a high priority. Collaboration between researchers was also seen as a high priority.

[39] Spending Review 2019. Analysis of Science Foundation Ireland Research Grants.

[40] https://www.centralbank.ie/docs/default-source/publications/economic-letters/vol-2021-no-6-analysis-of-medium-term-risks-to-the-public-finances.pdf?sfvrsn=5#:~:text=The%20Public%20Finances%20%E2%80%93%20Medium%20Term%20Outlook%20and%20Risks&text=Direct%20fiscal%20supports%20are%20expected,just%20prior%20to%20the%20pandemic.

[41] Irish Fiscal Advisory Council's Fiscal Assessment Report (Dec 2021): https://www.fiscalcouncil.ie/wp-content/uploads/2021/11/Fiscal-Assessment-Report-December-2021-Managing-the-Recovery.pdf

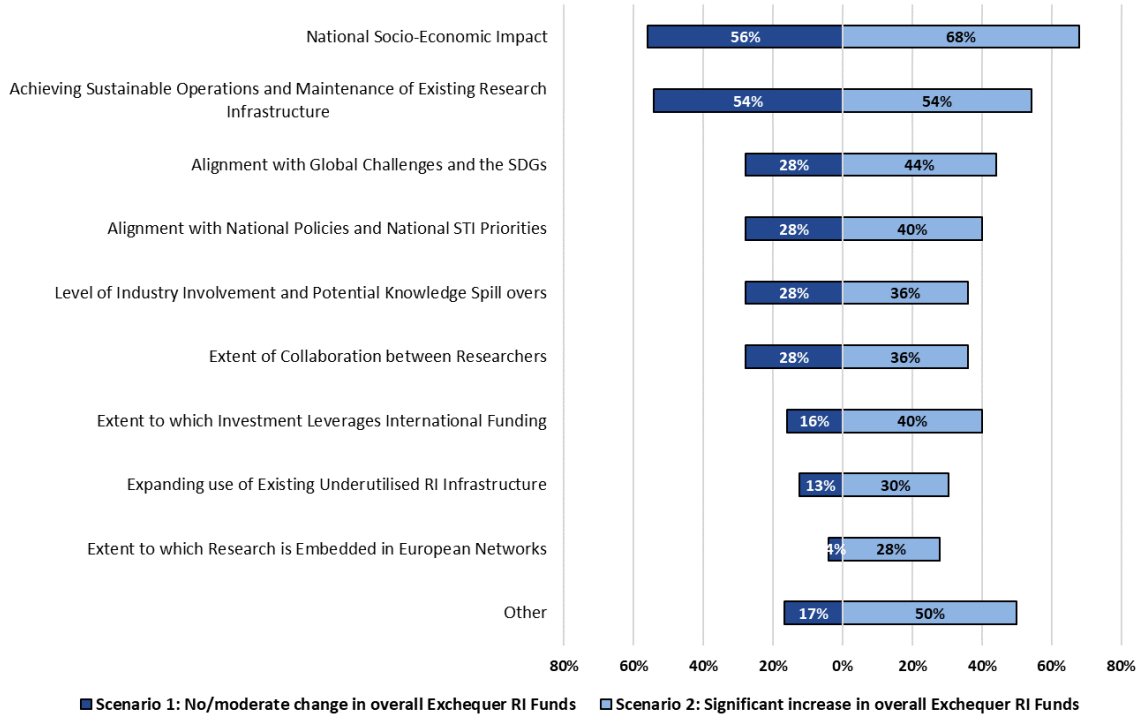
Figure 6.1: % of Researchers that consider the following criteria as High Priority



Source: Indecon Survey

The corresponding figures for institutions when asked the same questions are shown in Figure 6.2.

Figure 6.2: % of Institutions that consider the following criteria as High Priority



Source: Indecon Survey

For both researchers and institutions, regardless of the funding scenario, a strong view was expressed of the need to fund the operation and maintenance of existing research infrastructure. This is viewed as a high priority by both researchers (almost two-thirds of respondents) and institutions (over half). This issue is discussed in greater detail in sub-section 6.4. Improving the extent of collaboration between researchers was given a high priority by around half of all respondents in both funding scenarios, and by one-third of all institutions who responded. Issues around access, including in terms of access plans, the LIRE database and issues concerning the interoperability of RI, are discussed in Chapter 7.

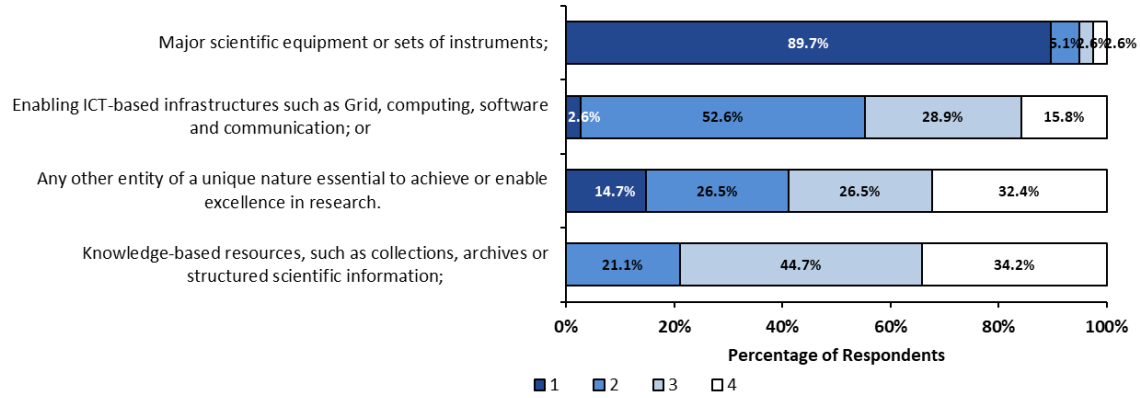
Access to state-of-the-art equipment can raise the ambition levels of researchers and the quality of the research they produce. This in turn impacts Ireland's reputation which can serve to attract international collaboration particularly from our neighbouring EU Member States, both from the European research community and from industrial stakeholders.[42] For example, this could be through greater alignment with the Horizon Europe European Research Infrastructures agenda.[43] However, Indecon's survey of researchers and institutions shows that greater collaboration internationally is not seen as a priority, unless there is a significant increase in funding.

[42] Enterprise Ireland submission to Indecon, 2021

[43] https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/wp-call/2021-2022/wp-3-research-infrastructures_horizon-2021-2022_en.pdf

Indecon also surveyed the research community regarding the type of RI investment which should be given the highest priority. The results showed a very strong preference for major scientific equipment or sets of instruments. This is illustrated in Figure 6.3.

Figure 6.3: % of Institutions that consider the following criteria as High Priority



Source: Indecon Survey

6.3 Needs by Research Domain

In this section we discuss the prioritisation of needs for investment in RI based on research domain. A number of submissions received by Indecon as part of this study highlighted specific research domains that merited additional investment. The new national research and innovation strategy (Impact 2030) will ultimately influence RI strategy, in particular by setting policy areas priorities, and may also influence the resources available for investment in RI.

An increased focus on environmental concerns, particularly regarding climate change, is reflected in in the European Green Deal, the Climate Action Plan and the Programme for Government.[44] The European Green Deal frames Europe's response to the climate and environment challenges and commits to delivering net-zero greenhouse gas emissions at EU level by 2050. Domestically, The Climate Action and Low Carbon Development (Amendment) Act 2021 places on a statutory basis a commitment to achieve a climate neutral economy no later than 2050. Scientific evidence and advice can help underpin Government policy and support the actions in the Climate Action Plan. This could span a range of areas from fundamental and applied science, to technology and innovation, to the production of knowledge and evidence to inform public policy.

