Dimensions of Research and Innovation Policies to Address Grand and Global Challenges

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Preface

This report is the position paper from an “exploratory initiative” project supported by the European Forum for Studies of Polices for Research and Innovation (Eu SPRI, http://www.euspri-forum.eu/). The project, called “The emergence of challenge-driven priorities in research and innovation policy” (CPRI), was a collaboration between researchers from NIFU, Norway (Egil Kallerud, Antje Klitkou, Dorothy Sutherland Olsen, Lisa Scordato), Manchester Business School, UK (Effie Amanatidou), University of Leeds, UK (Paul Upham), and VTT, Finland (Mika Nieminen, Maria Lima Toivanen, Juha Oksanen). The project was co-ordinated by Egil Kallerud, NIFU, who is corresponding author (egil.kallerud@nifu.no). An identical version of the position paper is published on the Eu SPRI website (http://www.euspri-forum.eu/key_missions/exploratory_initiatives.doc/) .

Oslo, August 2013

Sveinung Skule
Director

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A new discourse in research and innovation policy

The notion that research and innovation should address *major societal challenges*, generally with the added epithets "grand" and/or "global", has become salient in contemporary research and innovation (R&I) policy. One notable example is the increasing centrality and extended use of the "grand challenges" term in recent EU policy developments. It was officially introduced in the so-called "rationale report" from 2008 (EUC, 2008), and soon became incorporated in official EU policy discourse through, in particular, the Lund declaration (July 2009), and has hence become implemented in as emergent EU research and innovation policies, in particular as one of three main pillars of the Horizon 2020 programme. Other influential international organizations promote similar notions about addressing global challenges through R&I. The OECD "Innovation Strategy" from 2010 (OECD, 2010) included a chapter on "applying innovation to global and societal challenges" and the topic of a recent OECD report is how to upscale and enhance the governance of international cooperation in science, technology and innovation to address global challenges (OECD, 2012). The Royal Society has added its voice to calls for improving and scaling up international co-operation in science, technology and innovation to address global challenges (Royal Society, 2011). It is also part of official US R&I policy, where "*harnessing science and technology to address the "grand challenges" of the 21st century*" is one of the goals of president Obama's 2009 Strategy for American Innovation. This list can be expanded to include other organizations, regions and nations, where the (grand) challenges notion has come into common use in the way overall policy goals and rationales for supporting and mobilising research and innovation are being framed.

Articulating the question: "a new paradigm or old wine in new bottles?"

The distinct emergence of both the term and notion of societal/grand/global challenges in R&I policy discourse is taken by many to indicate that "something new" is emerging in R&I policy, i.e., new ways of framing the missions of R&I, new goals and priorities, new approaches to collaboration and to governance, new instruments etc. As long as the notion remains indeterminate and incompletely developed, and the term is being used in divergent meanings, in ever new contexts, and in increasingly elliptic and parasitic ways, it seems difficult or impossible to be specific about what its novelty is, exactly, in what respects and in relation to what it is new, without making more or less explicit normative selections of one or a few exemplary or "paradigmatic" cases of "genuine" challenge-driven priorities or approaches. This may be the case for some analytical attempts to pinpoint how (grand/global) challenge approach-based R&I policies differ from previous, well-established and well-documented approaches in R&I policy. Some have characterized as "a new mission-led approach" (Gassler, Polt, & Rammer, 2008) which exhibit major differences compared to "systems of innovation" approaches. According to this analysis, the rise of the national system of innovation framework in the 1980s led to a systems-oriented approach which emphasized functional and generic aspects. They see now a shift towards a new approach oriented around the development of technologies for coping with new societal challenges like demographic change, ageing society, (global) health care concerns, security, environmental and sustainability issues etc.

In another analysis, the "recent policy debates about research, technology and innovation towards societal challenges, rather than economic growth only" is seen to indicate the emergence of a new type of policy for "transformative change" (Weber and Rohracher, 2012). Policies for transformative change do not only address "failures" as defined within systemic innovation policy frameworks, i.e., infrastructural, institutional, interactional and capability failures; one needs to add a new type of failure, viz. *directional* failures: policies for

transformative change not only require that innovations be generated as efficiently and effectively as possible, but also that these innovations contribute to a particular *direction* of transformative change. This involves, inter alia, the identification of major societal problems or challenges for which solutions need to be developed with the help of research and innovation, the formation of collective priorities and the development of shared visions. This framing of the turn towards social challenges indicates a central role for such frameworks as transition management, multi-level governance and co-evolution of social, institutional and technological systems.

As Gassler et al. (2008), Mowery, Nelson and Martin (Mowery, et al., 2010) characterize R&I policy to meet the global climate as a form of mission-oriented policy. The novelty of this type of mission-orientation is spelled out by comparing and contrasting it to the type of mission-orientation that was characteristic of such mission-oriented projects as the Manhattan project and the Apollo programme. While the latter were designed, funded, and managed by federal agencies to achieve a specific technological solution for which the government was effectively the sole 'customer', technological solutions to global climate change must be deployed throughout the world by many different actors, and these deployment decisions will require huge outlays of private as well as public funds" (Mowery, et al., 2010, p. 1012). The "high degree of administrative centralisation" of these mission-oriented projects contrasts with the new challenges, which require that a large number of heterogeneous actor groups have to develop, produce and deploy a large variety of technological solutions in a diverse array of sectors throughout the world, not just inside the realm of one nation. The dominant supply-side research policies of earlier mission-oriented projects will also not work in programmes for addressing climate change, where technology policy has to be supplemented with demand-side policies aimed at changing human behaviour and halting the increasing demand for energy and degradation of biodiversity.

These are some initial attempts to capture in *analytical* terms what appears to be new in the emergent R&I policy debates and developments linked to the notion of grand/global challenges. No doubt, they capture important aspects of that novelty. But by taking their point of departure from within a given analytical framework, their perception of novelty may as much stem from limitations of the analytical framework itself as from "real" novelties. This is, e.g., self-reflexively noted in the introduction to the *Research Policy* special issue on "The need for a new generation of policy instruments to respond to the Grand Challenges" (Volume 41, Issue 10, Pages 1697-1792), [1]

> Much of the economics literature on these policy issues [social challenges] focuses on public support of R&D as a response to "market failures." Although market failures are clearly present in many of the current challenges, economists have tended to overlook the significance of R&D support programs that are focused on specific objectives, in spite of the size and significance within most industrial-economy public R&D budgets of these programs. More generally, scholars writing about science and technology policy have

