

Submission by the Royal Irish Academy to the Consultation on the Successor to the Strategy for Science, Technology and Innovation

March 2015



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Executive Summary

Response to consultation paper

In the following sections, the Royal Irish Academy (hereafter, the Academy) sets out its response to several of the questions posed within the Consultation Paper for a Successor to the Strategy for Science, Technology and Innovation. In doing so, it has selected themes about which it feels it is particularly qualified to comment, drawing from the collective expertise of its membership representative of the most distinguished Irish scholarship in the humanities, social sciences and science-based disciplines. Before doing so, however, the Academy wishes to emphasise at the outset some key considerations that it believes need to underpin any future strategy for science, technology and innovation (STI), and which are insufficiently addressed either within the consultation paper or within the questions to which a response has been invited.

The importance of excellent people and talent in delivering on the ambitions of the strategy.

Success at global level in research and innovation is critically dependent on nurturing a qualified cohort of excellent people, at every level of the system, ranging from school-leavers to PhD graduates, from primary-school teachers to internationally renowned academic researchers. The next national strategy to 2020 should recognise that the most effective transfer of research skills and insights from academia to industry and wider society takes place through the employment of graduates. While pillar 8 of the consultation paper recognises ‘developing human capital’ as a factor within a strategy for STI, the importance of excellent people to every pillar and across the entire strategy needs much greater recognition than at present. Another critical aspect is to address the serious current under-representation of women in science, technology, engineering and mathematics (STEM)-related research.

The importance of achieving a balanced portfolio of competitively-awarded publicly-funded research between areas of research priority and other areas.

In his address to the Academy in November 2014, Professor Jean-Pierre Bourguignon, president of the European Research Council (ERC), argued ‘If science is to make truly influential innovations, funding cannot be short-sighted. To maintain a healthy research ecosystem, it is right to invest substantially in long-term curiosity-driven research as well as in more targeted endeavours.’¹ While the Academy notes the consultation paper’s assertion that research prioritisation will continue within the new strategy, it strongly urges that the new strategy explicitly recognise the need and importance of designating a significant proportion of publicly

¹ Address by Professor Jean-Pierre Bourguignon, president of the European Research Council, to the Royal Irish Academy, 14 November 2014.

funded research for competitive-funding awards across *all* disciplines so as to support a strong baseline of scholarly-based research enquiry based on excellence. This should include research in the humanities and social sciences (HSS) as well as the full range of science-based disciplines not directly identified with a particular topic of research priority. The importance of research in the HSS within research prioritisation should be more clearly acknowledged.

Recognition of the currently weakened state of Ireland's higher-education sector.

The Academy believes that leading-edge research is best conducted within a research-intensive, autonomous, higher-education (HE) environment, where positive interdisciplinary synergies between scientific discoveries, education and human-capital development, and enterprise and wider civic engagement can be fully exploited. A great part of the aspirations to be contained in the strategy for STI will rest on the quality and vitality of Ireland's HE system, and yet the last eight years have seen a serious reduction of the funding base of the system, a significant decline in academic staff numbers, and a major increase in undergraduate-student numbers that is projected to continue into the future. These realities and their implications are inadequately reflected in the consultation paper.

The next national science strategy to 2020 should:

- Recognise and take into account that Ireland's future research-and-innovation excellence is in danger of being undermined by reduced investment in higher education coupled with increasing demands upon the sector, especially from rising student numbers.
- Recognise *people* as the bedrock for Ireland's future success in research, innovation and education.
- Support a more balanced portfolio of competitively awarded research funding for all disciplines across areas of prioritisation/applied research as well as curiosity-driven research.
- Explicitly recognise the value and importance of HSS research, and include specific actions to support its advancement.
- Promote gender-sensitive practices to address current challenges specifically with regard to the retention and progression of females within academia, research and STEM careers.
- Consider a range of measures to meet supply and demand for trained researchers including but not confined to post-graduation residency work permits and new targets for doctoral-graduate rates.
- Include public engagement as a key strand.
- Review the processes by which government science, technology and innovation policies and processes are developed and evaluated.

Introduction

The Royal Irish Academy/Acadamh Ríoga na hÉireann, Ireland's national academy for the sciences, humanities and social sciences, welcomes the opportunity to respond to the background paper prepared to inform the deliberations of the Interdepartmental Committee on Science, Technology and Innovation (IDC) as it works towards a successor to the Strategy for Science, Technology and Innovation 2006–2013 (SSTI).² Detailed submissions from the Academy's committees for engineering and computer science, life and medical sciences, and physical, chemical and mathematical sciences are included as appendices.

Ireland is at a unique point in terms of its development as a research-intensive economy, supported through both indigenous and foreign direct investment. Ireland is enjoying internationally enviable growth in student numbers throughout its primary, secondary and tertiary education systems. This continuing growth in student numbers comes at a time when the substantial investment in the research-and-development ecosystem since the late Nineties is beginning to pay dividends, as evidenced by numbers of researchers, high-quality publications, patents, academy–industry interactions and a growing international reputation for research achievement.

The fortunate coexistence of favourable demographics, with a growing and young population, internationally recognised talent in major science, humanities and social science disciplines, and an enhanced research-and-development ecosystem as a result of significant previous public investment is an excellent starting point for the next phase in the evolution of national science strategy.

²The Royal Irish Academy expresses its thanks to the following members of the Royal Irish Academy for their significant contribution to the preparation of this paper: Professor Tom Brazil, Professor Eugene Kennedy and Professor Imelda Maher; and for the contribution of the Academy committees in the sciences, humanities and social sciences. The views expressed in this submission are not necessarily shared by each individual member of the Academy. Please note that the Academy made an earlier submission to the IDC, 'Principles to Underpin the New National Science Strategy to 2020', which can be viewed at <http://www.ria.ie/about/our-work/policy/academy-advice-papers-.aspx>

Context

Before we can plan for the future we need to be clear on Ireland's starting baseline: where we are, what we have achieved, what works well, what could be improved, and how we measure up relative to suitable comparator countries. The 2014 Forfás review of the implementation of SSTI provides some useful insights,³ as does this particular consultation document. Further evidence will emerge as the numerous ongoing reviews commissioned by the Department of Jobs, Enterprise and Innovation (DJEI) to examine the implementation of research prioritisation, future research-infrastructure needs and membership of international research organisations are completed and shared with stakeholders.

By international standards, Ireland has a well-educated population, and Ireland's universities are more focused on science, technology and maths than many comparator countries.⁴ There was a dramatic advancement of research capacity and achievement in Ireland from the late 1990s up until the mid-2000s:

- In 2008 Ireland appeared in the 'Top countries listed by citations per paper in all fields' for the first time. In the period 2001–11 Ireland moved from thirty-sixth to twentieth place in the world.⁵
- In the period 1981–2013 the number of research papers produced in the EU-27 increased by nearly 200 per cent. Over the same period, the number of research papers produced in Ireland increased by over 560 per cent.⁶
- At the same time, Ireland more than doubled its percentage share of world research papers in the period 1981–2013. Currently, Ireland produces 0.55 per cent of all world research papers.⁷
- Ireland's research impact has exceeded the world average over the past ten years, and is rising (the world baseline is 1.0, Ireland is at 1.4).⁸
- SSTI goals for growing the number of doctoral graduates in HSS and STEM disciplines were exceeded ahead of schedule.⁹

³ Forfás, 2014, Summary of Findings of Data Review of RD&I in Ireland, internal paper produced for the Department of Jobs, Enterprise and Innovation (hereafter Forfás, 2014).

⁴ Forfás, 2014, 3.

⁵ Thomson Reuters Essential Science Indicators cited by N. Brennan, 'Harnessing the H-index: presentation to the FHS Development Seminar, December 2014, <http://www.healthsciences.tcd.ie/assets/doc/HR%20presentation%20-%20Research%20Office%20-%20Niamh%20Brennan.pdf>

⁶ Ibid.

