Foresight and ''grand challenges'' within research and innovation policies

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Abstract

Purpose – *The paper seeks to discuss how foresight is used to understand the implications of global changes for research and innovation policies. It aims to present a recent Irish case study that identified grand challenges in the national context, with their implications for research and innovation.*

Design/methodology/approach – *The foresight project is described and provides knowledge and analysis for a broader, national research prioritisation exercise. The paper analyses the implementation of the Irish foresight exercise and the main outputs generated. It connects the results of the project with the literature on foresight, innovation and grand challenges.*

Findings – *The emergence of grand challenges within research and innovation policy discourse in Europe has refreshed key questions for foresight theory and practice. Although many grand challenges have relatively clear implications for research and innovation (investment), others do not. A bottom-up, participatory process produced a broader set of grand challenges.*

Research limitations/implications – *The concept of grand challenges is still relatively new.*

Practical implications – *Not all research and innovation priorities are linked to grand challenges. National policies need to take account of grand challenges whilst continuing to support other research and innovation needs.*

Originality/value – *The paper introduces a novel approach for identifying grand challenges and responses within the research and innovation system through a bottom-up process.*

Keywords *Foresight, Grand challenges, Research and innovation policy, Research prioritization, Forward planning, Innovation, Ireland*

Paper type *Case study*

1. Introduction

Foresight methods have been used widely around the world to enable the research and innovation system to assess the implications of new technologies and wider socio-economic changes (Martin and Johnston, 1999; Rappert, 1999; Saritas *et al.*, 2007; Georghiou and Cassingena-Harper, 2011). Such approaches are often built into prioritisation exercises, where national governments formulate strategic responses that take into account the existing and anticipated developments in the sciences and technology. Policy-makers and politicians are keen to find an answer to the challenging question of where they should be investing their resources to produce economic, environmental and social dividends.

Economic competitiveness has been – and remains – a key objective of investment in research and innovation programmes. However, another factor has emerged in the European context, which has had an influence on the research and innovation agenda: the concept of ''grand challenges'' or ''grand societal challenges''. Foresight has long been used for social purposes. However, with the increasing acceptance of grand challenges, Foresight is expected to make a contribution to orienting innovation towards broader issues (Georghiou *et al.*, 2011; Könnölä *et al.*, 2011). The provenance and scope of the grand challenges are discussed in the article, below; they are broadly understood in terms of

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themes such as energy, resources, health and security. There has not been a clear distinction between the terms ''grand challenges'' and ''grand societal challenges'', although ''societal'' has been used in some of the initiatives to emphasise the social scale and impact of the challenges (European Commission DG Research, 2010). This article will use ''grand challenges'' as the main term for these developments.

This article presents some recent experience of how national research and innovation systems use futures to construct responses (such as new investment priorities) to emerging global challenges and opportunities. It relates the case of foresight or future-oriented technology analysis (FTA) used for research and innovation policy agenda-setting, conducted in Ireland. It describes the methodological approach taken by the project in identifying research implications of global drivers and trends, which combined analysis of global changes with a participatory process involving national stakeholders. The exercise was designed to assess the implications of global changes for research. A relatively novel aspect, which evolved during the course of the exercise, was the focus on translating future-oriented knowledge (from drivers and trends) into grand challenges for the national research and innovation system. Several issues are addressed that are relevant for those interested in foresight, research and innovation, and grand challenges. These include the means by which grand challenges are constructed or interpreted, how research and innovation systems respond to grand challenges, and re-conceiving or re-framing questions for the research and innovation system.

The method used in the case study is to examine outputs from the foresight project conducted on global drivers and trends – and their (national) implications for research and enterprise. As one of the research consulting team that carried out the work on behalf of the lead organisation, I also draw on insights from the participatory events convened as part of the work programme. The article takes the structure that follows. The second section sets the scene, and briefly traces the provenance and meaning of grand challenges. Section 3 presents the methodology used in the Irish case study. The main results from the foresight exercise on global drivers, grand challenges and research responses are then presented in section 4. Finally, some conclusions and implications for research and practice are offered – particularly on how foresight addresses the ''challenge of grand challenges'' in research and innovation systems. Grand challenges refresh and re-cast some important questions for Foresight and research and innovation policies.