[1] "[Cu]rrent discussions of R&D policy responses to today's social challenges have proceeded with little awareness of these programs, except for Manhattan and Apollo. Much of the economics literature on these policy issues focuses on public support of R&D as a response to "market failures." Although market failures are clearly present in many of the current challenges, *economists have tended to overlook the significance of R&D support programs that are focused on specific objectives*, in spite of the size and significance within most industrial-economy public R&D budgets of these programs. More generally, scholars writing about science and technology policy have largely focused on measures intended to stimulate overall economic growth. And scholars doing research on the role and nature of public R&D in support of particular sectors and objectives like national defense, or public health, or agriculture have tended to publish their work in specialized journals that are unfamiliar to most readers of *Research Policy*." (Foray et al, 2012, p. 1697, italics added).

largely focused on measures intended to stimulate overall economic growth. (Foray et al, 2012, p. 1697, italics here)

A next step in this type of self-reflexive program for developing a framework for understanding and analysing these R&I policies may, then, be to resume and incorporate up to now neglected knowledge from, i.a., other fields of study about public R&D programs (as seen in the quoted special issue of *Research Policy*). Again, this "re-discovery" may no doubt be a necessary step in the re-articulation of dominant policy analytical frameworks, but one question is, how far state-of-the-art knowledge about *national* R&D programs can go in capturing the specificity and novelty of challenge-driven R&I policies if one of their key is their *supra-national scope* (which is one of our arguments below).

These few references indicate some strategies that are being developed to capture and conceptualise what appears to be new in the emergent, distinctive discourse on challenge-driven R&I policy. We make in this paper an argument for a more cautious and circumvent approach, emphasizing the need to "follow the (policy) actors", tracing and describing how policies are framed, justified and implemented in terms of responses to grand and global challenges. Hence, we refrain from making premature claims from a vantage point within established analytical frameworks about the "really" new of these discourses and policies. Thus, as the uses and meanings of the term in R&I policy contexts at global, regional and national levels multiply, we think it is useful to develop a broader empirical and conceptual basis for describing and assessing the strength and direction(s) of the drivers of innovation and change in these developments, recognising in particular that drivers of novelty and innovation as well as processes of capture and co-optation are involved. Understanding the interplay and relative strength of these drivers is, according to our argument, an essential part of the basis on which answers may be given to questions such as: to what extent, in what respects substantive reorientation taking place in developments of challenge-driven R&I policies, and, inversely, in what ways and to what extent are they subject to co-optation and capture, by which impulses of innovation are being diverted?

Mapping diversity, ambiguities and tensions

If there may be ample basis for claims that real change is involved, the situation presents itself *prima facie* as one where the grand/global challenge terms are used with multiple meanings by different actors and in different contexts, increasingly so in all respects as it is being picked in a bandwagon-like effect. The (increasingly) multiple and heterogeneous uses of the challenge term derive partly from the wide thematic range of the different challenges involved: climate change, clean energy, food security, aging societies, biodiversity, terrorism, health (in poor countries, pandemics), poverty/inequality, clean water, etc. The list is in principle open, as no well-defined and authoritative thematic criteria are given as to what candidate challenges may appropriately be considered as sufficiently "major" to count as grand and/global. There seems to be a multitude of meanings and uses of the grand challenge term, - sometimes diverging to an extent that make them mutually incompatible, sometimes indication of convergent uses that may form the nuclei of emergent coherent conceptual frameworks. As a weakly defined term used in multiple meanings and for different purposes, it lends itself to uses by actors for framing problems in ways which make *their* contribution appear as key to their resolution, leaving open if "challenges" in such cases function as "garbage cans" or as "boundary objects". These developments may thus be structured by tensions between, on the one hand, processes of re-labelling of policy objectives, priorities and instruments that remain largely unchanged, while in other cases they may reflect a genuine drive for policy change, innovation and learning.

Methodology. As the number and variety of uses and developments of the grand/global challenges term and notion in R&I policy contexts rapidly increases, it becomes impossible to make an exhaustive map of these developments. Hence, making choices about which documents and cases warrant being highlighted as seminal and exemplary is inevitable. A choice has to be made of documents and policy developments that are accorded a "privileged" status as authoritative and seminal, as sources where the very notion of a challenge-driven policy approach is developed and set down. This privileged status may in principle be confirmed on the basis of, e.g., the documented number of references and citations received. The OECD Innovation Strategy and key EU communications about the rationale and structure of Horizon 2020 [2] are obvious examples of documents which would be found to qualify as of privileged status on that basis. This may thus justify their use as sources and main steps in the development of key criteria and standards of what a challenge-driven policy approach "appropriately" is and should be. While we have in our subsequent analysis accorded some policy documents and initiatives a privileged status, these choices are not made nor justified on such strict basis, but on the basis of a shared, largely implicit understanding of overall international policy debates and developments within our field. At the other end of the spectrum, there is a huge number of specific uses of the term and notion, uses that are often highly elliptic, thus drawing on the authority and reflecting the rhetorical impact of seminal documents and developments. These may indicate the diffusion of the term and notion, without claiming the normative authority that of the seminal documents and uses, against which the "authenticity" of these "derivative" uses may be assessed.

Assigning, then, a certain normative authority to what is at this explorative stage a loosely delimited number of seminal documents and developments, we may trace the emergence of some recurring issues in these developments. They form the basis for an emergent core of policy dimension that are, explicitly or implicitly, key in discussions and uses of the challenge term within R&I policy contexts. The rest of this paper is a first step in trying to identify and describe these core dimensions, as a point of departure for developing an analytical framework by which the application in R&I policy contexts of the grand/global challenges term and notion may be characterized in terms of "location" along dimensions which make up constitute this analytical space. We do not only look at "discourse" (documents, statements) in the narrow sense of the terms, but also at discourse is embedded in practice, i.e., funding, governance, design of instruments etc.

Main policy dimensions

1. *Framing (rhetorics).* The introduction of the language of "challenges" are sometimes justified in explicit *rhetorical* terms, as seen in particular in the 2008 report of the Rationale Expert Group to the EUC. The group propose the "grand challenge" approach to *reframe* overall EU research policy. It is argued that it is more effective than the 2000 Lisbon strategy in rhetorical terms, i. e., as a means to "capture the imagination of publics, politicians and stakeholders". In framing EU research policy in terms of responding to grand challenges, it provides an image or presentation of ERA policy that may positively affect the perceptions of the public and stakeholders. It redresses the failure of the overall ERA rationale of the 2000 Lisbon strategy which focused on "remedies for perceived failures in the research system", *in casu* fragmentation and deficit (Barcelona target). In contrast, "[t]his report presents a rationale for a *European Research Area* that has a *clear purpose* which is *meaningful to Europe's citizens and political leaders and relevant to its key actors*.

[2] In particular COM(2011) 808 final: Horizon 2020 - The Framework Programme for Research and Innovation.

