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Food Policy 62 (2016) 78–87

Contents lists available at ScienceDirect

Food Policy

journal homepage: www.elsevier.com/locate/foodpol

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ARTICLE INFO

Article history:
Received 23 May 2014
Received in revised form 28 April 2016
Accepted 30 April 2016
Available online 26 May 2016

Keywords:
Food and health
Research funding
Innovation
Europe
Responsible research and innovation
RRI

ABSTRACT

Responsible Research and Innovation (RRI) has recently emerged as a new framework for science and technology governance. The concept articulates the need for mutual exchange by which societal actors become responsive to each other early on in the process of innovation, with a view to facilitate ethically acceptable and sustainable innovation. There is relatively limited evidence to explore the extent to which the process of research and innovation under the terms of RRI is realised in practice, particularly in the context of food and health research. Although research to date has been examining innovation from the point of view of inputs and outputs—R&D funding and patents—we propose to examine the cognitive framing of innovation that shapes decisions of those who constitute a part of the innovation chain. This paper explores how the concept of innovation is understood and used in policy implementation, with a particular focus upon 'food and health' science and research policy and funding. Our analysis is based on 55 interviews of various actors engaged in research funding decision-making across eight European countries. Three themes emerged from the analysis: concept of innovation; conditions for innovation; and drivers of innovation; through these themes, the cognitive framing was drawn out. The cognitive framing suggests that innovation in the food and health domain is perceived to be focused on biosciences and marketable applications to the neglect of social sciences and broader public interest; that the "innovation network" is primarily viewed as centred around scientific/technical and industrial actors; and that the demand-pull dynamic is relevant to innovation in the area of food and health, despite having been relegated in contemporary thinking and policies around innovation. These findings point to the inadequate consideration of the normative issues—how problems are to be defined and addressed—among national research funders in the food and health domain, and indicate a gap between the ideas of innovation under the terms of RRI and innovation as conceptualised by those involved in its governance.

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http://dx.doi.org/10.1016/j.foodpol.2016.04.004
0306-9192/

1. Introduction

1.1. Background

Over the past decade, the concept of innovation has driven much of the European research agenda (European Commission, 2013a). This emphasis on innovation is a response to the acknowledged need to manage global challenges by harnessing technology, the increased requirement to demonstrate research 'impact' and calls for greater integration between science and industry (Owen et al., 2012). In particular, there has been an emergence of the concept of Responsible Research and Innovation (RRI) as an extension of the science in society discourse about co-production of solutions to global challenges and purposeful science (Jasanoff, 2005), upstream engagement (Wilsdon and Willis, 2004), and reflexive responsibility of scientists and innovators (Owen et al., 2012). Responsible research and innovation differs from existing governance concepts in its emphasis on deliberation about the purposes and motivations, not just products, of innovation (Owen et al., 2012) and on responsiveness, "the capacity to change shape or direction in response to stakeholder and public values and changing circumstances" (Stilgoe et al., 2013, p. 1572).

Seen as one of the drivers of research and innovation, and situated at the nexus between government strategy and scientists, research funders have an important role in fostering RRI and the purposeful exchange between science, business and civil society. While the mantra of upstream involvement in innovation has a long history (notable in the conceptual developments within the areas of technological assessment, democratisation of science, and public participation), there is limited evidence of the extent to which it is practiced by research funders—key actors in research and innovation agenda setting. We extend to the area of innovation other scholars' assertions that cognitive factors have long been overlooked in studies on technological change, but are essential to understanding these dynamics (Kaplan and Tripsas, 2008; Weick, 1990). Adopting cognitive framing (Borrás, 2002) as the theoretical lens, the current paper argues that through understanding the dominant cognitive framings of the innovation process that variably situate innovation within different social actors (e.g. market, industry, researchers, or civil society), the potential for RRI can be assessed. Indeed, the extent to which purposeful exchange is fostered will partly be premised upon the way innovation itself is conceptualised. The aim of the paper is to examine perspectives of actors engaged in the funding of food and health research in order to point to how innovation is conceived of and research trajectories set by those making decisions about research funding. We do this within the substantive domain of food and health, identified as one of the important global challenges by the Joint Programming Initiative (Joint Programme Initiative, 2010). Food, having long been a major subject of technology-related societal concerns, such as genetic modification and nanotechnology (Brook Lyndhurst, 2009; Klerck and Sweeney, 2007; Williams and Hammit, 2001; Zhou, 2013), is an appropriate vehicle through which to assess embeddedness of RRI in the context of health-related innovation.

Public research funders covering the area of 'food and health' are situated at the interface of government strategy and scientists; however, few European countries have dedicated 'food and health' research strategies or funded programmes. Although some progress has been made in the development of coordinated, intersectoral national nutrition policies in individual countries, called for in the First Action Plan for Food and Nutrition Policy adopted in 2000, 'food and health' tends to be segregated in terms of research strategies and programmes at both the European level and the national level (McCarthy et al., 2011; WHO Regional Office for Europe, 2004). The dearth of dedicated institutional and procedural structures for the funding of 'food and health' research agendas provides a further challenge to those intent on promoting RRI, as diverse considerations are likely to shape the decision-making relevant to the final outcome of the research programming process. In this context, understanding the cognitive frames through which funding for innovation within the 'food and health' domain is applied will provide a novel lens for the study of RRI in this area.

