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European sectoral innovation foresight: Identifying emerging cross-sectoral patterns and policy issues

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ABSTRACT

The research presented in this paper pursues two main goals. Empirically, it aims to explore sectoral futures at European level in a range of different sectors (automotive, construction, textile, KIBS, wholesale & retail), to identify cross-cutting patterns of sectoral change, and to highlight implications that these may raise for European innovation policy. In order to do this in a systematic manner, it also has a conceptual and methodological ambition, namely to devise a sectoral innovation foresight methodology that builds explicitly on concepts derived from sectoral innovation systems approaches. This theory-led methodology allows exploring and interpreting future developments at sectoral level in a coherent and comparable manner. Technologies and knowledge, actors and organisations, user needs and demand, as well as institutional and policy frameworks are taken into account; elements that need to co-evolve for any innovation system scenario to unfold. This conceptual framework is translated into a sector innovation foresight methodology that was used to guide a multi-sector foresight initiative.
Based on a meta-analysis of insights from five different sectors, cross-sectoral patterns of future change as well as cross-cutting policy issues are pointed out. Three areas of cross-cutting changes have been identified: a) the shift from products to systems and services, b) blurring boundaries between sectors, and c) sectoral and cross-sectoral integration of sustainability demands, and the governance of interactions between sectors.
Foresight projects at sectoral level have been conducted rarely as compared to technology-centered or societal-issue centered foresights or retrospective sectoral innovation system studies. By relying explicitly on a theoretical framework of sectoral innovation systems, this paper explores the potential of better linking innovation theory to policy- and strategy-oriented foresight.

1. Introduction

A strategic turn has taken place in research and innovation (R&I) policy over the past years. Technology foresight is increasingly oriented towards socio-economic aspects, interdependencies, and towards innovation systems and its transitions. (Weber, 2012). This turn is characterised by a shift away from structure-centered approaches to R&I policy, aiming to foster innovation performance per se as a main driver of competitiveness, and towards prioritisation of R&I societal challenges and generic technologies.

Particular attention was paid to fostering societal demand side aspects in the governance of science, technology and innovation (Edler and Georghiou, 2007). Arising first in programmatic manifestations (Declaration, 2009) and extending to wider processes in innovation policy, the result is a proliferating variety of new approaches, processes, and instruments (Cagnin et al., 2012; Georghiou and Harper, 2011; Haegeman et al., 2012; Marinelli et al., 2014). Beyond the EU, the need for a broader understanding of innovation for societal demands is also reflected in concepts such as green economy (Gibbs and O'Neill, 2015), social innovation (Shier and Handy, 2015), and in the 2030 United Nations Agenda for Sustainable Development (Sustainable Development Goals).[1]

This strategic turn also implies that it is not sufficient any more derive the rationales for R&I policy from a deficit model, i.e. by drawing on the identification of perceived deficits in the conditions and practices of research and innovation in order to legitimize policy action. Instead, a forward-looking approach is needed to address in a pro-active way the challenges and opportunities that are likely to arise in a faster than ever changing future (European Forum on Forward Looking Activities (EFFLA), 2012), often referred to as 'foresight'.

This changing policy context had an influence on the way foresight is conceived and embedded in policy making. From the initial focus on technology foresight, we have moved a long way towards a much

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[1] http://www.un.org/ga/search/view_doc.asp?symbol=A/69/L.85&Lang=E.

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stronger emphasis on societal aspects, from a linear understanding of how science and technology exert an influence on society and economy towards a systemic one, and from traditional expert based advice to engagement with stakeholders and embedding in policy making processes.[2] More differentiated foresight approaches have been introduced, starting with national exercises to regional, sectoral or sectoral ones.

This broadening scope of foresight not only mirrors a strategic shift in policy interest but also a change in the understanding of innovation. Despite cross-disciplinary differences, recent attempts to conceptualize innovation dynamics paint a remarkably congruent picture. Early linear notions of technological development are giving way to more complex, dynamic pictures of systems of research and innovation (Cagnin et al., 2012; Hekkert et al., 2007; Markard and Truffer, 2008; Sharif, 2006; Weber and Rohracher, 2012).

Early attempts of establishing foresight for research policy already stressed the systemic nature of research and innovation (Martin and Johnston, 1999), but they were bound by the – then – dominant focus on national innovation system boundaries. The subsequent evolution of foresight as inspired by a more differentiated understanding of innovation has led to an equally differentiated spectrum of foresight approaches and methods. More recently, the importance of taking the systemic nature of innovation seriously in foresight has been re-emphasized foresight by Andersen and Andersen (Andersen and Andersen, 2014), and in particular in the context of sectoral innovation foresight.

However, two limitations still remain. First, while the initial starting point of foresight from a territorial angle (national, regional) and with a technological focus has been relaxed over the past years, the differences in innovation dynamics across different sectors have not been fully embraced by the foresight community yet. These differences, however, matter for anticipating future developments and thus for policy.

Secondly, there is gap between foresight and innovation theory (Andersen and Andersen), in spite of early references interpretations of foresight as a means to "rewire the innovation system" (Martin and Johnston, 1999). Such a sound theoretical foundation is important if the ambition is to look beyond individual sectors and technologies. As innovation is a practice that involves different actors, and as innovation dynamics differ across sectors, exploring future perspectives on general innovation patterns needs to be rooted in the specific sectoral dynamics but at the same time allow to identify cross-sectoral patterns. One recent example to monitor such related innovation processes is the observatory of Key Enabling Technologies (KETs). KETs are seen as providing the basis for innovation in a wide range of products and processes across all industrial sectors (emerging and traditional), and are essential to solving Europe's major societal challenges (Van de Velde et al., 2015). In spite of these technological and sectoral differences, common policies need to be devised that take into account cross-cutting emerging patterns.

Against this backdrop our main ambition is to move towards a theory-based approach to a sectorally differentiated foresight, and thus allowing to compare sectoral foresights and draw lessons with regard to the anticipation of cross-sectoral future developments.

The common theoretical (and not just methodological) basis should allow for comparative and integrative perspective on (cross-)sectoral dynamics. In this regard, we draw on the concept of sectoral systems of innovation and production (SSIP) (Malerba, 2002, 2004, 2005) which provides a multidimensional, integrated and dynamic view of how and why sectoral innovation systems change. In line with other innovation systems approaches, emphasis is put in the SSIP framework on the role of different types of actors and institutions in shaping innovation, but also on the influence of the demand side of innovation, the specificities of the sectoral knowledge base and the co-evolutionary dynamics linking these elements to each other.

With this paper, we want to show the benefits of a sound theoretical foundation by looking at cross-sectoral dynamics.