While there is a pressing need to improve the effectiveness of the public research system, the ultimate justification of the resources and commitment needed to achieve this lies in increasing the value of the contribution that public and private sector research makes, and is seen to make, to Europe's economic, social and environmental goals." (p. 4, italics in the original). The rhetorical dimension is also salient in other reports in the EU policy process, as seen, e.g., by its use to sustain, e.g., the "new renaissance" of ERAB reports. The rhetorical dimension of challenge-oriented policies may be more or less explicit in specific uses. It may often be highly explicit in *general* policy documents, here often used to structure and justify *overall* policy orientation, structure and priorities. This dimension may be more implicitly present, when it is used elliptically and "derivatively", without much explicit rhetorical content, thus implicitly borrowing authority from the positive connotations and general adoption of the term in general policy discourse.

Box 1:

As part of the study was conducted an analysis of the strategy documents and annual reviews of three major Finnish science, technology and innovation policy organizations: Research and Innovation Council, Tekes – the Finnish Funding Agency for Technology and Innovation, and the Academy of Finland. The analysis focused on documents from the mid-1990s to the present.

The analysis of the documents of the three agencies indicated that the themes which are currently called "Grand Challenges" or the ways their nature is understood are not new ones in the STI policy.

For instance, environment has been a longstanding issue in the policymaking. It has only increased its significance over the years and the issue has become increasingly nuanced and manifold. Environment was not either a rhetoric aspect in the policy documents. For instance, the funding of environmental technologies developed positively already in the beginning of 1990s. Between 1992-1995 the rise in Tekes funding was approximately 75%. Already in 2002 Tekes also released a strategy, in which it defined explicitly global challenges, which act as drivers for societal development. The strategy also connected various macro-level societal trends together in order to argue for certain actions or technological developments. It was understood that the trends were "systemic" by nature and they were connected to several aspects in our living environment. "Grand Challenges" were presented as "drivers" or "trends" that affect profoundly to our natural and social environment, which meant, in turn, that systemic policy measures has to be developed to tackle these problems. It was stated e.g. that:

- "Technological development may bring along social inequality, which must be taken into consideration in the development of educational and social services. Regional differences are also likely to be highlighted."

- "International cooperation is necessary in environmental and safety issues, the steering of the market economy as well as in the improvement in the conditions of slowly developing countries."

- "Globalisation brings along social challenges and problems in interaction between various population groups and cultures. (…) It must be ensured that the development of technology is planned and controlled to promote welfare. Tensions between the approaches of different cultures, population groups and political attitudes must also be prevented from creating social and security problems." (Tekes 2002, 7)

2. *Scale of stakes.* Discourse on challenge-driven policies often emphasize the high, even extreme, stakes in the search for effective solutions to challenges. These are challenges that are grand, often alleged to be truly "existential" in nature and scale. In this respect, the global warming/clean energy challenges clearly lead the way. Thus the challenge discourse follows earlier "life and death" rationales of R&I policies (winning the cold war; "life-saving" medical progress; "survival" of firms and national economies in the increasingly competitive global economy etc). The Royal Society report talks about "significant threats to societies and ecosystems". However, with the diffusion (and dilution) of the challenge discourse, examples may often be found of its application to issues that are, arguably, of a less "grand" nature, as concern the stakes involved, hardly exceeding those of "normal" problems, often with merely nominal connection to challenges that are generally recognised to be grand in scale.

Box 2:

In the stock-taking exercise under the VERA (Visions for ERA) project (see footnote 3), the novelty of the 'grand challenges' concept or the extent of (re)framing it to the current policy debates appears to be of less importance in the documents studied[1]. The concept is primarily used to establish rationales for policy interventions. It could be argued that in the EU strategic policy documents and to some extent the forward – looking activities (FLAs) of international scope the concept is used as a means to capture the imagination of publics, politicians and stakeholders so as to align and orient efforts towards the achievement of specific goals that serve the public good. Interestingly the concept seems to serve the needs and interests of all different cohorts (society, policy, business) the least from a communicational aspect. Thus, a 'promotional' or 'normative' tone can be identified in these documents in terms of the need to tackle the grand challenges addressed. Following the EU vocabulary, FLAs on national research priorities may also have a similar promotional character. Beyond the surface however the focus is placed on the particular circumstances facing each country and how the (grand) challenges are interpreted in the local contexts. This is true primarily for EU countries. In other parts of the world (India, China, Brazil) the 'grand challenges' rhetoric is less profound. FLAs with a specific sectoral focus may follow the 'grand challenges' approach in establishing policy rationales but they also give a more pragmatic approach to the relevant discussions by going deeper to understand the particularities of specific challenges for specific sectors in defining possible strategic (technology) roadmaps.

Grand or global? While the notion "grand challenges" has become ubiquitous in European R&I policy, other players (the OECD, Royal Society) prefer the "global" term, which more explicitly link this approach to processes and issues of "globalization", both in terms of stakes, thematic focus and interactional requirements (international cooperation). However, the similarity and overlap between the notions of grand and global challenges is extensive, as, e.g., emphasized in the following statement in the EU Innovation Union: "many if not all of the societal challenges on which Europe's research and innovation efforts must focus are also global. Overcoming many of these challenges calls for worldwide sharing of efforts. In particular, many major research infrastructures require massive investments that can only be raised through global cooperation." (COM(2010) 546 final, p. 27). Both grand and global challenges are, however, "societal" (see quote

above; OECD, 2010, Chapter 6: "Applying innovation to societal and global challenges"), see dimension 9 below.[3]

Box 3:

While the requirement for some form and degree of formal multilateral cooperation and collaboration are in some cases explicitly part of the definition of grand/global challenge-driven R&I policy approaches, national policymakers may assign the now rhetorically laudable epithet "addressing global challenges" to extant national programmes and priorities, without requiring much change in the collaborative framework for pursuing the objectives of the priority ion question. This applies to a large part of those Norwegian policies that are explicitly framed and justified in terms of addressing global challenges. The most important policy innovation in the 2009 Norwegian White Paper on research policy (Kunnskapsdepartementet, 2009) was the introduction of "global challenges" as a new, overall thematic priority. The reframing of a number of general thematic priorities as "global in scope and approach may be seen to be the major innovation in that White Paper, seen against the background of stability and only incremental change in overall national R (&I) policies. Its use in reframing the *overall* profile and structure of national research policy, may thus be seen as a case of stroing rhetorical impact. The recently published 2013 White Paper on research policy makes no change in this respect.

However, the strong impact on the rhetorical dimension is not matched by much change in actual policies. The "global challenges" priorities of the 2009 and 2013 White Papers encompass topics such as climate, energy, protection of biodiversity, oceans/marine research and food security, many of which were already established thematic priorities with their own, (mostly) national programmes, before the White Paper was published. These policies and programmes can in practice hardly be seen to have changed much since 2009, either in terms of funding, organization and scope.