2. Grand challenges – the emergence of a new frame of reference

In the public funding of research, there are often tensions between two basic principles:

1. the intrinsic benefits of pure or ''blue skies'' research; and
2. a more explicitly problem or impact-oriented approach.

In the European Union – as in many other parts of the world – research, technology and innovation policies and programmes have adopted, to a large extent, an instrumental expectation – that investments will address particular problem areas and boost economic competitiveness. It could be argued that the main narrative of EU Research, Technological Development and Innovation (RTDI) programmes hitherto has focused on economic competitiveness in an increasingly globalised business environment. Although the focus on economic competitiveness is still important, it appears that there is now a new type of narrative – of grand (societal) challenges.

The shift to a larger frame of reference could be attributed in part to the broader sustainability narrative, which has become stronger (broader and deeper) since the 1990s. Climate change and environmental consciousness have reinforced a concern with the global and holistic. In this framing, the grand challenges are a manifestation of the extent to which sustainable development has become increasingly embedded politically, in policy terms, and socially. In a more tangible sense, the European Union Sustainable Development Strategy (2006) – although not couched at the time in precisely the same language of

''grand challenges'' – set out a similar framework for addressing the critical themes in achieving a more sustainable EU and planet.

The seven challenges identified by the EU's SD strategy are:

1. climate change and clean energy;
2. sustainable transport;
3. sustainable consumption and production;
4. conservation and management of natural resources;
5. public health;
6. social inclusion, demography and migration; and
7. global poverty and sustainable development challenges.

Within this general backdrop, there emerged a focus on ''grand challenges'' and within the European Union. Specifically, the issue identified was the effective marshalling of research, technological and innovation funds to support broad goals for Europe. The Lund Declaration of 2009[1] (the outcome of a conference on ''New Worlds – New Solutions'' held under the Swedish Presidency of the EU) crystallised several important aspects related to the mobilisation of scientific, technological and innovation knowledge geared towards large challenges. It calls on European institutions and Member States to focus European research on the major challenges facing our world.

According to the Lund Declaration:

> European research must focus on the Grand Challenges of our time moving beyond current rigid thematic approaches. This calls for a new deal among European institutions and Member States, in which European and national instruments are well aligned and co-operation builds transparency and trust.
>
> Identifying and responding to Grand Challenges should involve stakeholders from both public and private sectors in transparent processes taking into account the global dimension.

The Lund Declaration emphasises importance of problem solving – that the ''challenges must turn into sustainable solutions in areas such as global warming, tightening supplies of energy, water and food, ageing societies, public health, pandemics and security. It must tackle the overarching challenge of turning Europe into an eco-efficient economy''.

The Lund Declaration followed the work of an Expert Group Report on the European Research Area, which emphasised that it needed to address a series of Grand Challenges (European Commission DG Research, 2008, p. 5). The same focus on grand challenges and the increasing shift towards addressing societal needs was identified in the first report of the European Research Area Board (European Commission DG Research, 2009). A further milestone in the explicit recognition of directing research and innovation resources towards grand challenges came with the publication of a report on the European Technology Platforms by DG Research (European Commission DG Research, 2010).

In summary, over the last five years or so, an increasingly consensual view has emerged that Europe needs to direct its investment and support in RTDI towards addressing grand challenges– in areas such as energy, resources, demographic change, health and security.

3. Irish foresight project on global drivers and their implications for research and innovation: context and methodology

3.1 Introduction to the case study analysis

The presentation and analysis of the case study below is based on my role as part of the research and consulting team that examined the implications of global drivers and trends for national research and enterprise policy-making in Ireland. It draws on the project outputs

(interim and final) and the consultative events arranged with stakeholders. A number of points are then developed that are related to the process and results described in the case study.