The objectives of the paper are thus

- To develop theoretical underpinnings of sectoral innovation foresight, based on Malerba's initial work and subsequent refinements by other authors;
- To propose an approach and methodology that builds explicitly on the sectoral innovation systems approach to systematically underpin the exploration of future developments in and across sectors;
- To illustrate the value added of the approach and methodology by showing how the interlinked dynamics identified in a multi-sector foresight study[3] inspired by this theoretical and methodological underpinnings allows to identify and analyse cross-cutting future developments. Here, we look in particular at a) the shift from products to systems and services, b) sectoral and cross-sectoral integration of sustainability demands, and c) blurring boundaries between sectors and the governance of interactions between sectors.

In order to capture their respective specificities, findings from both industrial and service sectors are used, particular automotive (Leitner, 2010), textiles (Zahradnik et al., 2010), construction (Schartinger, 2010), retail and wholesale (Giesecke and Schaper-Rinkel, 2010), and knowledge-intensive business services (Dachs, 2010). With these sectors, examples of traditional (construction), innovative (automotive) and generic (textiles) industries are chosen, complemented by examples of innovative (KIBS) and seemingly traditional (wholesale and retail) services.

This paper is structured as follows. First, the conceptual underpinnings of the sectoral innovation foresight is outlined. Second, the methodological considerations on the implementation of sectoral innovation foresight is outlined. Third, an overview of the cross-cutting developments that result from the future exploration of individual sectors is given. Fourth, reflections on the results will be placed in the context of new developments in the area of STI policies. Finally, some conclusions are drawn on the policy implications raised by these cross-cutting developments. The hypotheses is that sectoral innovation foresight as key component to support the development of key enabling technologies and to direct innovation towards goals such as sustainability and coping with climate change adaptation.

2. Conceptual framework

Developed initially in the late 1980s in order to understand better why some nations are more competitive than others, the approach of National Innovation Systems proved both highly productive in scientific and highly influential in policy terms (Sharif, 2006). It stresses the interactive, non-linear nature of the innovation and the importance of institutional conditions to enable interaction and learning.

Initially focused on territorial, in particular national, system boundaries, a process of differentiation could be observed during the 1990s. A whole family of innovation systems approaches were developed to give justice to the regional, sectoral or technological specificities of innovation, thus putting the emphasis on the role of institutional settings at regional (Cooke, 2007), sectoral (Malerba, 2005), organisational (Hauschildt, 2004; Tidd and Bessant, 2013), and technological levels (Carlsson and Stankiewicz, 1991; Hekkert et al., 2007).

Sectoral Systems of Innovation and Production were suggested as a specific framework by Malerba in order to reflect not only the sectoral specificity of innovation activities and knowledge bases, but also the

[2] See different generations of foresight as proposed, for instance by Harper (2013).

[3] The INNOVA Sectoral Innovation Foresight, a foresight on sectoral innovation challenges and opportunities, was conducted as part of the Sectoral Innovation Watch (SIW) project within the Europe INNOVA initiative between 2009 and 2011.

crucial link with sectoral production systems as an important demand-side factor for innovation (Malerba, 2004). Ultimately, sectoral systems of innovation and production are understood as the engines that drive sectoral change and transformation (Dolata, 2009).

Subsequently, the main building blocks of Sectoral Systems of Innovation and Production are introduced, in a way that is compatible with the perspectives, the vocabulary and the methodologies prevailing in foresight.

2.1. Towards understanding the sectoral dynamics of innovation systems

The dynamics and transformation of sectoral systems of innovation is conceptualized as the result of variety creation in products, technologies, firms, institutions as well as emergence of new agents (both new firms and non-firm organisations), of selection mechanisms by market and non-market forces and of stabilizing mechanisms to create new path-dependencies (Malerba, 2002, 2004, 2005).

In other words, change in sectoral systems is the result of the co-evolution of various elements including technology (science and technology drivers), skills (knowledge base, learning), demand (demand side drivers), and structural change (firms, non-firm organisations and institutions). In sectors in which the pace of innovation is very rapid, this implies that sectoral boundaries are not necessarily fixed, but may well change during the time period explored as a result of these dynamic processes.

The framework for examining factors that affect innovation in sectors includes the following main building blocks (Malerba, 2005):

- Knowledge and technologies,
- Actors and networks,
- Institutions.

In addition, two further important aspects need to be stressed:

- Demand, stemming in particular from the production side of a sectoral system, and
- The co-evolution of these different elements in an inter-dependent manner.

Whereas knowledge and technologies are at the heart of what innovation is about, actors and networks, including the demand side, represent the main types of agents performing and shaping innovation. Institutions represent the "rules of the game" according to which these agents interact. The principle of co-evolution implies that in order for a sectoral system of innovation and production to change, these different elements need to change simultaneously and coherently. And they are therefore also the key elements to be investigated and explored in the foresight exercise.

2.1.1. Knowledge and technologies

Within the concept of sectoral systems of innovation, sectors could be characterised by specific knowledge bases, technologies and inputs. In other words, it is the shared body of knowledge that distinguishes a sectoral innovation system from others. The focus on knowledge and technology places the issue of sectoral boundaries at the centre of analysis, as in sectors in which innovation is quite rapid, sectoral boundaries change (e.g. boundaries between the sectors of food and beverages and biotechnology). Dynamic complementarities that take into account interdependencies and feedbacks (both at the demand and at the production levels) "may set in motion virtuous cycles of innovation and change" (Malerba, 2005).

In the context of foresight, the identification of the drivers of change (science and technology drivers as well as demand side drivers), both from within the sectors and from outside, represents a core part of the ground-laying analysis. At the intersection of S&T drivers and demand-side drivers of change, innovation (product, process, organisational) takes place, and with it changes in knowledge and technology, in actor constellations, in networks, institutions and emerging demand. Identifying innovation themes is thus crucial for starting and accelerating the virtuous cycles of innovation and change.

2.1.2. Actors and networks

A sector is composed of heterogeneous agents (organisations and individuals) that are characterised by specific learning processes, competencies, goals, organisational structures and types of behavior, and they interact through processes of communication, exchange, cooperation, competition and command. Connected in various ways through market and non-market relationships, the networks to generate innovations and commercialize them differ between sectoral systems.

From a forward-looking perspective, it is important to analyse issues related to organisational change, skills requirements and strategies of various agents for dealing with innovation themes in interaction with other organisations and their overall environment.

2.1.3. Institutions

The actions and interactions within and between the sectoral systems are shaped by institutions (including norms, established practices, rules, laws, standards, labor markets and so on) on different levels (regional, national, European). What is important to take into account is that beyond geographically specific institutions, sectorally specific institutions also matter. The set of institutions can constrain or enable the development of innovation in specific sectors.