Areas of healthcare were also highlighted by the HSE. While the importance of health research as a driver of life sciences and healthcare research, "development and investment" is a thread running through National Research Prioritisation exercises. Ireland has fallen behind its international counterparts in the conduct of clinical trials.[45] In 2017, there were 97 regulated clinical trials ongoing in Ireland. These figures are significantly lower than countries with a similar population, i.e., Denmark and Finland, which had 365 and 180 clinical trials, respectively, registered on EudraCT during the same

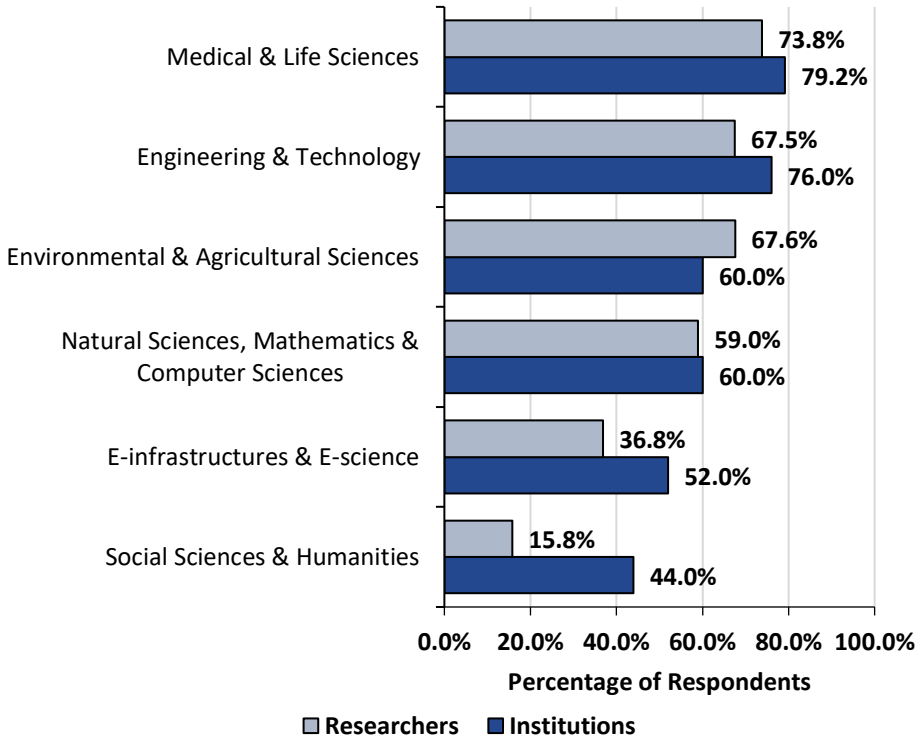
[44] Submission by Department of the Environment, Climate and Communications to Indecon, 2021
[45] HSE submission to Indecon, 2021

time period. They report concern that the lack of a cohesive national system with defined timelines and processes is driving a reluctance to run clinical trials in Ireland.

National needs are also reflected in other policy objectives. The IDA has identified several global megatrends that have potential to create new opportunities including: advanced manufacturing and integrated supply chain; a digitised industry; healthcare transformation; sustainable industries and technologies; and the future of work. Due to their cross-cutting nature, they are anticipated to require new hybrid infrastructure that involve multiple disciplines. Digital platforms are expected to be a prominent requirement to enable these future opportunities. Infrastructural investment and a variety of different financial supports to encourage and accelerate multi party business to business collaborations such as these will be required.

When asked which research domains should be prioritised, Medical and Life Sciences, followed by Engineering and Technology, are considered as highest priority research domains by a majority of survey respondents, whether individual researchers or institutions. This is illustrated in Figure 6.4.

Figure 6.4: % who reported the following research domains in future RI investment as high priority to maximise the economic and social effect of funding

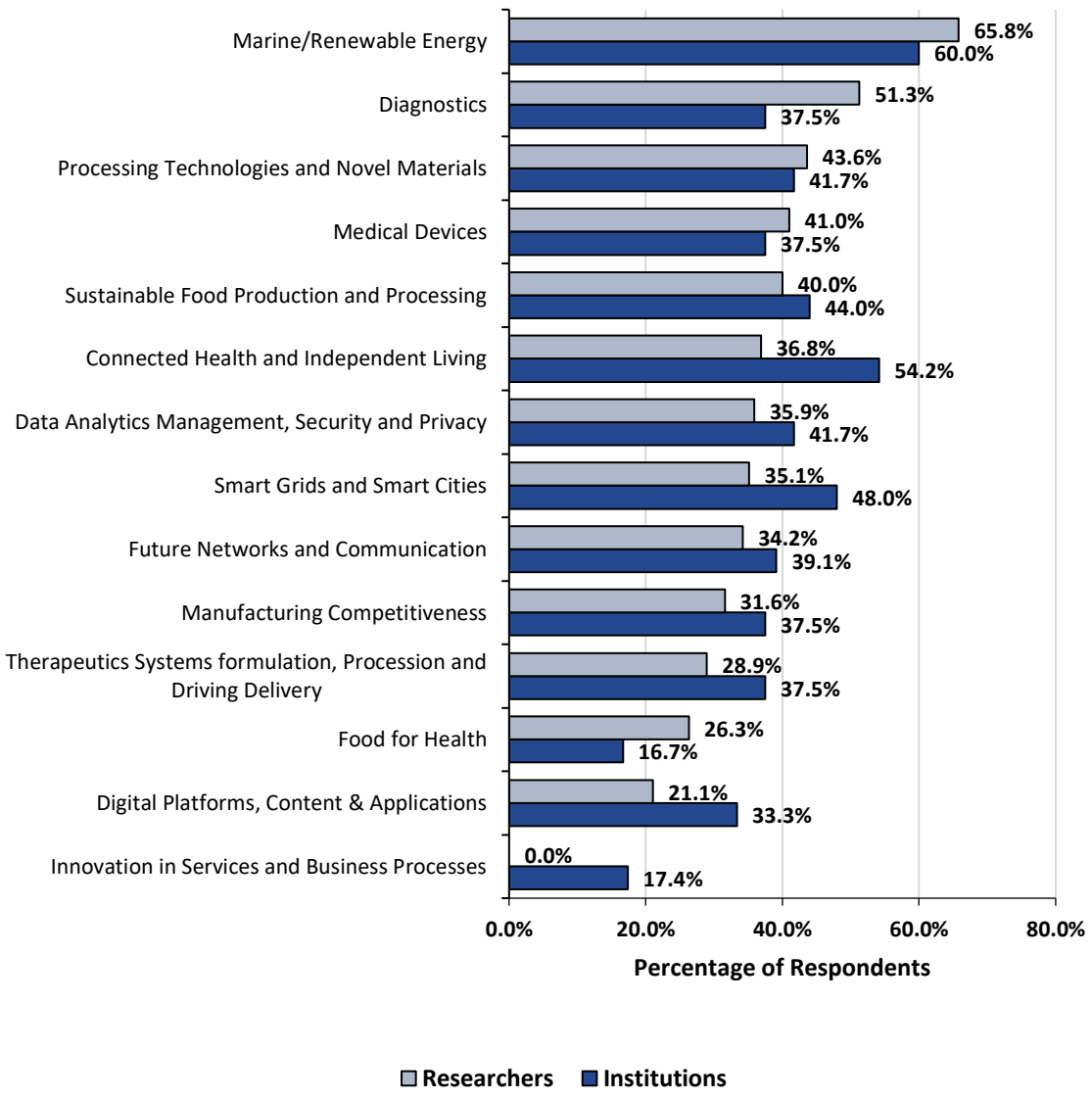


Source: Indecon Survey

Indecon also asked stakeholders to suggest priority areas within a specific list of science, technology and innovation areas, as shown in Figure 6.5. Research areas encompassing environmental issues and health were ranked as being of highest priority. In terms of the environment, renewable energy

ranked highest, with two of every three respondents ranking this as a priority. In terms of healthcare, diagnostics, medical devices and connected health all ranked highly.

Figure 6.5: % who reported the following research domains in future RI investment as high priority to maximise the economic and social effect of funding



Source: Indecon Survey

6.4 Operations and Maintenance Supports

Given that much of the national equipment stock was procured under previous PRTLI calls, a significant proportion of Ireland's RI stock is at least a decade old and in some instances 15-20 years old. National funding mechanisms in general do not account for the continued cost of ownership or depreciation of infrastructure which has led to a situation of key pieces of equipment being no longer viable due to an inability to fund maintenance contracts and support.[46] Further, much of the specialised investment in RI requires suitably qualified and experienced support staff to operate. These positions are not included as an allowable cost under many national funding instruments. There was a strong view among national stakeholders engaged by Indecon and the research community that Ireland should provide additional support for the ongoing operation and maintenance of RI.