In order to lay the foundation for our analysis, we first review models of innovation in relation to developments in science and innovation policy, leading to the most recent development of the concept of RRI, which signalled a shift in the thinking about policy of science and innovation. We then review the role of research funders and the need for the study of cognitive frames, in order to assess the potential for RRI in the current 'food and health' research programming decisions.

1.2. Innovation: key conceptual models influencing the arena of science and innovation policy

Historically, science and innovation policy has been influenced by the linear, supply-driven (push) model of innovation in which science and technology was the major force; alongside of this model, a demand-pull framework emerged but was short-lived and later supplanted by network-oriented frameworks (Godin and Lane, 2013). Various proponents of the supply-driven model posited innovation as occurring through a sequential process that began with basic science as the initial driver, continued with applied research and then development, and culminated in diffusion; this came to be known as the linear model (Godin, 2006; Greenhalgh and Rogers, 2010; Mytelka and Smith, 2001). Alternatives to this conceptualisation viewed need, or demand, as the main force 'pulling' innovation (Godin and Lane, 2013). Although some US government studies in the 1960s found evidence of need driving innovation, needs—broadly defined, were not further studied in relation to innovation. Rather, any studies were conducted in the context of the firm. Over time, the idea of need became aligned with market demand—which fit with economic theory—and excluded human and social need, which does not necessarily manifest as market demand (Godin and Lane, 2013).

Later, non-linear models began to portray innovation as an unpredictable process involving feedback loops between variables of the linear model. Models shape policy, and policies influenced by the multidimensional, non-linear models highlighted the role of national or local environments in creating conditions conducive to such interactions (OECD, 1992). However, these models tend to have an underlying linear basis in which technology is the driver, while the demand-pull idea ceased to be a factor in any contemporary innovation frameworks (Godin, 2006; Godin and Lane, 2013). The linear model has characterised innovation policy in Europe, and in particular, the knowledge society goal of the Lisbon agenda, whereby scientific research is linked to economic competitiveness via continuous technological innovation (Felt et al., 2007). According to the report *Taking European Knowledge Society Seriously* that was commissioned by the Directorate-General for Research, Science, Economy and Society, such 'master-narratives' "are the cultural vehicles through which ideas of progress are linked to S&T in particular ways. These are not 'merely' stories or fictions. They are an important part of the cultural and institutional fabric, of taken-for-granted aspects of social order" (Felt et al., 2007, p. 12). The master-narrative that innovation is the motor of economic growth conflates broad societal progress with specific 'technoscien tific' advances through an approach where "there is no role for civil society other than as a collection of prospective customers",

thereby bypassing normative issues of who defines needs or solutions (Felt et al., 2007, p. 25; Levidow et al., 2012).

In addition to influencing innovation policy, the economic impetus has underpinned science policy. Indeed, science policy has been closely associated with industrial policy in many countries; societal benefits of science were viewed as occurring through the vehicle of economic growth (Borrás, 2002; Godin, 2006). However, there has also been a shift in policies toward a more direct link between science and broader benefits including environmental sustainability and social equality, exemplified in the recent formulations around responsible research and innovation. With the advent of these policies, new strategy bodies were created to strengthen the links between basic science and social benefits in terms of innovation, health, environment, and social cohesion (Trepte et al., 2013). In the food and health domain, the Healthy Diet for a Healthy Life Joint Programming Initiative marked a multi-country, coordinated research strategy on the impact of diet and lifestyles on health, contributing to a European Research Area on prevention of diet-related disease (Joint Programme Initiative, 2010). Moreover, innovation itself has been broadened to include 'social innovation', which is defined as "innovative activities and services that are motivated by the goal of meeting a social need and that are predominantly developed and diffused through organisations whose primary purposes are social" (Mulgan et al., 2007, p. 8). Social innovation is addressed in Innovation Union and other policy initiatives, and social innovation projects have received Structural Fund support. In addition, social innovation has been explicitly incorporated into the Structural Funds Regulations to facilitate investment by member states through the European Regional Development Fund and the European Social Fund (European Commission, 2013b).

In recent years, the policy discourse of innovation has become strongly aligned with key concepts of science in society. Responsible research and innovation was coined in 2011 by the Directorate-General Research to denote a "*transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view on the (ethical) acceptability, sustainability and social desirability of innovation process*" (Von Schomberg, 2011). A series of workshops, policy documents, as well as a 2012 Science and Public Policy Special Issue on RRI (Owen et al., 2012; Stilgoe et al., 2013) have developed the key tenets of RRI to include socially desirable science and innovation ("anticipatory"); processes of mutual exchange in setting research and innovation direction ("inclusive"); and flexible, reflexive and socially responsible ("responsive") governance of the process. The concept has found its most clear policy expression—that effective innovations are those that consider ethical, legal and policy issues early in the innovation chain—in the Horizon 2020 research strategy, which aligns research and innovation goals of the European Commission with broader societal needs through Horizon 2020 Societal Challenges themes (European Commission, 2013a).

