IIT Deliverable

2.1 Conceptual Framework

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Abstract

Innovation practices in companies are changing. Major changes include the way how innovating companies relate to their broader innovation environment, to other innovation actors and how they interact. This report provides a concise review of literature which describes characteristics, concepts and recent developments of and around key innovation practices, their use, conditions and impact on innovation. In particular, we review insights on innovation ecosystems, sectoral patterns of innovation, trends in open and demand-based innovation, corporate foresight and other forms how companies map their environment, the use of web-enabled tools, and different forms to organize innovation strategy and management. Based on this, we further specify the research gaps the IIT project will address, and derive conclusions for data collection and analysis.

Contents

1 Introduction

The Industrial Innovation in Transition (IIT) project builds on the key assumption that the innovation practices and output of a company are important for a company's ability to grow, be profitable and to create employment. Numerous studies conducted over the past decades are supporting this assumption (Kleinschmidt and Cooper 1991, Baldwin and Gellatly 2003, Lööf and Heshmati 2006, Mansury and Love 2008). More broadly, innovation is a key condition for regional, national and European growth, for the creation of new businesses, and for the development of products and services which can be applied for the benefit of its users and society. According to an OECD study (1996), a key finding was that innovative companies are more profitable, grow faster, and employ more people than less innovative companies. Also, in general, 50 percent of economic growth can be attributed to technological progress.

Innovation is by definition about change, about creating new technologies, products, services, and about enabling new practices and social activities, new business practices and industries. What is more, innovation processes themselves are in transition. Major changes include the way how diverse innovation actors relate to each other and interact. As a result, the innovation practices of industry companies are changing, as well as how the companies relate to their broader innovation environment, in particular the expanded network of actors jointly involved in the innovation processes with a particular company, the innovation ecosystem. Open innovation, social media, crowd sourcing, new IPR provisions and public-private partnerships are more and more becoming essential elements of a company's innovation toolbox.

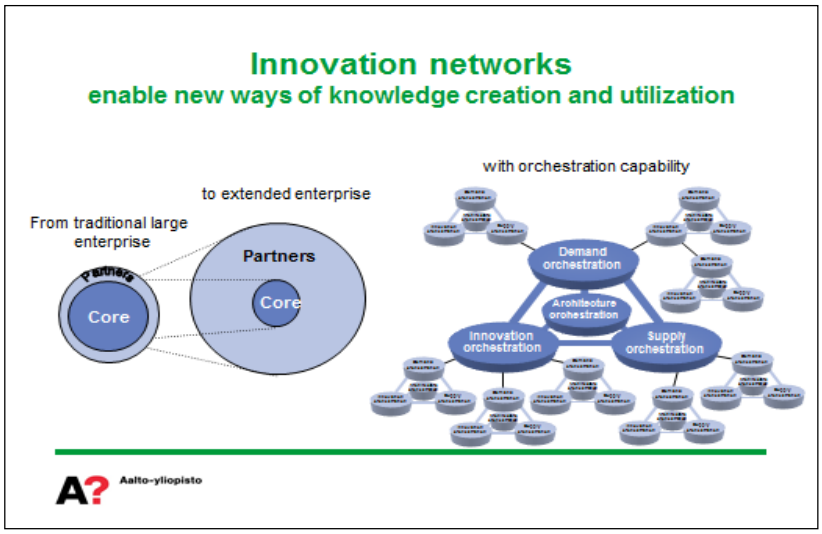

Figure 1. The expansion of innovation networks and ecosystems

These changes are arguably most apparent for many multinational corporations which play a significant role in innovation and have amended their practices to reflect most of these changes. For instance, high tech multinational corporations are actively building innovation networks and are orchestrating the emerging ecosystems to maximize the value generation by acquiring control of the new value chains through advanced management practices (Figure 1). Also, many SMEs are adapting their innovation processes to reflect the changing environment e.g. by building linkages with larger companies or becoming part of business platforms. Many of these new practices directly or indirectly emerged based on the use of new web-based tools.

By innovation practices we refer to the ways how companies' actually conduct and organize innovation processes along certain recurring patterns. These innovation practices comprise different levels. At the core are innovation processes such as idea generation, information search, product design and market introduction. A second level is to establish the conditions for innovation, for example ensuring the capabilities and resources for innovation, setting in place arrangements for management of IP, and allocating resources to innovation priorities. A third level is the organisation of the innovation process in terms of strategy development, innovation planning and decision making, organising cooperation within the firm and with external partners, and the nurturing of innovation communities. The ambition of our project is, however, not to provide fine-grained observations of practices in action, but rather to work towards a broadly based overview of innovation practices in use, analysing which practices are central for achieving sustainable growth and identifying which practices are relatively new.

The IIT project's research interest therefore concentrates on taking stock of current innovation practices across European companies, of how these innovation practices are changing and why, and in particular to understanding how changes in the way how innovation is organized across a network of companies, public research organizations, civil actors, users and others influence current innovation processes. Furthermore, our aim is to understand which practices work best for the companies, in order to derive at suggestions how the innovation performance of European companies can be enhanced. A special interest lies with innovations, which are not only incremental, but can also build the ground for developing new businesses and markets, and in this way enable new possibilities for growth, employment and profitability. Building on the derived understanding of current innovation practices and directions of change, we will in a second step assess which innovation policy instruments are appropriate for supporting and intervening in innovation. Due to the nature of our research interest, a focus will be on systemic policy instruments.

While a dedicated analysis of policy instruments will be conducted at a later step of the IIT project, the aim of this report is to provide a concise review of literature which describes characteristics, concepts and recent developments of and around key innovation practices, their use, conditions and impact on innovation. Based on this we derive at implications for further specifications of the research gaps IIT will address, and conclusions for data collection and analysis. As part of this, we derive implications for the survey of 800 companies across Europe which is at the centre of the IIT project's research design, in terms of the questionnaire to be used and the sampling of companies to be included (see also IIT deliverable 2.2). Where appropriate, also implications for a web survey and case studies which will be conducted at later steps within the project will be drawn.

The report is structured as follows. The second chapter addresses important conditions and developments in the context of companies' innovation practices. One section conceptualizes our understanding of innovation ecosystems, and presents current insights on its role for innovation and impacts for innovation processes in companies. The other discusses insights on how innovation practices differ across industry sectors.

The third chapter addresses two trends in innovation practices – open innovation and demand-based innovation, which – as mentioned above – relate to the changes in how innovation is organized across companies and other innovation actors. In the following fourth chapter we move to how companies shape their innovation practices with a stronger focus on company-internal processes. The role of intelligence and becoming aware of trends, developments and opportunities in the company's environment via different forms of foresight or otherwise is discussed. The use of ICT-based tools and in particular the more recent

web-based based tools plays a special role in supporting the open and demand-driven types of innovation, and first insights on their use are reported in the second subsection of this chapter. The last subsection addresses practices in innovation strategy and innovation management. Due to the focus of the IIT project and the fact that the general management of innovation processes is an already well-researched area, we will only highlight selected issues related to the trends in innovation practices.

The topics addressed by these chapters strongly interrelate, as is visualised in Figure 2. The upper layer represents the context of company's innovation practices: the innovation ecosystem and the sectoral patterns. The middle layer presents two key trends: open innovation and demand-driven innovation. The bottom layer focuses on how the company shapes innovation practices through innovation management processes and through mapping the environment and using ICT-based tools.