The issue of the costs of operations and maintenance supports has also been seen in other jurisdictions. In the UK, the Chair of the House of Lords Science and Technology Committee said on publication of its report, 'Scientific Infrastructure':

> *"… we are concerned about the 'batteries not included' syndrome – very expensive, large scale scientific equipment has been built, but there is not enough money to keep it running. This lack of provision for operational costs has seen facilities not being used to a maximum capacity, with severe research consequences."*[47]

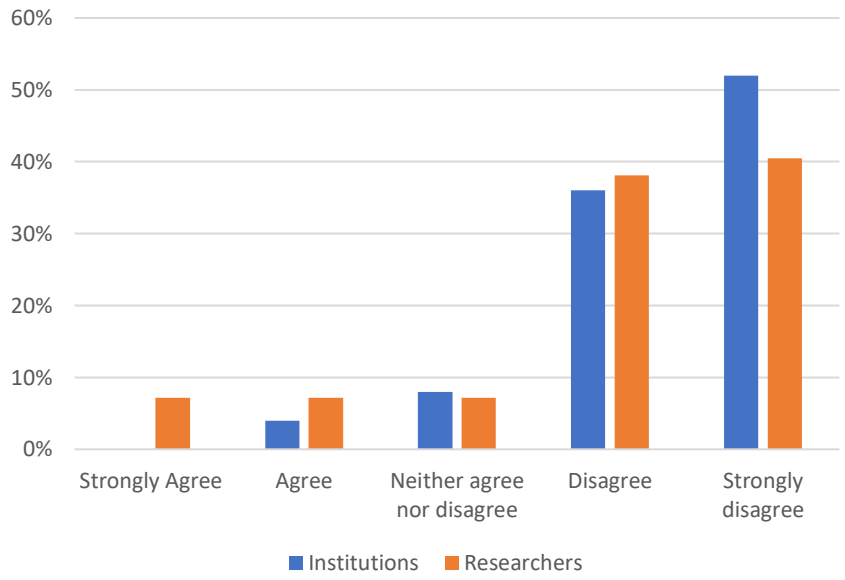
The issue of maintenance supports was raised by a number of national bodies which Indecon engaged with as part of this study. A selection of comments made are shown in the next figure.

Figure 6.6: Selected comments from national stakeholders on the issue of operation and maintenance supports
Geological Survey Ireland: *Applications for funding for medium to large scale infrastructures need to have an option to include staff and technical support*.
Environment Protection Agency: *The need to ….. provide funding throughout the infrastructure lifecycle (establishment, operation, maintenance and upgrading).*
Enterprise Ireland: *Investment in human capital (technical support staff) required to ensure that the professional running of research infrastructure is appropriately resourced ensuring greater quality of utilisation through proper maintenance and operation*.
Irish Research Council: *The following principles should be reflected in the foundational management of research infrastructures: ….. Sustainability of both equipment and people*.
IDA Ireland: *For strategic national infrastructures staffing costs should also be considered where appropriate.*
Source: Indecon Consultation

There was also a strong view among the research community that Ireland was not providing adequately for sustainable operations and maintenance supports. This is illustrated in Figure 6.7.

[46] IUA submisison to Indecon, 2021
[47] https://old.parliament.uk/business/committees/committees-a-z/lords-select/science-and-technology-committee/news/scientific-infra-report-published/

Figure 6.7: % who believe Ireland provides sustainable operations and maintenance supports for existing and new RI



Source: Indecon Survey

6.5 Needs of Technological Universities

Ireland's Higher Education landscape is currently undergoing a transformation with the creation of five technological universities from 12 institutes of technology:

- Atlantic Technological University, commencing April 2022 and bringing together Galway-Mayo Institute of Technology, Institute of Technology Sligo, and Letterkenny Institute of Technology;
- Technological University for the South-East Ireland, commencing May 2022 and bringing together Waterford Institute of Technology and Institute of Technology Carlow;
- Technological University of the Shannon: Midlands and Midwest, formed in October 2021 by a merger of Athlone IT and Limerick IT;
- Munster Technological University, formed in January 2021 by a merger of Cork IT and IT Tralee; and
- Technological University Dublin, formed in January 2019 by a merger of Dublin IT, IT Tallaght and IT Blanchardstown.

Dundalk Institute of Technology has announced that it is pursuing technological university status. The Institute of Art, Design and Technology is also actively considering its strategic options in this area.

There are a number of research and innovation metrics which the State has set down in legislation for TUs/TU consortia to achieve pre- and post- designation, which will require TUs to carry out substantially more R&D activity than their predecessor institutions:

- 4% research student enrolment, increasing to 7% within five years of designation
- PhD Programmes and research activities in no fewer than three ISCED narrow fields of education, rising to five fields within five years of designation
- 45% of academic staff to have a Level 10 (typically a PhD) qualification, rising to 65% within 10 years of designation

The meeting of these targets will require significant increases in research and innovation capacity for TUs. This will include the need to effectively double the number of postgraduate research student from approximately 2,200 enrolments in the 2020/2021 academic year to over 4,000 enrolments by around the 2032/2033 academic year.[48] Supporting this overall increase in student numbers will also require an increase in RI, and the space to house it.

Historically, TUs and predecessor institutions have won only a small share of SFI RI awards, accounting for 2% of funding of previous SFI Programmes. This is shown in Table 6.1. Further, the award size was around one-third of the typical award size. However, Enterprise Ireland run Capital Equipment Calls for Technology Gateways and Technology Centres for amounts ranging from €25,000-€250,000. Technology Gateways works in partnership with Institutes of Technology and Technological Universities consisting of 16 specialised Gateways and three sectoral clusters, with the aim to deliver innovation expertise for Irish industry. The Technology Centre Programme is a joint initiative between Enterprise Ireland and IDA Ireland, allowing collaboration on market focused strategic R&D projects with research institutions, including TUs/IOTs. There are no figures available centrally on access by TU researchers to RI in other higher education institutions.

[48] THEA Submission to Indecon, 2021.

Table 6.1: Distribution of Award Holders by Research Body	
Research Body	**Number of Projects**
Trinity College Dublin	21
National University of Ireland, Galway	13
University College Cork	13
University of Limerick (UL)	13
Maynooth University (MU)	10
University College Dublin (UCD)	8
Dublin City University (DCU)	6
Royal College of Surgeons in Ireland	4
Tyndall National Institute (TNI)	4
Teagasc	2
Waterford Institute of Technology	2
Dublin Institute for Advanced Studies	1
Marine Institute	1
Total	**98**
Source: Science Foundation Ireland	

6.6 Summary of Findings

This section set out stakeholder views on the prioritisation of needs for investment in RI. A summary of the key findings of this section is as follows:

- Any determination as to the 'need' for RI will be driven in the first instance by broader national research and innovation policy and prioritisation, given that RI expenditure represents only a small share of the overall research budget. SFI's Research Infrastructure Programme represents only 10% of its total programmatic expenditure.
- Indecon developed two scenarios for future investment in RI:
  - Scenario 1: No change, or only a moderate change, in exchequer resources allocated to RI
  - Scenario 2: A significant increase in exchequer resources allocated to RI
- The institutions surveyed rate achieving National / Social / Economic impact as a high priority and Indecon believes this should be a core objective of any future programmes. Maintaining existing infrastructure is also seen as a priority.
- For both researchers and institutions, regardless of the funding scenario, a strong view was expressed of the need to achieve sustainable operations and maintenance of existing research infrastructure. Improving the extent of collaboration between researchers was also given a

high priority by around half of all respondents in both funding scenarios. The importance of alignment with global challenges and the SDGs was also noted. Collaboration between researchers was seen as a priority by researchers.

- Indecon also asked stakeholders to suggest priority areas within a specific list of science, technology and innovation (STI) research areas. A number of research areas relating to environmental issues and health ranked as being of a high priority. In terms of the environment, renewable energy was ranked highest, with two of every three respondents ranking this as a priority. In terms of healthcare, diagnostics, medical devices, and connected health, all ranked highly.