1.3. Why examine research funders' framing of 'food and health' innovation?

With relatively few innovation strategies or programmes containing a priority explicitly about 'food and health', a gap remains regarding knowledge about how innovation is conceived of and reified among public research funders in the food and health or nutrition domain, despite much work showing that technological development is socially constructed (Klein and Kleinman, 2002; Pinch and Bijker, 1987; Williams and Edge, 1996). Science and technology studies scholars have long argued that technological development is not neutral, and instead is shaped by groups to preserve or alter social relations—that it is in essence political, and can be seen as the impetus for RRI and its emphasis on socially responsible governance (Hard, 1993; Latour, 1988; Wallace, 2010). This has practical implications in understanding the boundaries of innovation in publicly-funded food and health research, power asymmetries in actors' influence in research and innovation trajectories, and ultimately, how certain types of innovation come to be supported financially and otherwise. In relation to 'food and health', some authors have criticised the corporate interest-influenced prioritization of technologically advanced biomedical research over investment in public health research and services both within the European Union's programmes and some national strategies (Beaglehold et al., 2004; Buchanan et al., 2006; Groves, 2006; Sarraci et al., 2005; Woolf and Johnson, 2007, 2005). Other researchers have pointed to the gap in implementation research that is necessary to develop effective strategies for tackling diet-related chronic disease, which would likely have a larger impact on global burden of cardiovascular disease than new drugs (Nieuwlaat et al., 2013). Still others lament of knowledge generation concentrated in disease-specific institutes without balancing this with research that cuts across such boundaries (Stange, 2009).

According to Sarraci et al. (2005), the European Union needs "a coherent research strategy for all citizens' health rather than be the sum of studies plugged into projects conceived primarily in biological or biotechnological terms, often with industrial production development as the key objective" (Sarraci et al., 2005). More recently, this trajectory has continued with the European Commission's FP7 projects and in the draft health research work programme under Horizon 2020, the EU's latest programme for research and innovation (IEA et al., 2013; Wallace, 2010). European public health organisations had criticised the draft programme of Horizon 2020 for inadequate prioritisation of public health research and overemphasis on personalised medicine (Kogevinas et al., 2013). In the context of these criticisms about how research strategies have addressed public health issues such as diet-related chronic disease, this study provides insights on an understudied aspect of research funding in food and health—how innovation, deemed a significant factor in achieving societal and economic goals, is conceived of by those making decisions about research funding. Identifying and reflecting on decision-makers' cognitive frames about, for instance, the origins of innovation and its utility or purpose, can inform the potential for RRI, such as, for example, the promise of opening up the innovation trajectories to broader public deliberation and the degree of reflexivity and mutual responsiveness. The current analysis is based on an examination of research funding decision-makers' cognitive framing of innovation, in food and health across eight EU countries.

1.4. Framing

There is a range of concepts of frames and framing that have developed across different disciplinary traditions; however, what is held in common is the idea of frames as sense-making mechanisms. Concepts of frames include: cognitive representations of knowledge (Minsky, 1975); tools used to interpret situations (Levin et al., 1998); packages of ideas that serve to mobilise people to action (Benford and Snow, 2000); boundary-setting schema (Rein and Schön, 1996); and narratives that guide action (Davidson, 1985). Tannen and Wallat (1987) have distinguished between two major types of framing—cognitive frames and interaction frames—cognitive frames being relatively static constructs in people's minds, and therefore more difficult to change than interactive frames which involve co-construction of frames through actors' interactions (Tannen and Wallat, 1987). Cognitive frames can therefore be thought of as belief structures, with relatively stable properties. As such, they are less prone to change in response to new policy initiatives (though they, too, change over time), and can shape the dynamics of new policy implementation.

We have adopted cognitive framing as the theoretical approach, drawing also on Borras's assertion that changes in the 'real world' of economics and politics are associated with changes in the cognitive framework of how innovation is understood (Borrás, 2002). Cognition and 'micro-level processes' are also deemed important to understanding the dynamics of technological change, and how problems and solutions are defined (Weick, 1995, p. 7). We use *framing* to refer to the process of applying or expressing cognitive frames, which are stored in memory (Dewulf et al., 2009). This study addresses the question of how innovation is framed by those involved in making decisions about 'food and health' research funding.

2. Methodology

2.1. Design & analytical approach

A qualitative semi-structured interview design was used to explore the framing of innovation by actors involved in the development of publicly funded research programmes with a food and health research component. Data were collected in Austria, Germany, Italy, Netherlands, Portugal, Scotland, Spain, and UK-wide. These particular countries were chosen to represent a broad geographical spread covering different economic situations and different funding modalities (e.g. responsive-mode and targeted mechanisms), and based on the resources available to the project (see Table 1). Purposeful sampling of interviews was employed; it was decided to focus on publicly funded programmes, which included public–private partnerships, because all participating countries had such programmes and due to greater accessibility compared to private sector research actors. The programmes served as a point of departure for the study—a means to recruit people who had directly engaged with food and health research innovation funding. Identifying individuals responsible for decision making in funding 'food and health' research was difficult, not least because in most countries there was a lack of dedicated 'food and health' research programmes. An example is the prioritisation of both food security and healthy lifestyle as grand challenges at the European level; the area of 'food and health' is considered a component of both, but is not headlining or defining either. The main European funding instrument for innovation research, Horizon 2020, has seven priorities, two of which are 'health, demographic change and wellbeing' and 'food security, sustainable agriculture, marine and maritime research and the bio-economy'. In total, 55 interviews were conducted across eight countries from September 2012–July 2013; the countries were selected to cover different economic situations and regions. The primary reason for studying programmes in different countries was to see whether RRI concepts of socially responsible innovation and mutual exchange, developed largely at the EU level, permeated framing among those involved in food and health innovation funding at the national or sub-national level. It is important to note, however, that this study was not a cross-country analysis.