One exception to this is, however, the emergence of a strong climate/energy priority: a Climate Agreement from 2008 between all political parties in the Parliament led to a steep increase in funding from 2008 to 2010 for clean energy research (and innovation) and (to a less extent) for climate research. These developments did not, however, include much change in terms of the actual global scope and supranational organization of the supported efforts. Most of the increased funds for energy research was distributed between various branches of the national energy industry on the basis of a national strategy (Energy21), developed in corporatist collaboration between the affected industries themselves and the research communities that serve them. That strategy was criticized for having neglected altogether the global scope of the effort, taking the interests of affected interests more into account than concerns with how policies could make the most effective contribution to the global climate/energy challenge.

Another related change is that Norway decided to take part in all ten European JPIs, if to highly variable extents in the various JPIs. The Seas and Oceans JPI has highest priority, where Norway is one of the leading/coordinating countries. This priority corresponds well with the established national marine/maritime priority, which was (at least part of it) reframed and re-categorized in the 2009 White Paper as one of the global challenges. This may be seen as one step towards a stronger commitment to redesigning at least one thematic priority for its further development within a supranational, collaborative context.

[3] 70 docs were reviewed under the VERA project (http://eravisions.eu/) in relation to how grand challenges are discussed. This list included ERA governance related policy documents, European forward-looking activities (FLAs) addressing the future of ERA, FLAs in national R&I priorities, FLAs on important European sectors like IT, agriculture, security, transportation, energy and new emerging technologies and FLAs of international scope. The review of these documents addressed the ways grand challenges or issues associated with grand challenges were discussed. More specifically, information was retrieved in relation to the thematic areas of the challenges discussed, the explanations of justifications of the challenges, the aspects implied in relation to ERA and R&I governance, and the associated scenarios and solutions suggested.

3. *Supranational scope.* The importance of international collaboration and joint supra-national efforts are emphasized in many initiatives that are framed in the terms of addressing grand/global challenges. In some versions, international collaboration is integral to their very definition, as, e.g., in the OECD innovation strategy: "global challenges are *defined* by the need to cooperate on a global scale" (italics added) (OECD, 2010). Grand and, in particular, global challenges affect by definition more than one nation and cannot adequately be addressed within the constraints of national policy frameworks. As this is arguably the by far dominant political context of R&I policy development and implementation, this could imply a call for radical change in the way R&I policy is framed, organized and implemented. The grand/ global challenges straddles national boundaries, they affect "everyone", so it is, in the common interest for all populations in "all" nations and regions of the world that they be resolving through a common effort. The supra-national scope and nature of the challenge in question may also imply that addressing and resolving them effectively require, by definition, much more extensive and effective international collaboration and coordination at the organizational and policy levels (not only at the performing level): "Global challenges are *defined* by the need to co-operate worldwide to create a public good (mitigation of climate change, health) or protect the global commons (the environment, fisheries)". (OECD, 2010: 165, italics added). "Global challenge science looks set to increase in terms of importance, scale and impact. It requires international co-operation on a large scale because of the nature and magnitude of the potential consequences of these problems. No one country or scientific discipline will be able to offer complete solutions." (Royal Society, 2012: 72). Which propels the issue into to the challenging and complex field of multilateral international collaboration in science, technology and – now even – innovation.

   The same applies to the introduction of the grand challenges approach into the overall framework of European R&I policy framework, adding essentially a rationale for the role of the EU as framework for collaboration, coordination and pooling resources over and above the limitations of what member states can achieve within the constraints of their respective national policy contexts. Hence, addressing grand and global challenges only or predominantly within national R&I policies could, according to this definition, be seen as a *contradictio in adjecto*. While the requirement for some form and degree of formal multilateral cooperation and collaboration is inherent in this definition of grand and global challenges, this does not prevent national policymakers from assigning, by re-labelling, the laudable epithet "addressing global challenges" to programmes and priorities the scope of which remain exclusively national, without adding any significant elements of formal collaboration or explicit coordination across national borders.

4. *Scale of effort.* This is the verso of the supranational scope of grand/global challenge-oriented R&I policies. For such challenges to be effectively addressed, *more* intellectual and monetary resources are required than what single actors, even large nations, can muster alone. This point is particularly clearly stated in the ERA rationale group: while EU framework programmes already encompass programmes that address issues such as clean energy, food, health, demography etc, a shift towards a challenges approach implies that a few efforts and programmes should be considerably up-scaled so as to reflect the much higher stakes involved in those particular cases than for any "normal" mission-oriented R&I effort. The rationale report emphasises the high scale of stakes and the extreme up-scaling of efforts required: taking the European Strategic Energy Technology SET-Plan as "exemplary

response to a grand challenge", it argues that "with grand challenges potentially costing 5 billion € to 10 billion € each, it is hard to see Europe affording more than three or four at a time even within an increased budget" (Nature, op cit., p. 936). As we now know, as many as ten JPIs have been selected, probably with more to come, launched as efforts to respond to "major societal challenges" (COM(208) 468 final).

The ERA rationale report weaves together the framing, scale and scope dimensions (dimensions 1-3) in its summing up of its conceptualization of the grand challenge approach: "Grand Challenges should derive this name from the fact that they are of sufficient scale and scope to capture the public and political imagination, create widespread interest among scientific and business communities and NGOs and inspire younger people. They must be capable of acting as an important tool for percolating attention at all levels of society all the way down to civil society and the public at large. Grand Challenges should be few in number at any moment" (Rationale Report, p. 37).

Box 4:

This national – international clash can also be identified in the documents studied in the VERA stock-taking exercise. In FLAs of international scope where it is international organisations that are the key players, the approach in the discussions reflects the global scope of the challenges and need for international collaboration. The need for international collaboration as well as what this implies on current collaboration structures and attitudes is discussed particularly in relation to the challenges regarding health, ageing, migration, security, and basic resources shortages. The need as well reluctance to delegate power at international level has been noted alongside the need to strengthen existing structures or create new ones.

In contrast, cross-national collaboration is not strongly highlighted in national FLAs which may seek for example solutions to the energy shortages quite differently from other EU member states of other world regions Eventually it is national specificities and national strengths and interests that are reflected in the ways grand challenges are discussed, interpreted and proposed to deal with. This is natural for the national FLAs given that it is national institutions that are called to take action even if in coordination with counterparts from other countries.

5. *Thematic variety and centrality.* While climate change, global warming and clean energy are issues that are always listed as grand and global challenges, it varies much more between context both *which* other topics qualify as grand/global challenges and how they are framed *as* challenges at those levels of stakes and efforts. We quote a few lists from a selection of arguably influential documents:

   EU documents: The *Lund declaration: "*sustainable solutions in areas such as (sic) global warming, tightening supplies of energy, water and food, ageing societies, public health, pandemics and security…. turning Europe into an eco-efficient economy".