As part of our sectoral foresight approach, potential institutional adjustments that are needed for realizing major innovation themes are a core element of the future exploration. This includes issues such as regulation and standardization, but also issues arising from future skills requirements.

2.1.4. Demand

In addition to knowledge producers, the demand side is assigned a key role in the sectoral systems of innovation and production perspective. Demand is formed by heterogeneous buyers, individual consumers, firms and public agencies, each characterised by their specific knowledge, competencies and goals, and affected by emerging trends, trend-breaks, social factors and institutions. Thus, in a sectoral system, demand is generated by heterogeneous agents whose interactions with producers are shaped and transformed by institutions. The emergence and transformation of demand play a major role in the dynamics and evolution of sectors and in cross-sectoral developments.

In the context of sectoral innovation foresight, the identification of potential future demand as a driver and shaping force of innovative activity within and across different sectors represents an important element to consider.

2.1.5. Co-evolution

Change in a sectoral system is a collective outcome of the dynamic interactions and co-evolution of its various elements. This process involves the aforementioned elements, i.e. knowledge and technology, firm and non-firm actors, their interactions and learning processes, it includes the demand side and the institutions that guide interactions. Sectoral analyses need to focus on intertwined changes in relation to these elements. The sectoral innovation foresight analyses specific innovation themes and emerging markets with a view to exploring the organisational, structural, institutional and skills-related requirements for their realisation. The aim is to capture different variants of the dynamics resulting from the interplay of different factors, for instance by way of scenarios.

Building on Malerba's earlier work, Dolata (Dolata, 2009) points out that there are two key determinants of the likelihood of sectoral change arising through innovation, namely a) the transformative capacity of new technologies and b) the sectoral adaptability of socioeconomic structures, institutions, and actors confronted with the opportunities presented by these new technologies. Ultimately, the transformative

dynamics of sectoral change are driven by various kinds of self-reinforcing mechanisms or cumulative causation necessary in order to overcome established path-dependencies in sectoral systems.[4]

2.2. From sector analysis to sectoral foresight

The majority of sectoral (innovation) studies are analytical in nature and provide a retrospective view of the development and dynamics of sectors (Bergek et al., 2008; Carlsson, 2007; Malerba, 2004). While they are certainly an important inputs to any kind of sectorally oriented policy strategy, government, in particular in periods of fast change, cannot restrict its intervention strategies to a responsive mode of remedying deficits, but needs to anticipate possible changes ahead and actively shape framework conditions and incentives accordingly. In order to spearhead the evolution of a system in a particular direction, a major challenge consists of achieving a suitable degree of coherence of the actions taken by the distributed actors in that system. It is thus crucial to involve actors early on in the process of anticipating future challenges and problem perceptions, guiding visions, and collective agendas, which subsequently help guide their individual strategies.

Against this backdrop, foresight is defined as "*a systematic, participatory, future-intelligence-gathering and medium-to-long-term vision-building process aimed at enabling present-day decisions and mobilising joint actions. It can be envisaged as a triangle combining 'Thinking the Future', 'Debating the Future' and 'Shaping the Future*".[5]

This definition recognizes that future developments are not pre-determined, but uncertain and open to judgement, intervention and active shaping by the actions of distributed actors in a system. Foresight is not a tool for predicting a pre-determined future, but a process aiming to develop shared problem perceptions, make differences in expectations explicit, define common goals, and identify needs and options for action (European Commission, 2002), which can subsequently be put into practice by the involved actors in their respective local contexts. In this light, foresight can be interpreted as a soft mechanisms to coordinate strategies of distributed actors, and not just as an approach for anticipating the future.

In more operational terms, foresight can be used for sketching different plausible, but challenging variants of future sectoral system pathways, as well as the associated challenges, underlying determinants, goals, and options for realizing them. In order to achieve this, foresight is looking into a broad range of internal and external driving forces affecting the future evolution of a system. Such driving forces are developments that have the potential to exert a major influence on the sector under study and could thus shape the evolution of the sectoral innovation system, in particular when interacting with other drivers in such a way that a mutually reinforcing processes are set in motion. These driving forces are captured, for instance, in emerging trends, but equally in unexpected novel developments and potential trend breaks that can give rise to qualitatively different future development paths in the sectors under study. Foresight processes can also look at 'wildcards', i.e. at seemingly unlikely developments that – in case of happening – could give rise to highly disruptive future pathways, very different from any kind of "business-as-usual" assumption.

Next to these substantive benefits, foresight does also have a range of process benefits. It is seen as a tool to build new networks and linkages across fields, sectors and markets or around problems. These different kinds of benefits of foresight have been systematised in recent evaluations and meta-evaluations, taking into account also foresights that have been looking at individual sectors (Georghiou and Keenan, 2006; Havas et al., 2010), but hardly any future explorations of cross-sectoral linkages and spill-over effects have been conducted.

Although the relevance of foresight for national innovation systems stood at the beginning of the introduction of the notion of "foresight" in innovation policy (Martin and Johnston, 1999), an explicit theoretical foundation of foresight in innovation systems thinking has hardly been attempted. Havas (2003) and Havas et al. (2010) explicitly refer to innovation systems in their review of impacts of foresight. Also the range of regional foresights has been tied to a broad understanding of regional innovation systems, but without tying the methodology to the specificities of the RIS framework (Gavigan et al., 2001). Foresight actions looking into sectoral implications have been largely dominated by a technology-centered rather than a systemic approach, and thus paid limited attention only to demand-side aspects and systemic interdependencies. If, however, the argument about sectoral and technological specificities of innovation systems is taken seriously, then these specificities should also be taken into account in the foresight approach used to explore future developments, challenges and policy issues.

So far, forward-looking sectoral innovation studies have been mainly restricted to short-term futures and/or pursued a purely expert-based approach. Few systematic foresight efforts have been made at sectoral level that would involve the degree of participation and interaction required for foresight that is in line with the philosophy of thinking, debating and shaping the future.[6] Recently, sectoral innovation foresight has been suggested using an innovation systems framework explicitly (Andersen and Andersen, 2014; Andersen et al., 2014), and building on an earlier multi-sector foresight project by the authors (Weber et al., 2009). In line with this stance on foresight, the sectoral innovation foresight approach presented here aims to look beyond time horizons that can be addressed by simply extrapolating current trends, and to explicitly consider systemic interactions between technology and demand side developments. While for some fast-changing sectors this may imply exploring a time horizon of three to five years, for others looking ten or fifteen years ahead may be more appropriate.