For most countries, a research project or programme that included a component related to the development of more nutritious food—which could range from basic to more applied research—was first identified (see Table 1). The topic was determined based on previous desk research on research programmes in the countries, which showed that all countries participating had research programmes that would fall within this broad topic. In the case of Austria and Portugal, which have predominantly responsive-mode research funding, projects found to be the subject of past funding were identified and provided an overarching research area that served as the starting point for this investigation. This was followed by desk research and email and phone inquiries to identify individuals for recruitment. For the UK-wide case, the Nutrition for Life programme was first identified, but due to difficulty in recruiting enough individuals over a period of three months, the Global Food Security Programme, which contained a component on 'healthy, safe diets', was also identified and individuals involved in its development were recruited.

Table 1
Research projects/programmes/areas examined.

Country	Research area, project, or programme examined	Main funding organisation(s)
Austria	A project in the DAFNE database (Federal Ministry of Agriculture and Forestry, n.d.) – specific name withheld due to anonymity concern	Federal Ministry of Agriculture, Forestry, Environment and Water Management
Germany	Adipositas Project among kids and teens	Federal Ministry of Education and Research
Italy	Selenella Potato	Italian Quality Potato Consortium
Netherlands	Muscle Health and Function Research Theme	Top Institute Food and Nutrition
Portugal	Dairy products with improved nutrition	Programa Operacional Temático Fatores de Competitividade (COMPETE); Fundação para a Ciência e a Tecnologia (FCT)
Scotland	Strategic Food, Land and People Research Programme 2011–2016	Scottish Government
Spain	Pirolisis Industrial de Subproductos de Almazara (PYROEX)	Spanish Economy and Competitiveness Ministry and the European Regional Development Fund
United Kingdom	Global Food Security Programme Nutrition for Life Programme	Biotechnology and Biological Sciences Research Council Technology Strategy Board

2.2. Recruitment

Recruitment of individuals for interviews was based on the criterion of involvement in the process that resulted in the particular area, project or programme being funded; this could range from participation in consultations on the particular project to participation in high-level committees involved in agenda-setting. In some cases, the relevant person was no longer in that organisation and inaccessible, and their successor was interviewed based on their knowledge and access to archived material. Interviewees were categorised as government (G), academic (A), industry (I) or non-government organisations (N – included charities, consumer and special interest groups). Most participants were interviewed via the telephone or face-to-face and were recorded with prior obtained consent and ensured anonymity; the recordings were then transcribed. In Austria and the Netherlands, some participants requested to be emailed the interview questions as a condition of participation and some responded by email. Telephone interviews lasted between 30 and 70 min. Response rates ranged from 15% to 100%. The sample descriptions with response rates (number of respondents who were interviewed) are presented in Table 2.

Quotes are attributed to respondents by country abbreviation, category reference, and a number, e.g. PT G1—quote from an individual representing a Portuguese governmental organisation.

The interview schedule consisted of questions about the respondent's position; innovation in general; innovation in the area of 'food and health'; and the decision-making process for the funded programme. This paper is based on the questions pertaining to innovation, although extracts from other parts of the interview that pertained to innovation were also included in the analysis.

Table 2
Participation rates by category.

Country	Government	Non-profit	Industry	Academic	Public–private partnership	Total participation (%)
Austria (AT)	5/8	–	–	–	–	5/8 (63)
Germany (DE)	4/6	0/2	3/3	3/9	–	10/20 (50)
Italy (IT)	–	1/1	6/6	3/3	–	10/10 (100)
Netherlands (NL)	1/1	–	2/3	3/4	1/1	7/9 (78)
Portugal (PT)	0/4	–	3/18	2/5	–	5/27 (15)
Scotland (ST)	4/4	0/1	–	1/2	–	5/7 (71)
Spain (ES)	2/2	2/2	2/2	1/1		7/7 (100)
United Kingdom (UK)	5/9	1/2	–	–	–	6/11 (55)
Total participation (%)	21/34 (62)	4/8 (50)	16/32 (50)	13/24 (54)	1/1 (100)	55/99 (55)

2.3. Analysis

The chosen method of analysis was thematic analysis, which is a pattern-based form of data analysis. We conducted an inductive thematic analysis (Braun and Clarke, 2006), because it can be used flexibly in line with different priorities as determined by the research focus and stance of the researchers. Our thematic analysis was based on cross-case analyses, yielding findings in terms of shared rather than idiosyncratic meanings, and was inductive, with themes and subthemes having strong links to the data. A protocol for analysing cross-country data was developed based on Lundkvist et al. (2010): each country completed initial coding in their own language using a skeleton coding structure created and modified by partners during preliminary analyses (Lundkvist et al., 2010). The initial coding conducted by each country was reviewed by the research leaders. Subsequently, researchers from across the countries held a conference call to identify themes. Three main themes emerged from the data: concepts of innovation; conditions for innovation; and drivers of innovation, and these served as the basis for analysing and classifying cognitive framings of innovation. The research leaders then held one-to-one calls with each country team during the subsequent thematic analysis process to ensure consistent approach across countries. An English-translated summary of identified themes and illustrative quotes was produced for each country, and was reviewed for consistency by the researchers leading the project. The current paper is based on the country summaries.

[] is used in this paper to indicated that a small section of text, considered irrelevant to the sense of the quote, has been removed.

3. Results

For each of the three themes—concept of innovation, conditions for innovation, and drivers of innovation, the framings of innovation emerged. Exemplary quotes are presented and discussed by theme and frames in this section.