7 Access to RI by Researchers and Industry

7.1 Introduction

Given the significant investments made in RI over the last 20 years, facilitating access to RI can help achieve a greater return on investment and value for money for the state and for the broader research community. Two aspects of access can be considered: first, visibility, the extent to which other researchers are aware of the availability of certain RI; and secondly, accessibility, to ensure that RI is made available in an appropriate manner to interested researchers from Ireland, including the setting of appropriate access charges. Respondents to Indecon's survey of the research community also suggested that there were mixed views regarding the extent to which it was believed that investments in RI in Ireland were managed as a 'national asset', as opposed to a once-off investment, as shown in Figure 7.1. Assets considered a 'national asset' can be considered as being available for other researchers, in terms of being both visible and available. This should be seen in the broader context of the 'Open Science' agenda. The OECD described Open Science as:

> *"Efforts to make the output of publicly funded research more widely accessible in digital format to the scientific community, the business sector or society more generally."*[49]

Innovation 2020, Ireland's research and development, science and technology strategy, contains an action to support national and European open access policies and principles.

In this chapter we review issues around the access by other researchers and industry. We discuss the current system in place to ensure access to RI, including with respect to the LIRE database and the extent of interoperability of technology.

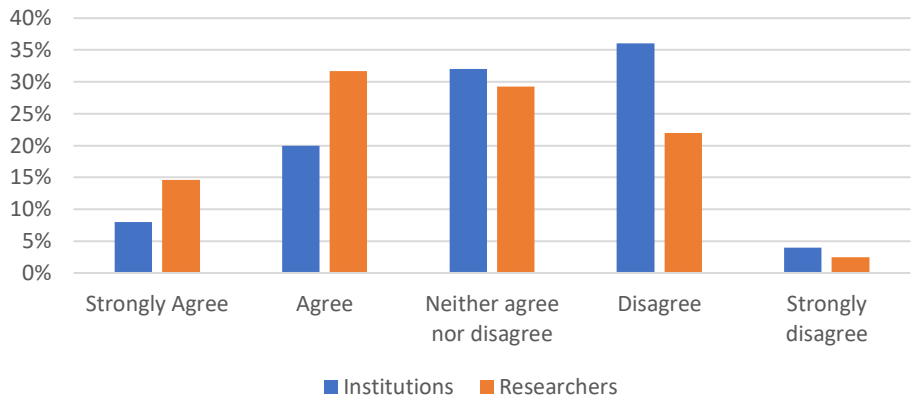
7.2 Assessment of current access

Two aspects of access can be considered, firstly visibility, the extent to which other researchers are aware of the availability of certain RI, and secondly accessibility, to ensure that RI is made available in an appropriate manner to interested researchers from Ireland and internationally, including the setting of appropriate access charges. The levying of access charges can both increase the sustainability of infrastructure, while also offsetting any cost implications that such access may have for the host institution.

Respondents to Indecon's survey of the research community also suggested that there were mixed views regarding the extent to which it was believed that investments in RI in Ireland were managed as a 'national asset', as opposed to a once-off investment. See Figure 7.1 overleaf. Managing an asset as a 'national asset' may mean ensuring appropriate access to other researchers is available, and that investments are made in a way that are consistent with national goals.

[49] OECD (2015) "Making Open Science a Reality". OECD Science, Technology and Industry Policy Papers, No. 25, OECD Publishing, Paris

Figure 7.1: % who believe Investments made in RI are managed as a national asset as opposed to a once-off investment



Source: Indecon Survey

Access by industry users is also important. Companies accessing infrastructure in the HEIs can result in a range of benefits including improved technological knowledge; an improvement in developing a culture of innovation; securing access to further capital; and development of new products and processes.[50] Ireland's advanced research programme has already displayed a significant level of partnership and collaboration between academia and enterprise that was enabled by previous investment in the sector. For example, in 2018 there were:

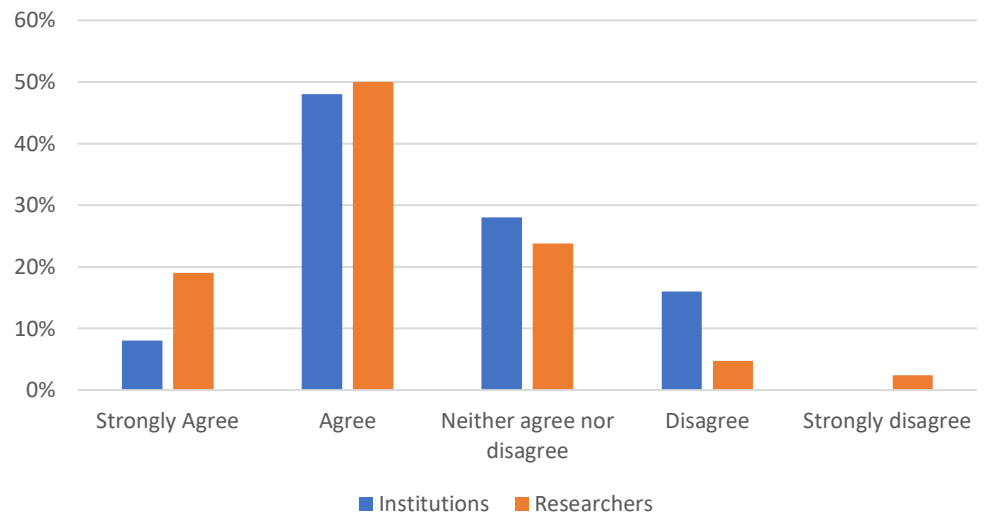
- 1,824 live research collaboration agreements with industry, 80% of companies that signed collaboration agreements with research performing organisations were based in Ireland, and 95% collaboration agreements with the SME sector were with Irish SMEs; and
- 30 new spin-out companies formed, 119 spin-outs still operating at least three years post incorporation, and 933 jobs in active spin-out companies.[51]

Input from Ireland's national industry development agencies, Enterprise Ireland and IDA Ireland, indicated that industry did have access, though raised concerns regarding 'discoverability', in particular how aware many businesses were of the RI that was available. This is discussed further in Section 7.3. Academic respondents to Indecon's survey broadly thought that industry in Ireland had access to RI, with around two in three agreeing or strongly agreeing with this statement. This is illustrated in Figure 7.2. However, as well as having access, it is also important to ensure that researchers are appropriately trained and prepared for work in industrial settings and to provide a 'commercial' service to industry partners.

Further, evidence reported earlier in this report showed that RI purchased with the support of the SFI RI Programme was only being used for just over half (56%) of total available time and, of this, it is mostly in academic use, though there is significant industry usage also. This suggests that there may be significant potential to increase the utilisation of some RI.

[50] Enterprise Ireland Submission to Indecon,2021.
[51] IUA Submission to Indecon, 2021.

Figure 7.2: % who believe Industry in Ireland has access to RI in a State-Aid compliant manner



Source: Indecon Survey

The HEA has usefully developed national guidelines for access to research infrastructures hosted by higher education institutions or other research bodies in Ireland.[52] The guidelines state that access would be facilitated by the Large Items of Research Equipment database ('LIRE') to provide relevant contact information. The HEA guidelines also state that while free access to RIs in the context of academic collaborations and partnerships was encouraged, access charges may be used as a means of spreading costs among research collaborators.

The Large Items of Research Equipment database, maintained by the HEA, was compiled following the completion of a national inventory of all significant publicly funded research infrastructure and equipment. However, the LIRE database was only updated periodically between 2010 and 2017 and has not been updated since. The LIRE database does not report when the infrastructure was obtained or its current status (for example if it is still functioning), or when the database was last updated. Further, it does not sort the infrastructure into easily searchable categories. The latest (2017) version of the database had 705 entries, spread across 19 separate institutions. See Section 7.3 for a discussion of the use of the LIRE database.

It should be noted that not all RI might necessarily be suitable for open access, given the nature of the technology and the level of expertise required to operate it. For example, in the UK the RRS Sir David Attenborough, a polar research vessel, may not as easily accessible to external researchers as other forms of RI. For other infrastructure, access may be more appropriate by allowing external researchers to propose projects that would be run on a piece of RI, rather than directly giving access to the infrastructure.[53]

The issue of access charges is also addressed in the HEA guidelines. The guidelines state that while free access to RIs in the context of academic collaborations and partnerships was encouraged, access charges may be used as a means of spreading costs among research collaborators. In line with the

[52] HEA, "National Principles for Access to Research Infrastructure."
[53] For example, see the Diamond Light Source has explicit terms for external users,which includes calls for proposals. See: https://www.diamond.ac.uk/Users/Apply-for-Beamtime.html.