⁷ Ibid.

⁸ In the early 1980s the impact of Irish research was on a par with Greece, Poland and Portugal. From 2000 onwards Ireland's research impact grew, exceeding the world, EU-27 and (by 2008) the OECD averages; *ibid.*

⁹ HSS rates grew from 198 in 2005 to 377 in 2010, an increase of over ninety per cent on 2005. The number of SET PhD graduates from the university sector also grew in line with the SSTI target, from 576 in 2005 to 776 in 2010 (Forfás, 2014, 7).

Response to consultation paper

In the following sections, the Academy sets out its response to several of the questions posed within the Consultation Paper for a Successor to the Strategy for Science, Technology and Innovation. In doing so, it has selected themes about which it feels it is particularly qualified to comment, drawing from the collective expertise of its membership representative of the most distinguished Irish scholarship in the humanities, social sciences and science-based disciplines. Before doing so, however, the Academy wishes to emphasise at the outset some key considerations that it believes need to underpin any future STI, and which are insufficiently addressed either within the consultation paper or within the questions to which a response has been invited.

The importance of excellent people and talent in delivering on the ambitions of the strategy.

Success at global level in research and innovation is critically dependent on nurturing a qualified cohort of excellent people, at every level of the system, ranging from school-leavers to PhD graduates, from primary-school teachers to internationally renowned academic researchers. The next national strategy to 2020 should recognise that the most effective transfer of research skills and insights from academia to industry and wider society takes place through the employment of graduates. While pillar 8 of the consultation paper recognises ‘developing human capital’ as a factor within a strategy for STI, the importance of excellent people to every pillar and across the entire strategy needs much greater recognition than at present. Another critical aspect is to address the serious current under-representation of women in science, technology, engineering and mathematics (STEM) research.

The importance of achieving a balanced portfolio of competitively-awarded publicly-funded research between areas of research priority and other areas.

In his address to the Academy in November 2014, Professor Jean-Pierre Bourguignon, president of the European Research Council (ERC), argued ‘If science is to make truly influential innovations, funding cannot be short-sighted. To maintain a healthy research ecosystem, it is right to invest substantially in long-term curiosity-driven research as well as in more targeted endeavours.’¹⁰ While the Academy notes the consultation paper’s assertion that research prioritisation will continue within the new strategy, it strongly urges that the new strategy explicitly recognise the need and importance of designating a significant proportion of publicly funded research for competitive-funding awards across *all* disciplines so as to support a strong

¹⁰ Address by Professor Jean-Pierre Bourguignon, president of the European Research Council, to the Royal Irish Academy, 14 November 2014.

baseline of scholarly-based research enquiry based on excellence. This should include research in the humanities and social sciences (HSS) as well as the full range of science-based disciplines not directly identified with a particular topic of research priority. The importance of research in the HSS within research prioritisation should be more clearly acknowledged.

Recognition of the currently weakened state of Ireland's higher education sector.

The Academy believes that leading-edge research is best conducted within a research-intensive, autonomous, higher-education (HE) environment, where positive interdisciplinary synergies between scientific discoveries, education and human-capital development, and enterprise and wider civic engagement can be fully exploited. A great part of the aspirations to be contained in the strategy for STI will rest on the quality and vitality of Ireland's HE system, and yet the last eight years have seen a serious reduction of the funding base of the system, a significant decline in academic staff numbers, and a major increase in undergraduate-student numbers that is projected to continue into the future. These realities and their implications are inadequately reflected in the consultation paper.

Pillar I

Investment in STI and key goals/targets

What should Ireland's ambition be in STI?

Building a strong, excellent, sustainable research-and-innovation system is a demanding but vital goal for Ireland. The new strategy should be visionary and ambitious, anticipating the challenges of the kind of radically different Ireland that our younger citizens will grow into over the next fifteen to twenty years.

The next national strategy to 2020 should:

- Continue to sustain and grow levels of investment in research and development in the higher-education sector in a manner complementary to the goals of the National Strategy for Higher Education to 2030 so as to enable the integration of national goals in research, innovation and education.
- Recognise that state and higher-education-supported research centres are key vehicles in the delivery of national research, education development and innovation goals: they represent a set of centres focused on research excellence, with many having significant industrial linkages and collaborations, and all support the educational mission of higher education.
- Recognise *people* as the bedrock for Ireland's future success in research, innovation and education.
- Support a more balanced portfolio of competitively awarded research funding for all disciplines across areas of prioritisation/applied research as well as curiosity-driven research.
- Recognise the value and importance of HSS research, and include specific actions to support its advancement.
- Promote gender-sensitive practices to address current challenges specifically with regard to the retention and progression of females within academia, research and STEM careers.
- Consider a range of measures to meet supply and demand for trained researchers including but not confined to post-graduation residency work permits and new targets for doctoral-graduate rates.
- Include public engagement as a key strand.
- Review the processes by which government science, technology and innovation policies and processes are developed and evaluated.

Should Ireland have more ambitious targets for investment?

Yes, the next strategy should set more-ambitious targets for public and industry investment in research, development and education. In setting these targets, however, the strategy must recognise and take into account that Ireland's future research-and-innovation excellence is in danger of being undermined by reduced investment in higher education coupled with increasing demands upon the sector. Ireland's HE sector is greatly weakened as a result of significant institutional changes and recent cutbacks. Exchequer funding for HE declined from €2 billion in 2009 to €1.5 billion by 2014;¹¹ total spending per tertiary student showed a 20.1 per cent decrease in real expenditure per full-time student between 2003 and 2012; HE expenditure on research and development (HERD) fell approximately €100 million between 2006 and 2013. At the same time, the HE system has been absorbing significant additional students—up from 59,485 in 2006 to 73,091 in 2013–14.¹²

The decline in core funding has resulted directly in a significant reduction in the number of academic staff and increased substantially their individual workloads associated with teaching and administration of the increasing numbers of undergraduate students. This has serious implications for their continuing ability to write new research proposals as well as act as principal investigators for research projects.

How can that level of ambition be justified? Where would we target increased funding and how could this be justified?

Future iterations of national science strategy should have as a key objective the achievement of a more balanced portfolio of competitively awarded research funding for all disciplines across areas of prioritisation/applied research and curiosity-driven research. Ireland's research-funding instruments should allow **researchers to compete for regular and substantial project funding¹³ based first and foremost upon the excellence of their research question and their track record. The strategy to 2020 should redress the balance of funding for research-funding agencies**, specifically Science Foundation Ireland (SFI) and the Irish Research Council (IRC) for research-project funding.¹⁴ The time frame for this redress is important and should happen gradually to naturally build capacity in areas and so as to avoid funding areas in which the absorptive capacity is not yet adequate.

¹¹ Department of Education and Skills; Central Statistics Office.

¹² By comparison, at the time of the first SSTI, CAO acceptances for third-level institutions stood at 59,485. CAO acceptances for the academic year 2013/14 stood at 73,091, up 2.7 per cent on the previous year.

¹³ Such funding provides the necessary competitive foundation from which researchers can move to compete for international funding. The capacity to win, manage and ensure the delivery of a research project is a key competency sought in international funding competitions: this requires a meaningful line of national project funding to allow researchers to demonstrate this capacity.

¹⁴ This calculation is based upon an understanding that the budgetary allocation to the Irish Research Council and used to support postgraduate and PhD training and education should not be considered as providing a research-project grant but rather fulfils the SSTI mission of enhancing Ireland's population of skilled researchers.

European research-funding bodies such as the ERC cannot act as a substitute for national research funding. Drilling down through the international university league tables reveals that disciplines in the humanities and social sciences play a vital role in pulling Irish universities up the rankings. Similarly, the success rates of HSS researchers in ERC competitions is growing, but there is extremely limited national funding available for HSS researchers who fail to win an award but who show significant promise for future success. The next strategy to 2020 should look to address this gap.