3.1. Concept of Innovation

The elements of novelty and application were found to be most salient in conceptualisation framings of innovation; both areas were frequently associated with expression in the market. Broader concepts of innovation existed in an abstract way, but respondents emphasised the market as the main arena for innovation, i.e. novelty to the consumer or application in terms of a product. Serendipity was found to be less mentioned across all countries, but was a significant factor according to some respondents.

3.1.1. Innovation is the development of new products

Novelty was considered one of the defining aspects of innovation by nearly all respondents. There tended to be a predominant concern with novelty according to the market in terms of new products, as reflected in these comments:

> *It mainly involves the development of new products that don't exist on the market.* PT A2

> *Innovation is when research develops and that with a product that has a value in the market. That's innovation. Not when you're doing the research.* NL I2

> *For me, innovation means including economic components in science. For me, innovation is transferring research results in economic applications, meaning products. And concerning what has been discussed in the last years in the area of nutrition and food, all products, which for example make so called health claims, something that is processed in legal framework on EU-level by the European Agency for Food Safety lately, are products which claim to be innovations in a sense, that they offer a higher health benefit to consumers. And in this effect are labelled by the industry with an economical usability and therefore shall lead to an alteration and improvement of the market position. For me, this is innovation.* DE G3

The following respondent noted the theoretical breadth of novelty, but felt that within the funding organisation he had worked for, the tendency was to think of innovation in the business context:

> *I think [organisation name] would conceptualise innovation as being the introduction of a new or novel approach or way of doing something, building on perhaps pre-existing insight and knowledge, and it tended to think of innovation particularly in relation to business, so business innovation, new products and services or different approaches to delivery of products and services. I think that it would be fair to say that, whilst they have a broad conceptualisation of it, there has been a tendency towards a focus on economic activity and innovation within that.* UK G5

Similarly invoking the business emphasis, the following respondent frames innovation as solutions for companies:

> *Innovation doesn't need to come from fundamental/basic research, but rather it can be an intervention that is more incremental in nature and that provides a solution to concrete problems that companies present. Thus, there is a strong link with the business world.* PT A1

Only a minority of respondents took a broader view of novelty, as operating in different fields and with varied purpose, appropriate to the particular endeavour:

> *Innovation, to me, operates at several different levels. If you are talking about abstract sciences, the innovation can be a process of alterations in philosophy, alterations of paradigms; it can be alterations in approaches or in interactions. If you're talking about in experimental sciences, then it can be identification of new processes, identification of new information. If you're talking about it*

in industry terms, it's putting in new products. If you're talking about it in policy terms, it would be in bringing in new policies that you are using to try and answer questions that have not been answered by previous approaches. ST A1

The framing of innovation as new product development is consistent with studies on innovation in the food sector that reveal a focus on product and process innovation in small and large food firms (Avermaete et al., 2003; Bhaskaran, 2006; Earle, 1997; Galizzi and Venturini, 1996; Lagnevik, 2003; Traill and Meulenberg, 2002). Food and health related innovation has tended to be in the form of functional foods and innovations related to food safety, dominated by primarily technical decision-making relevant to, for instance, risk assessment (Hsieh and Ofori, 2007; Skogstad, 2001; Unnevehr and Jensen, 1996). The comments also reflect the European policy imperative to improve economic competitiveness via technological innovation.

3.1.2. Innovation as problem-solving

The problem-solving frame was closely linked to the discussions of benefit, in particular who defines benefit, who will feel the benefit, and how the concepts of benefit evolve through a series of historically connected technological innovations. It is closely associated with the calls for normative decision making about innovations, captured by the concept of "anticipatory governance" as a criterion of RRI. We also notice that some respondents recognise a dominance of a particular framing of the benefit as well as the possible solutions, such that it leads to the exclusion of the alternative and competing framings of innovation. Implicit in these narratives is the understanding that the way in which benefit is framed 'closes down' the range of technological developments.

A few respondents questioned who innovation was meant to benefit. One person, who spoke as a representative of a non-profit organisation focused on food policy and had been involved in a consultation for the Global Food Security programme, raised the issue of who the applicability is for:

I'd say, when we resort to a shorthand for it, we tend to talk about innovation in terms of problem-solving, so, and the reason we talk of it that way is because it helps to shift the focus towards... innovation in agriculture, on the farm, and to put a greater focus on the accountability of formal innovation programmes to the people and purposes they purport to serve. UK N1

In this vein, another person mentioned examples of innovation around low-salt products, suggesting that while innovation could reduce the salt content, such products should not be in the diet in the first place. The benefit of the innovation, and therefore its social desirability, should, according to this respondent, be valued in the context of the wider set of considerations including the historical dimension of the problem that the technological development is set to address:

Well, salt reduction is a major one, in terms of public health, and there are issues with certain food products in relation to processing. So, something like extruded crisps, savoury products, these kind of pelleted products, seemingly you need quite high salt content to produce these types of snack products. Whilst we can argue that they might not necessarily—they shouldn't really necessarily be in the diet, but they still exist, so we would want to reduce salt, so technology and innovation around that processing. ST G1

These types of products would have been innovations themselves at one time, but now that they exist and are considered detrimental, further innovation is sought to reduce the potentially adverse impacts. As another respondent noted, "*Innovation doesn't necessarily have to be good. Innovation can be disruptive and not particularly helpful, as well as being helpful*" (UK G5).