Andersen and Andersen (2014), Andersen et al. (2014), drawing on Andersen and Rasmussen (2012), concentrate on proposing a generic multi-phase foresight approach and apply them to individual sectors. Drawing on the requirements for Sectoral Innovation Systems Foresight suggested in their conclusions (Andersen and Andersen, 2014), we develop and pilot a framework and methodology that take these requirements up and put them into practice. More specifically this means that a) we stress the importance of taking the demand side of innovation into account in Sectoral Innovation Foresight, b) we move towards a process design and methodology that builds explicitly upon the main conceptual building blocks of Sectoral Systems of Innovation and Production, and c) we put emphasis on a participatory approach involving not only technology specialists, but the types of actors that are key to the entire sectoral innovation system (including some potential future actors).

In addition, based on our systematic conceptual and methodological frame, we look at cross-sectoral developments on the grounds of comparing the results from individual sectors. Foresight of different but interlinked sectors is crucial today because innovation is a collectively shaped process, a distributed process, and a path-dependent process, which needs to be understood as being embedded in wider contextual developments. While foresight that focus on individual sectors can concentrate on exploring the different elements of sectoral systems of innovation and production, the cross-sectoral perspective approach here requires paying particular attention to emerging and future developments arising at the interfaces and boundaries between sectors. Moreover, a systematic comparison can only be conducted by applying the same conceptual, methodological and interpretative frame to all sectors

[4] In this context, Suurs and Hekkert suggest the notion of "motors of innovation" to capture these self-reinforcing dynamics (Suurs and Hekkert, 2009).

[5] Due to the popularity of the term "foresight", very different meanings are attached to the terms nowadays. In this paper, we stick to the definition provided by the European Foresight Platform, www.foresight-platform.eu.

[6] One of the very early exceptions is the Nordic Hydrogen Energy Foresight conducted between 2003 and 2005 (Holst Jørgensen and Andersen, 2005).

that. This is what the methodological approach of Sectoral Innovation Foresight is about.

3. Conceptual and methodological approach – combining a sectoral innovation systems perspective with a foresight methodology

3.1. A sectoral innovation foresight framework

Innovation at sectoral level depends partly on the developments within the innovation system, but they are also driven by developments in its context, like for instance changes in science and technology, but also on the demand side. To explore future patterns of innovation, it is thus necessary to investigate these contextual developments, as well as corresponding developments within a sectoral innovation system.

Foresight activities have a limited theoretical basis and respond to practical needs of exploring the future. Even if the origins of foresight can be traced back to innovation studies and science and technology studies (Martin and Johnston, 1999), a gap can be identified between innovation theory and foresight practice, i.e. there is not specific framework available that would combine both. For the purposes of this foresight exercise, the main building blocks of sectoral systems of innovation and production (knowledge and technologies, actors and networks, and institutions) have been taken into account, but integrated with the kinds of concepts that are used in foresight approaches. We will thus talk about driving forces, innovation themes and emerging markets. We argue that in order for innovation themes to evolve into markets, the different elements of a sectoral innovation system need to co-evolve.

The conceptual framework to structure the sectoral innovation foresight is based on a pattern of analysis and future exploration, which builds on the theoretical underpinnings of the sectoral innovation systems approach (Weber et al., 2009). This methodology consists of subsequent main conceptual building blocks:

- Driving forces, i.e. emerging trends and trend breaks in S&T developments, of expected demand – both internal and external to the sectors under study – that are likely to exert a major influence on emerging innovation themes. Broader crosscutting developments/trends (e.g. the extent to which globalisation affects a sector) are also taken into account.
- Innovation themes, which are seen as the results of the interplay of S&T developments and changes in expected demand. In contrast to driving forces, however, innovation themes are rather specific areas on which attention and innovation effort are likely to be focused in the coming years. They can thus be interpreted as sector-specific bundles of product and/or process innovations, together with the associated technologies and organisational changes.
- Emerging markets which can achieve significance if an innovation theme evolves successfully, i.e. if potential barriers can be overcome and enablers be strengthened. Initially, innovation themes have a potential to evolve into a market. However, whether this potential can actually be seized depends to a significant extent on the context conditions provided by the sectoral innovation system.
- Requirements and co-developments in a sectoral innovation system can serve as enablers and barriers for innovation and for markets to emerge. They can even be essential in order to allow markets to emerge. For instance, regulations can provide an orientation for future innovation trajectories to pursue, and the ability of firms to collaborate with research organisations may be essential for being able to exploit a new technological opportunity. Such co-developments reflect the aforementioned building blocks of sectoral innovation systems. For the purposes of the exercise, the following dimensions were chosen
  - o organisational changes at firm level,
  - o firm strategies for dealing with emerging drivers,
  - o skills requirements needed, for instance, to absorb S&T developments,
  - o structural changes, i.e. changing configurations of actors in a sector.
  - o institutional change, i.e. changes in the 'rules of the game' determining the interactions between the actors

Along the lines of these four building blocks, the co-evolutionary dynamics of innovation and change in a sector can be captured by way of scenario building, i.e. scenarios serve as means to capture alternative co-development paths of a sectoral innovation systems. The interplay of different internal and external drivers, and their mutual reinforcement, can give rise to major, even disruptive changes in sectors, with important implications for firm strategy as well as public policy.

These conceptual building blocks of sectoral innovation foresight need to be translated in procedural terms. In brief, we suggest seven main steps that lead to forward-looking conclusions for government policy on individual sectors and/or on cross-sectoral matters. These seven basic steps refer to the general case of a sectoral innovation foresight applied to a single sector. In Section 3.2, we will explain in more detail how this general methodology has be operationalised in our INNOVA foresight on future issues cutting across several sectors.

Before conducting any in-depth future exploration, the time horizon needs to be defined. This depends very much on the questions to be addressed, but also on the sectoral dynamics, i.e. whether we are dealing with a fast-changing (e.g. ICT, KIBS), or a slow-changing (e.g. construction, energy supply) sector. The first step of our sectoral innovation foresight methodology consists of a situational analysis of the sector(s) in question in order to provide an empirical foundation for all subsequent steps. It is structured along the lines of our conceptual framework, and it looks at the sectoral evolution of the past few years. Second, different types of internal and external drivers likely to exert an influence on the sectoral innovation systems are identified and explored. These drivers can be of different kinds; they can refer to science and technology developments but also to developments on the demand side of innovation. Wider contextual developments, including at global level, also need to be considered, relating, for instance, to major shifts in global economic power, thus of potential future demand. A third main step focuses on the innovation themes that might emerge in the future at the intersection of science and technology drivers on the one hand, and demand side drivers on the other hand. In parallel to the exploration of innovation themes, sector-level scenarios are explored, which take into account in particular major contextual developments in addition to the sectoral dynamics. The next, fifth step is a very crucial one, because it aims at exploring future pathways of how innovation themes might evolve and open up future markets, and what requirements and co-developments need to be met for this to happen. As sector-level scenarios and the evolution of innovation themes into future markets are not independent from each other, they need to be mutually adjusted in an iterative process in order to make them cohere. In practice, this sixth step is realised by assessing the potential and the limitations of the innovation themes and associated future markets against the backdrop of the different scenarios. On the grounds of this comprehensive picture, in a seventh step various types of policy conclusions can be drawn. These conclusions can refer to different levels, i.e. to the promotion of individual innovation themes through demand- and supply-side measures, or to the shaping of framework conditions of sectoral innovation systems. The main advantage of the scenario-based approach consist of the possibility to identify 'robust' policy options that are promising across different scenarios, but also 'adaptive' options that aim to address specific issues that may be raised in one scenario only.[7]