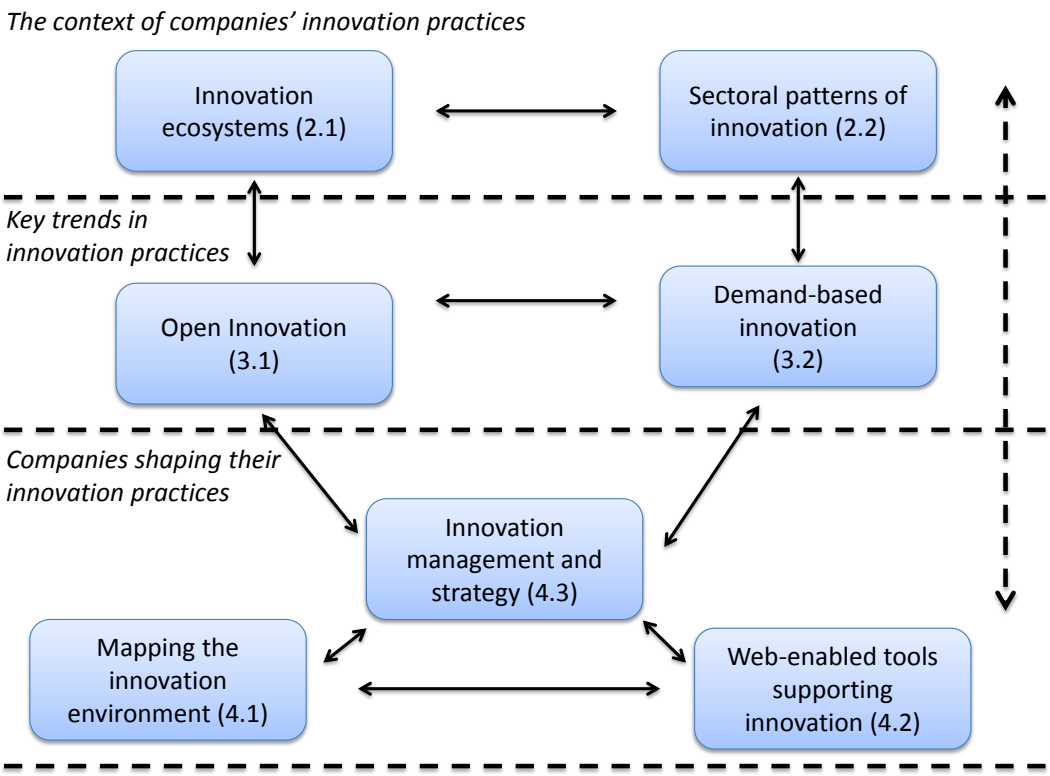

Figure 2: Structure of the document

The final chapter summarizes the implications for IIT's research approach, and provides an outlook on how they will feed into the further steps of the project.

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2 The context of innovation practices

2.1 Innovation ecosystems

Issue description

Adapting new technologies, introducing innovations, establishing and sustaining important business interrelations, and keeping and enhancing a companies' competitiveness is a challenge that often cannot be managed with internal resources and capabilities only. Companies more and more start to systematically shape their innovation environment in order to improve their innovation capabilities and processes. New technologies and digitalisation facilitate this effort and open up new opportunities for accessing new ideas, knowledge and collaborations. These reconfigurations of industrial innovation processes and actors were highlighted by Coombs and Georghiou (2002) in a policy discussion published in 2002 in Science. They describe the change of company strategies to *interact more actively* with their environment and to *(re-)position* themselves within. They observed increased spending from domestic as well as foreign companies for external R&D, e.g. in universities. Innovation processes have also become more interdisciplinary which provides additional opportunity for "curiosity-driven science" (ibid.) especially in large interdisciplinary projects. But interaction is not reduced to more or stronger co-operations, e.g. as a result of outsourcing R&D activities. Interaction means also reacting to environmental changes or improve the position of a company within the innovation value chain. As one strategy to reposition within the "innovation ecosystem" and to enhance own capabilities, Coombs and Georghiou (2002) observed increased in-house R&D and processes of insourcing specialised innovation activities.

The concept of "innovation ecosystems" (IES) has become an important heuristic to analyse companies' strategies to interact and position themselves within their innovation environment. In the following section the concept of innovation ecosystems is introduced in order to provide a common understanding and to deliver conceptual and empirical insights which disclose opportunities for the empirical research in the IIT-Project.

Key insights on relevance and impact on innovation practices and performance

Defining innovation ecosystems and their structures: By outlining companies' role and activities within their innovative environment it becomes more and more apparent what the concept of "innovation ecosystem" is about. The concept has its roots in the wider framing of 'systems of innovation' as defined by Lundvall (1992), Freeman (1987, 1995) and others to encompass the systemic relationships between invention, innovation and in particular the institutions which are present in a geographical or sectoral space which support and moderate the behaviour of innovation actors. The state in particular is highlighted in a coordinating role and policies are assessed in terms of systemic failures. In the move to the concept of an ecosystem the emphasis switches from the institutions to the flows between them to identify their interdependency, as in a biological ecosystem. In the European context the ERA Rationales group (European Commission 2008: 23) stated: "The added value of thinking of this system as an ecology is the focus it brings to the distribution and abundance of research performers and knowledge and their interactions with each other and the broader environment." The report went on to state that the system operated through four key flows at European, transnational and transregional levels:

- Money (Funding for research and investment in innovation);
- Knowledge (IP and informal knowledge transfer);
- People (e.g. Researchers);
- Services (Scientific services such as metrology).

Turning more explicitly to the business sector, (cf. Buciuni et al. 2013: 972), there is a common understanding based on Moore's (1993) definition of "business ecosystems":

"I suggest that a company be viewed not as a member of a single industry but as part of a business ecosystem that crosses a variety of industries. In a business ecosystem, companies co-evolve capabilities around a new innovation: they work cooperatively and competitively to support new products, satisfy customer needs, and eventually incorporate the next round of innovations." (ibid: 76)

Therefore, from the perspective of a firm an ecosystem is not limited to an industry sector or to a specific region as implied by concepts such as sectoral, regional innovation systems or clusters (Malerba 2002; Braczyk, Cooke and Heidenreich, 1998, Porter 1998). It is arranged around the products or technologies the companies develop. In this process not only suppliers and customers are involved, but also competitors or universities provided they contribute to value creation and the mutual development of capabilities and knowledge (cf. Bowonder and Miyake 2000). Hence, the ecosystem of a company comprises all the contacts and interlinkages to organizations involved in the process of value creation, possibly led by a focal company (Buciuni, Coro et al. 2014; Adner and Kapoor 2010). The interactions within an ecosystem are not limited to economic transactions: Moore (1993: 76) highlights the mutual development or 'co-evolvement' of capabilities which is an important point since it speaks against a simple reduction to a linear top-down process from large high-tech companies to their smaller or less innovative partners (cf. Robertson and Smith 2008). The actors within an IES may have different roles, like the focal company as system orchestrator, its partners along the value chain (suppliers and customers) as well as independent actors like universities. These different roles imply a specific division of innovative labour, specific power constellations and dependencies which develop and change. Such reconfigurations and changes of actors may also have consequences for the distribution of power and control to influence and overview processes within the ecosystems, e.g. innovations. Buciuni, Coro et al. (2014) addressed this issue referring to changes in the furniture industry. They identified three types of producers. Especially the "innovative maker" tries to realize its innovation strategy through "a high degree of control over operations". In order to realize such strategies it is not sufficient to react to changes, but rather to actively "govern its ecosystems interdependencies and integrate each partners advances into a unitary systemic innovation" (ibid: 972). Especially for the automotive industry it is a well-known fact that large car manufacturing companies and their first tier suppliers as system integrators dominate and control the value chain and the innovation processes top-down. We may distinguish between active and passive participation in an ecosystem. The active role does not only seek to direct the relations involved in the act of innovation as indicated above but also to shape the demand environment through the establishment of favourable standards or regulations. This necessitates interactions with both private and public actors.

Turning back to the company level, Teece (2007) discusses how (dynamic) capabilities are shaped through collaborations and which competences need to be developed or acquired. Besides the positive effects of collaborating within an IES Adner and Kapoor (Adner and Kapoor 2010) suggest to distinguish between different forms of external impulses since not every collaboration enhances a company's internal capabilities. For instance, the development of components provides the opportunity for learning and therefore for

improving the competitive advantage since imitations are difficult. In contrast, development of complements runs the risk of "slowing its advance down the learning curve" which facilitates competitors to follow (ibid: 326 et seq.). Therefore – and this links to Coombs' and Georghiou's findings (2002) – insourcing of R&D as a means of vertical integration becomes more important as a "strategy for managing ecosystem challenges" (Adner and Kapoor 2010: 327).

Returning to the four flows a key issue is how these move across the boundaries of the firm and what mechanisms and relationships regulate both their entrance and exit. This provides a direct link to the concept of open innovation dealt with below.

Due to this broad definition of IES distinguishing empirically the in- and outside of an ecosystem can be a challenge, especially when different ecosystems are interlinked as reported for cases in Japan where three different industries were brought together by mobile phone operators (Park and Choi 2014: 13). Dedehayir, Ortt et al. (2014) go a step further and examine in which way disruptive innovations change the ecosystem. In their explorative study they found that the changes differ with the modularity and the degree of sophistication of the introduced disruptive technology. High end innovations as well as those with a high modularity tend to open the ecosystem for new actors whereas low-end innovations may subtract actors from the system (ibid.).