The examples of processed foods mentioned by ST G1 can be construed as disruptive innovations, insofar as the types of foods mentioned are designed to be addictive, fuel market demand, and are consumed in quantities that are deleterious to health, albeit they provide benefits in terms of convenience (Moss, 2013).

Some German respondents noted the bias toward bioscience related innovation at the expense of social science-based innovation that could benefit public health; below is a comment from one:

You can make innovations in the area of nutrition in developing new products, but also in ways of communicating with the target group, too. And I think there are possibilities of exciting new approaches in the field of nutrition prevention, really aiming at an overall better and healthier nutrition. And, [] if you have a look at the German scientific landscape and what happens there, there is too much research regarding the molecular level, the level of natural science, whereas the issue of behaviour, meaning the nutrition psychology, food habits etc., how do I influence people, how can I make them do things differently, the whole issue of motivation is neglected. DE G4

This statement suggests the dominance of the 'innovation as the development of new products' frame, such that the problem to be solved is centred on products, and is therefore more aligned with business interests than that of wider society.

3.1.3. Innovation along the steering-serendipity axis

This 'axis', at one end, is marked by the idea that innovation occurs solely from steering and intentional endeavour, and at the other end, by the idea that innovation can only occur spontaneously. This frame was less salient than those pertaining to novelty and problem-solving; it nevertheless constitutes a frame insofar as respondents fell somewhere along this axis. Although some respondents felt that serendipity was important, others felt strongly that innovation should not be left to chance. Generally, respondents in countries with greater resources felt that there should be a dual approach to innovation to allow for spontaneity while also steering innovation; whereas respondents in Portugal and Spain felt that it should be entirely steered:

Planning is essential; (Innovation) occurs through the planning of R&D projects. PT A2

Innovation cannot be spontaneous but should be directed at giving solution to a problem or meeting a necessity, while being, at the same time, a priority for the governments. ES I2

You can't always steer it from the top, but what you should do is, you should do both, so you should make it possible that things spontaneously occur, but on the other hand you should also try to have (a) strategy where you can clarify as much as possible what are the important research topics for new business or for societal challenges and to make sure that there is already a match between the needs and what you want to research, so it's two sides of the same coin I would say. You need to do both to make it work. You can't always steer everything from the top, so it should also be spontaneously, but if you only rely on spontaneously, you miss a lot. NL G1

Implicit in many of the comments is responsiveness to a need which may be determined at the point of research prioritisation in steered processes or at the point of innovation diffusion in more serendipitous processes. In either case, there is no indication of ongoing exchange between those involved in innovating and societal actors that are considered the source of 'needs' that innovation addresses—one of the tenets of RRI.

3.2. Conditions for innovation

The main conditions for innovation were found to be flexibility and interactions, particularly between academia and industry. These two frames are closely linked to the responsiveness and inclusivity dimensions of RRI (Stilgoe et al., 2013).

3.2.1. Flexibility as freedom from financial and time constraints

A number of respondents felt that freedom from financial constraints, time constraints, and regulatory constraints were key conditions for innovation. Conversely, the presence of these factors—particularly health claims regulation—constituted barriers for innovation. Health claims regulation was suggested as a reason to seek innovation in other areas, such as sustainability, rather than pursue innovation around nutrition.

> *Different ways, ways of thinking about problems, to be able to develop new approaches and thinking, and there probably needs to be the financial flexibility, some sort of support to enable innovative developments to take place within the company.* UK G3

The excerpt below highlights a curious contradiction; a sustained and significant financial support (as an enabler of innovation) through large-scale research grants is simultaneously construed as overly directive, resulting in restricted academic freedom and flexibility.

> *I think [] in the last years, especially in regard to European and national funding programs, the top-down approach is [] more common, which…limits the scientist's possibility to analyse things directly I consider this to be important and interesting. So there are more big budget projects carried out by vast networks with very explicit and detailed demands given by the funding body leading to less flexibility in acquiring funding of those sciences which are not close to the major issues.* DE G3

Flexibility as a precondition of innovation is discussed vis-à-vis broader policy context, a clear example of which is that of health claims and the recent EU health claims legislation.

> *I think the regulatory framework really limits a lot of the innovation. You have a lot of generic claims which are quite, giving a lot of space for claims already, but if you're doing innovation, it takes a very long time before we have a stronger claim than a generic claim, so that's not really supportive to start the innovation process, so that really blocks us in starting up the innovation project…..I would not allow a lot of generic claims that are really now on the market, I think they are too broad, too strong, and it's really not what is needed for innovation, so more guiding principles on what is enough evidence for making a new claim, that would help us a lot.* NL I2

With regard to health claims, Regulation (EC) No 1924/2006 referred to by respondents requires scientific evidence for any claim about nutritional benefits; health—as implied in a relationship between the product (or one of its ingredients) and health; or reduction of disease (European Commission DG Health and Consumers, 2012). This regulation replaces national regulations in member states and was intended to offer greater protection to European consumers. The comments here indicate that the regulation runs counter to policy goals of innovation and, in particular, food and health innovation. Regulation—often considered as hostile to market—is, in the case of health claims, perceived as impeding innovation in food. Yet again we see the respondents' framing of innovation as close to the market and economic realities and, arguably, further from other societal actors – a key to the realisation of RRI. The cognitive frame of flexibility identified here stands in contrast to the notion of flexibility advocated by the proponents of RRI as mutual responsiveness and willingness to change direction in response to societal values and changing circumstances. Responsiveness is closely linked to reflexivity about the limits of knowledge and evidence that make certain claims (e.g. health claims) possible. Arguably, the current frame, construed as it is as 'freedom from constraints' suggests limited possibilities for practical realisation of RRI.