3.2. Operationalisation of the framework

The INNOVA Sectoral Innovation Foresight was explicitly geared towards the exploration not only of sector-specific issues, but also of

[7] This logic of interpreting scenarios is based on the concept of robust and adaptive strategy development using foresight, as suggested by Eriksson and Weber (2008).

cross-cutting future developments and resulting policy implications. For this reason, the basic sectoral innovation foresight methodology as sketched briefly above had to be implemented in a modified way in order to explicitly address also cross-cutting matters. The INNOVA foresight exercise was implemented in five main operational stages and the results of these steps were integrated in nine sectoral foresight reports:

- *Situational Analysis and review of potential drivers*: An analysis of recent developments in all sectors was conducted by the project team using statistical indicators and a range of sectoral studies.[8] It served as background and input for a first set of future-oriented reports along the lines of a common analytical framework. It was based on a review of existing forward-looking sectoral studies that provided information about expected future developments that might impinge on the evolution of the sector. This information, complemented by a limited number of expert interviews in each sector, served as the basis for suggesting a first set of potential drivers of change and potential innovation themes, but also of likely requirements for these innovation themes to grow. The drivers were both internal and external to the sectors, and they cover S&T developments, demand side developments, and wider contextual developments. The underlying hypotheses was that some of the drivers would be of a cross-cutting in nature and shared by different sectors. Also first ideas about possible scenarios were presented – to the extent that information was available from secondary sources – as well as first insights about possible emerging cross-linkages between sectors were explored. This material was compiled into a set of interim sector reports, reflecting the current state-of-the-art.
- *First Foresight Workshop: Development of scenario sketches*: The interim sector reports served as inputs to a first foresight workshop.[9] This 1.5 days workshop was attended by about 70 participants from research, industry, government and various associations, but also by some journalists and foresight experts. The workshop was based on a sophisticated choreography, consisting of some brief plenary sessions for introduction and joint discussion of results, but mainly relied on sectoral working groups. These working groups used open brainstorming and structured discussion formats to a) review and validate the empirical analysis, drivers and innovation themes suggested in the interim reports, b) revise and expand the list of innovation themes, c) develop first scenario sketches, and d) explore possible future markets for the innovation themes identified. A plenary session at the end of the workshop was explicitly foreseen to identify cross-cutting issues and cross-linkages between sectors. In methodological terms, modified World Café format was chosen to foster knowledge exchange across sectoral working groups.
- *Sense-making and scenario development*: Based on a synthesis of workshop results, which was fed back to all participants in order to maintain a continuous electronic dialogue with them, the interim report was substantially revised, refined and extended. The common report structure was revised by the project team to take up lessons learned from the first workshop, but it continued to reflect the main lines of the conceptual framework underpinning the project, not least in order to ensure comparability of results across sectors. The scenarios section in particular was expanded significantly as compared to the initial interim reports, and the sections of drivers and innovation were – in some cases – substantially revised. The result was a set of revised interim reports as inputs to the second foresight workshop.
- *Second Foresight Workshop: Scenario assessment, requirements for change, and policy*: Whereas the first workshop was predominantly exploratory in nature, the second workshop had a much more evaluative character. It was attended by about 60 participants from similar constituencies as the first workshop.[10] The refinement and assessment of the scenarios played an important role at the workshop, in particular in order to systematize the sets of scenarios in each sector along some key dimensions. Potential risks and opportunities that the scenarios might raise for the future of the sector in Europe were elaborated. These much richer scenarios were used as contexts in which to refine and subsequently assess the different innovation themes in terms of market perspectives, competitiveness perspective, and societal perspectives. This assessment was made for each innovation theme, leading to a quite differentiated picture of assessments under the conditions of the different scenarios. Moreover, systemic requirements and co-developments for innovation themes to succeed on emerging markets were identified in organisational, institutional, and knowledge terms. Cross-sectoral issues were explicitly addressed again using a multi-round World Café format, focusing on common drivers of change across sectors and on possible influences of one sector on others. This second workshop also addressed policy issues in a quite differentiated way. The assessment results of the innovation themes were used to extract issues for policy attention at both innovation theme and sectoral levels, and differentiated by scenarios. At least for some sectors, considerations regarding the 'robustness' of possible policy actions across scenarios were added.
- *Policy exploration for innovation themes, sectors and across*: In the follow-up to the second foresight workshop, the interactive elements shifted towards bilateral interactions with participants in the process and with European Commission services, mainly in the form of interviews or small focus groups. The emphasis was put on the elaboration of policy issues that the exercise had raised, with the aim to elaborate more specific suggestions at the levels of innovation themes, sectoral policies, and cross-cutting matters. The underlying logic of formulating these suggestions was based on the argument that the potentialities of different possible futures, captured by the scenarios, need to be taken into *account* in the formulation of advice. At least for some sectors, a clear distinction was made between those actions that would be beneficial across a range of different scenarios ("robust"), and others that would be specific to individual scenarios ("adaptive"). These policy actions can also fulfil two different purposes, namely either to prevent negative consequences that might arise in some scenarios, or to capture opportunities and exploit possible synergies.

4. Cross-cutting issues - results, discussion and implications

The comparative analysis of the different sectors revealed major cross-cutting issues. It was based on the approach that the exploration of scenarios and the analysis of innovation themes, emerging markets and requirements/co-developments were conducted along the lines of the same pattern of analysis. In this comparison, the same themes arise across different sectors. These cross-cutting issues refer to innovation policy topics with high political leverage and become visible when analysing the more dynamic and successful scenarios.