3.2 Scope and context of the exercise

In the second half of 2010, Forfás, the national policy advisory body for enterprise and science in the Republic of Ireland, undertook an exercise to assess the implications of global drivers and trends for the country's research and enterprise base[2]. The project, ''Review of Global Drivers and Trends from a National Perspective in a Global Context'', was a four-month exercise that sought to ''to develop a catalogue of global drivers and trends, their potential impact and the opportunities (including market opportunities) they present for Ireland and the research areas that will be required to address the challenges and meet the opportunities'' (Project Terms of Reference).

It was one of the projects undertaken by Forfás to provide analytical support to a national research prioritisation exercise. Undertaken by Forfás under the guidance of a high-level Steering Group, the 12-month exercise has had the aim of identifying up to 20 priority areas for the allocation of public funding of research and development over five years. An action plan was to be developed for each priority area. The Minister for Enterprise, Trade and Innovation asked ''that the group focus on areas that will yield the best return for taxpayers' investment in research and ultimately, create high quality jobs''[3].

3.3 Project methodology

A methodology was designed and implemented that provided the main output required by Forfás, i.e. a catalogue of global drivers and trends together with an analysis of their potential impact and opportunities for the Irish research and enterprise base. An iterative methodology, consisting of different stages of analysis of the drivers and trends, and a series of meetings and workshops, served to validate and contextualise the principal themes and questions raised for the nation as a whole – and the more specific dimensions of research, technology and enterprise. Although not explicitly designed into the methodology at the outset, the identification of grand challenges was introduced whilst the exercise was in progress.

3.3.1 Phase 1: Global drivers and trends analysis. The first main phase of the exercise consisted of an initial analysis of global drivers and trends across the PESTLE categories (Political, Economic, Social, Technological, Legislative, and Environmental). The scope, as suggested by Forfás, was purposefully wide-ranging. This meta-analysis used an assessment framework, which formed the basis of the subsequent project catalogue, which is demonstrated in Table I.

A further important aspect of this stage was to begin to identify how other countries were responding to global challenges. This work led to the production of an intermediate output, the ''First Level Catalogue''.

3.3.2 Phase 2: Key stakeholder consultation. Having developed a first catalogue of drivers and trends, the second phase was designed to engage with key stakeholders in Ireland to explore their significance and potential implications for the national context. The stakeholder phase had three specific aims:

Table I Drivers and trends assessment framework

1	Overview – description; rationale and evidence
2	Potential impact (global and national); emerging indications; timescales
3	Potential disruptive factors – trend breakers, accelerators, wild cards
4	Connectivity and contingencies – links with other drivers and trends
5	Challenges that this presents
6	Opportunities that this presents

1. validation of the trends/drivers in national context;
2. assessment of existing policy, research and commercial activity; and
3. opportunities for further market and research development.

Two methods were used during this phase: ''roundtable discussions'' and interviews. Twelve roundtable discussions were facilitated with senior representation from a cross-section of policy areas, mainly from government ministries and agencies (approximately 90 participants in total). Each discussion had four to five focus questions to ascertain the degree to which these drivers and trends were visible and relevant for their thematic areas, the potential impact they might have on the Irish national context over the coming ten to 15 years, and the degree to which organisations were already addressing issues raised by them (see Table II for focus questions used in the roundtable discussions).

The participants in the roundtable discussions were grouped into common areas of interest. Half a day was allocated to each discussion and participants were asked to focus on three or four key thematic groups of drivers (briefing material on the drivers had been distributed to participants ahead of discussions).

The roundtables provided immediate calibration and focus in analysing the drivers. There were instances in which participants did not feel that certain drivers and trends were as relevant to Ireland (as they might be to other, larger countries). Similarly, there were examples where the drivers appeared to be even more amplified in the case of Ireland – particularly in terms of economic geography and scale.