3.2.2. Networking between universities and industry enables knowledge transfer toward an application

Most respondents perceived networks and collaboration as essential for the process of innovation. Often, collaboration between industry and academia was highlighted as a means of linking knowledge production to its potential use in application. This also relates to the previously mentioned dominant conception of innovation as geared toward commercialisation. Below are some comments illustrative of a pattern found across countries and categories of respondents.

> *We believe that relationships between industry and university are crucial for the innovative process; there can't be innovation without a tight bond between industry and university.* IT I2

> *You need on one side the science to come up with scientific concepts on one hand, but you need also industry to transform it into an application, because science in itself has wonderful ideas which will never come to the market, because it's sometimes too expensive, it will not work, it is not whatever, and on the other hand, the industry will sometimes not have the creativity to come up with completely new ideas to come up with new products, so you need a combination of the two—very important.* NL A1

The quote above is particularly illustrative of the linear model of innovation, with feedback loops between stages of innovation from idea generation in the higher education sector, to translation of the ideas and knowledge into applications via the industrial sector. Interactions and networks are discussed less as a process of co-production but rather as that of knowledge transfer, and at best, a process of collaboration between scientific and industrial actors. Again, other societal actors are missing from this discourse, indicating some distance from RRI principles. Inclusion of new voices into the innovation process is advocated by the proponents of RRI in order to preclude problems that can be associated with exchanges between an often narrow range of innovation actors. Inclusivity of wider publics addresses the call for innovation framing to take normative criteria into account.

3.3. Drivers of innovation

Two types of factors were found to drive innovation—one pertained to motivation or will and the other related to supply-push and demand-pull forces.

3.3.1. Individual motivation propels innovation

This driver was variously expressed as commitment, 'active' individuals, and user utility, which all related to motivation. A few respondents noted individual will as an important driver of innovation, and one person extended this to the will of organisations that follow through on individuals' ideas.

> *Mainly the personal commitment is the motor for innovations, people with ideas and visions and additionally companies or organisations who want to take up and implement them.* AT G2

> *What it takes is an active person— as simple as it might sound. And in this case [person X] was not the responsible researcher after all, but in a position located at an intersection, there is a kind of*

transfer institution from research to practice... and [person X] took the first step and just because of [person X], there was fundamental research on this topic in the first place. DE G2

In the excerpt below, the respondent mentions user-led innovation; in this case, user need is the motivating force propelling users to innovate:

In some respects, it is the...in whatever field one's looking at, it's the practitioners within that field who are the...who are the...who are the innovators. So, in farming, a lot of innovations tend to be down to farmers, whether or not they get recognition for it. You know, they're adapting practices to their circumstances. They're sometimes generating completely new ways of doing things and so on. UK N1

User-led innovation addresses need more directly rather than as expressed via the market, and is widespread in some areas, such as in open-source technology and agriculture. User-led innovation, in a broad sense that encompasses user-centred and collective innovation, is gaining currency in the European innovation policy domain (Innovation Futures in Europe, 2012). As user-led innovation inherently engages different societal actors, it also has greater potential to actualise RRI compared to conventional innovation processes, where the main actors involved are the business sector and public sector institutions, such as universities.

3.3.2. Push and pull factors

Different respondents had different ideas of the role of push/pull factors in the innovation process. Need, or pull, was construed as a driver of innovation, most often through market expression, but technology, or push, was also identified as a driver of innovation.

3.3.2.a. Societal need pulling innovation via the market. The following respondent, who worked for a government research funding body, felt that the government's innovation agency responded to needs identified by companies in the food and drink sector. In this case, the need was to create healthier food.

You create a competition because there is an area of opportunity that's been alerted to you, and that happens by talking to people. So, you go out and you meet companies in the specific sectors... had meetings with all the related companies in the food and drink sector, and they said, alright, we—it's a dialogue. They say 'we're really struggling, we know there is a market opportunity, and we know that, as a society, we need to do better with the food we eat,' so maybe government intervention in the light of [] competition could help them unlock those potentials. UK G1

Notably, though, the competition referred to was sponsored by the government's technology agency, the Technology Strategy Board; the companies sought government assistance via the innovation competition to address what they identified as a societal need.

3.3.2.b. Technological and economic competitiveness pushing innovation. In contrast, another respondent from the non-profit sector felt that the Technology Strategy Board focused on technology and on being ahead in technological developments for international competitiveness. He felt that government's approach to innovation centred on technological advancement rather than societal need:

I don't think its (Government's) contributions to innovations are, always drive innovation as much in the public interest as it could do, so it drives innovation, but sort of for whom and for what is the question. I think there's some aspects of what the Government does through the Technology Strategy Board that are...quite welcome improvements somewhat to previously, but the focus still is very much on technology, on competitiveness, international competitive as the key outcome, and so on, picking the winners, even though there's a little bit more diversity built into the programme nowadays, it is still, still the vast bulk of the cash goes for kind of mega projects basically, as far as I understand it. UK N1

Such questioning of whether government's facilitation of innovation serves the public interest was also raised more broadly within the aforementioned discourse about benefits of innovation. This line of questioning signifies a potential shift in framing toward one that is more aligned with RRI, as it posits that, through processes of mutual exchange in setting research and innovation directions, the resulting innovation pathways would likely be in line with the broader societal concerns.