Implication for data collection and analysis

The concept of an innovation ecosystem is helpful as a heuristic for capturing important elements of the innovation environment of innovating companies and in this way also informs our data collection and analysis. We understand IES as a social structure built upon mostly economic but also non-pecuniary weak and strong ties with various actors up- and downstream the value chain as well as independent partners like universities. While not explicitly mentioned in the literature, financial investors and policy makers can also be part of the IES provided they actively support innovation activities, e.g. with financial means. To which degree such an IES structure is established around a particular firm and actually supports innovation activities may vary and depends for instance on how the involved actors cultivate their interrelations: open (coupled) innovation, crowd sourcing and formalised bilateral collaborations or public funded projects are opportunities to make use of an ecosystem in innovation practices, possibly supported by ICT based tools. These concrete tools and innovation practices are described in the following chapter 4. Developing a broad empirically based understanding of the relevance of IES for innovation practices is thus an important research aim of the IIT project. More specifically, we will investigate for which innovation practices and for which particular types of firms or sectors this is particularly salient and if there are indications of change. Furthermore, we will inquire to what extent companies' try to actively shape their innovation ecosystem and how.

The concept of the innovation ecosystem provides a conceptual framework as well as a useful heuristic for *describing and analysing the systemic character of innovations*, while being able to address this issue from a company perspective. As a conceptual framework it describes structures of the industrial innovation environment and its advantages for companies as well as the position of companies within these structures (system). The IES concept offers the opportunity to focus on both: Firstly, on the company and its whole company specific innovation (eco-)system since it is neither restricted to regional or sectoral borders nor to a single technology. In comparison to SMEs the ecosystem of a large company may contain more than one technology. Working with and developing the different technologies shape the company specific ecosystem and create synergies and specific capabilities. Interdisciplinary knowledge is diffused within the company and

within the ecosystem. Each innovating company has its own innovation ecosystem which is the focus of the empirical IIT-research. But each company also belongs to ecosystems of other companies overlapping with the own company specific IES. If being part of different IES, a single company may have different roles referring to its position in the value chain, their technological competences etc. In addition to this company perspective, secondly, the IES itself as a systemic structure that emerges and develops can be described and analysed as part of the IIT case study research.

New insights on how the ecosystem features in the innovation practices (from a company perspective) will help to answer the question why (and when) IES are particularly important for innovation processes and success. Knowledge about ongoing changes will help to identify key issues for the future.

For the company survey, the following questions can be used in the interview, in order to inquire into the particular role of an IES for the companies investigated.

Analysts today regularly refer to the concept of an 'innovation ecosystem' to describe the interdependencies firms have with collaborators, suppliers, customers, public research bodies, other infrastructure, finance and regulators. These typically involve flows of knowledge, people, finance and services. These may be international, national, sectoral or specific to a market. We have some questions about your interactions with this extended network:

- How important for your innovative activities are: business collaborators (large firms/ SMEs/ start-ups), suppliers, customers, public research bodies (including universities), other infrastructure, finance, regulators, any other players?
- Which of the above have the greatest influence on the form and direction of the ecosystem?
- Has this changed in the past five years? If so what were the main drivers of that change? (competition, technological progress, regulation etc.?)
- What is your firm's position/role within this ecosystem?
- How do you maintain / strengthen your position within the ecosystem?
- How relevant is this concept for your firm's innovation activities?
    - Has the relevance/importance changed in the past five years?
- Could you describe the most important elements of the innovation ecosystem(s) in which your firm operates?
- Do you seek to influence the ecosystem as a part of your firm's strategy?
- Do you have an explicit strategy for influencing other parts of the ecosystem?
- How do you respond to the efforts of other players to alter or influence the ecosystem?
- What are the main levers available for you to do this?

For a deeper insight in the system structures the question emerges how the interlinkages are organised within the daily company innovation practices. Here the innovation ecosystem concept opens up the opportunity to use the concept as framework to link more specific conceptual approaches about innovation processes, like open innovation, innovation management or questions of sectoral specifics (section 3). The interview survey can only deliver a sketchy, and necessarily one-sided picture of the IES a company belongs to. A more thorough approach to this can be provided by case study research, which is foreseen for later steps within the IIT project.

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2.2 Sectoral patterns of innovation

Issue description

While innovation ecosystems refer to the innovation-specific environment of a company, the industry sector a company is part of, is not per se related to innovation. However, for a long time, scholars studying innovation processes have argued and examined how innovation patterns differ between industrial sectors. The industrial economic literature has highlighted the role of structural features of industrial sectors such as the degree of concentration and vertical integration. The new industrial organization theory has focused on firm behaviour instead. For a review of these literatures, see (Marsili 2001). More recently, scholars working with an evolutionary economics perspective have characterized differences between sectors via technological trajectories and regimes (Pavitt 1984, Malerba and Orsenigo 1997, Marsili 2001, Van de Poel 2003, Castellacci 2008) or sectoral (rather than national or regional) systems of innovation (Edquist 1997, Malerba 2002).

In this section we offer a concise discussion of conceptual building blocks to identify and characterize relevant sectoral characteristics, and how these relate to differences in innovation patterns, e.g. regarding the distribution and coordination of innovation labour between firms and users. In addition we highlight some limitations, in particular the reminder that within sectors there will be diversity among firms. The chapter concludes with identifying implications for the IIT project, especially with regard to the sampling of firms to be investigated.

Key insights on relevance and impact on innovation practices and performance

A sector can be characterized as a set of activities around related products for an existing or future demand, sharing a certain knowledge base. A sectoral system is composed of a set of agents engaged in market and non-market interactions for the creation, production and sale of the related sectoral products, see (Malerba 2002, Intrasoft, Joanneum Research, TNO, Tecnalia 2014). The concept of "organizational field" within institutional theories offers a similar perspective on what might constitute a sector, that is "those organizations that, in the aggregate, constitute a recognized area of institutional life: key suppliers, resource and product consumers, regulatory agencies, and other organizations that produce similar services or products. The virtue of this unit of analysis is that it directs our attention not simply to competing firms (. . .), or to networks of organizations that actually interact, (. . .), but to the totality of relevant actors".[1] The understanding of the "totality of relevant actors" is not restricted to a single sector like machine building, metal working or pharmacy but the relevant actors within a specific field. This goes along very well with the in the last section introduced idea of the innovation ecosystem whose actors are not limited to an single industry but distributed over several sectors, including finance and policy institutions.

A good number of commonalities and interdependencies make sectors a relevant unit of analysis and policymaking, even with the observed wide variety at the firm level within sectors. The relevance of a sectoral perspective on innovation in a European context is clearly illustrated by a study conducted by the Europe INNOVA consortium (Montalvo and Van der Giessen 2011). The study shows that there are great differences among sectors in terms of for instance R&D expenditures and propensity to innovate. It also highlights that sectors differ in terms of their distribution of innovation labour. That is, how much innovation is carried out by either large or small firms, but also between suppliers and system integrators of new technologies. The

[1] Definition of organizational field by DiMaggio and Powell, quoted in Geels and Schot (2007: 402).

report also found that the most innovative sectors tend to be associated with better performance in terms of employment and business creation (p. 22).

Still we have to take into consideration that sectors are not homogeneous (Intrasoft, Joanneum Research, TNO, Tecnalia 2014). One reason for variety is that firms can take different positions in a sector, and one firm may play different roles across a variety of sectors. Firms can operate at different positions in (industry level) value chains, which we assume to have different dynamics and implications for innovation practices within a firm. To clarify, we assume that a division of labour, an 'industry architecture' (Jacobides, Knudsen et al. 2006), regarding production/creation of value as well as innovation exists. Firms may take different roles in such divisions of innovation labour and one of the questions of this project is to examine how these roles are changing and whether policies need to better reflect such changes in order to foster innovation for sustainable growth. A specific example of such changes is the emergence of system integration as a key capability of modern firms (Hobday, Davies et al. 2005). An example at the other end of the chain is the growing importance of firms supplying general purpose technologies (Arora, Fosfuri et al. 2001, Gambardella and McGahan 2010). Such a division of labour will differ between supply chains, for instance because some supply chains may be more fragmented than others.

While intra-industry diversity exists (Leiponen and Drejer 2007, Peneder 2010), sectoral categories do offer useful conceptual building blocks for selecting industries for interviews and analytical questions for interviews. A sectoral system is continually undergoing change and evolution as a result of the co-evolution of its various elements. An aggregation of sectors or a differentiated discussion of specific sectors still makes sense as long we are able to vouch for comparability concerning selected policy questions and the availability of sector-specific information for the policy maker (Intrasoft, Joanneum Research, TNO, Tecnalia 2014). In many cases intra-sectoral differences in the research and innovation relevant behaviour of companies are as large or even larger than the difference between sectors.