3.3.3 Phase 3: Identifying grand challenges. During the second half of the project, Forfás posed the question of how the global drivers and the national context could be cast as (grand) challenges for Ireland, which could inform the work of the Research Prioritisation Steering Group. The aim was to synthesise the materials into a collection of 12 (or so) challenges. The project team devised a way of constructing these challenges and proposed the following approach:

- a challenge has connectivity across two or more drivers or themes at the global level;
- the challenge has a clear Irish national context; and
- the challenge has potential for a set of research implications or the potential for applications of research results.

The following structure was used to link the national context, the global drivers and the challenges:

> Ireland has/is/needs (national context) but is challenged by/with /to (global drivers). How can Ireland/Can Ireland (the challenge)?

3.3.4 Phase 4: Final catalogue. The final stage of the project consisted of the production of the final catalogue of drivers and trends. These were produced by synthesising the

Table II The roundtable discussion focus questions

1	The initial drivers work has identified some global drivers that may be relevant. Do you recognise these? If not, why not, and what additional or alternative drivers or trends would you suggest?
2	What are the challenges for Ireland that you expect these drivers to raise in the next 10-15 years? Which are most likely to be influential? Why? Which will have the biggest influence? With what impacts and challenges?
3	What are the implications, if any, of these drivers for Ireland's research needs and opportunities?
4	Are these drivers and trends currently addressed by your organisation? For example: – recognised and aware of them – discussed within work, for example referenced in operational programmes or strategies – actively addressed through specific initiative, policy, strategy.
5	Has your organisation had contact with other governments internationally in discussing these drivers and trends?

outcomes from the consultation and the empirical evidence gathered, with an emphasis on connectivity between the external environment and the national issues identified. The final output incorporated the grand challenges identified for Ireland, with emerging implications for the research system.

4. Project results: from drivers and trends to grand challenges

4.1 Catalogue of global drivers and trends – from the national context

The third level catalogue is a substantial volume that analyses global trends and drivers from a ''national perspective in a global context''. It contains 47 ''fiches'', grouped into eight themes:

1. Global governance and political economy;
2. Social values;
3. Climate change;
4. Demographic pressures;
5. Mobility and transport;
6. Education and skills;
7. Technological development; and
8. Resources.

A list of themes, drivers and trends is provided in Table III.

Each fiche has a description of the driver/trend, supported by data and literature. The fiches draw out potential disruptive factors – that will constrain or accelerate the phenomenon described. The national context for each driver is then developed and a series of potential research implications added – particularly responding to challenges and opportunities presented by the global drivers. The research implications developed were based on the consultants' experience in research prioritisation exercises, international comparators and the inputs from the Roundtables.

4.2 Participants' views of global drivers and trends: anticipation of likelihood and impact

Participants in the roundtable discussions were given time individually to appraise the drivers and trends through a scoring framework. A scale of 1-5 was used for likelihood and impact. There was an average of 29 responses for each question, with a range of 19-35 responses.

There was broad agreement on the most likely and highest impact trends (Table IV). Six of the trends appear in the ''Top 10'' both for likelihood and impact:

1. ageing populations;
2. renewable energy;
3. peak oil;
4. converging technologies;
5. increasing pace of change; and
6. energy security.

Figure 1 shows the distribution of drivers and trends on an impact versus likelihood matrix. For illustrative purposes, an example is given of a high impact and high likelihood trend (converging technologies); there is one example of a high impact but lower likelihood trend – ''global trade falters''.