The strategy to 2020 should support the creation of a **mini European Research Council-style funding scheme**, *open to all disciplines* irrespective of national research priorities, in order to further build the capacity of Irish researchers to succeed at the ERC. Given that SFI's legal remit precludes it from funding outside of the National Research Prioritisation Exercise (NRPE), such a scheme could be held and run by the IRC.

Business investment in R&D into academia remains low when looked at against Ireland's comparator countries, and while philanthropy can—and does—play a valuable role in stimulating new research, it is an unreliable foundation upon which to build a sustainable critical mass of expertise. The next strategy to 2020 should have as a clear **goal to grow business expenditure on research and development (BERD) intensity to at least the OECD average**, and to grow the percentage of HERD financed by industry to EU-27 and OECD average.¹⁵

¹⁵ In 2010 just 3.8 per cent of Irish HERD was financed by industry, and 2 per cent by business. The percentage of HERD financed by industry is well below both the EU-27 and OECD averages (Forfás, 2014, 5).

Pillar 2

Prioritised approach to public research funding

How can research prioritisation better serve our national objectives of a strong sustainable economy and a better society?

Ireland's HERD has declined, the vast majority of competitively awarded public R&D funding across state funding agencies is now funnelled to fourteen prioritised areas as per the NRPE, and there is a comparatively slim line of funding available for non-NRPE related research.¹⁶ There is a widespread feeling amongst researchers that the current public research-funding structure fails to recognise the complex, integrated and interconnected nature of much scientific endeavour. Many researchers within the HE sector seamlessly move back and forth between basic research, teaching and learning activities, and exploration of commercialisation opportunities. This type of integration is vital to ensure the long-term health of the research-and-innovation ecosystem.

The NRPE was a three-pillar structure, but to date the research for knowledge and research for policy pillars has been underdeveloped.

Future iterations of national science strategy should have as a key objective the achievement of a more balanced portfolio of competitively awarded research funding for all disciplines across areas of prioritisation/applied research and curiosity-driven research. Ireland's research-funding instruments should allow **researchers to compete for regular substantial project funding based first and foremost upon the excellence of their research question and their track record.** The strategy to 2020 should **redress the balance of funding for research-funding agencies**, specifically Science Foundation Ireland (SFI) and the Irish Research Council (IRC) for research-project funding. The time frame for this redress is important, and should happen gradually to naturally build capacity in areas and to avoid funding areas in which the absorptive capacity is not yet adequate.

The **Prioritisation Action Group (PAG)** or its successor could usefully consider how best to ensure sufficient flexibility in the application of the NRPE within the wider overall research strategy so as to allow research funders to respond to and fund emerging opportunities based on excellence.

¹⁶ This is not to overlook the funding supplied by the Irish Research Council (and the previous Programme for Research in Third Level Institutes (PRTLTI) programmes) for support for training (postgraduates, PhDs, post-doctoral) in all disciplines irrespective of research area, which has proved central to Ireland's success in meeting SSTI targets in respect of growing the number of researchers in Ireland's population. Nonetheless, one cannot deny that the pot of money for research outside the prioritised areas is slim (following cessation of PRTLTI funding), with such awards as are offered by the Irish Research Council proving extremely competitive and with a much smaller rate of success than other comparator countries.

The Academy is representative of the scholarship across the sciences and the HSS, and urges the IDC to give appropriate **recognition to the importance of HSS-based research** in developing and implementing the strategy to 2020 and in any further iterations of the NRPE. Ireland's international reputation for research excellence depends substantially upon the humanities, with successive international rankings placing humanities disciplines in the highest bracket internationally.¹⁷

The great research challenges facing society are complex and interdisciplinary in nature, and require a broader response than can be provided solely by traditional science, technology, engineering and mathematics disciplines. Support for excellent research within a wide range of disciplines and across multidisciplinary teams in STEM plus the HSS will pay rich dividends in terms of building diversity within the research ecosystem and in opening up new breakthrough areas of research and application. This in turn will position Ireland as a world leader in research pertinent to major global challenges.¹⁸

How best do we identify emerging areas of opportunity and challenge—i.e. horizon scanning?

Consideration should be given to the initiation of a **foresight exercise** bringing together the research performers, key government departments, funders and public research organisations to identify emerging and existing areas of research-and-innovation excellence—likely areas of strategic research that Ireland can leverage for economic and societal benefit. **As Ireland's leading body of experts in the sciences, humanities and social sciences, the Royal Irish Academy would be delighted to assist the government and its agencies with such an exercise.**

¹⁷ Response by the Irish Humanities Alliance to the consultation paper for the successor to the Strategy for Science, Technology and Innovation, March 2014, <http://irishhumanities.com/>

¹⁸ For example, Irish researchers have already made important contributions as authors and reviewers of the Intergovernmental Panel on Climate Change (IPCC) assessment reports and in the development of European policy on sustainable energy and the development of low-carbon economies. We need to ensure that they can contribute to the next IPCC assessment report, the preparation of which is now under way, by supporting nationally relevant research in this area (internal submission by the Academy Committee for Climate Change and Environmental Sciences to the Academy Working Group on the Successor to the Strategy for Science, Technology and Innovation, March 2014).

Pillar 4

International collaboration and engagement

How can we further increase/strengthen the effectiveness of our international collaboration and engagement across all areas of STI investment in pursuit of economic and societal goals?

The consultation paper speaks persuasively to the importance of **Horizon 2020** funding while also recognising the extremely competitive nature of these funding schemes. The active dialogue fostered by the IRC, the HSS research community and the national delegate to the Societal Challenge 6 Programme Committee is an excellent example of how to connect and engage researchers in framing and shaping research questions at a European level. The current host of schemes to support researchers to develop proposals for Horizon 2020 funding (for example, Enterprise Ireland support schemes) provides valuable support and should be continued. Funding mechanisms to support access to international research infrastructures should be explored as part of the ongoing review of Ireland's research-infrastructure needs.

In terms of future opportunities, the 2014 European Commission Communication (July 2014) paves the way for an integrated approach to cultural heritage in Europe and seeks to make Europe a centre for heritage-based innovation. There are currently, and will into the future be, enhanced research, training and education support programmes to support this objective. This requires enhanced engagement by Ireland, and a coherent approach and policy to facilitate Ireland's participation at a European level.

Are there research policy or programme developments taking place at EU level where enhanced engagement by Ireland could provide opportunities for research collaboration and ultimate economic or societal benefit?

Fostering and supporting international engagement and collaboration by Irish researchers should be a central objective of the next science strategy. The Royal Irish Academy supports Irish researchers in their participation in high-level, academy-led research-and-education policy forums in Europe and globally. Examples of such activities include Irish membership of the All European Academies (ALLEA) working groups on e-infrastructures, open access and research integrity; membership of the board of the European Academies Scientific Advisory Council; and membership of the International Council of Science Unions Committee for Scientific Review and Planning. Such forums offer significant opportunities for Irish researchers to ensure the voice and perspectives of Irish science and research are influential in defining the issues to be addressed and in shaping the overall outcomes. The Academy also supports the participation of Irish scientists in highly prestigious scientific working groups that provide analyses of the scientific evidence applicable to topical policy issues for the European Commission: recent issues examined include GM crops and antibiotic resistance. This type of international collaboration serves not only to increase the international networks of the individual participant but, equally importantly, to showcase the world-excellent calibre of Irish science.

Pillar 5

Organisational/institutional arrangements to enhance research excellence and deliver jobs

- What could we do to further enhance our landscape and institutional arrangements to maximise the impact of research excellence and deliver jobs?

The next national strategy to 2020 should:

- Expand membership of key STI governance and oversight structures.
- Review the processes by which government science, technology and innovation policies and instruments are evaluated.
- Invest in appropriate national digital infrastructures.