Sectoral systems affect firm level R&D, via the industry structure and competition (entry barriers), via its technological environment (Teece, 2010) but also via the respective appropriability regime (environmental factors, apart from firm and market structure, that enable an R&D and innovation performers to capture the rents of their activity; see: Encaoua et al. 2006; Gallini, 2002; Teece, 1986). A pathbreaking contribution comes from Teece's (1987) study which finds explanations why the firm that introduced an innovation did not benefit while customers, imitators, and other industry participants could gain from it (Teece, 1987). He showed that under a "weak appropriability regime" most profits go to the owners of specialized complementary assets required for commercializing an innovation.

By now, a number of well-known conceptualizations and taxonomies of industrial sectors have been developed which offer an instrument for selecting a sample of industries for our research project. These conceptualizations draw upon evolutionary economics concepts such as technological trajectories and regimes as a basis for the categorization[2].

Of the various taxonomies, Pavitt's and especially Castellacci's work is particularly relevant as it not only distinguishes between technology-related dimensions, but also takes into account different actor constellations. That is, Castellacci takes into account the position of firms along value chains. That said, even

[2] Tables 5 to 8 (appendix) offer a state of the art overview of these taxonomies.

within these categories, such as electronics, consist of value chains where actors can take different roles (OEMS, re-sellers, material suppliers, assembly and integration).

This is important as it links up with our observation of the move from big integrated firms to smaller firms with a large set of partner firms around it. So part of the dynamics is related to a sector's position in larger value chains and specific user-supplier patterns. Unlike other classifications, this taxonomy also includes service industries in addition to manufacturing industries. This is especially relevant for the project proposal considering the importance of ICT and internet-based technologies, which have spawned a great number of services (Castellacci 2008: 981).

Van de Poel (2003) has elaborated these two dimensions of technology dynamics and actor constellations by conceptualizing regimes as rules guiding the further development of new technologies and innovation patterns which describe the roles and division of labour among actors regarding the development of new technologies. The innovation patterns in turn are inspired by the well-known taxonomy of Pavitt. These regimes and division of labour are part of the governance of innovation practices of firms. Table 1 offers an overview and characterization of these patterns.

Table 1: Innovation patterns

Characteristics of the four innovation patterns

Innovation pattern	Type of innovating firm	Type of user	Source of innovation	Typical sectors
Supplier-dependent innovation pattern	Supplier-dominated; scale-intensive	Anonymous consumers	Suppliers (component parts)	Housing Traditional manufacture
User-driven innovation pattern	Specialized suppliers	Professional users	Users (functional requirements)	Machinery Instruments
Mission-oriented innovation pattern	Pavitt's fifth category	Government as client	Governmental actors (missions)	Infrastructure
R&D-dependent innovation pattern	Science-based	Mixed	R&D (technological promises and presumptive anomalies)	Electronics Chemicals

Source: Van de Poel (2003: 54)

This, non-exhausting, overview of sectoral characteristics and taxonomies suggests that there are particular patterns on either the user or producer side of innovations, as well as to how they interact and that these differ among sectors. This implies that innovation practices will vary and that innovation policies may be more or less effective in supporting. The implications for the IIT project will be discussed in more detail below.

Implications for data collection and data analysis

The discussion above and the conceptual building blocks drawn upon in this project have important implications for the set-up of the IIT project. First, it highlights the importance of asking questions in the interviews regarding heuristics followed in innovation processes and how firms interact with other actors in their sector(s). This is relevant as the literature and conceptual framework predicts considerable variety among sectors. For an accurate and meaningful description and analysis of innovation practices these items need to be taken into account.

Second, it clearly points to making a careful sample of firms in the interviews in order to be able to capture the expected diversity in innovation practices. This also enables to develop tailored policy recommendations rather than (only) generic advice. The following domains are foreseen to be analysed in all countries: ICT and services, manufacturing, biopharma, agro-food and clean technologies. Considering the taxonomy, especially ICT and services, manufacturing and clean technologies are broad categories which are in need to be of further specification for linking with the taxonomy, e.g. via the subcategories of the used sector classifications

(see IIT deliverable 2.2), as they can cover multiple elements in the taxonomy. This has to be reflected in particular in the analysis of the data. By relating a selection of subcategories of the prioritized sectors of the IIT project with Castellaci's taxonomy it becomes clear that these sectors in any case cover the expected variety of innovation patterns (see table 9, appendix).

As mentioned above intra sectoral differences in the research and innovation relevant behaviour of companies can be as large as or even larger than the difference between sectors: due to specialization (in subsectors or market niches) due to different systemic positions of firms in the value chain. Thus, for data collection and analysis it is important to characterize the firm and its activity in a broader environment and furthermore in the value and innovation chain.

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3 Trends in Innovation Practices

3.1 Open Innovation

Issue description

The concept of open innovation (OI) has received high attention in recent years, both from an academic and practitioner's perspective. It is based on the idea that firms can and should use methods, strategies and business models to increase the exchange of knowledge between different parts of organisations, networks, value chains and markets to improve the success rate of innovations, and in this sense links up with the innovation ecosystem concept elaborated above. Web-enabled tools like crowd sourcing (see 4.2) have importantly contributed to the success of this concept as drivers of open innovation practices.

The popularity of the OI concept comes from the benefits to firms stressed in many publications from being exposed to ideas external to an organisation, thereby reducing development costs and risks (Chesbrough, 2003; Lichtenthaler, 2011). Sources of these ideas and collaborations include users, suppliers, venture capitalists and competitors (e.g. Enkel *et al*., 2005; Gassmann and Reepmeyer, 2005; von Hippel, 1986), associating the concept with other practices such as demand-led innovation and supply and value chain management.

The IIT project aims at adding to our understanding of the challenges related to practicing open innovation, the variety of its practical manifestations across different companies and its relative importance to different types of firms, and at exploring the technologies, processes and competences required to support it at company and network level. In the following the concept of OI is described in more detail, highlighting also insights on different forms of OI being practiced, in order to concretize the research approach taken by the IIT project.

Key insights on relevance and impact on innovation practices and performance

Open Innovation: Definition, Challenges and Competencies

The original definition of OI refers to the exchange of ideas and the selection of paths to market involved in the advancement of technology (Vanhaverbeke and Chesbrough, 2014: 52) and is concerned with "purposive inflows and outflows" of knowledge - as opposed to passive or accidental ones - to "accelerate innovation in [a firm's] own market, and expand the use of internal knowledge in external markets" (Chesbrough, Vanhaverbeke and West, 2006: 1) for profitability, growth and employment. In a recently published special issue in Research Policy about "open innovation" West and colleagues (2014) review and redefine the definition of open innovation referring to Chesbrough and Bogers (2014):

"We define open innovation as a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organization's business model."

It becomes apparent that open innovation is not a randomly emerged innovation procedure but a rather purposeful strategy to organize innovation between different actors. In so doing stakeholders in these open innovation environments are confronted with challenges related to a lack of competence, diverse expectations and cultures, conflicting public and private objectives, various measuring and benchmarking methods, as well as obstacles in interoperability and integration of solutions. Besides, open forms of

innovation do not always have a positive effect on firm performance. Faems, De Visser, Andries and Van Looy (2010) found that on the short term, the costs of open innovation through alliances exceed value generating effects and Belderbos, Faems, Leten and Van Looy (2010) showed that collaborative technological activities often have a negative impact on a firm's market value, as the costs and complexities of value appropriation in collaborative innovation may offset its positive potential.

Dealing with these challenges and trade-offs, as well as initiating knowledge transfer and learning requires specific competences and capabilities that the innovating companies need to establish. Identifying, convincing, bringing together and managing relevant partners in order to initiate knowledge exchange and creating mutual benefits, learning and development is a crucial capability (cf. Bender/Laestadius 2005). The specific knowledge related-competences have been addressed by Lichtenthaler and Lichtenthaler (2009), who distinguish between different knowledge processes that can be performed internally or externally. Dahlander and Gann (2010) also conclude that internal R&D is a necessary requirement for outside-in OI, but it is less clear whether outside ideas can be a substitute for internal R&D.

Diffusion of Open Innovation Practices

A survey of open innovation adoption by large firms in Europe and the US found that 78% of firms practise OI and the intensity of doing so has increased over the years (Chesbrough and Brunswicker, 2013 cited in Chesbrough and Bogers, 2014).