HEA guidelines, the SFI allows grant applications under its various programmes to charge for infrastructure access to support infrastructural sustainability. SFI also encourage research bodies to have appropriate planning in place to maintain research infrastructure, allowing the maximum usage of infrastructure, with an appropriate access charge plan.[54] While there is no 'standard' access charge policy that acts as a baseline for core facilities to use across all funders and institutions, the SFI's access charge template is used in many cases.[55] The latest iteration of the SFI's Guidelines for Preparing a Research Infrastructure Access Charge Plan was published in May 2021. In addition to access rules and charges, awareness by researchers and industry as to the availability of RI is important to promote greater use and access. This issue is dealt with in more detail in Section 7.3.

There is evidence that the existing stock of RI is not being optimised. Evidence in this study (see Section 5.5) shows that less than half of projects supported under the SFI RI Programme still had an Access Plan in place, despite having submitted a draft access charge plan as part of the SFI application process. IDA Ireland also report that Research Infrastructure can still be difficult to find. A study on RI in 2015 also reported general agreement with the need to increase the transparency and harmonisation of access policies.[56] Enterprise Ireland stated that a national access programme is needed to provide the flexibility that SMEs need to innovate once it is available in parallel with the capital and human infrastructure needed to deliver. For SMEs, effective access often means access to a HEI in their locality.

7.3 Use of the LIRE database

The Large Items of Research Equipment (LIRE) database is maintained by the HEA. It is intended to contain items of research equipment items with a value of at least €100,000 and was compiled following the completion of a national inventory of all significant publicly funded research infrastructure and equipment. However, the LIRE data base was only updated periodically between 2010 and 2017 and has not been updated since. As such, the LIRE database does not have information on any RI purchased as part of the SFI RI Programme 2018 call. None of the database has been available for search by researchers since 2017. In its current form, the LIRE database contains a limited array of details on each piece of RI available nationally, as set out in Figure 7.3.

[54] SFI (2021), " Guidelines for Preparing a Research Infrastructure Access Charge Plan."
[55] IUA (2021), Submission to Indecon.
[56] Technopolis 2015

Figure 7.3: % information contained in LIRE database
• Institution where the infrastructure is located • Type of research infrastructure available (for example, an x-ray device or a cell sorter) • Name, make, and model of the device (a string variable with no set categories, just text entry) • Serial number (a string measure, sometimes omitted) • Weblink for the host institution (for example, Cork IT's listing for a mass spectrometer leads to the Munster Technological University's Applied Physics page). • Correspondent's name; email; phone number and affiliation
Source: Indecon Review of LIRE database

The LIRE database does not report when the infrastructure was obtained or its current status (for example if it is still functioning), or when the database was last updated. Further, it does not sort the infrastructure into easily searchable categories. The latest (2017) version of the database had 705 entries, spread across 19 separated institutions (as they were constituted at the time). Trinity College Dublin holds the most scientific infrastructure (26%), followed by UCC (22%) and DCU (12%). A list of the number of entries by institution, and their share of the total number of records listed in the database, is shown in Figure 7.4.

Figure 7.4: Infrastructure quantities by institutions		
Institution	**Frequency**	**Percentage**
TCD	186	26.4
UCC	156	22.1
DCU	84	11.9
UCD	69	9.8
NUIG	64	9.1
UL	38	5.4
NUIM	23	3.3
DIT	18	2.6
IT Tallaght	17	2.4
Cork IT	14	2.0
WIT	11	1.6
DKIT	7	1.0
AIT	6	0.9
GMIT	4	0.6
LIT	3	0.4
IT Tralee	2	0.3
DLIADT	1	0.1
IT Carlow	1	0.1
IT Sligo	1	0.1
Total	**705**	**100**
Source: Indecon analysis on HEA data		

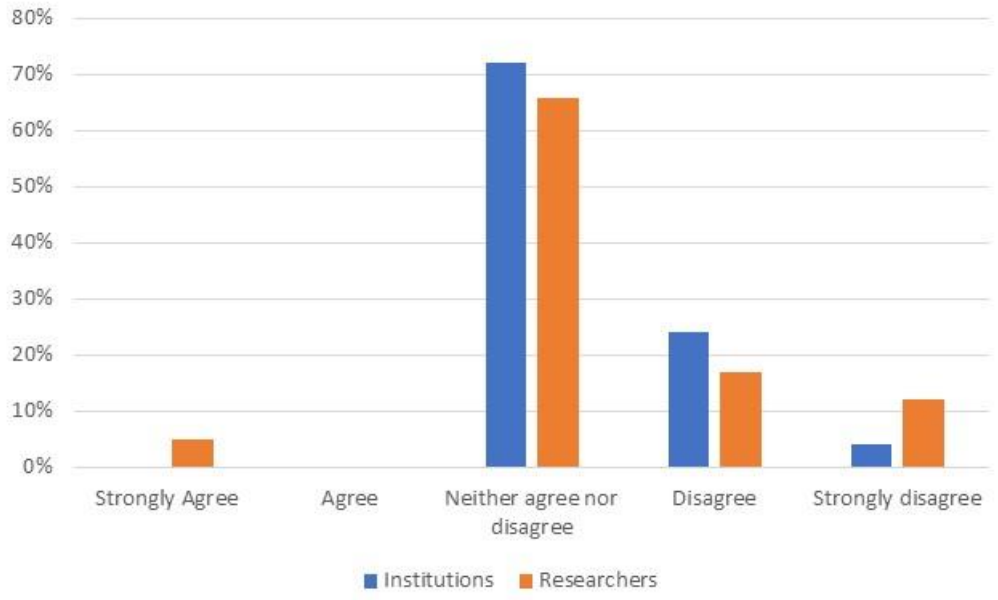
Indecon understands that the LIRE database has not been accessible for a period and as a result few respondents to Indecon's survey believed that the LIRE database was being used optimally. This is reflected in Indecon's engagement with key national stakeholders, as shown in the next figure.

Figure 7.5: Selected comments from national stakeholders on access to database of RI
Enterprise Ireland: *Development of a fully functioning searchable central equipment/ infrastructure database accessible to all.*
IDA Ireland: *Up to date and comprehensive information on the research infrastructure (contact details, charges etc.) is require ensuring that the infrastructure investments have optimal impact. Infrastructure is still siloed within Ireland and can be difficult to find.*
Technological Higher Education Association: *Improved structures for accessing infrastructure, both HEI-to-HEI and industry-to-HEI, should be established ….., with improved usability, and which includes guidance about how to access the infrastructure and details of any associated access charges.*
Irish Universities Association: *Investment in a national database will ensure that all potential users, including other HEIs and enterprises, especially SMEs, can source and access the technologies they require to innovate for the future.*
Geological Survey Ireland: *A national research infrastructure database should not be limited to the HEA – it needs to be something the research funders are engaged with plus the inclusion of e.g. ESFRI projects.*
Source: Indecon Consultation

This was also as reflected in responses from researchers/industry, as illustrated in in Figure 7.6. While many institutions, research bodies and researchers reported that they neither agreed nor disagreed, this may have been from a lack of understanding of the status of the LIRE database. Stakeholders consulted as part of this study reported that a national database could impact on supporting access to RI. The 2018 report by the Royal Irish Academy recommended the creation of a National Database of Research Infrastructures to avoid duplication and improve accessibility.[57]

[57] Royal Irish Academy,2018, "*Future- Proofing and Improving Research Infrastructures in Ireland*."

Figure 7.6: % who believe LIRE database being used optimally



Source: Indecon Survey

Stakeholders consulted as part of this study reported that a national database could have on supporting access to RI. According to the IUA, investment in a national database could ensure that all potential users, including other HEIs and enterprises, could access the technologies they require.[58] IDA Ireland also state that up to date and comprehensive information on the research infrastructure (including contact details, charges etc.) was required to ensure that infrastructure investments have optimal impact. The 2018 report by the Royal Irish Academy recommended the creation of a National Database of Research Infrastructures to avoid duplication and improve accessibility.[59] A 2015 report on RI in Ireland concluded that visibility of RIs and high-quality access and support services were important.