Although this respondent is referring to the UK context, NGOs have made similar criticisms about the setting of European research priorities (EU Food Law, 2010). Below, a Scottish respondent from a government body also notes government's interest in promoting innovation because of its perceived contribution to economic growth; but only if the innovation benefits public health:

I would say [] in some respects, Government wants to do that (promote innovation in food and health), not from a public health point of view, but from a point of view of economic growth, so wealth generation because, obviously, it wants companies that are based in their country to do well and to [] grow and to generate wealth for the economy. But, I think, from a public health point of view, then, in my role, we would only want that if it's positive to improving public health. ST G1

4. Discussion and conclusions

This article has explored cognitive framings of innovation among a set of actors involved in food and health research funding and has highlighted their concepts of innovation and their ideas about conditions for facilitating innovation. Although not representative of all actors engaged in this domain, this study is the first to look at the way actors engaged in research funding in this domain frame innovation. This framing of innovation will partly inform the success of the RRI principles, as they are likely to affect the types of projects they fund to advance innovation. The findings revealed that the dominant cognitive framing of innovation is strongly associated with economic output (Felt et al., 2007). To this end, interactions between universities and industry were perceived as an important condition for innovation and innovation was largely thought of in terms of products. There was limited discussion about the inclusion of broader societal actors into this interaction. Freedom, particularly from regulatory constraints, was also considered an important condition for innovation, clearly aligning innovation with the dynamic of an unconstrained market.

These findings further suggest that the demand-pull dynamic is still seen as relevant to the process of innovation, although 'need' remains predominantly associated with the market. As Godin and Lane (2013) assert, the phasing out of the demand-pull model was not based on empirical findings that 'need' ceased to exist as a factor propelling innovation. The findings of this study raise some questions about the universality of models that obscure this dynamic. In addition, among a minority of those interviewed, there was a concern about the emphasis on innovation for wealth generation, which points to a need for reflection on normative issues raised here about who defines needs or problems that are to be the 'subject' of innovation, and therefore also delineates the solutions. Many respondents felt innovation facilitated economic

activity, which resulted in societal benefits generally; improved public health seemed to be seen as an implicit, if incidental benefit of economic activity. Such framings of innovation indicate that civil society engagement in research and innovation is positioned 'downstream', after agenda-setting and prioritisation has already taken place, as highlighted by Felt et al. (2007). As RRI calls for innovation processes that are based on ongoing, mutual exchange between civil society and innovators and reflexive governance more upstream, these framings are not conducive to the actualisation of RRI in food and health research.

Much of the cognitive framing expressed in this study may be seen to reflect the master-narrative underpinning innovation policies of the European Union, but nonetheless contradicts evidence on the relationship between economic growth and health outcomes. Studies have shown that while up to a certain level of gross domestic product (GDP), economic growth has been associated with some improved health outcomes, after this point, growth can have a negative effect on health progress (Egger, 2009; Granados and Ionides, 2008); growth can result in better health outcomes if not associated with increased inequality in wealth (Biggs et al., 2010; Egger et al., 2012); and affluent countries with market-liberal regimes have higher obesity prevalence compared to other affluent countries with less liberal market economies (Offer et al., 2010). Although no respondents directly questioned the idea that economic growth would result in improved public health, some respondents did question the dominant focus on bioscience and commercialisation at the expense of other areas in which innovation could occur and lead to improved understanding of how to address nutritional challenges. Dixon (2009) has referred to this as 'nutritionalization', the "co-optation of nutrition science to extract surplus value and authority relations from food. . .most transparent when corporate strategies and public policies are framed in terms of nutritional disease and health and wealth advancement" (Dixon, 2009, p. 322).

The pursuit of nutritionalization has long resulted in the closure of certain pathways for innovation—e.g. innovation related to healthy eating rather than product reformulation and new product development—in the food and health area (Lee, 2012; McCarthy et al., 2013; Pinch and Bijker, 1987), and was alluded to by some respondents from non-industry sectors in this study. What is also evident from the interviews is that despite the recent focus on social innovation in European policy, few respondents mentioned it, suggesting that more work needs to be done to raise awareness of this among those involved in designing and deciding upon research funding in the food and health domain. This, along with the emphasis on commercialisation, indicates a need for greater 'upstream' consideration of normative issues around innovation, an important component of RRI. More specifically, in the arena of food and health, an approach to innovation that transcends technological progress and economic impacts needs to be applied in policy and research around healthy, sustainable diets; product innovation alone will not deliver the impacts required to prevent, or cope with, a rapidly changing climate.

In short, while a new discourse of RRI is emerging at the EU level about the need for science with society and emphasises the institutionalisation of inclusive and reflexive deliberation in the setting of research trajectories, this study suggests that there remains a gap between RRI and how national research funders in the area of food and health conceive of innovation. As cognitive frames are slow to change, one implication of this study is that the master-narrative of innovation as fuelling economic growth may itself need to change in order for the project of RRI to progress; as things stand, the strong link between innovation and economic growth seems to influence funders' framings of innovation more so than RRI. Without this shift, RRI is likely to be construed as simply the repackaging of extant science and society discourses, and food and health research proposals that lack prospects of links to commercialisation may be marginalised in decision-making about funding.

Acknowledgements

This research was funded by the European Community's Seventh Framework Programme (FP7/2007-2013) under the Inprofood project.

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