The incidence of OI appears to be widespread across different types of firm and industry, but differences in firm size may be a factor affecting engagement with OI. For example a survey of innovative SMEs in the Netherlands explored the incidence of OI and the motives and perceived challenges for SMEs (van de Vrande *et al.*, 2009). OI was measured using eight innovation practices reflecting technology exploration and exploitation. SMEs were found to engage in many open innovation practices and have increasingly adopted such practices during the past seven years: No major differences were identified between manufacturing and services industries, but medium-sized firms were more heavily involved in open innovation than their smaller counterparts. SMEs pursue open innovation primarily for market-related motives such as meeting customer demands, or keeping up with competitors. The most important challenges faced relate to organisational and cultural issues as a consequence of increased external contact.

Approaching and Distinguishing Practices of Open Innovation

There is no single or typical mode of open innovation, but rather multiple forms that are grouped into frameworks containing different sets of practices and degrees of openness. Chesbrough and Crowther (2006) distinguish between two major activities:

1. Inbound: companies use results of external R&D activities
2. Outbound: bringing new ideas to the market mediated over other companies

A recent survey about the use of *inbound and outbound* open innovation practices found the former were not only more dominant (particularly customer co-creation, informal networking and using university grants) but also more investigated by researchers (Chesbrough and Brunswicker 2013; West et al. 2014). Popular outbound OI practices include joint ventures and standardisation. Customers, universities and suppliers were deemed to be the most important actors involved in OI. Gassmann and Enkel (2004) introduced "coupled" activities as a third major mode (Gassmann and Enkel: 2004) which they describe as a mixture of inbound

and outbound activities of innovation co-operations. Indeed, this topic was taken up in the following years for further elaborations.

In addition to these three rather general categories more precise distinctions were made through adding further attributes. These classifications may be helpful in the analysis of open innovation practices. The model of Dahlander and Gann (2010) offers a useful starting point for empirical research that aims to better understand the activities relating to OI and the relative effectiveness of OI for different organisations and in different contexts. They use the dimensions of inbound versus outbound OI and pecuniary versus non-pecuniary interactions to define a matrix of four different activity groups associated with OI: acquiring, sourcing, selling, and revealing. This links to effectiveness highlights a recent argument put forward by Vanhaverbeke and Chesbrough (2014) that OI should be understood in relation to a firm's business model as this will influence the type of OI activity that the firm pursues. Under the current trend towards the "division of innovation labour" parties that develop novel ideas can sell them to other parties who take them to market, thus speeding up and improving the productivity of the innovation process. In an open business model this division of labour is used to create value by leveraging more external ideas and capturing greater value by using assets resources etc. in other companies' businesses (Chesbrough, 2006). This definition can be used to create a classification of innovation strategies and open business models (Table 2):

Tabel 2: Classification of open innovation strategies and open business models

	Closed/Standalone Business Model	**Open/Linked Business Model**
Outside-In Open Innovation	Use others knowledge to develop new offering	Use other's knowledge to develop new Business Model
Inside-out Open Innovation	Unused knowledge generated by others	Internal knowledge accessible to others to develop a new Business Model
Closed innovation	Closed Innovation Model	Search for assets owned by others to develop a new Business Model

Source: Vanhaverbeke and Chesbrough (2014: 54)

Most of the examples of OI in the literature sit within the left hand column, as they are focussed on developing new products and services based on the competitive drivers specific to the firm itself, and the linked or networked business models in the right hand column, which are concerned with strategic drivers for innovation such as licensing and joint-development, have received less attention.

Open innovation practices can also be categorised by distinguishing between process and outcome. This model links discussions in innovation management with those in innovation technology and innovation systems management, where much research has been focused on open source software, see von Hippel (2010). Both the process and the outcome of innovation can be closed or open (Table 3):

Table 3: Closed and Open Processes and Outcomes of Innovation

	Innovation Outcome	
Innovation Process	**Closed**	**Open**
Closed	1. Closed innovation	3. Public Innovation
Open	2. Private Open Innovation	4. Open Source Innovation

Source: Huizingh (2011: 3)

Many case studies belong to the second category, such as Procter & Gamble (Huston and Sakkab, 2006 cited in Vanhaverbeke and Chesbrough, 2014). Interest in the second dimension – the outcome of the innovation

process – which is either proprietary (closed) or available to others (open) is growing with an awareness that advantageous appropriability regimes do not always equal strong intellectual property protection (Pisano, 2006 cited in Vanhaverbeke and Chesbrough, 2014).

Prospective OI Research

In the above mentioned issue West and colleagues (2014) and also Vanhaverbeke (2014) reviewed the previous OI research and identified several future fields of research covering methodological and theoretical improvements as well as a shift of the empirical focus. They encourage to develop a deeper understanding about the relationships within OI practices directly relevant for IIT:

1. Understanding "appropriability"
2. Innovating with different partners: OI as "coupled" innovation processes
3. OI beyond monetary interests: Collaborations based on non-pecuniary interests, e.g. with universities

Implications for data collection and data analysis

In recent years open innovation has been more and more adapted by different types of companies in various sectors. Beyond existing academic definitions and concepts OI practices have been established and need to be identified and analysed systematically. Especially since diverse definitions exist in parallel, a common understanding and a distinct definition of open innovation is lacking. The IIT research shall help to identify current modes of OI innovation practise and contribute to sharpen the definition of this topic. The above mentioned strategies and outcomes of OI (Huizingh 2011; Vanhaverbeke and Chesbrough 2014) can be used as a starting point to classify and group the results of the 800 company interviews but the core of IIT research is to identify the conditions and types of OI relationships and practices. Understanding OI as a purposive process linked to company strategies leads to the following research questions:

Under which conditions do companies decide on OI or on closed innovation practices? Closed innovations are always a reasonable way of innovating when costs and risks of open innovation exceed their benefit. So companies may opt for in-house innovation and also to vertically integrate new businesses. Keeping this in mind helps to contrast and identify specific conditions for open innovation and their practices. Focusing on identifying open innovation in practice bears the opportunity to learn more about newer and less researched forms of open innovation like coupled OI and non-pecuniary relationships. This may also illuminate parts of the innovation ecosystem which are a bit outside the core IES. Collaborations driven by non-pecuniary interests are of special interests here, since they could be an indicator for outstanding co-operations with, e.g. a high degree of uncertainty and novelty or strong future perspectives. In the survey, the following questions will inquire into the role of forms of open innovation in the company's innovation practices.

- Is open innovation a part of your innovation strategy?
    - How is it used? What are the experiences?
    - to what extent do you rely on outside organizations to provide/augment core technological knowledge?
    - apart from your core technologies what innovation-related knowledge would you seek to source from outside the company?
    - Do you have internal start-up or entrepreneurship activities within your company? If so how are these integrated in the innovation strategy?
    - What is the role of IPR and how do you manage your IPR portfolio?
    - Do you provide R&D and services for other firms as part of your business strategy?

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3.2 Demand-based innovation

Issue description

Changes in demand for goods and services (defined as the willingness to pay for a particular specification or performance requirement – and distinguished from 'needs' which are the difference between the performance of existing products and services and user requirements (Georghiou *et al*., 1986)) may trigger firms to add innovation activity (demand pull), subsequently accelerating the adoption and diffusion of innovation by unlocking markets from perceived/actual lock-in; overcoming inertia in value chains, and steering social and cultural expectations via standards. Schmookler's famous analysis of patent statistics (1966) concluded the volume and direction of invention responds to the pull of demand (see also Carter and Williams, 1957; Office of the Director of Defence Research and Engineering, 1969; Myers and Marquis, 1969; Rosenberg, 1969; Langrish *et al.,* 1972; Illinois Institute of Technology Research Institute, 1968; Battelle Memorial Institute, 1973; and University of Sussex SAPPHO studies of the early 1970s), and evidence continues to support an enduring association between levels of innovation and both domestic and foreign demand (Geroski and Walters, 1995; Jaffe *et al*., 2002; Jaffe and Palmer, 1997; Peters *et al*., 2012). The importance of demand as a driver of innovation in firms has also been empirically demonstrated through company studies and surveys (see Allman *et al*. 2011; Horbach *et al*., 2012; Howells and Tether, 2004).

The IIT project aims to address demand-based innovation using a sectoral or systemic perspective, and following the general aim of the project to understand changes in the innovation practices of firms.

Three issues relating to the role of demand in company innovation could therefore be considered:

a. What practices are involved in capturing and utilising information relating to demand for innovation, and during which parts of the innovation process does the firm engage in them?
b. What is the relative importance of demand as an innovation catalyst for different types of companies?
c. How does demand-driven innovation relate to other sources of innovation – e.g. the role of demand in innovation systems?