Expand membership of key STI governance and oversight groups

The strategy to 2020 should not be understood as the responsibility of any one government department, funding agency or research performer. Each has a role to play. The key role of **research performers should be recognised in representation in the oversight group** for the next strategy to 2020 as well as in the implementation groups associated with each of the research-prioritisation thematic areas.¹⁹

The absence of the Department of Arts, Heritage and Gaeltacht (DAHG) from membership of the IDC is considered a weakness in the structure given the importance of its relevant sectors: culture, heritage and tourism to Ireland. The absence, for example, of any reference to cultural policy in pillar 7 is striking, and perhaps reflects the lack of DAHG representation in the formative discussions.

Review the processes by which government science, technology and innovation policies and instruments are evaluated

The strategy to 2020 should include actions to develop a structure for ongoing critical review and policy studies of research expenditure, **independent of the agencies involved in research funding**. This function is often executed through the office of the chief scientific adviser in other countries. However, the current scenario that sees the director of the largest scientific public funder in Ireland also acting as the chief scientific adviser creates a potential conflict of interest and makes this a less-viable option for Ireland. An immediate action that can be taken is to ensure that research performers are directly represented on STI review-and-evaluation committees/groups. Further transparency could be achieved by advertising such

¹⁹ The first SSSI PAG included government departmental representatives but did not include representatives of the main research performers.

opportunities and inviting researchers to apply in a process similar to the appointments procedure for state boards.²⁰

Invest in appropriate national digital infrastructures

It is important for Ireland to have trusted digital repositories for storage, preservation, access and exploitation of digital content, including research data. The average lifetime of a weblink is a hundred days; exploitation of digital content relies on stable, robust sources of curated content.

A key aspect to enable this is the development of funding instruments that accommodate the medium to long-term view required to maintain and grow a national digital infrastructure that can achieve optimal performance and engagement with the designated user communities. Big data, data analytics, digital-content exploitation, secondary analysis and research reproducibility all benefit from stable access to open-data services. The Digital Repository of Ireland is one such national digital infrastructure, and is an enabler for Irish researchers seeking Horizon 2020 funding and helps Ireland to achieve open data.

Is there a need for a complementary market-focused research-centre structure in Ireland, and how should this be organised?

A view of this kind is sometimes expressed—i.e. that a new institutional sector of research performers is needed in Ireland, separate from the HE sector. While exemplars on both sides of this case can be found, the Academy considers that leading-edge research is best conducted within a research-intensive, autonomous, higher-education environment where positive interdisciplinary synergies between scientific discoveries, education and human-capital development, enterprise and wider civic engagement can be fully exploited.

²⁰ For more information on this process see <http://www.per.gov.ie/appointments-to-state-boards> (accessed 21 March 2015).

Pillar 8

Research for knowledge and developing human capital

What more can we do to best harness the potential of our knowledge base for sustainable economic and social well-being?

The strategy to 2020 should build upon previous government strategies, including research prioritisation, in recognising that people are at the centre of Ireland's future success.²¹ Training, retaining and creating human capital is a matter for all government bodies, research performers, industry and research funders.

What additional steps can government take to ensure the development of human capital across the population to ensure the success of the new strategy?

In order to achieve a sustainable research capacity, are the outputs of our research system at doctoral and postdoctoral level the right ones in term of volume, quality and relevant discipline?

The next national strategy should:

- Include actions to grow graduation rates at doctoral level across STEM and HSS disciplines to at least the OECD average.
- Support the roll-out of the National Framework for Doctoral Education.

Achieving research, innovation and societal goals requires talented people with the right skill set and knowledge base in academia, public research organisations, schools, media, government and industry. A persistent issue for many high-technology companies wishing to expand in Ireland is the shortage of quality graduates with the necessary skills.

The achievement of the SSTI targets in respect of PhD training represents a clear success story: the higher-education institutions achieved a substantial increase in graduation rates at doctoral level between 2000 and 2009.²² However, Ireland's graduation rates at doctoral level remain below the OECD average.²³ The strategy to 2020 should commit to actions to grow graduation rates at doctoral level across STEM and HSS disciplines to at least the OECD average, and clearly identify how this training will be funded.

²¹ DJEI, 2014, National Research Prioritisation Exercise: First Progress Report June 2014, http://www.djei.ie/publications/science/2014/NRPE_First_Progress_Report.pdf

²² These goals were among the most successful of SSTI. Ireland's HEIs have successfully grown the proportion of new doctorates awarded to science and engineering graduates to a point where this is among the highest in the OECD. SET (science, education and technology) PhD graduates from the university sector grew in line with the SSTI target from 576 in 2005 to 776 in 2010. The SSTI goals set for growing the number of doctoral graduates in humanities and social-science disciplines were exceeded in advance of schedule (from 198 in 2005 to 377 in 2010), an increase of over ninety per cent on 2005 and ahead of the SSTI target of 282 (Forfás, 2014, 7).

²³Forfás, 2014, 7.

The strategy should support initiatives to enhance Ireland's reputation as a destination country offering the highest-quality graduate and doctoral education. The Higher Education Authority (HEA) and Quality and Qualifications Ireland will shortly launch a **National Framework for Doctoral Education**, developed in consultation with the university and institute-of-technology sector. The roll-out and implementation of this framework should be seen as a key enabling activity for the strategy to 2020.

How can we better leverage our research talent into the economy?

- Ireland's immigration policy is likely to be a crucial enabler for future success in STEM research and innovation.
- Possible measures include a postgraduate work-permit programme for researchers in strategically important research areas, and a streamlined application process for research visas/residency/work permits for researchers in strategically important research areas and for outstanding performers across all disciplines.

The strategy to 2020 should be used to further build Ireland's population of highly skilled graduates and researchers.

There is a clear need for 'joined-up thinking' and implementation in fast-tracking visa/citizenship/postgraduate work-permit applications for non-European Union (EU) citizens in strategically important research areas, including, but not confined to, those areas associated with the NRPE.

Many of those undertaking graduate education in Ireland originate from outside of the country and represent a high-value import of talent and financial support for Irish HEIs, but one that is not easily retained beyond the period of their studies.²⁴ Retaining talented graduates with specific skills necessary to the Irish economy should be made easier. For example, international students graduating from Canadian universities are actively encouraged to take up employment in the country via the postgraduate work-permit programme.²⁵ This offers graduates a work permit for a period of time up to the duration of their course.

How can gender equality in publicly funded research activity be further enhanced?

- There is a clear need for actions to tackle low rates of female progression and poor retention of women within research and education roles to be central to the strategy to 2020.
- Publicly funded HEIs and R&D STEM centres should aspire to winning a Gold Award from Athena SWAN within five to ten years.

The continuing poor progression, and retention, rates of female academics and researchers into senior grades in academia and in STEM careers represents a significant loss of natural talent and resources for Ireland. Women are massively under-represented in senior academic positions across virtually all of the country's third-level institutions—fewer than one in five of all

²⁴ The 2011 census shows that around thirty-six per cent of PhDs in the country were born outside Ireland (Forfás, 2014, 7).