Table III List of thematic groups, drivers and trends identified

Theme	*Drivers and trends*
Global governance and political economy	Rise of the BRICs
	Global trade falters
	The emergence of new middle classes
	Uncertain results for banking regulation
	A challenge to liberal democracy models
	Conflict follows geo-political shifts
	Terrorism continues to pose a threat to security
	A multi-polar governance system
	Religion versus secularism
Social values	Behaviour lags in sustainable development
	Digital natives
	Complexity and uncertainty
	Social capital brings returns
	Quality of life and experiential consumers
Climate change	Global warming
	Rising sea waters
	Can mitigation succeed?
	Consequences of climate change adaptation
	Acidification
Demographic pressures	Global population growth
	Ageing populations
	Urbanisation
	Migration impacts
Mobility and transport	Traditional transport modes
	Infrastructure investment
	Smart travel
	Carbon taxes
	Transport market liberalisation versus environmental regulation
Education and skills	The knowledge economy
	ICT in education
	Social mobility and higher education
	Social mobility and higher education
	Learning as a lifelong behaviour
	Vocational skills gaps
Technological development	Converging technologies
	The increasing pace of technological change
	Technology platforms
	Open innovation models
	Death of intellectual property?
	Biosciences and the genome
	Cloud computing
	Privatisation of agricultural science
Resources	Renewable energy
	Energy security
	Water scarcity
	Food scarcity
	Peak oil
	Mineral and resource depletions

4.3 An emerging set of grand challenges for Ireland – research needs and implications

A set of 12 challenges was provided for consideration[4]. The two examples provided in Table V illustrate the breadth of potential research implications that could emerge from the challenges. Although there was understandably a strong focus on ''hard'' research in science, engineering and technology, within several challenges there was also a clear role for social sciences and humanities. For example, with the recent economic difficulties in Ireland clearly vexing participants in the exercise, the challenge of developing a more resilient societal system was identified, with potential implications around social research on resilience, and modelling work on areas such as health.

Table IV Most likely and highest impact trends (identified by roundtable participants)

Ten trends most likely to happen	*Ten highest impact trends*
Rise of BRICs	Converging technologies
Ageing populations	Knowledge economy
Global population growth	Energy security
Renewable energy	Renewable energy
Peak oil	Global trade falters
Converging technologies	Increasing pace of change
Increasing pace of change	Open innovation models
Cloud computing	Peak oil
Energy security	Ageing populations
ICT in education	Banking regulation?

Figure 1 Distribution of drivers and trends on an impact versus likelihood matrix