4.1. Scenarios and cross-cutting issues

We now give a brief overview of the scenarios from different sectors that address the cross-cutting issues. The interpretation of the scheme is simplified by the obvervation that only the 'success'-scenarios address the cross-cutting issues. We have in each of the industrial sectors a business-as-usual scenario that does not anticipate major changes and we also have in all sectors a kind of negative scenario where the future of the sector is characterised by a decline in key capabilities. Positive scenarios in the industry sectors are based on solutions for the challenges to address market needs or societal needs (Table 1).

[8] These analytical reports were not part of the Sectoral Innovation Foresight as such, but part of a different work package of the INNOVA project. However, they served as background material for the foresight work.

[9] This workshop '*Sectoral innovation foresight: key drivers, innovation themes & emerging markets*' took place on 23–24 June 2009 in Brussels.

[10] This second workshop 'Sectoral innovation foresight: Future requirements and policy issues' took place on 30 November and 1 December 2009 in Brussels.

Table 1
Key features of scenarios in different sectors.

	Business as usual	Market driven/high dynamic	Strong public engagement for transformation/high dynamic	Low dynamic
Automotive	Recovery and business as usual More income, incremental energy storage innovations, differentiated mobility behavior and an incremental increase of regulation	Green cars - you can have it all Increase of relative available income, breakthrough innovation, differentiated mobility behavior, strong & quick increase of regulations	Sustainable revolution Less income available, only incremental advances in energy storage technologies, a change of mobility behavior with a stronger use of public transport, and a strong regulation regime.	Low cost and conventional technology Less relative available income, incremental innovation, differentiation of individual mobility and an incremental increase of regulation.
Construction	Innovative niches Market-driven sustainability, tight financial conditions, incremental improvements, Leading organisations as drivers and supporters of change. Because of increasing prices only those who can pay for it can innovate.	Greening business General market growth, high demand for green products. Companies as major drivers in radical greening, alternative business models for sustainable consumption; R&D driven by private sector; variety of innovation and new bottom-up business ideas.	Public drive Government-driven change, regulations and investments for sustainable infrastructures. Public sector support for innovative solutions for new buildings, as well as for existing buildings. Incentive schemes generate virtuous circles, from innovation to economies of scale; demand for new know-how and capabilities in workforce.	Restricted opportunities Regulation-driven sustainability & lack of financing. Regulations without incentive schemes or public investment. Industry is passive, firms need to comply with regulation. Lack of R&D funding; incremental improvements with focus on cost
Textiles and clothing	Clothing: sustained globalisation Very price-sensitive consumers; high demand for cheaper and simpler products that are mainly produced in low-labor-cost countries outside Europe. Limited role for sustainable production Open markets with a very low level of regulation accelerate the shift of production to low wage countries.	Clothing: high risk, new options Scarcity of resources (water, energy, natural fibers and oil for the production of artificial fibers) force the T/C sector to more sustainable production models; return to localized production chains in combination with a closed market. Replacement of international brands by local brands	Clothing: sophisticated and high value Demand for sophisticated high quality products that are produced in a sustainable way. Ecologically sustainable production based in Europe; Unique sustainable fashion brands; Open markets; international standards regarding health, safety and labor are introduced under the pressure of consumer demand for sustainable clothing	
Textiles and Clothing	Technical textile: evolutionary Incremental integration of new technologies; product development compete with products and materials from other sectors; secrecy to maintain their technological advantage.		Technical textile: breakthrough Breakthrough innovations by a highly skilled labor force. New interactions with other sectors; severe restriction on the supply side for raw materials. Co-operation within the textiles industry and especially beyond; protection of research based innovation through patents	Technical textile: drag-out Lack of skills in Europe; new products are developed and produced outside Europe; high dependence on foreign suppliers. Lack of state-of-the-art textiles industry; dragging effect on other technologies to move out of Europe
Wholesale & Retail	Big boxes everywhere & green big boxes everywhere High concentration in the retail sector; limited number of retail chains across Europe; In the outskirts of towns large supermarkets are targeting car owners. Retailers are entirely in the lead of what they offer in their 'big boxes' (that also can be small boxes of big retail chains) and define what producers have to produce.	The rise of lifestyle stores and malls Consumer demand for stimulating shopping experience ranging from high-tech entertainment and shopping facilities at spectacular sites to onsite eco-farmers' markets; combination of products and services. Lifestyle driven and heterogeneous development including green malls, malls based on religious orientation, ethnicity based shopping centres, high-tech-oriented malls or sports-oriented malls.	Green digital consumer High growth of online commerce and digital consumerism; greening based on regulation and high demand; available income; Value driven; such as sustainability, creativity and flexibility are addressed by retailers through information (c.f. to calculate the impact individual decisions and their general buying behavior) and community building. Policy making is coordinated all stakeholders to improve greening of the whole sector.	Local markets – connected through the web/the supermarket as a public good Local markets are strongly based on products that are possible to produce locally. Local supply chains are supported by local governments and European regulation and incentives, ensuring local communities continue to benefit economically and socially.
KIBS	Customised delivery High degree of tacitness and a stable environment, where internal experts contribute to innovation and the provision of services at their clients. Innovation is very much ad-hoc, codification of knowledge is low; KIBS importance in the innovation processes characterised by specialisation and cost advantages	Creativity & interaction High degree of tacitness and a dynamic environment; co-operation is project-based involving individual expertise; close to "open innovation"; KIBS as facilitators, providing platforms to support collaboration. High degree of openness higher innovativeness in general based on tacit knowledge.	Explorative research Low degree of tacitness and a dynamic environment; more opportunities for codification and a more decisive role of ICT for service provision. Higher degree of automatization, lower importance of individual expertise. KIBS based on ICT and software (c.f. data mining). Codification of services may lead to increasing returns to scale and decreasing unit costs of service provision. Competition between in-house service provision and external service providers or in-house-use of codified knowledge in business software and tool-kits to enhance the competencies of internal departments.	Automated delivery Low degree of tacitness and high importance of ICT; closer Co-operation of limited number of partners in more routinized innovation processes. Services are provided as projects in the context of firms (c.f. Internet-based banks, Amazon). Growth based on codification, facilitated by ICT. Cost degression for codified services and the increase of do-it-yourself, business software and tool-kits beside codification.

4.2. From products to systems and services – towards industry 4.0

A major cross-cutting and cross-sectoral development can be characterised as a shift from products to systems and services. Sectoral scenarios with successful innovation practices that either contribute to growth or address societal challenges include a shift towards services.

In the *automotive sector*,[11] the scenario "*Green Cars - You can have it All*" is on the one hand based on breakthrough innovation for instance with regard to powertrain technologies. In this market-driven, highly dynamic scenario, the sector's main game changer is on the other hand the embeddedness of cars into service networks both to personalize cars and make them part of an integrated mobility and energy service network. Innovation is enabled through specialized engineering fields and design schools, developing manufacturing systems, traffic management systems and new forms of customization by design. Cars are embedded in new infrastructure of personalized services to individualize the car according to specific needs and values of the users. These Green cars link transport and energy in the future when the batteries of electric cars are used as home power storage devices and become energy producers as part of the electric grid.