²⁵ For more information see <http://www.cicnews.com/2013/10/work-canada-graduation-postgraduate-work-permit-102966.html>

professors are female.²⁶ At the same time, more and more women are taking STEM undergraduate courses and completing doctoral training.²⁷ A 2012 report by the Royal Society of Edinburgh shows the stark economic imperative of tackling this challenge: it estimated that the Scottish economy could add £170 million (c. €197 million) if it doubled the number of women staying in science, as these women would be likely to earn high salaries.²⁸ Professor Alan Smeaton MRIA has recently drawn attention to this issue:

We have role models, such as Aoife McLysaght, who was on the team that analysed the initial sequence of the human genome; Emma Teeling, who studies the genome of the bat and why it lives for so long; Mary O’Connell, who in 2014 had papers published in *Science*, *Nature Reviews* and *Cell*, three of the top-ranked journals in the world; and Linda Doyle, who directs the Centre for Telecommunications Value-Chain Research (CTVR) centre, one of the most successful of such centres in the world. The world-class work of these women, and many more like them, deserves to be highlighted and used to inspire others to follow in their footsteps and help to make STEM an even more powerful contributor to this country.²⁹

Proactive measures on the part of research-funding agencies and public research organisations to address issues of gender bias and gender discrimination, and to recognise and respect diversity (whether in relation to ethnicity, cultural background or sexual orientation) within Ireland’s population of researchers should be warmly recognised and supported. The launch earlier this year of the Athena SWAN Awards in Ireland is a welcome step by HEIs in tackling some of these challenges.³⁰

The strategy to 2020 could support additional **gender-sensitivity initiatives**. For example, an EU-funded project recommended that all committees making decisions about public R&D expenditure on science and scientific funding should have at least a thirty-per-cent female membership³¹ Within research centres and industry, the strategy should promote initiatives that address issues of recruitment, promotion and career development of staff; the allocation of workload; the timing of meetings and outreach activities; support for new employees; mentoring of female students; and support for existing members of staff at key transition points.³²

²⁶ HEA, 2015, <https://static.rasset.ie/documents/news/third-level-staffing-figures.pdf>

²⁷ Forty-eight per cent of total doctorates in Ireland are awarded to women, equivalent to the OECD average (Forfas, 2014, 8).

²⁸ Royal Society of Edinburgh, 2012, Tapping Our Talents: Women in Science, Technology, Engineering and Mathematics: A Strategy for Scotland, http://www.royalsoced.org.uk/cms/files/advice-papers/inquiry/women_in_stem/tapping_talents.pdf

²⁹ Alan Smeaton, 2014, opinion piece, ‘Continuous professional development essential for excellent STEM education’, *Silicon Republic*, 10 November 2014, <http://www.siliconrepublic.com/innovation/item/39241-opinion-continuous-profess/>

³⁰ Claire O’Connell, 2015, ‘Athena SWAN launches in Ireland to address gender inequality in higher education’, *Silicon Republic*, 6 February 2015, <http://www.siliconrepublic.com/innovation/item/40534-wit2015> (accessed 21 March 2015); RIA–*Silicon Republic* opinion series on STEM, November 2014, see <http://www.siliconrepublic.com/innovation/item/40534-wit2015>

³¹ The EU Framework Programme 7-funded GENDERA project proposed this measure as one of a suite of measures to tackle issues of unconscious bias.

³² Maria-Adriana Deiana, 2010, ‘Hidden costs of being a female academic’, research report, Queen’s University, Belfast School of Psychology, <http://www.qub.ac.uk/schools/media/Media,424063,en.pdf>

Should research-and-innovation performers be supported to engage citizens more actively in the innovation process to achieve optimal outreach to the public?

Building scientific understanding and interaction into everyday life is an ambitious but exciting goal. The strategy to 2020 should **stimulate public discourse** about the impact and value of scientific and scholarly enquiry by building upon recent initiatives that, for example, offer opportunities for people to meet with and see researchers in action (for example, Researchers Night), and through enhanced media coverage (through the appointment of a dedicated science journalist at RTÉ through to science-based radio shows such as *Future Proof*) and the exemplar BT Young Scientist & Technology competition.

To **offer the best possible STEM education for our citizens**, Ireland needs to continually invest in and support our primary and secondary schools and teachers. In particular, teachers should be supported through meaningful **continuous professional development (CPD) in STEM** topics for teachers at primary and secondary level³³ so that their practice is informed by a thorough knowledge and understanding of what it is they are teaching and new developments in STEM. In particular, actions to **promote engagement and interest in STEM subjects amongst girls and boys** from the earliest stage of formal schooling would be most welcome.

³³ The 2014 requirement by the Teaching Council that each teacher, at the point of professional registration, show their capacity to engage with CPD is welcome.

Appendix I

Submission by the Royal Irish Academy Engineering and Computer Science Committee to the Consultation on the Successor to Strategy for Science, Technology and Innovation (SSTI)

Introduction

The development of the new SSTI is one of the most critical issues for Ireland as it will define many key directions for the next decade. Thus, it is essential that this strategy is optimal.

The consultation paper is effectively a comprehensive background document that describes the current science technology and innovation landscape in Ireland. However, it is also a long way from being the new strategy document with a clear vision for the future.

The committee would like to make the following comments and suggestions on the consultation document:

Vision

- The consultation paper offered does not articulate a clear vision statement for the SSTI. The vision should be forward-looking and inclusive of all disciplines and types of research from basic to applied.
- A series of questions at the end of each pillar does try and prompt a thought process, but no direction is evident in the document.

A holistic approach is needed

- The focus seems to be on enterprise, jobs and the economy. However, SSTI should also recognise the value of research in educating the leaders of tomorrow that does not directly meet these impact criteria.
- A holistic approach is needed that will consider all factors that can contribute to the achievement of the vision for SSTI. Impact needs to be defined more broadly to capture these concerns.
- In addition to the focus on enterprise need, the strategy should also be focused on the value to society.

The architecture of the pillars

The architecture of the strategy should be revisited so as to explore the significant interdependencies between the themes and actions identified within the pillars. A more holistic

approach would lead to a greater linkage between these structures.

Funding

- Economic impact should not be the sole determinant of funding.
- Growing business investment in research and development should be a key goal of the new strategy. An aim of the new strategy should be to grow BERD intensity.

Patent registration

Great strides have been taken in Ireland in developing an intellectual-property regime to raise our international profile. Further committing to growing Ireland's patent registration should be a goal of the new strategy.

Knowledge transfer

- The SSTI must include a strategy for knowledge transfer, and this should be reflected in a separate pillar.
- Research-led teaching is critical so as to ensure the highest quality of knowledge transfer in education.
- Having a diversity of disciplines within research teams is important for improving knowledge transfer and the overall quality of research.

Time frame

- There is no sense as to how long the new strategy will be for.
- The consultation document does not describe the process and time frame for developing the new strategy.

Impact of previous strategy

- It would have been helpful if the document contained a more critical analysis of the impact of the previous strategy.

I. Development of human capital

Pillar 8 looks at both research for knowledge and development of human capital. It is recommended that this pillar should be split into two parts, and that human-capital development should be a separate pillar, and not just tacked onto the end of the last pillar.

As highlighted in the discussion document, the Action Plan for Jobs 2015 states that 'Ireland's competitive advantage in international markets ... will increasingly be driven by the availability of world-class skills at all levels', and the first report of the Research Prioritisation notes that 'human capital is the single most important enabler of the National Research Prioritisation Exercise'. The emphasis on the development of human capital must be evident throughout the strategy.

The education of the graduates of tomorrow to all levels—bachelors, masters and PhD—in the sciences, engineering and technology must continue, building on the advances over the last ten years.

Some of the points that need to be articulated in the strategy document include:

- (i) The number of graduates needed.
- (ii) The funding plan for educating PhDs.
- (iii) Where the emphasis for PhD students lies.

2. Research-centre structure in Ireland

In pillar 5 consideration has been given to organisational arrangements to enhance research in Ireland. The document contains a good summary of the research structures in Ireland, and many of the leading SFI, EI and IDA centres are mentioned. Given the growth and evolution of these centres over the last fifteen years, there is no doubt scope for the enhancement of the structures that currently exist.

However, one of the questions at the end of pillar 5 did give some cause for concern: Is there a need for a complementary market-focused research-centre structure in Ireland, and how should that be organised?

This might imply the migration of research away from universities and the establishment of separate research entities. Such a development would be very dangerous for this country for the following reasons:

- There has been enormous investment into the research capabilities of Irish universities since the initiation of PRTL and the launch of SFI. Many of the benefits of this investment would be lost.
- Ireland is a relatively small country, and it would be an inefficient use of resources to establish separate research structures.
- Separating research and teaching would be very much contrary to the motivating concept of excellence through research-led teaching.
- It would be more difficult to attract high-quality individuals to the third-level sector, and there could be a drop in the quality of teaching.