Key insights on relevance and impact on innovation practices and performance

Demand-led Innovation practices and their innovation process

The literature on demand articulation emphasises the importance of learning and interactions between users and produces, i.e. firms have to learn about users' demands and users have to learn about future options offered by suppliers (Teubal 1979; Lundvall 1988; Rip 1995). However, demand is often fragmented amongst many uncoordinated customers, implying firms employ strategies or make decisions about how they manage their interactions and exchanges with the demand environment.

A firm exists in a state of limited information, but it exists within a network of contacts that allow the firm to recognise user-demand characteristics and convey this information to actors/units engaged in innovation (Georghiou *et al.*, 1986). Innovation based on information outside this network may be restricted by learning and adaptation requirements inhibiting diversification (ibid: 45). This may explain why innovations that are reactions to changes in user needs are not generally associated with radical innovation or changes in technological trajectories (Kleinknecht and Verspagen, 1990; Mowery and Rosenberg, 1979), as current or emerging demand tends to be incremental (Nemet, 2009). Therefore one question for the IIT project to address is what the role of demand side innovation is in generating and guiding different types of innovation,

and *whether there are currently any best practices in demand based radical innovation.* More specifically, some studies point to the important role played by intermediaries and stakeholders in articulating demand for innovation (Klerkx and Leeuwis 2008; Boon *et al*. 2011; Roelofsen *et al*. 2011), particularly in instances of radical innovation or when applications for innovations are difficult to assess in advance.

A further factor to take into account are differences in user-producer relationships along the value chain and how this influences innovation practices. Users can play a variety of roles in the innovation process; as inventors, co-developers, evaluators and adaptors (Herstatt and Von Hippel, 1992; Morrison *et al*., 2000; Utterback, 1971; Von Hippel, 1986) in manufacturing and service industries (Sanden, 2007). A recent framework of user-producer interaction (NESTA, 2010) captures multiple interaction modalities but concedes there is a lack of data to understand the actual levels of user-producer innovation interaction taking place in different sectors. Therefore, an issue for the IIT project is whether or how we can capture both the modes and levels of user-producer interaction the firms interviewed engage in. The second aspect of this question is during which part of the innovation process does the firm engage in practices associated with demand-led innovation and by implication what is the most beneficial stage? While already early research in the field has found that the influence of demand may be particularly strong in the early phases of an innovation strategy (Langrish *et al.* 1972), during these early phases there may be uncertainty about the future performance and applications of innovation, which makes it difficult for users to articulate demand (Edler, 2013). Interactions with users in early development stages are in practice often limited (Boon *et al*., 2008) and demand projections can contain poorly articulated assumptions about potential markets (Boon *et al.,* 2011). Misunderstanding of demand as a result of articulation activities can result in innovation failures (Edler 2013).

Relative Importance/influence of demand for different companies

A firm's position in the value chain, the type of innovation, and the market an innovation is aimed at affect the relative importance of demand as an innovation incentive according to von Hippel's theory of variation in sources of innovation. This theory explains innovation as originating from any one of at least three distinct sources: suppliers, producers, and users (or their combination) (van Hippel 1988: 3-5). The source selected by firms varies according to expected shares of 'economic rents' based on the category of the (potential) innovators and types of innovations being considered. This increases the complexity of each firm's 'interaction' with demand as a possible source of innovation, and it is possible that large firms positioned within multiple value chains approach demand differently across their range of products and services, and that firms in different positions along a value chain may value sources of demand differently.

Changes in demand for goods and services may also be a response to innovations offered by the market place (supply push), e.g. customer preferences and behaviour change as a result of an innovation offer from firm(s). The potential for supply to drive changes in demand differs between markets and technologies as entry points for supplier driven innovations differ (Klepper and Malerba, 2010). Supply-push innovation failures can occur if adopting agents (e.g. end users) are inert or lack adaptive skills (Bleda and del Río, 2013). Markets and technologies containing public sector bodies may be more susceptible to demand-led innovation as public bodes can coordinate demand in response to innovation by orienting a wide range of end users towards new products through large scale purchases or signalling (Saviotti and Pyka, 2013); specifying standards that lead to increased demand for compliant products (Uyarra, 2012), or ending one product life cycle and replacing it with another (Rolfstam, 2013).

Influence of Demand in a Systemic Setting

The demand and interactive learning approaches to innovation sit within the broader shift to a system of innovation approach that focusses on how inter-related components contribute to innovation functions. From this perspective, the distinction between demand pull and technology push in systemic or open innovation processes can become blurred (Lundvall, 1988; Moors *et al*., 2008; Von Hippel, 1986), as users and producers co-produce innovations (co-production), and users may produce innovations themselves, for their own purposes but with a potential to spread across markets (user-led innovation). Therefore it seems useful to consider demand-based innovation not as an isolated practice, but rather as one particular form to engage the ecosystem in innovation practices.

Implications for data collection and analysis

The role of demand-side actors in innovation practices and the forms of interactions with them will be synthesised from the responses to multiple areas of the interview questionnaire that ask questions about innovation ecosystems, innovation strategy, open innovation, practices relating to mapping the environment, and broader contextual issues relating to innovation funding and policy. In particular, the following questions will be important here:

- How would you describe your innovation strategy (scope and concept)?

    - - organised around technologies, functionality, product areas/markets, affiliations/locations, customer needs

Analysts today regularly refer to the concept of an 'innovation ecosystem' …

    - How important for your innovative activities are: … customers, any other players …?

- Is open innovation a part of your innovation strategy

- Apart from your core technologies what innovation-related knowledge would you seek to source from outside the company?

- Please outline the main stages of an innovation project within your firm from conception to market?

- Do you seek to expand the market prospects for innovations after initial introduction to the market?

    - What are the roles of … social media, crowdsourcing …

- Do you seek to 'map' the innovation environment for your firm? If so, which aspects?

Comparing the results from different companies can be used to identify different demand-led innovation practices. The combined company interviews and web survey methodology of the IIT project provides an opportunity to compare both the practices used and the frequency of their use (using the survey) for companies in different countries/sectors/innovation ecosystems. The survey also provides an opportunity to understand how different companies in different countries/sectors/innovation ecosystems rate the importance of different sources of innovation (suppliers, producers, and users (or their combination).

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4 Companies shaping their innovation practices

4.1 Mapping of the innovation environment

Issue description

There are various ways how companies can map and develop an understanding of relevant developments of and within their environment, and how they can make use of this for strategy-building and innovation processes. Firstly, there is quite a number of methods and tools supporting corporate foresight, that is, dedicated foresight activities conducted at the level of the firm, partly organized by specialized departments. Secondly, recent literature has suggested to pay attention to networked foresight – foresight which is conducted at the level of innovation networks and ecosystems. We may add policy-induced foresight as a possibly relevant form, which may involve corporate actors, and therefore could inform company strategies and innovation processes as well. Almost all national or regional foresight activities involve the business sector with multiple motives for participation. One early analysis by Martin and Johnston (1999) famously described the role of national foresight as being to wire up the national innovation system through allowing anticipation of the effects of current decisions and the opportunity to shape the future around science and technology. Georghiou (1996) connected foresight to systemic innovation, postulating that:

"as firms become increasingly dependent on complementary or external sources of technology, formulation of strategy, previously an internal activity, must at least in part now be carried out in the public arena. By collaborating in their thoughts about the future, organizations may be better placed to anticipate the actions of their customers, suppliers and others, such as regulators, who are likely to influence the environment in which they will operate. This argument is particularly strong for innovation in complex public/private systems such as vehicle route information technologies, where coordinated action over a period of years is needed to put the system in place. " (p. 361)

In addition to these dedicated and rather formalized procedures, companies draw on various other sources to develop an understanding of their future environment. These may be generic reports and commissioned studies of consultancies or other external providers of 'future knowledge'. Decisive impact for developing an understanding of relevant developments, is most likely not only created by dedicated foresight procedures and reports, which are usually not accessible to all, particularly smaller companies, but information is gathered, interpreted, and made sense of via more informal processes of following various media, scanning of literature, discussions in professional communities, at conferences and fairs etc. In the following we will sketch insights from the literature on the actual use, relevance and impacts of these different types of mapping for innovation at the company and network level.