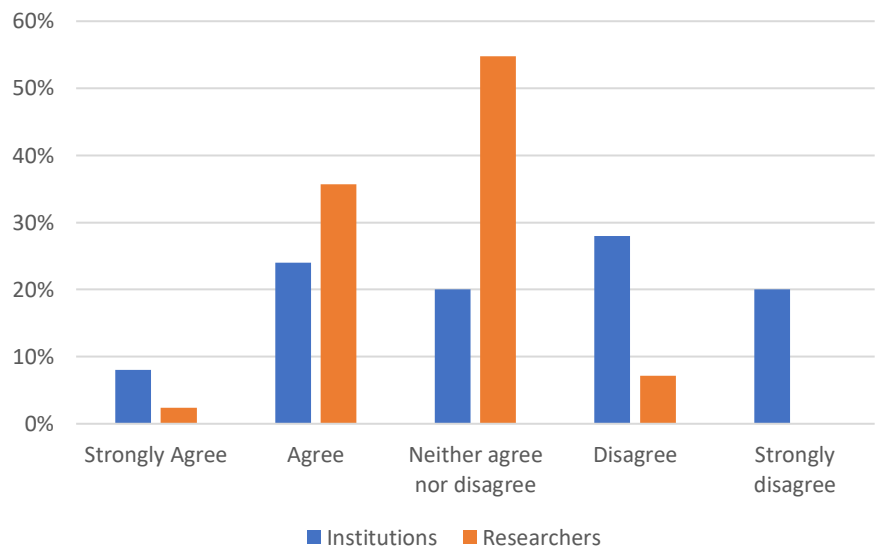
There are also examples of sector-specific mechanisms. In 2019, the EPA published the EPA Research Report 297 on Water Research Infrastructure, which was motivated by the fact that while Ireland had a National Research Infrastructure Roadmap to address RI need in overall terms, the water sector was not identified in that plan specifically.[60] In response, recommendations on how to develop Ireland's WRI in the future were developed, informed by the findings of a mapping study, a literature review of research infrastructure strategies and policies, and interviews with research infrastructure managers.[61] This included planning for a WRI database to help ensure effective planning for future WRI, by helping to identify gaps in existing infrastructure and opportunities for new infrastructure.

[58] IUA Submission to Indecon, 2021.
[59] Royal Irish Academy,2018, "*Future- Proofing and Improving Research Infrastructures in Ireland*."
[60]https://www.epa.ie/publications/research/water/research-297-identification-and-mapping-of-water-related-research-infrastructure-in-ireland.php.
[61] EPA Submission to Indecon, 2021.

7.4 Digital RI Needs

Beyond the provision of a centralised database of RIs, there are different aspects of digital needs which are relevant to researchers, including project specific RI needs, access to High Powered Computing[62] and open research infrastructure. When surveys, researchers reported mixed views when asked whether they believe that there was good access to digital RI. This is shown in Figure 7.8. Access to digital RI is also reflected in more general responses as set out in this report. For example, one issue regarding operation and maintenance supports raised during the consultation process was the lack of sufficient funding to facilitate necessary software upgrades.

Figure 7.7: % who believe Irish researchers have very good access to digital RI



Source: Indecon Survey

One aspect of digital need is the infrastructure to facilitate open access to research outputs. The shift towards Open Science improves the quality, efficiency and responsiveness of research, but requires significant human capital, training, and sustainable, trustworthy digital infrastructure.[63] In 2019, the Irish Government published the National Framework on the Transition to an Open Research Environment. This was developed by the National Open Research Forum (NORF), which was set up in 2017 to bring together members of the research community to drive Ireland's open research agenda. The National Framework set out 27 principles to promote access to open research, grouped under the five following categories:

- Open access to research publications
- Enabling FAIR (findable, accessible, interoperable, reusable) research data

[62] The need for High Powered Computing is outside the scope of the Terms of Reference of this study.
[63] IUA Submission to Indecon, 2021

- Infrastructures for access to and preservation of research
- Skills and competencies
- Incentives and rewards

Platforms that support open access to research publications and enable FAIR research data can be considered technical infrastructure. There is growing need for research data hosting where academic based researchers are not in a position to make data open access in the long term or host on a permanent basis, particularly for projects which generate very large datasets that need to be hosted.[64]

A national portal facilitating open access to Irish published research, RIAN, was launched in 2010. RIAN was to act as a single point of access to national research output and to contain content harvested from the institutional repositories of the seven Irish Universities and Dublin Institute of Technology with the aim of increasing the visibility and impact of Irish research. As of April 2021, RIAN aggregated 16 other Irish Open Access Repositories (OARs) so they could be accessed through a single portal. It began as an investigation of Irish universities' institutional OARs by the IUA Librarians' Group in 2005. In 2006, it was awarded funding from the Department of Education and Science's Strategic Innovation Fund. RIAN is no longer accessible, and no evaluation of its operation and usage has been conducted.[65]

IReL is the e-resource licensing consortium providing access to online resources to participating Irish higher education institutions and can be defined as a form of research infrastructure. Staff and students of participating institutions can access IReL resources on or off-campus via their own institution's library's website.[66] IReL has been hosted at Maynooth University since 2016. IReL is overseen by the Governance Committee of the IULCC (Irish University Libraries Collaboration Centre) comprised of representatives from partners and funders. A value for money assessment conducted in 2019 found that IRel had been successful in reducing costs for participant organisations.[67]

7.5 Technology transfer and knowledge spillovers

Technology transfer and knowledge spillovers amplify the economic and social impacts of ideas and technology. Innovation diffusion also creates knowledge flows that lead to further innovations. The importance of technology transfer and knowledge spillovers is also reflected in the SFI RI Programme. However, the issue of technology transfer and spillovers go beyond the RI itself and include how best to ensure that the products of research diffuse. This can be by, for example, publishing research, through the transfer of knowledge through the mobility of research staff, or by other means. Most researchers agree that there is scope for an increase in technology transfer and knowledge spillovers from RI. This is shown in Figure 7.8, which illustrates that 88% of both institutions and researchers either agreed or strongly agreed with this statement.

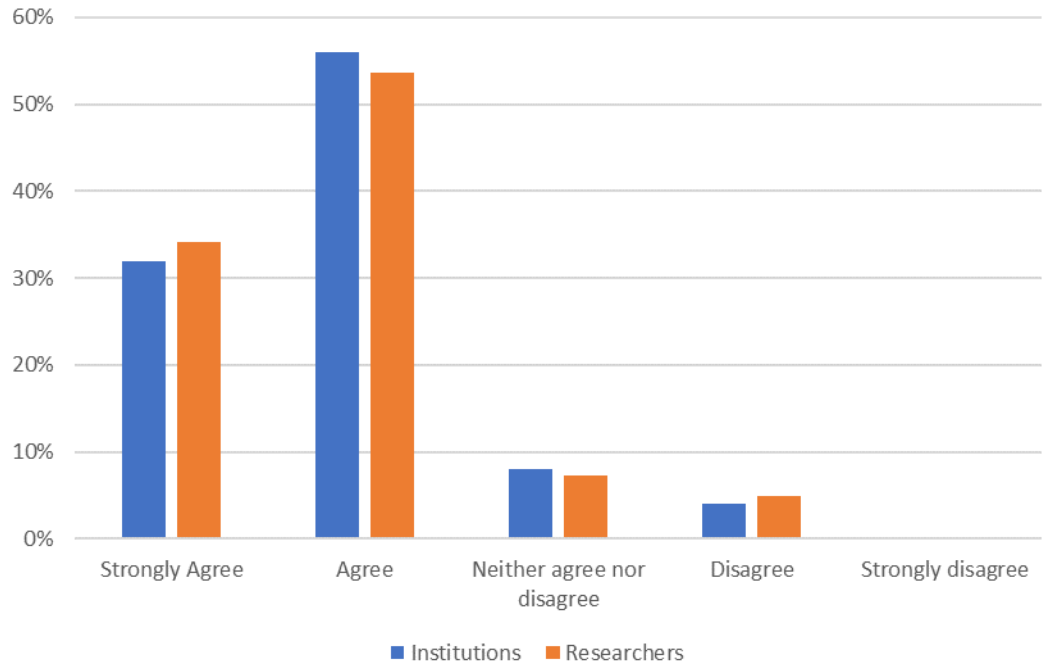
[64] GSI Submission to Indecon, 2021

[65] An archived version (from 28 June 2021) of rian.ie can still (as of January 2022) be accessed through https://web.archive.org/web/20210703031522/http://rian.ie/.