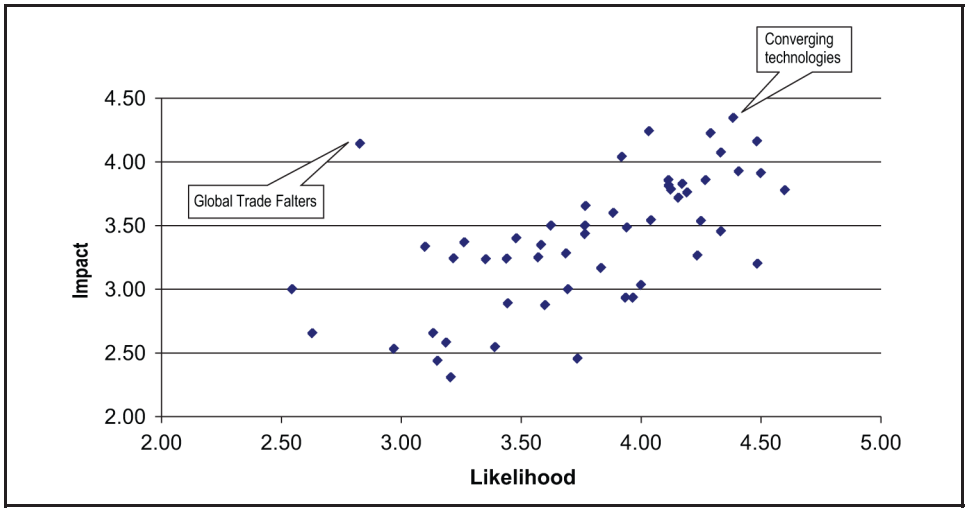

Table V Challenges identified with their potential research implications

Examples of challenges identified	*Potential research implications*
Energy	
Ireland is dependent on external sources of energy supplies at present and will continue to be so for at least ten years while renewable energy makes an impact on energy supply	Increase the available options for renewable energy generation capacity
The challenge for Ireland is to achieve greater energy security whilst meeting its international commitments to carbon emission reduction and without damaging its international competitiveness	Install advanced distribution networks with international connectivity
How can Ireland achieve this delicate balance taking advantage of its natural resources (wave and wind) to deliver environmental and economic dividends?	Develop and exploit ''smart grid'' technologies to ensure efficiency, distribution and competitiveness
Innovation and companies	
Ireland has a relatively modest ''home'' market and is therefore reliant to a significant extent on its enterprise base and institutions being creative, innovating and trading internationally but is increasingly challenged by the pace of technological change, globally mobile investors and concerns within the country regarding the scale and constant need for significant research investments	Gain a broader understanding of creativity and innovation and their role in the application of research within enterprises and more broadly across society
Does Ireland have in place the enabling mechanisms and absorptive capacities that are required to maximise the successful application of research and technology and to enable smaller Irish companies to absorb and then exploit research results?	Establish better ways of judging and valuing research in the humanities and social science and their contribution to Ireland's society and economy
	Be more ''creative'' by moving towards a stronger creative economy that combines arts/humanities and engineering and science skills

The project undertaken provided a national view on grand challenges that had been discussed in other settings. The results provide an interesting interpretation of grand challenges for the national context. Some of the challenges constructed through the methodology are well aligned with the larger themes discussed within Europe during recent years. The concern over sustainable, secure energy (first example featured in Table V) may be regarded as a grand challenge in this vein. Some of the other grand challenges identified are narrower and appear more specialised. The second example given in Table V – developing enabling mechanisms and absorptive capacities for RTDI – does not carry the same narrative of a fundamental problem facing Europe and the wider world. However, through the consultative futures process undertaken, it emerged as a significant (''grand'') challenge for the country's research and innovation system.

The participants that were involved in the consultative events recognised the significance of certain drivers (around, for example, energy and other resources) and this was reflected in the construction of grand challenges. In terms of engineering, science and technology, it was a relatively simple process to identify possible responses from the research and innovation systems at a national level, through addressing known gaps in capacity and building on emerging areas of strength. In some cases, the diagnosis of the grand challenge in the Irish context was more straightforward than the construction of a set of possible responses from the research and innovation system. One grand challenge that emerged from the confluence of economic and geo-political drivers and trends was the potential marginalisation of Ireland within multi-lateral frameworks:

> Challenge: Ireland ''punches above its weight'' in international arenas achieving a strong reputation as an independent country with good governance and respect for its global commitments and partnerships. Its strong institutional and governance arrangements are an advantage as a small, smart country. However, Ireland is challenged in maintaining this position as the smaller countries become increasingly marginalised within multi-lateral frameworks and where the traditional political and governance models are being disrupted.
>
> How can Ireland maintain its standing and reputation as ''a player'' and good partner in global politics and trade in uncertain times?

Although this may not appear a ''conventional'' research and innovation problem, it emerged as a grand challenge – reflecting key uncertainties of senior decision-makers operating in a small state as it adapted to changing external conditions in economics and governance. For these challenges, it was difficult to conceive of strategic responses based on research and innovation.

Even where there is a consensus on grand challenges, connecting them with niche areas of opportunity and development can be a very difficult task. This work was to follow the foresight exercise reported here, but the engagement with workshop participants indicated that there was a need for greater understanding of the pathways, dependencies and enabling conditions in areas such as renewable energy.

The small country context was an important dimension throughout the exercise and in constructing grand challenges. This was manifested in different ways (including the relationship of Ireland with Europe and the wider world through multilateral frameworks). First, some of the grand challenges discussed at the European level had much less resonance for Ireland – according to the views expressed by participants (e.g. security). Second, Ireland was suggested as a smart, innovative test-bed for new approaches for dealing with global challenges due to its small size and advantages of proximity. Through targeted research and development, it was put forward that Ireland could pilot new approaches for dealing with challenging areas such as energy and healthcare.