   Towards Joint Programming in Research, COM (2008) 468 final: "sustaining Europe's prosperity in the face of increased global competition; dealing with the needs of its ageing population and the challenges of immigration; and stimulating sustainable development, especially in the context of climate change, securing the supply of energy, preserving human and environmental health, ensuring food quality and availability as well as safeguarding citizen security"(p. 3).

EU JPIs: Healthy and Productive Seas and Oceans; JPI-Climate; More years, better lives; The microbial challenge – An emerging threat to human health; URBAN EUROPE - Global Challenges - Local Solutions; Water Challenges for a Changing World; Joint Programming Neurodegenerative Disease; Agriculture, Food Security & Climate Change; Cultural Heritage & Global Change; A Healthy Diet for a Healthy Life.

Box 5:

The analysis of the Finnish STI policy documents from the mid-1990s to the present suggests that the introduction of the Grand Challenges discourse in the EU did not change Finnish STI policy significantly. Tekes barely mentioned it in their documents, while Research and Innovation Policy Council have referred to different types of (societal, global) challenges in their tri-annual review documents increasingly since the turn of the millennium – albeit usually in rather general terms and from distinctly national perspective. The Academy of Finland paid some attention to it from the perspective of basic research. Apparently it did not, however, bring any new perspectives or instruments to the STI policy. The reason for this may be rather simple. As the themes which are now defined as grand challenges and related readily available policy instruments were already in use, the EU level policy discourse did not bring anything new to the policy making. This suggests, in turn, that there may be significant variety among countries, how they interpret, obtain or utilize Grand Challenge "vocabulary".

In an appendix of the Review 2006 of the Research and Innovation Council (a strategy on internationalisation of Finnish science and technology 12.11.2004) there is paid attention to global problems and challenges in general terms as well as Finland's responsibility in responding to them. At the outset of Review 2008 there is a direct reference to challenges understood in current discussion as grand ones: "The field of ERI policy is experiencing a rapid change. The change factors recognised in the report on innovation policy submitted by the Government to the Parliament on 9 October 2008 – globalisation, an ageing population and technological development, and concern over sustainable development – have an increasing effect on decision making pertaining to society and the economy. Policy measures must increasingly be connected with these changes, responding the challenges and utilising the opportunities opened up by them" (Review 2008, 8). The term 'Grand Challenges' is mentioned first time in the Review 2010 as such. However, the concept is not discussed or assessed to any extent. Instead the term 'societal challenges' is used a couple of times: "Major societal challenges that are faced by all countries, such as climate change, energy and food security, and the ageing of the population, require major investments, and, in the coming years, will guide national and international priorities in research and innovation policy. These challenges must be included as priorities in ERI policy guidelines, the allocation of resources and when developing actions. Finland must identify its own strengths, and resources must be combined to create new knowledge, expertise and business activities." (Review 2010, 22)

In general, the issues which might be related to Grand Challenges seemed to come to the fore particularly when changes in operational environment of Finland were discussed. The issues were, however, listed in rather sweeping manner giving an impression that concerns are well-known and shared by everyone.

OECD. *OECD innovation strategy*: "the effects of greenhouse gas (GHG) emissions are universal, and any solutions that reduce these emissions will benefit all countries. Similarly, most infectious diseases have no regard for national borders, and new medicines can benefit many countries if they are affordable and accessible. High food prices and food security are also an important issue for

developed as well as developing countries. (p. 165) Issues: “tackling climate change”; “global health challenges”; “(global) food security”.

The STIG project: “security and sustainability of energy and the food supply, the threat of (re-)emerging infectious diseases, climate change and the loss of biodiversity (“are only a few”). Cases studied: food (CGIAR); global health (Gates Foundation); global (climate) change (GEO, Inter-American Institute for Global Change Research, IAI), energy (IAEA, IEA); [EU JPIs: “agriculture, food security and climate change”.

Royal Society (2012): “… identified climate change, global health, food security, biodiversity, water security, population and energy security as humanity’s most pressing concerns. These are frequently referred to as ‘global challenges’ or ‘grand challenges’—those which transcend national boundaries and pose significant threats to societies and ecosystems.” (p. 72) Cases studied: global warming (IPCC); food security (CGIAR); global health (Gates Foundation); sustainable energy/TOKAMAK reactor (ITER); carbon capture and storage (CCS).

US*:* President Obama address sept 2009: *A Strategy for American Innovation: Driving towards Sustainable Growth and Quality Jobs: Harness science and technology to address the “grand challenges” of the 21st century*. The President’s commitment to science and technology will allow the United States to set and meet ambitious goals, such as educational software that is as effective as a personal tutor and smart anti-cancer therapeutics that deliver drugs only to tumor cells….. (p. xx) “Finally, innovation is itself the key to meeting some of the greatest challenges facing our nation and the world. It will be pivotal to ending our dependence on fossil fuels, helping Americans live longer, healthier lives, and protecting our freedom and our troops both at home and abroad.” (p. 4)

Lewis Branscomb, 2009 [Issues in Science and Technology]: “[Grand challenges are] technically complex societal problems that have stubbornly defied solutions”. “At or near the top of any list is the need to develop new energy sources that are clean, affordable, and reliable. The list also would include creating high-quality jobs for the nation’s population, finding cures for cancer, developing more effective ways of teaching and learning, identifying new ways to improve health and reduce the cost of care, improving the management of water resources, developing more nutritious foods and improving food safety, and speeding up the development of vaccines for deadly diseases, among others”.

These are but a few examples of the lists that come with the grand/challenges rhetorics, indicating the highly flexible and loose use of the notion to include a wide variety of topics and efforts that may fall under that category. While some of the issues recur in virtually all such lists – global warming and clean energy in particular, often also global health, food security and demographic change – otherwise, the difference between list as to what topics are listed (very often with the open-ended “etc” at the end). The quasi-ubiquitous presence of global warning in all lists provides in particular a venue for many topics to be “sneaked into” its scope, (e.g., the “Cultural heritage – global change” JPI). While some key conceptualisations of grand/global challenges make an overall distinction between social/societal and economic challenges (see below), in other case the list includes objectives that have been core objectives of R&I policies targeting economic/ growth objectives (competitive national economies, employment/high-quality jobs, etc, as in e.g., Obama’s statement above).

6. *Thematic scope.* In some conceptualizations, grand and global challenge-oriented policies deviate from established policies in defining a much wider and more open approach. In the Lund declaration this is a primary criterion in the definition of R&I policies predicated on the grand/ global challenge approach, providing as such an impetus to reform EU policies seen to be characterized by "rigid thematic approaches": "European research must focus on the Grand Challenges of our time moving beyond current rigid thematic approaches." The reform and innovation aspect of such a change is emphasized by calling for a "new deal" among European institutions and Member States. Instead, "response to Grand Challenges should take the form of broad areas of issue-oriented research in relevant fields". The ERA rationale report indicates similarly that within a reformed ERA approach predicated on the notion of grand challenges, "the first to go should be Framework Programmes that are divided into large numbers of small, very loosely connected projects defined years ahead by "work plans" with no clear providence" (Nature, 24 April 2008, p. 936).