[66] Members are Dublin City University; Maynooth University; National University of Ireland, Galway; Royal College of Surgeons in Ireland; Technological University Dublin; Trinity College Dublin; University College Cork; and University College Dublin.
University of Limerick

[67] HEA (2019), "Strategic Review of the Irish Research e-Library (IReL)"

Figure 7.8: % who believe there is scope for technology transfer and knowledge spillovers from RI to be increased



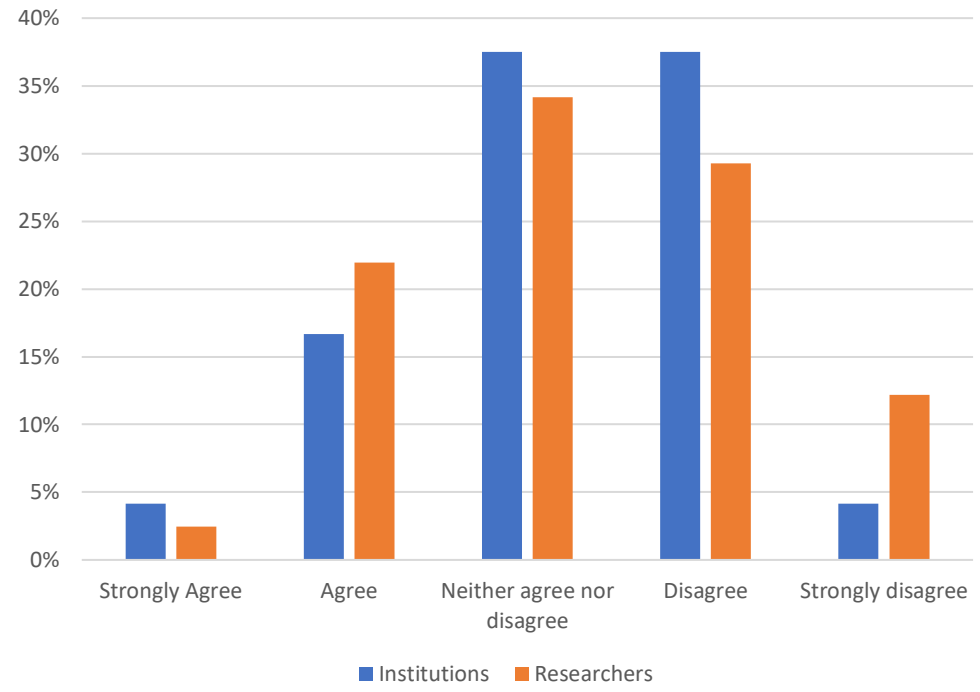
Source: Indecon Survey

7.6 Interoperability of RI in Ireland

Another issue relates to the extent that RI in Ireland is interoperable. When asked the extent of interoperability, about one in three institutions and individual researchers said that they did not agree or disagree, though another one in three disagreed (see Figure 7.9). It should be noted that RI does not necessarily need to be interoperable in many cases, and it may be more important that they are interoperable internationally.[68] As discussed in Chapter 3, in countries such as Italy, ensuring the interoperability of the research infrastructures is largely addressed via bottom-up initiatives.

[68] GSI submission to Indecon, 2021.

Figure 7.9: % who believe RI in Ireland is interoperable



Source: Indecon Survey

7.7 Summary of Findings

In this section we reviewed issues around the access by other researchers and industry. Some of the key findings of this section are as follows:

- Facilitating access to RI can help achieve a greater return on investment for the state and for the broader research community. Input from Ireland's national industry development agencies, Enterprise Ireland and IDA Ireland, indicated that industry did have access, though raised concerns regarding 'discoverability', in particular how aware many businesses were of the RI that was available.
- Access to RI aligned to industry needs incentivises collaboration which can help companies start new or expand on RD&I activities nationally. Ireland's advanced research programme has already displayed a significant level of partnership and collaboration between academia and enterprise that was enabled by previous investment in the sector.
- The LIRE database, maintained by the HEA, is intended to contain items of RI items with a value of at least €100,000, though has not been updated or available online since 2017. A very small percentage of respondents to Indecon's survey stated that they believed that the LIRE database was being used optimally.

- Irish researchers reported mixed views when asked whether they believe that there was good access to digital RI. A lack of sufficient funding to facilitate necessary software upgrades was raised during the stakeholder consultation, which can be considered another aspect of the broader issue of operation and maintenance supports.
- Technology transfer and knowledge spillovers can amplify the economic and social impacts of ideas and technology. A large majority (88%) of research institutions and individual researchers agree that there is scope for an increase in technology transfer and knowledge spillovers from RI.
- When asked the extent of interoperability of RI, about one in three institutions and individual researchers said that they did not agree or disagree, though another one in three disagreed. RI in Ireland does not necessarily need to be interoperable, and it may be more important that they are interoperable internationally.

Section IV: Recommendations

8 Conclusions and Recommendations on Potential Opportunities for Improvement

8.1 Introduction

The Programme for Government outlines an ambition for Ireland to be a leader in the technological revolution. It also prioritises the funding of research to address societal and environmental challenges and to support foundational and discovery research. A high-quality national research infrastructure will enable Irish researchers to compete for, and deliver on, project funding under European Framework Programmes, and promote effective research partnership with industry enhancing both research talent and innovation capacities. Section II of this report evaluated the investment Programmes implemented by SFI into Research Infrastructure 2015-2021 and provides an assessment of the Programme's performance and effectiveness in the context of the overall RI investment landscape. Section III provided a prospective analysis of the research needs with respect to RI.

In this section, we provide an overview of the conclusions of the evidence of the study, which form the basis for the recommendations, which are set out subsequently. The first sets out recommendations regarding potential opportunities for improvement in the SFI RI Programme, while the second sets out recommendations regarding the national approach to RI.

8.2 Conclusions

The evidence presented in this report shows the importance of the current funding for Research Infrastructure to the conduct of advanced research in Ireland. The SFI RI programme plays a critical role. There is evidence of a range of outputs which were supported by funding for RI provided through the SFI Programme, including publications, education/public engagement and collaborations, including with industry. Indecon believes that a continued focus on large-scale investments in areas of national priority is necessary to maximise additionality and collaboration. Indecon's analysis also identifies a number of ways that RI investment in Ireland could be further improved, to optimise the impact of the investment. This is important in order to maximise the effectiveness of scarce Exchequer resources. These focus on changes that can be made at a national level, as well as adjustments to SFI future programme calls. These are designed to build on the success of previous funding rounds. Indecon's independent assessment is that the SFI's RI programme can continue to play a critical element in Ireland's overall national effort to support excellence in advanced research.

Indecon believe that an important way that the effectiveness of future funding could be enhanced is to have funding mechanisms to support the operation, maintenance and repair of equipment. This issue was raised as one of the most important recommendations by national stakeholders engaged by Indecon as part of this study. It was also a major theme in previous reports on RI funding in Ireland. Ireland is not alone in facing this challenge, with the Chair of the House of Lords Science and Technology Committee in the UK referring to it as the 'batteries not included' syndrome. Reforms are needed to ensure that both existing and future investments in RI funded by the Irish Government have the resources available to ensure that they can be maintained and used optimally. This would enhance the utilisation of the infrastructure.

Another key area is to ensure that RI in Ireland is treated as a national asset, accessible where appropriate to leading researchers regardless of their institutional affiliation. Many of the mechanisms needed are already in place, though further measures are needed to ensure that they are used to their fullest extent. Most notably, we believe that it is important that Access Charge Plans

are published online and made publicly available. Indecon's review of international experience, however, confirms that Ireland is more advanced than other countries in requiring Access Charge Plans. This is due to policy in Ireland as reflected in the HEA's national guidelines for access to research infrastructures, as well as the requirements of SFI RI calls.

There are other ways that greater access to RI could be enhanced. Indeed, Indecon note that the most recent SFI RI programme call in 2021 has already done much to promote greater collaboration among researchers by further strengthening the need to collaborate to the selection criteria. Work to promote greater collaboration should continue and be a key feature of future programme calls.

Access to infrastructure is also about visibility, the extent to which other researchers are aware of the availability of certain RI. In this regard, the development of a fully functioning searchable central equipment/infrastructure database accessible to all is very important. This was seen as important not only for researchers in other higher education institutions, but also to promote visibility of RI for private industry. The Large Items of Research Equipment (LIRE) database was intended to contain items of research equipment items with a value of at least €100,000 and was compiled following the completion of a national inventory of all significant publicly funded research infrastructure and equipment. However, the LIRE database has not been updated, and is not currently in active use. The development of a central database of RI to replace LIRE which is accessible to public and private sector would facilitate the realisation of the full benefits of publicly funded infrastructure.