Thus it is argued that research should primarily be conducted under the umbrella of the universities (while noting the critical role of organisations such as the Marine Institute). The structures of the universities can continue to evolve to reflect international best practice in the manner in which research is facilitated and supported.

3. Expanding the focus of research funding

Basic research has led to discovery of the first human cancer gene; the first experimental confirmation of the existence of the quark; the first chemical synthesis of penicillin; and the discovery of *Prochlorococcus*, the most abundant photosynthetic species on Earth.³⁴

While there is a need to meet the demands of industry for the people and research necessary for its prosperity, it is a dangerous and risky strategy to focus on a narrow range of disciplines with emphasis on applied research. There are a number of reasons for this, not least of which is the prediction, according to the US Department of Labor, that in ten years around sixty-five per cent of the jobs that people will be doing have not even been thought of yet.

In order to mitigate the risk of disruptive future technologies making our industries and talent-supply chain obsolete, we must make significant investment in broad-based, basic research and multidisciplinary training.

Basic research is the key driver of innovation. The knowledge gained here about, for example, the laws of nature and mankind, or the structures and connections between quarks and electrons, or the immensities of the universe, creates the basis for revolutionary innovations. It is a question of more than just conventional technologies and employment—the results of this research are the foundation on which the world of tomorrow will be built.³⁵

Investment in basic research is absolutely essential if we are to be innovation leaders rather than followers, so what we need is a system in which there is a balance between basic and applied research and a research ecosystem that facilitates efficient translation of basic research into applications, companies and jobs. Establishing a programme similar to that of the ERC—whose funding criteria are not restrained by policy-driven prioritisations—within Ireland could assist with creating this balance.

In terms of the development of human capital to underpin our research ecosystem, it is vital that we take the view that to survive and prosper we must build in resilience and robustness to our training. We need to produce graduates and researchers with the capability to engage with and understand multiple disciplines. This requires depth in their own discipline but also breadth of knowledge of other disciplines, and it also requires excellent communication and interpersonal skills.

³⁴ Liz Karagianis, 'The brilliance of basic research', *Spectrum* (Massachusetts Institute of Technology), <http://spectrum.mit.edu/articles/the-brilliance-of-basic-research> (accessed 21 March 2015).

³⁵ Peter Gruss, 'Basic research is the key driver of innovation', MaxPlanckResearch, 2009, https://www.mpg.de/799746/VV000_Viewpoint_006-009.pdf (accessed 21 March 2015).

In his book *Five Minds for the Future*, Howard Gardner, Hobbs Professor of Cognition and Education, Harvard Graduate School of Education, outlines the specific cognitive abilities that will be sought and cultivated by leaders in the years ahead.³⁶ Considering the inclusion of these in training programmes in HEIs could be an aim of the strategy. These include:

- The Disciplinary Mind: the mastery of major schools of thought, including science, mathematics and history, and of at least one professional craft.
- The Synthesising Mind: the ability to integrate ideas from different disciplines or spheres into a coherent whole, and to communicate that integration to others.
- The Creating Mind: the capacity to uncover and clarify new problems, questions and phenomena.
- The Respectful Mind: awareness of, and appreciation for, differences among human beings and human groups.
- The Ethical Mind: fulfilment of one's responsibilities as a worker and as a citizen.

4. Gender balance in STEM

There is a very pressing need to highlight the issue of gender imbalance in STEM in the new strategy. We have a shortage of women studying engineering, physical sciences and computing, and the problem is further compounded by the retention problems in these careers.

To date, initiatives to improve recruitment into narrow STEM disciplines have had limited success. This is not due to a lack of commitment and effort on the part of those bodies involved in the promotion of STEM, but is partly due to the fact that these initiatives are necessarily restricted by the limited human resources available to deliver the initiatives year after year.

In terms of women in research, there is attrition in both academia and in industry when women have to balance childcare with careers. There is also the major issue of the lack of women in senior positions. The strategy needs to consider new approaches to solving these problems since it is clear that past and existing strategies are having limited effect.

There is a need now to move the emphasis from the women to the system, to design working environments and practices that are conducive to good work–life balance and promotions criteria that do not inadvertently discriminate against women.

³⁶ Howard Gardner, 2006, *Five Minds for the Future* (Harvard Business Press).

Appendix 2

Submission by the Royal Irish Academy Life and Medical Sciences Committee to Consultation on the Successor to Strategy for Science, Technology and Innovation (SSTI)

Introduction

The Royal Irish Academy Life and Medical Sciences Committee welcomes the opportunity to engage in the consultation process for the new national Strategy for Science, Technology and Innovation.

In the period 2001–12 combined investment in physical infrastructure and human capital transformed the Irish research landscape to a credible, internationally competitive research ecosystem: ranked thirty-sixth globally for research output in 2003 and twentieth by 2010. The committee would from the outset like to commend the work of the current administration in preserving the research budget during periods of fiscal contraction.

However, as the government embarks on establishing a new strategy, it is important to affirm that policy must be informed by evidence of outcomes that would support or indicate the need for revision of policy and associated priorities to deliver objectives.

I. Observations on current research-funding ecosystem

A sustainable 'knowledge economy' requires intelligent investment in the education-research continuum. Whereas the economic benefits of investment in applied 'close to market' research may seem attractive in the short term, this cannot substitute for a parallel commitment to basic research. We cannot anticipate the benefits of basic research, but we can know with certainty the benefits of rigorous education and training in core scientific disciplines. In economic terms basic research is a public good, it is non-rival and non-excludable.³⁷ There is growing recognition by funders internationally that responsive funding to investigator-led inquiry is highly productive and represents the greatest potential for advances (for example, the Wellcome Trust and National Institutes of Health). Therefore, achieving a more diverse funding framework that encompasses strong applied research programmes with more in-depth fundamental research initiatives should be the goal of the new strategy.

³⁷ Address by Professor Jean-Pierre Bourguignon, president of the European Research Council, to the Royal Irish Academy, 14 November 2014.

Without the capacity to produce excellent graduates at both undergraduate and postgraduate levels, we will be uncompetitive as a location for investment or growth; there will be no intellectual capital or property to develop. For decades, a core component of Ireland's ability to attract foreign direct investment has been the perceived quality of its graduates and, more recently, the activity of its universities and third-level institutions. Growing indigenous industry depends on translating quality research, and sustaining such growth depends on the quality of the graduates and their research.

Scientific excellence that is benchmarked against international standards must be the essential criterion for any state-funded research activity. Funding sub-standard research because it is in an area of perceived 'need' undermines the system, generates minimal value for money, and is a retrograde step in Ireland's pursuit of being an 'innovation island'.

Comments on individual pillars within the SSTI background paper:

2. Improving consistency with international collaboration (pillar 4)

Promoting international collaboration and cooperation should be an important feature of any new science strategy, and existing structures in some cases create a barrier to realising this goal:

- The National Research Prioritisation Exercise is understandable, and by its nature has limited the areas funded nationally, but these are even more narrowly defined for many of the international programmes (for example, SFI US–Ireland collaborations), restricting the ability of many researchers to participate. A broader perspective on research priorities within international programmes will both increase participation and facilitate internationalisation. Even within defined areas there are further limitations imposed by the national co-funders, which undermines pillar 4 prioritising international collaboration. For example, if the Health Research Board will no longer support biomedical research, then it is for the most part disingenuous to claim that there is national co-funding for collaboration with national institutes of health.
- We need to be innovative in how international partners can be incentivised to join research projects. Invariably this comes down to funding and developing a mechanism whereby, for example, a percentage of national-funded projects can be 'subcontracted' to project partners outside the state (that is, used as leverage to participate in international programmes). A similar idea is already in place for SFI-funded projects with Northern Ireland partners. The benefits of this approach are real: providing a significant springboard to facilitate the acquisition of Horizon 2020/ERC funding, which is a set target in SSTI. However, it is important to note that Horizon 2020/ERC funding cannot be seen as a replacement for adequate core funding of research infrastructure and projects by national funders.