   There is, hence, an element in (some authoritative versions of) thinking about grand and global challenges as a basis for R&I policymaking which critically opens up and expands the framework of established "mission-oriented", thematic programmes and priorities, by calling for broader, more open and flexible approaches. This could be seen to provide a degree of specificity to the grand challenges notion, which would prevent a simple relabeling of all and any thematic programme etc as *eo ipso* addressing some (grand) challenge, even if the criterion of thematic identity or extensive thematic overlap is fulfilled.

Box 6:

The review of the 70 documents under the VERA project resulted in around 761 statements about grand challenges. These were then brought together based on intuitive judgments of the partner experts into specific clusters of grand challenges that then formed 16 storylines about grand challenges. Like in the previous cases these storylines include all sorts of grand challenges in the social, economic and environmental domains:

- uncertainty arising from a multipolar world,
- increasing vulnerability of security due to increasing inter-connectedness,
- values and attitudes that are changing globally,
- traditional role of the state being challenged,
- health concerns of an ageing society,
- migration as consequence of other challenges,
- education trying to cope with new demands,
- health challenges in deprived regions,
- climate change impacts on health,
- risk of financial system failure,
- current non-sustainable economic model,
- difficulty in providing basic resources
- scarcity in material sources,
- current modes of energy supply and use threatening our survival,
- strain that transportation systems face, and
- shrinking EU competitiveness.

7. *Temporal scope*. The dimension of thematic scope links up that of temporal scope. On the one hand, it is "urgent" to find solutions to pressing major challenges (as in the OECD STIG report), on the other, an open, long-term effort is required to produce the new scientific knowledge and the truly new and innovative technologies that may open up new venues for effective solutions. Hence, at least in some versions the role of basic research is strong. [4]

[4] See, e.g., the document "A Nordic contribution to the Grand Challenges debate", which was a follow-up within the European Science Open Forum (ESOF) to the Lund Declaration.

8. *Multi-objective policy*. Often the challenge approach is introduced and developed as concerned with "social/societal" and/or "public" issues, in contrast to approaches developed within the *economic* policy domain, focused on economic objectives, in particular economic growth, and primarily targeting "private" actors, i.e., private firms, their framework conditions and primary field of operation (markets). This distinction is particularly explicit and salient in some key documents where the notion is introduced as basis and impetus for policy innovation. It is, e.g., made very explicitly in the OECD Strategy (OECD, 2010), where it is stated that "this economic challenge [future growth for emerging economies] coincides with increasing pressure to meet various *social* challenges, such as climate change, health, food security, or access to clean water" (p. 9, italics here). According to that same strategy the objectives of global challenge-oriented initiatives is, by definition, to "create a public good (mitigation of climate change, health) or protect the global commons (the environment, fisheries)" (p. 165). Some form of distinction and difference between economic and social, private and public, market and "beyond the market" may thus be seen to sustain the very notion of grand and global challenge in almost all uses, as requiring in some form and degree a type of R&I policies that differ from those which primarily target economic objectives and actors.

   This difference and distinction is, however, by far clear-cut one. If the idea of a *distinction* between the social and ("merely") economic objectives generally sustains the development of the *differentia specifica* of the challenge approach, that distinction does not take the form of an *opposition* between either/or alternatives. Addressing challenges will often and essentially require that economic objectives, including growth, be achieved, and that private companies are included as key partners, and that efficient markets must be created, and so on.

   One version of such a non-disjunctive distinction between policies to sustain growth/ (firm) innovation on the one hand and addressing grand and global challenges" on the other is found in the rationale report, where it is phrased in terms of policies' different centres of gravity. It is, according to the report, "artificial to separate economic, social and environmental opportunities since they all involve business, government and other stakeholders» (p. 36). However, the economic, environmental and social "spheres" may, for "convenience of discussion", may be categorized in terms of different "centres of gravity": "It is artificial to separate economic, social and environmental opportunities since they all involve business, government and other stakeholders. However, for convenience of discussion we could categorise them by their centre of gravity." (Rationale report, p.36).

If the relationship between economic and social (and environmental) objectives in challenge-driven policies cannot then be articulated as disjunctive opposites, it may, and often is, inversely be depicted as a relationship of confluence and mutual support, This is most saliently found in the "*challenge as (business) opportunity*" figure that pervade in particular EU policy documents following the official incorporation of the idea of grand challenge-driven R&I policies. That figure was prominent in the Lund declaration, if more explicitly so in background documents and discussions than in the letter of the declaration. It also pervades the background document to the Innovation Union ("Rationales for action", (SEC(2010) 1161 final), see e.g.: "Research and innovation have a critical role to play in the creation of economic prosperity and the resolution of major societal challenges, and win-win policies designed to stimulate the economy and tackle major societal challenges are both viable and desirable.» (p. 6). "The key therefore, is to mobilise resources at EU and global levels to tackle major societal challenges through investment in research and innovation, seeking win-win situations by focusing on areas where both market potential and the need to resolve major societal challenges are greatest." (p.10). It also sustains, e.g., the EU Green paper on the CSF for EU R&I funding (COM (20011) 48), where the intimate link between challenge and (business, research) opportunity is encapsulated in its very title: "From Challenges to Opportunities". "Challenges such as our ageing population or our dependence on fossil fuel do, however, also provide powerful opportunities to develop innovative products and services, creating growth and jobs in Europe.» (p. 3) The Horizon 2020 communication calls for "a strong focus on creating business opportunities out of our response to the major concerns common to people in Europe and beyond, i.e. 'societal challenges'" (COM(2011) 808 final, p. 4).

Box 7:

The VERA stock-taking exercise revealed certain conflicting issues especially in the overall "philosophy" on how certain challenges are to be tackled. On the one hand there is the classic "growth" rhetoric based on competitiveness and growth of the neo-classical paradigm. This approach sees climate change and sustainability challenges for example as an opportunities for new businesses. The major concern is Europe's lagging behind against its main competitors and emerging new economies and new technologies are seen and discussed with regard to competitiveness. The economy is a very prominent area among the areas exposed to grand challenges. The EU competitiveness always relates to the EU's position in the world and how the EU economy will perform in the future competing with emerging economies as well as with traditional great powers.

On the other hand, there are the advocates of new economic and business models that are socially and ecologically responsible. This approach calls for paradigm changes such as changing production and consumption patterns as well as societal values and ultimately acknowledges the limits to growth in a world of finite natural resources.