5. Conclusions

With the increasing recognition of the concept of grand challenges over recent years, the research community – amongst others – has been challenged to re-think the way in which it serves the broader needs of society. Some of the major themes frequently cited in this regard

are climate change, energy, food and demographic changes. The Lund Declaration and other initiatives have provided high-level impetus for actors in the research and innovation system to take stock of the way in which they develop and implement their activities. Foresight initiatives play an important role in this process by challenging the research and innovation communities to consider the impacts of changes in conditions, resources and other factors over different time horizons.

In the context of several European initiatives to promote approaches to dealing with grand challenges, this article introduces a country-level case study using a foresight approach to look at the implications of global drivers and trends for Ireland, particularly in terms of the challenges and opportunities that they presented. During the course of the exercise, the appointed research and consulting team was asked to translate the knowledge generated (global drivers and trends and their national implications) into a set of grand challenges for Ireland. Although this is not a final assessment of how the project has been used to inform research priorities, there are some important implications for foresight practice in RTDI and grand challenges.

Assessing how the research and innovation systems can address grand challenges can be done through bottom-up approaches. Although it was not originally designed in this way, the foresight exercise undertaken in Ireland became a participatory, bottom-up process that assembled grand challenges by combining knowledge on drives and trends with national context and insights. The method described in this paper is but one example of how work on grand challenges could be refined and adapted at a national level. An alternative approach would be to begin by explicitly addressing the grand challenges as they have been broadly defined in several European initiatives and transpose them to the national context. One potential disadvantage of the latter approach is that it may limit discussions and neglect potentially important national RTDI issues. Part of the value of foresight in further work on RTDI policy in national contexts is to provide forward-looking assessments that are bottom-up, reflecting the implications and meaning of grand challenges for individual countries.

5.1 Scale – the European versus the small country context

European-scale discourse can sometimes unwittingly neglect the specificities of national contexts – especially the smaller country contexts. For research and innovation policy, the implications of grand challenges may be quite different in smaller country contexts – particularly those that are on the periphery of Europe. There were other instances where thematic emphases may be very different from the European to the small country scale (e.g. certain dimensions of security).

The challenges may be easier to determine than the research and innovation responses: although problems or challenges can be contested, there is a relatively strong consensus on the definition of several of them – especially energy, climate change, demographics, etc. Identifying the challenge is a first step. The second step is to ascertain what, if any, might be an appropriate response in terms of the research and innovation system. The marginalisation of Ireland (as a small country) within multilateral frameworks was identified as a challenge by participants in the exercise. This is not a conventional innovation problem – yet was still regarded as a national challenge in its broadest sense. In such cases, it is difficult to conceive of clear research-based solutions.

How ''grand'' and ''societal'' should the challenges be? It is not easy to ascertain clear differences between ''grand challenges'' and ''grand societal challenges'' – at least in the way the terms have been used to date in the EU. In the Irish case, the challenges varied in scale and impact, where some appeared to be narrower and more specific for the national RTDI system. This suggests that not all RTDI priorities are linked specifically to grand challenges. It is important not to impose excessive constraints on innovation policies that do not overtly fulfil societal needs in the conveyed by debates on grand challenges.

Responding to grand challenges may require some longer-term investment decisions and commitments. There is a persuasive view that that longer-term thinking and commitments

are necessary to develop and sustain a successful innovation system. In the context of grand challenges, there is an important, on-going role for FTA in critically evaluating continued support for the allocation of resources within the research and innovation system, and the way in which they are organised.

Notes

1. See www.se2009.eu/polopoly_fs/1.8460!menu/standard/file/lund_declaration_final_version_9_july.pdf
2. The author was a member of the team that was appointed to carry out the work on behalf of Forfás. The team was made of CM International (lead contractor) and the Centre for Research in Futures and Innovation at the University of Glamorgan. The points made in relation to the exercise in the article are my own, and do not represent the views of Forfás.
3. See www.forfas.ie/newsevents/news/title,6828,en.php
4. The grand challenges were assembled by the consulting team at the request of the client and are provided for illustration. They do not constitute decisions made by Forfás nor any other organisation involved in the research prioritisation exercise.

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