The "*Greening business*" scenario in *construction* is based is based on general market growth and a high demand for greening buildings and greening the way of living and working in buildings. New green designs are based on integrating knowledge and services of new buildings products and services. Companies are major drivers in radical greening, they drive radical changes through alternative business models for sustainable consumption. Innovative activities that are oriented towards services around green building indicate the shift from products to services and systems. Turn-key solutions, including various forms of service contracting over the lifetime of a building are more and more common and provide incentives for efficient operation and maintenance of buildings (including matters of energy-efficient lighting and insulation). In the public sector there is growing interest in PPP-solutions for infrastructures. In practice, they are implemented through long-term contracting services for whole systems construction, operation, maintenance and recycling.

In the *textiles and clothing sector*, the "*Breakthrough*" scenario for technical textiles shows a similar textile show the shift. Breakthrough innovations in technical textiles as a rather disruptive development are anticipated as being driven by research-based technologies and a highly skilled workforce in combination with a severely restricted supply of raw materials. With a strong user sector in Europe, which is highly interconnected with the textile supplier, technical textiles are used in many more areas so that we have a growing demand for new textile fibers and applications and Europe becomes a world market leader. The close co-operation both within the textiles industry and with other sectors transforms the sector from a manufacturer of products to a service-oriented suppliers of solutions for material requirements in different sectors.

In the service sectors the shift from selling products to integrated systems of services can have different forms.

Consumer demand for stimulating shopping experience is ranging from high-tech entertainment and shopping facilities at spectacular sites to onsite eco-farmers' markets; combination of products and services. In the wholesale and retail sector, one scenario is "*The rise of Lifestyle Stores and Malls*" where a lifestyle driven and heterogeneous development lead to a variety of combinations of shops and services including green malls, malls based on religious orientation, ethnicity based shopping and service centres, high-tech-oriented malls or sports-oriented malls. Retailing also takes over additional service roles in healthcare or insurance services, or in public services (e.g. postal, e-government).

The emergence of important parts of the KIBS sector itself is a reflection of the shift from products to services. Partly driven by outsourcing of activities of manufacturing firms, KIBS comprise a range of activities from software developments and data processing, via R&D services, to legal, economic and engineering consulting.

Until now, aspects of the trend towards systems and services are captured in the concept of servitization, but mainly discussed and conceptualized at the level of firms, e.g. as product-centric servitization and addressing manufacturing-related concepts (Lightfoot et al., 2013). The transformation towards services is still mainly discussed as a management and operational issue (Lindberg and Nordin, 2008; Oliva and Kallenberg, 2003), not as a policy issues at the level of sectors or cross-sectoral level.

Seen from today many of the aspects explored in the INNOVA sectoral foresight pointed (avant la lettre) towards the industry 4.0 concepts and the current controversy about the expected loss of jobs (Ford, 2014; Frey and Osborne, 2013) in manufacturing. The scenarios that address shifts from products to systems and services are highly oriented towards new combinations of so far unrelated knowledge and the transfer of knowledge.

4.3. Blurring boundaries between sectors – co-creation of key enabling technologies in its applications

Another cross-cutting development refers to the blurring boundaries between sectors. In all scenarios with a high innovation dynamic and with growth perspectives, innovation activities are crossing boundaries of sectors. Today the blurring of boundaries become a crucial part of policies towards Industry 4.0, the integration of Cyber-Physical Systems, the Internet of Things and the Internet of Services.

The scenario "*Green Cars - You can have it All*" in the *automotive sector*, is based on blurring boundaries as it does not only integrate technologies form different sectors such as multimedia to create lifestyle products, but it combines transport and energy in the future when batteries of electric cars become power storage devices and part of the electric grid.

The blurring of boundaries between sectors is inherent in the concept of technical textiles. Technical textiles are used in sectors such as agriculture, construction, automotive and as protective textiles. At the same time, the textiles industry depends on ICT, on various materials industries (e.g. for nano-structured textiles), etc. The scenario that address an "Evolutionary" development as well the "Breakthrough" scenario are based on the ability of the sector to actively cross a variety of sectoral boundaries and to substitute other materials through lightweight textile solution (Fig. 1).

Another example of the blurring of boundaries draws on the transformation of the retail and wholesale sector which is expected to have a high leverage effect on related sectors. Similarly, the knowledge inherent in KIBS is a key mechanism interconnecting different sectors; KIBS can be mediators of cross-sectoral developments.

These findings point to the necessity of devising multi-level industrial policies, which address both sector-level specificities and the harmonisation of cross-sectoral issues in such a way that sector-level developments are effectively supported. A recent example underlining the significance of the blurring boundaries is reflected in the notion of Industry 4.0 or Digital/Smart Manufacturing. In fact, the digitalisation of manufacturing is at its very core about the instantaneous interconnection of activities in different sectors, and thus about trans- and intersectoral innovation dynamics.

[11] In the automotive sector, service offers have been expanded over the last years and are expected to continue in the future in most scenarios. Apart from maintenance/repair and financial services, some OEMs are promoting different types of guaranteed mobility services, including car-sharing. In terms of mobility management, large-scale systems are being established to provide mobility support services like travel information or integrated multi-model mobility services. Firms increasingly switch from selling services rather than products, or the post-sale services that are complementary to the product represent a large and growing share of turnover.

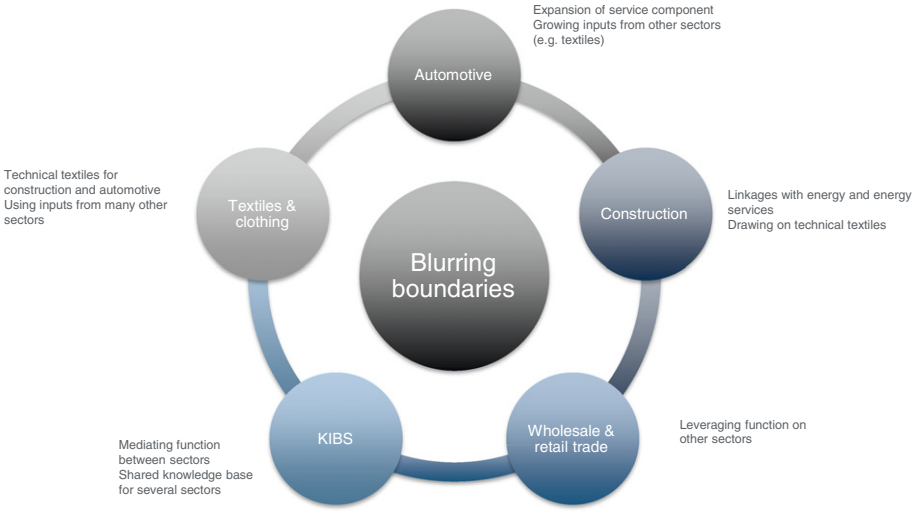

Fig. 1. Blurring boundaries between sectors.