Key insights on relevance and impact on innovation practices

Corporate foresight

In recent years, we see an increasing number of studies investigating the actual use of corporate foresight methods (see for example Cuhls and Johnston, 2008). Whether this corresponds also to an increase in the use of corporate foresight, or mainly testifies an increase in academic interest is not fully clear, but there are at least indications that corporate foresight is becoming more important, as reported for instance by a study of 40 companies. The majority of firms investigated saw an increased importance and appreciation of foresight in their own company and companies in general (Daheim and Uerz 2008). The same study also gives

hints as to which methods seem to be most popular: the methods mentioned most often as being used on a regular basis were trend analysis and media and publication analysis, followed by the use of scenarios, and as a third group roadmapping and participatory and creative methods (Daheim and Uerz 2008). For the IIT project, it is particularly important to consider how companies deploy foresight and create value in the context of innovation processes and as a means to enhance innovation capacity. This issue has been discussed in more detail recently (von der Gracht, Vennemann et al. 2010, Rohrbeck and Gemünden 2011, Heger and Rohrbeck 2012, Rohrbeck 2012, Rohrbeck and Schwarz 2013, Ruff 2014). There is broad agreement among these authors that corporate foresight is particularly important for the development of new business fields, and some examples are presented in more detail (Rohrbeck 2012, Ruff 2014). Drawing on a cross-case analysis, Rohrbeck and Gemuenden (2011) suggest that corporate foresight can serve three different roles for enhancing innovation capacity: a strategist role by e.g. creating a vision, providing strategic guidance, assessing innovation portfolios and new business models of competitors, an initiator role by identifying new customer needs, technologies and product concepts of competitors, and an opponent role by challenging basic assumptions, current R&D projects, and scanning for disruptions that could endanger current and future innovations. Their study covers firms from different industries (ICT, automotive, electronics, energy, finance and fashion), with different positions in the value chain, and with the primary business driver coming either from the market or technology. Thus, their study suggests that corporate foresight can be relevant for a great variety of firms; however, they do not report on possible differences of how it is used. Differences in the overall approach to foresight are reported by Vecchiato who compares firms operating in different sectors and thus environments exhibiting different types of uncertainty (Vecchiato 2012). Whereas firms in highly complex environments of global mature industries (referring to BASF and Shell) chose an explorative and adaptive approach, firms in highly dynamic industries as Nokia and Philips chose a more normative approach and rather tried to control to some extent the drivers of change. Differences in the aspects of the environment which are covered depending on what is most relevant in an industry (e.g. focusing on regulation or not) are reported in (Ormala, Tukiainen et al. 2014). From these and other studies emerged quite clearly that corporate foresight seems to be mainly conducted by large, multinational firms, whereas smaller companies had difficulties in commenting on value creation from foresight activities (Rohrbeck and Schwarz 2013).

There has also been reflection on a number of conditions to be considered for foresight processes to actually achieve impact. One issue is the involvement of important stakeholders, such as internal stakeholders as middle management that may be opposed to radical change, but also external stakeholders (Rohrbeck and Schwarz 2013). Ruff stresses the importance of considering “non-technical spheres” as market and society for development of new business fields (Ruff 2014).

Finally, a recent study has reported in some detail on the use of partly web 2.0 based IT tools in corporate foresight at Deutsche Telekom (Rohrbeck, Thom et al. in press) (for a broader overview on IT tools supporting innovation see the following section). Interestingly, these tools are just as, if not more important for organizing and sourcing foresight within the large company (230.000 employees) than for integrating the contributions of external actors, such as trend scouts. The tools are used to support foresight in diverse ways, for mapping as well as for the interpretation of developments, and also for supporting decisions on organizational responses. In particular, one tool supports early stage gate evaluations; it is reported to allow for a quicker process and for earlier challenging and shaping of projects, thus leading to less, and at the same time more mature projects entering the formal gate process (ibid., p.7).

Networked foresight

The literature on corporate foresight focuses on foresight conducted mainly within and for a particular firm. This is partly also mirrored in the type of conceptual frameworks chosen as the resource-based view (Rohrbeck and Gemünden 2011) that is mainly concerned with the competitive advantages of individual firms. Some authors have recently suggested to consider a type of foresight which is conducted at and supports innovation at the level of innovation networks, respectively innovation ecosystems. They relate this form of foresight explicitly to forms of open innovation, showing that information during the foresight process flows both outside-in and inside-out (van der Duin, Heger et al. 2014). Here, foresight is conducted among members of an innovation network, and value is created a) for the firms and other types of innovation actors in the network, and b) for the network as a whole (Heger and Boman 2014, van der Duin, Heger et al. 2014). With regard to the former, it is important to note that this allows also members of the network to profit from foresight which may have difficulty of affording their own foresight activities, such as SMEs or academic institutions, particularly if it comes to more sophisticated methods (Heger and Boman 2014). In line with this, Heger and Boman also found that SMEs and research institutions valued the benefits of networked foresight higher than MNCs. Furthermore, networked foresight does not only allow to profit multiple partners of the network, but at the same time to draw on the diverse expertise of the partners (cf. the discussion of inbound and outbound open innovation above). In addition to creating value for the members of the network, value is created for the network itself. In the same study, it was found that networked foresight was also valued for supporting the active shaping of the ecosystem and its environment, rather than just responding to it, by helping to shape an innovation agenda, create external visibility for the network, develop a shared vision, and bring together experts and support partnering (Heger and Boman 2014). This finding resonates with studies (in the energy domain) that concluded that roadmapping is nowadays used not only as a tool for supporting company strategies, but as a means to coordinate system- and sector-level innovation, and for mobilizing policy support (McDowall 2012, Jeffrey, Sedgwick et al. 2013, Budde and Konrad submitted). On the other hand, Roveda and Vecchiato have shown how policy-induced foresight supported innovation in regional industrial clusters (Roveda and Vecchiato 2008). Van der Duin et al. (2014) compared how different networks make use of foresight referring to the three roles identified by Rohrbeck and Gemuenden (2011). They found that one network actually made use of all three types, while the others used different combinations of some of the roles. Andersen and Andersen (2014) describe how the practice of foresight is integrating a systemic understanding of innovation to deal with issues such as the demand side.

Consultancies

For mapping the future environment and drawing strategic implications, companies and networks can rely on internal competences, partly even internal foresight departments, working groups etc. In addition, they may draw on external competence, such as services offered by consultancies. With a focus on innovating with IT, Swanson has shown that consultants may fulfill various roles in supporting innovation with IT via strategy consulting, technology assessment etc. for individual firms (Swanson 2010). In addition, he stressed their role beyond innovation in single companies, as they also function as intermediaries for the broader community, if not whole industries, by moving across companies, contributing to interpreting innovations and market developments, legitimating innovations, up to supporting hype around particular innovations (see also below and (Pollock and Williams 2010)). Swanson and Firth conducted a study among a sample of 88 Californian enterprises investigating the actual use of consultancy services, and found that three quarter of the respondents used IT services of consultants; most popular were the use of reports and attending

events organized by consultancies, with almost half making use of specific consultancy services (Firth and Swanson 2005). Firms considered these services and products most important for scanning and comprehending trends and innovations, less so for making strategic implications, which often requires specific knowledge of the firm and its context. In line with this, respondents considered consultancies' services particularly useful due to their knowledge of and moving about among various other actors in an industry, thus stressing implicitly that they may also be important for supporting innovation at the level of ecosystems and industries. Firth and Swanson differentiate between three types of users: proactive users making regular and planned use of consultancy services, situational users who do so only occasional and ad hoc, and reactive users taking an in-between position. The more regular and organized consultancies were used, the more useful their services were considered. Non-users partly preferred to rely on general information freely available and on their own network of relevant firms which may even be available to provide information more tailored to their circumstances. We may interpret this cautiously as indicating that mapping exercises conducted at the level of an innovation network may possibly strike a useful balance between capturing collective developments and considering more specific conditions of (a set of) firms. Overall, this study indicates the relevance of consultancy services for mapping the environment, though the study is limited to IT-based innovation, a particular region and time.