In conclusion, in grand (and global) challenges approaches, the relationship between, the combination, alignment and mix of economic, environmental and social objectives is a complex one – it is a relationship of difference (in emphasis), of combination, confluence and overlap, making it impossible to mark the exact

boundary where growth and innovation policies end and challenge-addressing policies start. This does not, however, dissolve the differences between them, whether they is phrased in terms of relative emphasis on social and economic objectives respectively, in the different roles of public, civic and private partners, in the relative emphasis on public and private goods/services as output, etc.

The salient "challenge as opportunity" figure built into the grand challenge approach may be seen to provide one perspective for assessing specific challenge-driven initiatives in terms of their innovation/co-optation mix and balance: do they really, and in what specific ways, represent new and innovative ways to address challenges or do they appear to be not much more than more appealing wrappings of research and business activities vying, as always, for additional resources and conducive conditions on their own terms?

Box 8:

The analysis of Finnish STI documents suggests interestingly that the themes, which could be considered as global, were primarily treated from the perspective of national interests. This means that while e.g. climate change and ageing are identified as global trends, they are not reacted from this perspective. The priority is usually given to the competitiveness of the country and to the necessary changes needed in social structures to keep welfare state up and running.

The orientation is instrumental. For instance, Tekes concluded in 2005 on environmental change: "Sustainable development is a driver that creates and shapes global markets. It also represents changes in the relative costs of production factors and thus market opportunities for those who react quickly. It emphasises an environmentally sound approach and eco-efficiency, but also includes human aspects and sustainable economic growth on environmental and social terms." (Tekes 2005, 5) Research and Innovation Council stated a couple of years earlier: "The main challenge for economic and societal development, in conditions of growing global competition, is to be able to keep Finland sufficiently attractive to business and jobs and as a living environment in general. Apart from the international challenges, there are a number of domestic issues to be addressed. Faced with an ageing population and the ensuing pressures for taxation, Finland will have to secure welfare services, to curtail unemployment, which is still high in the aftermath of the recession, and to solve other problems relating to human and social development. Employment rates must be raised and regional development balanced." (Research and Innovation Council 2003, abstract)

Noteworthy is that these problems or "challenges" are usually seen predominantly as business opportunities. While the perspective in the latest strategies becomes broader including also wellbeing and health, the business motif is the dominating perspective. For instance, climate change is both a boundary condition and an opportunity for the business. Likewise: "The ageing of the population issues a number of social, educational and economic challenges, while the growing number of senior citizens with more spending power also creates significant business opportunities. It is important to be able to provide developing living and housing environments, pharmaceuticals, equipment and services to enable better living conditions. The independent life-management of people and the efficiency of services must also be promoted." (Tekes 2002, 7)

The extensive overlap between "social" challenge-driven policies and firm-oriented innovation policies and the extent to which the one may be seen to shade into the other appears to be particularly evident in the similarities between challenge-driven innovation policy on the one hand and demand-side firm-oriented innovation policy on the other. In economic terms, demand is a primary policy driver in challenge-driven policies; while innovation policies assigned to the "economic sphere" (cfr. rationale report) have had a strong supply-side bias, this bias is redressed somewhat by the inclusion of demand-side instruments/elements, such as "lead market initiatives" and public procurement. In both challenge-driven policies and demand-oriented innovation policies, government and public agencies (and budgets) play a key role, albeit with slightly different rationales: while challenge-driven policies require that public actors (and resources) take the lead in guiding the search for solutions to specific problems and satisfy specific unmet needs, demand-side policies intervene actively in markets to create demand for innovative products and services, with the explicit (main?) intention to develop market conditions that may enable innovative firms to emerge and grow. Thus, only a blurred line can be drawn between demand-driven innovation policy on the one hand and challenge-driven R&I policy on the other, the one shading into the other as, e.g., procurement and the role of public demand is increasingly emphasized in the latter as a means to create opportunities and markets for innovative firms, that is, to create an "innovation-friendly market/society" conducive to innovative firms, as much as it is a way to solve public problems and meeting public needs.

It will also be impossible to evade issues of goal alignment and conflict between various "societal" goals, not only with economic. Given the comprehensive scope of all relevant challenges, indicating that it is not possible to target one challenge without taking into account how actions to resolve one challenge may impinge on others. Conflicts may surface between efforts to reduce climate gas release and actions to alleviate poverty and extreme inequalities, policies for increasing clean energy production may turn out to be in conflict with food security objectives etc.

9. *Orientation and steering.* The many interdependencies and extensive overlap between societal and economic objectives in (many) challenge-driven policies notwithstanding, a key difference between policies to address challenges and policies to sustain (overall) economic growth, is that the former involve some degree and form of *steering* of efforts towards a specific mission or objective. While the EU Rationale report emphasized that the difference between challenge-driven and economy/growth-oriented policies is one of emphasis rather than nature, it noted that for R&I policies which address grand challenges within the environmental and/or social spheres, "for most of these the drive will have to come from governments" (p. 37). Similarly, the accompanying "rationale for action" document to the EU Innovation Union communication states that the overall orientation of challenge-oriented and supply-oriented R&I policies differ by the fact that addressing challenges "involves placing a far greater emphasis than hitherto on attempts to influence the direction rather than the rate of technical change and innovation." (SEC(2010) 1161 final, p. 26). The centrality of the difference in this dimension between challenge-driven and innovation-oriented R&I is particularly strongly emphasized in Weber et al, 2012 (see above). That difference may also be phrased in terms of a difference, potentially even an opposition, between directive and facilitative (innovation) policies.

Box 6:

It is interesting to note that in the discussions about the ways and approaches that should be adopted in dealing with grand challenges in the documents studied under the VERA project the notion of 'users' is given a more active tone. Users are addressed as important stakeholders that should get involved actively at the outset in the discussions about how to deal with grand challenges. In this regard 'users' may also mean 'co-producers'[1], or 'co-innovators'[1]. This may also reflect emerging trends towards different types of production like peer production (Benckler, 2006) or open innovation (Chesbrough, 2003) or user-driven innovation (von Hippel, 1986).

10. *Interactional mode (collaboration/competition).* One dimension along which R&I policies to address challenges may differ from R&I policies to sustain economic growth and the competiveness of firms and national economies, may be in their different emphasis on collaboration and competition respectively, e.g., in a stronger emphasis in challenge-oriented policies to develop policies and deploy resources within formal collaborative frameworks (organizations, programmes) at the supra-national level, while in a national framework for developing R&I policies concerns with the competitiveness of the national economy will be strong. Schematically, while competition may be deployed in the service of collaboration in the GC approach, defined by search for common solutions through international collaboration, while the reverse may be the case in policies for growth and competitiveness within national (and regional) frameworks to support the interests and capability of the "own" actors (economy, firms, researchers). This tension will come to the fore in i.a., issues of "(juste) retour" and IPR.