3. Research for knowledge (pillar 8)

The committee agrees that a degree of prioritisation is justifiable due to national budgetary constraints, but this cannot be the norm as we strive to capitalise on the state's investment to date. In the opening pages of the SSTI consultation document, it is stated that 'Research Prioritisation did not represent a move away from funding basic research.'³⁸ It is unfortunate that nothing could be further from the truth.

The report of the Research Prioritisation Steering Group recommended that:

a proportion of investment should be available to support research driven by a knowledge creation motive rather than by a direct connection to a sectoral opportunity or a specific, identified enterprise need. This type of (typically) basic research should continue to be funded in Ireland as part of a sustainable, well functioning STI system.³⁹

The new strategy needs to ensure that the above recommendation is implemented to ensure a balance between the fourteen priority areas, research for policy and research for knowledge, as represented in figure 2 of the Report of the Research Prioritisation Steering Group.⁴⁰

If Irish research teams are to be competitive in Horizon 2020 and ERC (not just the starter grant scheme), we have to invest in fundamental research programmes. Establishing a mini, Irish ERC-type programme whose funding criteria are not restrained by policy-driven prioritisations (as in SFI, EI and the Department of Agriculture and Food) will address the knowledge gap that currently exists and provide opportunities and output that are relevant to securing non-exchequer funding. Existing SFI programmes such as the President of Ireland Young Researchers Award, Starting Investigator Research Grant and the Career Development Award are too few in number. In reality our early to mid-level researchers are not as competitive as those in other EU states in many panels at ERC level. The success in the Starting Grant programme often reflects achievements of our early-stage researchers during postdoctoral years spent abroad.

The speech delivered by Jean-Pierre Bourguignon, president of the European Research Council, to the Royal Irish Academy in 2014 should not be dismissed as mere narrative, for he succinctly described the importance of basic research within a broader funding landscape, and the positive social and economic impact it can have.⁴¹

This view has also been expressed by a number of others: for example, there is significant evidence of economic benefit deriving from 'research for knowledge'. A study from the Russell Group of twenty research-intensive universities found that blue-skies research driven by

³⁸ Interdepartmental Committee on Science Technology and Innovation, 2015, Consultation Paper for Successor to Strategy for Science, Technology and Innovation, 2.

³⁹ Department of Jobs and Enterprise, 2011, Report of the Research Prioritisation Steering Group, 21.

⁴⁰ Ibid. 25.

⁴¹ Address by Professor Jean-Pierre Bourguignon, president of the European Research Council, to the Royal Irish Academy, 14 November 2014.

curiosity can have a far greater social and economic impact than research carried out with a specific commercial application in mind. The report, based on data from eighty-two projects by Russell Group institutions, shows that the commercialisation of blue-skies research generated average returns of £44 million for the group—more than twice the average returns from applied research. Of the top ten projects measured by financial return, eight were the product of basic research. Based on the case studies, it was estimated that diversion of funds from basic to applied would have resulted in a loss of £1.2 billion to the UK economy. It concludes that ‘Funding policies that require a hypothecated impact could jeopardise outcomes that may arise unexpectedly, or that may take many years to come to fruition, yet have huge commercial significance.’⁴²

There is no arguing the fact that both basic and applied research is the breeding ground for new ideas, and it is clear that a new science strategy must seek a balance of both.

4. Early career researchers and human capital (pillar 8)

Young researchers need to have core funding nationally to leverage international funding (and to make them competitive at international level). ERC grants cannot be relied upon as a stable funding stream for early-career researchers. There is also a need to invest in ‘human capital’. The Teagasc PhD Walsh Fellowship scheme is a template of how this may be achieved. The numbers of Irish Research Council postgraduate and postdoctoral fellowships available each year (which *do* fund basic science) are not sufficient to maintain a strong researcher base across the prioritised disciplines. Only 219 postgraduate fellowships and thirty-two postdoctoral fellowships were awarded across all STEM disciplines and all third-level institutes in 2014. It is imperative that such schemes are grown to ensure a researcher career structure is a focus of the new strategy.

There also needs to be greater clarity around future funding calls (in the medium term). It is almost impossible for research groups to plan beyond short-term goals, since securing ongoing funding for even successful projects is far from guaranteed. This impacts on the types of research that can be pursued, and feeds into the larger but related problem of a lack of structured research careers for early-stage researchers (one to fifteen years post-PhD).

5. Gender equality (pillar 8)

The issue of gender equality must be adequately addressed in the new strategy. Women are severely under-represented at higher levels in both industry and academia, and as such are not fully represented in the decision-making process. Issues surrounding gender equality often focus on family obligations, but according to Professor Nancy Hopkins at Massachusetts Institute of Technology:

⁴² Hannah Fearn, ‘Reach for the skies: applied research is half as lucrative’, *Time Higher Education*, <http://www.timeshighereducation.co.uk/404301.article> (accessed 21 March 2015).

It is the undervaluation of equal work if done by a woman that is the primary cause of women's low representation at the top in science. Failure to redesign professions to accommodate family obligations contributes as well, but it is unconscious gender bias that is by far the greater obstacle to women's equality.⁴³

The new strategy represents an opportunity to address this issue in a tangible way.

6. Organisations for science/research

While there are distinct advantages in a coordinated research-funding landscape, the reality is that in avoiding overlaps there are significant gaps that have emerged and that must be addressed. Biomedical research has been impacted significantly by changes to both SFI and Health Research Board (HRB) funding programmes. The Canadian model of funding is frequently cited by HRB as best practice. In this context it is noteworthy that the Canadian Institute for Health Research (CIHR) operates in parallel with other basic and enterprise-driven funding streams. The CIHR funds population health, health-services research and patent-oriented research, but eighty-five per cent of its budget goes on biomedical research.

The committee would make the recommendation that we need a single national ethics committee. The current situation where each hospital's custom and practice differ is inefficient. The committee would also recommend that the Office of the Chief Scientific Adviser be aligned to the Department of An Taoiseach to ensure a closer connection with central government across discipline and research interests. We believe the current situation is not in the national best interest.

7. Research for policy

We would advocate an independent research study be commissioned from the outset of the new strategy that can adequately measure the impact of funded research in Ireland not only in terms of direct economic benefit but also the wider impact in society and education. This should be seen as a unique opportunity to inform future policy with a real-time assessment of current strategies. An immediate action that can be taken is to ensure that research performers are directly represented on STI review-and-evaluation committees/groups. Further transparency could be achieved by advertising such opportunities and inviting researchers to apply.

⁴³ Professor Nancy Hopkins, 'Gender bias and science', Letters, *Irish Times*, 10 December 2014.

Appendix 3

Submission by the Royal Irish Academy Physical, Chemical and Mathematical Sciences Committee to Consultation on the Successor to Strategy for Science, Technology and Innovation (SSTI)

The Royal Irish Academy Physical, Chemical and Mathematical Sciences Committee notes with acclaim that government strategy since the economic crash in 2008 (and earlier) has been to continue to fund scientific research, and that this is based on the value in economic terms of such investment.

We do not repeat here the many facts and figures in the consultation paper (February 2015). Modern developed economies are certainly complex in their operation, and one of the key things that enable them to work is depth and strength in the workforce, including an ability to develop new ideas and to adapt to new ideas that come from external sources.

We feel that it is not possible to distil the requirements for Ireland to hope to compete on the same level as more successful countries into a short list. For instance, we could hope to equal the economies of countries of broadly similar size such as Switzerland, Finland or the Netherlands in the strength of their indigenous high-technology industries. This could enable us to hold on to the large multinationals that are so much the driving force of our economy, as well as building more native powerhouses.

The committee's brief relates to the somewhat narrow area directly related to physics, chemistry and mathematics, and we do not aspire here to comment more generally on the draft consultation paper.