Indecon believes that the SFI RI Programme has been effective but that a greater co-ordination of national strategy for research infrastructures is needed. An oversight and coordination group could help in guiding many aspects of national policy in a way that reflects the evolving changes in society, the economy, and in the research community itself. Such a group could help inform the national prioritisation for RI, promote greater collaboration and usage of RI, and identify emerging issues faced by the research community and industry. We also note that the research needs of Technological Universities are likely to change rapidly in the coming years, as reflected in the research and innovation metrics set in legislation for TUs/TU consortia to achieve. Indecon believes that greater tracking of TUs use of RI should be carried out.

Indecon’s analysis suggests that the wider economic and research impact of RI infrastructure is significant. With the adjustments proposed the full benefits of this important investment will be realised.

8.3 Recommendations for Future SFI RI Programmes

In this section we summarise recommendations for improvement in the SFI RI Programme, which are discussed in the subsequent text. These are designed to build on the achievements of the current Programme and to enhance its impact. These are consistent with our recommendations for a national approach to research infrastructure.

Table 8.1: Summary of Recommendations for Future SFI RI Programmes
1.1: All future applications for new SFI RI supports to take account of maintenance/upkeep costs.
1.2. Dedicated funding for upkeep/maintenance of existing and new RI
1.3. Continue current focus on large-scale investments
1.4. Access plans should be published online and made publicly available
1.5. Additional weight to projects which leverage external sources of funding and joint projects
Source: Indecon

1.1: All future applications for new RI SFI supports to take account of maintenance/upkeep costs: As noted in Recommendation 2.4 below, the maintenance, upgrading and operation of research infrastructure is a key element of ensuring that public investment in Ireland's national stock of research infrastructure is optimised. The SFI RI Programme can support this by requiring that future Programmes which fund new RI require, as one of the selection criteria, to provide sufficient evidence showing the sustainability of that RI in the medium to long term. This would include allowing applicants to apply for funding through the Programme for service contract, maintenance costs and other upkeep costs (e.g., software upgrades) for the lifetime of the equipment, or applicants setting how maintenance and upkeep would otherwise be achieved.

1.2. Dedicated funding for upkeep/maintenance of existing and new RI: While the implementation of Recommendation 1.1 above would help in funding the support and maintenance required for new RI, there exists a significant stock of RI in need of investment, including investments made as part of historical PRTLI calls dating back to 2000. As part of the next call of the RI Programme, SFI should consider dedicating a proportion for the upkeep and maintenance of existing and new RI or ensure co-ordination with other government departments and agencies to ensure funding is provided. Depending on the quantity and quality of applications received, this could be repeated in future Programme rounds.

1.3. Continue current focus on large-scale investments: Over the course of the period from 2015 to 2021, there was a change in emphasis within the SFI Programme towards larger calls. This is reflected in both the minimum size of SFI budget request as set out in the call documentation, as well as the average larger size of award in 2018 compared to 2015. Larger calls are more associated with collaboration, are more likely to have published access plans, and show a greater time in use. Further, it is likely that a focus on higher cost RI increases the additionality of the Programme, by supporting investments which may not have been otherwise made in the absence of SFI funding. As such, we recommend that the SFI Programme continues to focus on large-scale investments in areas of national priority but includes provision for targeted small-scale projects.

1.4. Access plans should be published online and made publicly available: Research Infrastructure should be viewed as 'national assets' and not solely institutional ones. A culture of collaboration,

sharing, and accessibility must be fostered to ensure they are utilised effectively. This study shows that for many projects, including many large projects, access plans are not published online and made publicly available. The process for ensuring that access plans are published should be strengthened. For example, this could be done by tracking and reporting the percentage of RI awardees by institution that have published up to date access plans. Any request for funding to support the upkeep/maintenance of existing and new RI should also be made contingent on access plans being published online and made publicly available.

1.5. Additional weight to projects which leverage external sources of funding and joint projects:

The SFI Programmes make mention of a number of important aspects as part of the call process. These include setting out recommended cost shares to leverage funding, facilitating a more rapid commercialisation of research, encouraging strategic infrastructural planning by research bodies, and the fostering of collaboration and partnership between researchers, including in Northern Ireland. Indecon believes that significant weight should be given to projects which leverage external sources of funding, and to joint projects involving a number of institutions. Indecon note the 2021 call was developed to place emphasis on broad collaboration and usage in Ireland, and this emphasis should continue. In terms of leveraging of income, as well as public funds (whether Irish or European) and industry contributions, consideration should be given to the potential role of philanthropy in developing the RI in Ireland. In terms of joint projects, large scale investments which are applied for jointly by more than one higher education institution should be given particular consideration in the evaluation process.

8.4 Recommendations for National Approach to RI

In this section we set out recommendations regarding the national approach to RI. These are summarised in Table 8.2 and discussed in greater detail in the subsequent text. These are designed to build on the success of the investment made in Research Infrastructure.

Table 8.2: Summary of Recommendations re. National Approach to Research Infrastructure
2.1. Consider the establishment of a national RI oversight group
2.2. Develop a RI roadmap
2.3. Track access by TUs to RI in other institutions
2.4: Develop supports for the sustainable operations and maintenance of RI
2.5: Develop and maintain a national centralised database of RI and its utilisation
Source: Indecon

2.1. Consider the Establishment of a National RI oversight group: Indecon believes there is merit in the Government considering setting up an oversight and coordination group to establish the national prioritisation for RI investment. This would build on existing initiatives which have been taken and could involve mechanisms to facilitate sharing of infrastructure among institutions and industry users.

This group might also consider establishing a common evaluation framework to guide the allocation of resources available from different funds and include key metrics to measure the impact of RI investment. This group could also suggest initiatives to enhance interoperability among RIs; and engagement by research-and-innovation communities.

2.2. Develop a RI roadmap: A greater co-ordination of national strategy for research infrastructures could be achieved through the development of a roadmap for RI investment in Ireland. Securing the appropriate long-term structures, processes and principles, combined with a multi-annual strategy, should be a priority for RI in Ireland. The process of developing a roadmap could involve the RI oversight group and co-ordinate views from Government departments and agencies, the higher education sector, representatives of industry, and other important stakeholders. This roadmap could build on and be guided by the new national strategy for research and innovation, *Impact 2030*.

2.3. Track access by TUs to RI in other institutions: Technological Universities (TUs) will require significant increases in research and innovation capacity in the coming years to meet targets set down in legislation. In the short to medium term, it will be important that researchers in TUs have access to existing RI investments where appropriate. This could be supported by ensuring that a national centralised database of RI is created (see Recommendation 2.5 below), and also that access plans are in place setting out terms of usage.

2.4: Develop supports for the sustainable operations and maintenance of RI: The maintenance, upgrading and operation of research infrastructure is a key element of ensuring that public investment in Ireland's national stock of research infrastructure is optimised. Outdated equipment, or the lack of personnel with the right skillsets to operate it effectively, would undermine Ireland's ability to deliver world class research in a globally and highly competitive environment. The continuous support and maintenance of equipment requires the development of a funding model that can ensure equipment remains effective over its lifetime. Whether as part of the SFI RI Programme or otherwise, Ireland needs to consider funding mechanisms to provide sustainable operations and maintenance of existing and new RI.

2.5: Develop and maintain a national centralised database of RI and its utilisation: The development of a central database of RI which is accessible to public and private sector could facilitate the realisation of the full benefits of publicly funded infrastructure. Innovation 2020, the Irish Government's strategy for research, development, science and technology, states that in making future investment decisions, system efficiencies must be continuously sought, for instance through the provision to industry of access to infrastructure promoted through online resources. The existing LIRE database is currently not accessible to researchers. A new national database should be created providing details of RI investments including access plans, indicating what RI is available to other researchers and industry, and who the contact point is. To ensure high levels of take-up and use, this database needs to be maintained online, made easily searchable by research area, and the status of the RI in question should be updated on a regular basis (e.g., regarding availability, contact details, whether it is fully functioning, etc.). This new database could replace the current LIRE database.