11. *STI spectrum*. Lastly, one important dimension along which policy initiatives to address some grand and global challenge may differ widely from each other is the relative "location(s)" of actions along the STI spectrum – from basic, oriented/strategic and applied research over development on demonstration to innovation commercialisation or effective resolution of the challenge in question. While schemes for collaboration in research is well developed, few collaborative models exist at the "innovation" part of the spectrum (except within contexts of development, aid and philanthropy), where concerns of commercialisation, market return, competition and protection of intellectual property often prevail. Hence, this is also where tensions between concerns with effective collaborative challenge-orientation and search for opportunities for (national) business may surface acutely, and where it may be most difficult to get balance and mix between collaboration and competition right (see dimension 5 above).

    The strong emphasis on "resolving" challenges may indicate that efforts at the innovation end of the spectrum may be mandatory in any "complete" challenge-oriented policy, as neither new knowledge nor new technologies can in themselves be expected to resolve any major issue/challenge.

12. *Stakeholder involvement*. While the political authority and the privileged access to resources of governments and national and international agencies and organizations put them in key positions in the organization, funding and implementation of challenge-oriented initiatives, addressing challenges through R&I is nowhere seen to appropriately organized through top-down steering and hierarchical organisations

structures. While the notion of "partnerships" are becoming common as a venue also for addressing grand and global challenges, these partnerships are conceived as having to be particularly extensive, inclusive and heterogeneous (in contrast to, e.g., the Triple Helix structure of partnerships for "the knowledge-based economy"). Statements along the line of the following abound: "Nevertheless, some common strategies are emerging: greater involvement of the private sector, non-governmental organisations, philanthropic organisations, and other stakeholders in the prioritisation and delivery of science and innovation …. They call for closer involvement of the developing world and a build-up of these countries' research and technology capacity." (OECD, 2010: 181). It is an issue of "empowering new players": "Non-governmental organisations, private, often philanthropic, foundations and social entrepreneurs which often are driven by non-profit motives can play an important role in catalysing innovation to solve social problems that are insufficiently addressed by governments or the market." (ibid).

13. *Governance.* Having listed above some relevant "dimensions" for characterising and assessing challenge-driven R&I separately, one may need a category for describing how each challenge-oriented policy "item" combines and configures its "solutions" to the issues indicated by these dimensions. In this regard, Upham et al (2013) argue that the assumption of collective, collaborative steering of socio-technical change found in transition management thinking accords well with the governance themes explicit and implicit in grand challenge discourses. Although there is diversity in these discourses (Giesecke and Warnke, 2013), themes of integration, systems thinking and inclusive decision-making are typically evident. Transition management appeals to concepts of complex adaptive systems, social learning, co-evolution, adaptive capacity and self-organising networks (Loorbach, 2007), which involve varying degrees of societal involvement and co-operation.

Towards a matrix for benchmarking challenge-driven R&I policies?

Through our selective and cursory overview of a few cases and aspects of the international development of R&I policies framed in terms of addressing grand and global challenges, we find then a number of recurring issues and dimensions that will have to be included in framing, implementing and assessing what may be – or become – a novel type of R&I policy. They are defined by the much *higher stakes (2)* involved in resolving such challenges than "normal" in regular public, mission-oriented and national R&I policies. Their *scope* (3) is also far more extensive than that of "regular" issues and problems; they affect (almost) "everyone in the world", and reflect in that respect the increasing interdependence of nations and regions caused by rapid processes of globalization and internationalisation. The increasing stakes and scope of such challenges also requires that a *higher level of efforts, of intellectual and material resources* (4) needs to be mobilised for the challenges to be adequately addressed and effectively resolved. This implies that resources need to be pooled and efforts effectively coordinated, providing a specific and strong rationale for (some form of formalized) *international collaboration and coordination (3 [10])*. While R&I policies for (overall) economic growth has during this time been increasingly been developed in response to the effects of economic globalization, these policies have been framed in terms of ensuring that national economies and firms may survive in an increasingly competitive global(ized) economy, the challenges approach call for *collaborative efforts* (10) across national borders. It is generally accepted that the grand and global challenges that this type of R&I policies address are of a *social or societal* nature (8), but in a sense where social and economic objectives combine, and political, civic and commercial actors collaborate in variable and complex configurations, calling for multi-objective policies where goal alignment

and the balancing of potentially conflicting policy objectives are necessary. Hence, a requirement for *some* form and degree of *steering and direction* (9) must be ineradicably built into in any challenge-driven policies, indication that a kind of "market failure" need to be addressed which requires different (or at least additional) directional incentives and/or articulation of demand and user needs than those which emanate from the market. Addressing challenges means doing more than scientific research and technology development, it is, at the end of the day, about making an *impact on the "real world",* i.e., at the "innovation" end of the STI spectrum (13). However, as the conditions for effective "innovation" will often differ widely from normal market conditions, and the concept of innovation has, as Benoit Godin in particular has shown, become intimately associated within R&I policy contexts with the successful commercialisation of products and services, one should perhaps look for a different term and concept for innovation in challenge-oriented policy contexts. [5]

Policy initiatives, programmes etc may in principle be *descriptively* characterised in terms of how each dimensions listed is reflected in that policy "item's" framing and organisation. Along at least some of the dimensions listed items may also – also in principle – be assigned *normative* "more-or-less" or "strong-or-weak" values. While normative interpretations and uses of the dimensions have many pitfalls, normativity is nevertheless explicitly built into the grand and global challenge discourse itself, so the normative use may be justified from within and not applied from the outside, on the basis of criteria selected according to some political, personal or theoretical "preference". They should address *grand* challenges, not small problems, they address challenges of *global*, not national or regional, scope, addressing these challenges effectively requires that *large, huge, efforts* and resources are mobilised, that collaboration and coordination be improved, etc etc. So assigning to individual policy "items" "high/low" or "strong/weak" values along (some of) these dimensions , may reflect and make explicit normative criteria built into the grand and global challenge discourse itself. If some policy "item" comes out with "low/weak" values on the stakes, scale and scope dimensions, if it is located close to the national and far from the international collaboration end, if is peripheral in thematic centrality, if concerns are all on the effects on firms' innovative capacity and relaxed on effective mission resolution, if it is all about research and nothing about "innovation" and so on, then such "benchmarking" *may* provide some basis for critical assessment of policies framed and developed in terms of (contributing) to the resolution of grand and global challenges. Of course, with all the necessary caveats and cautionary notes.

[5] As, e.g., suggested in OECD, 2010: 182: «Traditional innovation concepts and models are inadequate for distinguishing socially driven innovation from profit-driven innovation. The small size and fragmentation of markets for social goods also discourage firms from investing in and committing resources to these areas. This does not mean that socially and economically oriented innovation are necessarily at odds. They can in fact be complementary, but this will require changes to the way policy makers promote innovation, for example by involving stakeholders so as to link social demands with research agendas."

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