The committee has set out its feedback into two sections commenting on the following:

- Aim should be to increase Ireland's relative position and to build more indigenous high-technology industries.
- Broadening the scope of funding outside targeted areas to nurture human capital.
- Physics, chemistry and mathematics are all vital for the modern economy and have been shown to deliver value from research, sometimes in surprising ways.
- The importance of continuing research funding in recent years.

The benefit of physics, chemistry and mathematics to the Irish economy

We point out that there is concrete evidence available of the economic benefits of our subjects. The 2012 Institute of Physics report *Importance of Physics to the Irish Economy*⁴⁴ contains hard evidence in the Irish context that physics has a key role to play in the economy, with physics-based industry providing over 86,000 jobs and gross value added to the economy of €7.4 billion in 2010. The robustness of this sector is one of the main reasons why Ireland is now emerging from the economic crash of 2008. Hence it is essential to support the ecosystem underpinning this aspect of the economy.

Chemistry also plays a key role in the economy. For example, in 2013, according to Pharmaceutical Ireland, the pharmaceutical and biopharma sector exported products to the value of €50.8 billion. Pharmaceutical and chemical products account for over fifty per cent of Irish exports, contributing more than €1 billion in corporation tax annually. The sector employs over 25,400 people directly, and as many again indirectly.

For mathematics, there is no Deloitte report for Ireland to parallel the one for physics, but there are such reports for the UK⁴⁵ and the Netherlands.⁴⁶ One cannot quote the figures as directly applicable to Ireland, but one of the messages from both reports is that there is a large economic impact from mathematics directly, a very significant impact when account is taken of the mathematical education that is required for the workforce in technical, engineering, scientific and financial disciplines. In Ireland, apart from the huge impact of multinationals that depend on mathematics or physics skills (for instance, the International Financial Services Centre (IFSC) has a trading and market-analysis activity), there are some home-grown small-and-medium enterprises (SMEs) that have arisen from locally produced graduates. For instance, Corvil (<http://corvil.com/>) started in 1998 with a substantial number of PhDs in mathematics, and it continues to develop innovative products in network-traffic analysis and online trading, all the time emphasising their special competence in mathematics. Alder Capital (<http://aldercapital.com/>) is a currency-fund-management company based in Dublin with a mathematics graduate as one of its leaders.

Research for knowledge and development of human capital

We cannot easily forecast where the next idea for a successful high-tech company will come from, and the next national strategy to 2020 should allow us to encourage human capital development across diverse areas. We should not underestimate the influence of ideas that were ahead of their time, such as the work of George Boole, first professor of mathematics at University College, Cork, who was born two hundred years ago, in 1815. The influence of William

⁴⁴ Deloitte, 2012, *The Importance of Physics to the Irish Economy*, http://www.iopireland.org/publications/iopi/page_59020.html (accessed 23 March 2015).

⁴⁵ Deloitte, 2012, *Measuring the Economic Benefits of Mathematical Science Research in the UK Final Report*, November 2012, <http://www.epsrc.ac.uk/newsevents/pubs/deloitte-measuring-the-economic-benefits-of-mathematical-science-research-in-the-uk/>

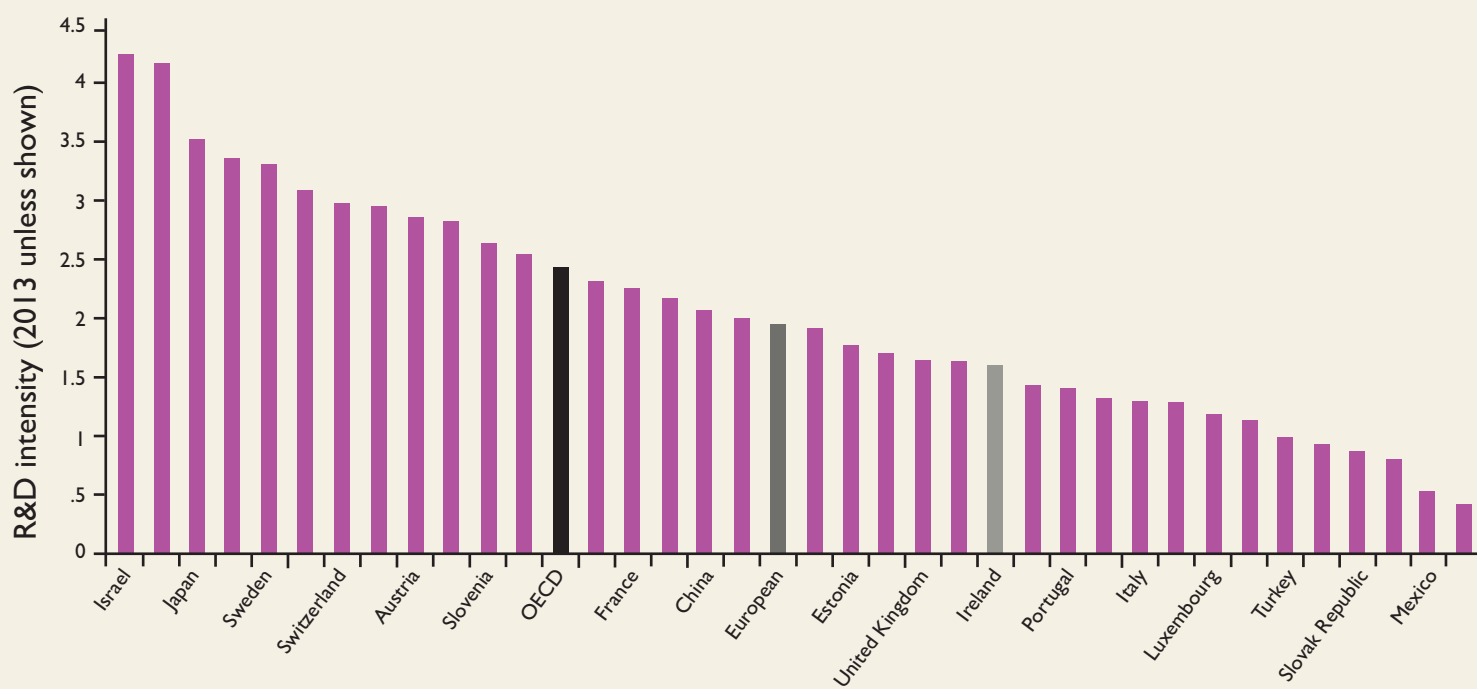
⁴⁶ Deloitte, 2014, *Mathematical Sciences and Their Value for the Dutch economy*, <http://www.euro-math-soc.eu/system/files/uploads/DeloitteNL.pdf>

Rowan Hamilton's work (roughly at the same time as Boole) continues to be strong to this day across many areas of mathematics, physics and computer graphics. The inspirational effect of a few outstanding figures should be kept in mind when forming strategy for funding. A new strategy should allow for the funding of excellent researchers irrespective of whether their research falls into one of the fourteen priority areas.

There is no doubt that the literary and artistic names associated with Ireland (Joyce, Beckett, Yeats, Heaney and others) contribute more to our reputation than do those of our scientists (even including the more recent Nobel Prize-winner Ernest Walton) or engineers (for instance, William Dargan). However, young students are certainly attracted to the mystique of topics at the frontiers of research, without reference to their seeming utility as reckoned in funding policy. We need a proportion of funding so that we can retain new generations of students here, and we will certainly reap benefits from them in the future even if it is not always clear now how that will come to pass.

While there is some evidence in the consultation document that Ireland is punching above its weight in terms of outputs from its research investment, as part of its strategy the country should be much more ambitious in the amount of funding that is made available to research. Certainly, the cutbacks in recent years at third level coupled with the increase in student numbers are putting researchers under considerable strain, and it is unlikely that these outputs can be maintained without increased and sustained support. Currently, OECD figures for R&D intensity show that Ireland's investment is in twenty-fourth place within OECD countries. At the very least we should aspire to be at or above the EU average. We conclude with a chart from the OECD on government investment in research and development (2013) illustrating these figures.

Research and development investment



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