4.4. Sectoral and cross-sectoral integration of sustainability demands: Open question of responsibility

The sectoral and cross-sectoral integration of sustainability demands can be observed frequently in the different scenarios. There was a wide consensus in different sector panels that industrial development continues to move in an unsustainable direction. For the sectors at least one scenario emphasizes a sectoral innovation system focusing on sustainability demands.

While the scenario "Green Cars - You can have it All" is based on a set of optimistic assumptions that combines technological breakthroughs with an increase of relative available income, a green shift of mobility behavior as well as a strong and quick increase of regulations to transform the system, another scenario addresses it as necessity because of restrictions: The "Sustainable Revolution" scenario is based on less available income, only incremental advances in energy storage technologies, a change of mobility behavior with a stronger use of public transport, and a strong regulation regime. Efforts to realize more energy-efficient and less polluting vehicles are part of all scenarios but only in the market driven green growth scenario and the government driven de-growth-scenario is a transformative shift towards sustainability anticipated.

New production methods are also a major technological driver in the textiles and clothing sector, to reduce the amount of energy and raw materials used, and increase the flexibility and quality of production processes. Some customer segments pay growing attention to the sustainability of the products they buy, requiring the clothing industry in particular to be transparent about the sustainability of their value chains.

Sustainability in construction is likely to play a more important role in the future, but the expectations are different whether this development will be regulation- or market-driven by consumers and builders. The scenario "Innovative niches" expects limited market-driven sustainability under tight financial conditions or even – in the scenario "Restricted opportunities" – a regulation-driven sustainability with improvements with focus on cost. Similar to the automotive sector, two scenarios address a transformative shift either by the market through green business or in the case of Public drive by public intervention. In the "Greening business" scenarios a general market growth is expected that leads to a high demand for green products, so that companies and private sector R&D are major drivers in radically greening. The "Public drive" scenario with its government-driven change as well as regulations and investments for sustainable infrastructures is based on an innovation system that is highly coordinated towards a transformative shift towards sustainability. The question of how the innovation system might change radically remains open as sustainability is conceptualized mainly as driver outside of their sector that will change its sectoral innovation system, but not in the opposite direction from the sectoral innovation system to other sectors. Therefore, also the question of responsibility remains open.

Transparency in regard to the environmental and social impact of different retailers and retail services will allow consumers to make informed choices while stimulating innovation and diversity in retail services. Regarding wholesale, transparency about the sustainability of the entire value chain is expected to become an important issue in the future. Local or regional sourcing of products is an issue in several scenarios.

KIBS benefit from the growing interest in sustainability. Environmental consulting is one of the growth segments in KIBS, but also other KIBS need to respond to the growing demand for sustainability, e.g. in R&D, legal or financial services.

Within the workshops of the sectoral innovation foresight, sustainability demands were often seen as abstract future drivers, beyond the direct responsibility and control of actors within the sector. For instance, a shift towards greater environmental consciousness was claimed to be important, but the responsibility for triggering more sustainable sectoral practices remained unclear. Neither were greater environmental consciousness and sustainable practices of actors within sectors seen as accompanied by complementary shifts in public policy and especially in regulation.

In general, sustainability is scarcely addressed in sectoral studies in conjunction with its public policy dimension. The few studies available see government policies as important, not only with regard to regulation but also in the sense to create spaces for experimentation through collective enactment by a range of actors as well as encouraging engagement (Gibbs and O'Neill, 2015).

A more future-oriented strategy to address sustainability at a cross-sectoral level might become the policy concept of Responsible Research and Innovation (RRI): "Responsible Research and Innovation is a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society)" (von Schomberg, 2013). Until now, sectors are not the level to be mainly addressed in RRI, although it is seen as necessary to address a greater diversity of innovation system agents (Wickson and Forsberg, 2015).

5. Conclusions

The purpose of this paper has been twofold, namely a) to outline the conceptual and methodological features of Sectoral Innovation Foresight approach, underpinned theoretically by innovation systems thinking, and b) to illustrate the benefits of a systematic multi-sector foresight by extracting some cross-cutting insights generated. These cross-cutting insights have been presented in a stylised manner, but they were helpful to demonstrate that cross-cutting findings open up the possibility to devise cross-cutting policy inroads. The Sectoral Innovation Foresight methodology suggests that sector-level insights from foresight can indeed be translated meaningfully into cross-cutting policies and strategies.

A second benefit of the scenario-based approach to sectoral innovation foresight consists of offering prerequisites for robust and adaptive rationales for policy. Policies can be devised either to promote desirable developments as reflected in (some) scenarios, OR to counteract negative development reflected in (other) scenarios. While this may be common wisdom for many experienced foresight experts and practitioners, it seems to be less common for sectoral and industrial policy, which tends to rely on analysis of the present situation of sectors rather than future perspectives on sectors. In a time of faster and cross-cutting change processes, policy development on situational analysis only could be easily misleading.

The explicit theoretical foundation of the sectoral innovation foresight approach on the sectoral innovation systems framework facilitated the comparative interpretation of findings across sectors, and in particular the identification of cross-cutting developments and policy issues. It also has methodological advantages because it provides a sound basis for structuring the different forms of forward-looking enquiry along the lines of some key concepts, and thus helps guide discussion and future exploration, both within the project team and between the project team and the participants of the foresight process.

With this paper, we give an example of how the innovation systems approach can be explicitly connected with a foresight perspective. Although innovation systems thinking was one of the sources of inspiration for foresight, next to other social science perspectives from Science and Technology Studies, its potential for guiding the implementation of foresight and the interpretation of its results has not been fully exploited yet. By using elements and interpretative lines of reasoning from innovation systems approaches, we have tried to make a step forward in foresight towards explicating and specifying future expectations of different actors in theoretically sound terms.

A crucial point for further research is how to conceptualize the cross-sectoral co-creation of innovation pathways. It has been shown that sectoral foresight is able to make cross-sectoral issues visible. This might be an inspiration for innovation systems research, where one of the next steps could be to look more deeply into mutual sectoral requirements in technological, organisational, institutional and policy terms for innovation to unfold.

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