'Informal' mapping

Besides explicit, and rather formalized foresight methods as scenarios, trend analysis and reports, roadmapping etc. there are more informal ways how companies develop an understanding of their future environment and derive at strategy implications. Some authors investigating the use of foresight in companies also include such informal information sources as media, conferences, trade fairs, personal networks etc. as one element of company foresight; moreover, this type of informal foresight is supposed to be particularly suited in highly dynamic areas (Reger 2001). Alternatively, one may also think of foresight as embedded into a wider field of expectations circulating in communities and discourses guiding strategic considerations (Truffer, Voß et al. 2008, Van Lente 2012). In the latter case, we may expect foresight exercises to draw on social repertoires of expectations (that is precisely such repertoires of expectations circulating in communities, media etc.), or the initiative to undertake foresight may be motivated by the circulation of expectations of what seem to be important developments a company should turn to. Foresight may then serve as a means to further specify or scrutinize those collective expectations, and/or to derive at strategic implications for a particular firm or network. In this case, researching the role of (formal) foresight may indirectly capture the role of collective expectations. Collective expectations may, however, also inform innovation strategies without the 'intermediation' of formal foresight. Given that corporate (and networked) foresight is not a pervasive practice in all companies and for all innovation projects, it seems even likely that this may be more often the case than not.

The strategic role of expectations for mobilizing, guiding and coordinating innovation activities has been investigated in a strand of literature known as the 'sociology of expectations' (Borup, Brown et al. 2006) and related studies. Similar as for the formal types of foresight, we can distinguish between impacts at the level of particular companies, and impacts at the level of networks of innovation actors. It has been shown that collective expectations, not the least in hype-like phases, mobilize companies to invest in new fields and businesses or intensify their innovation activities; they may also mobilize those companies that may be somewhat sceptical, but for instance follow the activities of their competitors (Konrad, Markard et al. 2012). Exactly because these expectations circulate in interorganizational communities and discourses they are not only relevant for mobilizing and guiding innovation within a company, but also for mobilizing, guiding and

coordinating innovation in innovation networks and systems, by informing multiple actors and by supporting network- and institution-building (Konrad, Markard et al. 2012, Musiolik, Markard et al. 2012). In a similar vein, Swanson and Ramiller have pointed out the importance of interorganizational communities in developing what they call an "organizing vision" (Swanson and Ramiller 1997), which emerges as the result of the collective sense-making of the communities producing IT innovations as well as the companies considering their adoption - by mobilizing and legitimating innovation efforts, and supporting the sense-making of what the innovation is supposed to be good for, under which conditions, and how it can be implemented. Further, organization-specific expectations may then help to explain why different organizations may derive at divergent strategic considerations, even if being exposed to similar discourses and collective expectations (Budde, Alkemade et al. 2012, Konrad, Markard et al. 2012). Here, corporate foresight may play an important role in the formation of such more specific expectations and strategic considerations (Rohrbeck and Gemünden 2011, Rohrbeck and Schwarz 2013).

Implications for data collection and analysis

To summarize, our review of the literature shows that the mapping of developments in the business environment can be an important element of innovation strategies, and partly also the management of innovation projects and portfolios of companies, supposedly in particular for radical and new business innovation. The actual form of mapping activities and their linkage to the innovation process shows quite some variety, even if a number of more widespread methods and patterns in the purposes emerge. Some of the studies also show a clear link between open source innovation and the use of foresight. Of particular interest for the IIT project seems to be as well the use of *networked* foresight within innovation ecosystems. This issue is addressed for some cases only, but the studies indicate that it may in principle have a high impact potential, due to making foresight accessible for many and serving additional functions at the network level. The studies, which mainly cover limited sets of cases, and seem to have a geographical bias towards multinational corporations based in Germany, are, however, less suited to provide a picture which covers innovation across Europe, and different types of companies. Here, the IIT project will be able to contribute to our knowledge about actual use, and relevance for particular types of companies and types of innovation. Different sectors are sometimes covered, though only partly also differences in the used approaches and impacts have reported. This suggests, to keep this as an open question for the empirical analysis. Similarly, for web-based tools the literature provides basically a 'proof of existence' with some indications for interesting linkages with the innovation management process. The IIT project could indicate the broader (real and potential) usefulness of such tools. Our overview also showed the relevance of external sources of knowledge as consultancies and of less formalized forms of mapping, highlighting in particular its role for innovation processes involving more than single companies, suggesting that these should be considered beyond more formalized ways of mapping as corporate and networked foresight.

Many of the studies taking the innovating companies as their starting point (rather than particular methods) show a rather large variety of tools and methods actually applied, not necessarily going into the details and specific impacts of each tool and method. In line with this, within the IIT project we should take an open approach, which is flexible with regard to the approaches deemed relevant by the firms, and the level of detail appropriate for each firm.

The following interview questions inquire into which aspects of their environment the companies map, which types of mapping they use, and how these insights are applied in the innovation practices.

- Do you 'map' the innovation environment for your firm If so, which aspects?

- If so what methods do you use? What is the value of these to your mapping?
  - Quantitative: patent analysis, bibliometrics, analysis of social media, crowdsourcing, …
  - Qualitative: scenarios, horizon scanning, roadmaps, surveys, analysis of media, consultants, …
  - Informal approaches such as conferences, public information?

What about big data analysis?

- How do you apply the results of these analyses? eg at which stage of innovation planning and for which type of innovation (radical/incremental etc)?
- Has your approach to or use of mapping changed in the past 5-10 years?

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4.2 Web-enabled tools supporting company innovation practices

Issue description

Web-enabled tools such as team-based workspaces and crowdsourcing are important means to support effective innovation practices. This section provides an overview of the state of the art and best practices of such tools and explains how such tools support modern open innovation practice. In this section we do not cover general, conceptual tools for management of innovation as the focus is primarily to address web-enabled tools which support specific aspects of innovation process and innovation management. However some attention is paid to how the ICT tools support collaboration, as collaboration is an important precondition for effective and open innovation (Ebersberger et al. 2015). The main issues addressed are: 1. What are the tools commonly in use and to be considered as good practice, 2. How do such tools affect the actual innovation process and the management of innovation, 3. What are the current gaps in innovation support tools and what are the requirements for the future.

Key insights on impact on innovation practices and performance

Web-enabled innovation support tools

Innovation processes in companies comprise a variety of activities, managerial and operational, requiring different ways of support. At the **managerial level**, a broad range of portfolio management tools are in use to help identifying and selecting priorities in research and innovation themes and shaping the company innovation strategy. Web-enabled tools are also used to gather and analyze technology and market intelligence and facilitate the foresight process. Companies also use web-enabled tools to facilitate portfolio management of innovation projects, such as databases to manage detailed project information in terms of projects, deliverables, planning, progress report and other (Filippov et al. 2010). At the **operational level** a variety of tools is helping the company innovators to innovate. Examples are tools to support creative idea generation, knowledge sharing and knowledge management, team collaboration (through different innovation stages), and facilitation of (large-scale) innovation communities. In this category of operational-level tools also fits the concept of living lab or innovation lab in its various forms. For interacting across the boundaries of the company and connecting the company and the outside world, social media approaches such as crowdsourcing received a lot of interest. In addition to such general tools for supporting the innovation process, there exist dedicated task oriented tools. For example, companies specialised in product innovation often use dedicated tools for supporting the design and engineering process. For service innovation, a variety of service platform approaches exist to support design, development, prototyping and validation. As explained, web-enabled innovation support tools are diverse.

Table 4 below positions the tools in a matrix based on two dimensions, time and place (adapted from J. Grudin a.o. 1994). Face-to-face meetings (same place, same time) are still important for managing the innovation process. However forms of collaborative innovation have emerged, enabled by ICT-tools, which are not dependent on place or time. The more traditional well-known ones such as conferencing and e-mail are still coupled to place and time. Tools such as crowdsourcing, social media or platforms of innovation intermediaries have now emerged that are even more flexible, in terms of increased independency from place and time. These tools also allow the involvement and engagement of larger groups or communities, thus bringing the vision of collaborative innovation networks closer to reality (Gloor, 20056).

Table 4: Matrix of web-enabled tools to support the innovation process (adapted from Grudin, 1994)

TIME PLACE	Same	Different, predictable	Different, unpredictable
Same	Decision making tools Design reviews Creative brainstorm support Roomware	Creative brainstorms	Innovation team rooms Post-it exercises
Different, predictable	Videoconferencing Design/engineering team reviews	E-mail Living lab (comprising a sequence of sessions) Innovation project management tools	Collaborative workspaces Wikis for collaborative editing
Different Unpredictable	Virtual worlds Shared screens Multi-user editing	Crowdsourcing platforms (intermediaries) Business-controlled platforms Group blog	Crowdsourcing platforms (intermediaries) Business-controlled platforms Blog

The following types of tools are highlighted, in regard to their role in supporting innovation practices:

Creativity and idea generation. A wide range of web-enabled tools for creativity support exist. The Laboranova project (www.laboranova.com), focusing on early-stage innovation, systematically identified, developed and validated a range of web 2.0 creativity tools to be used in the innovation process, including team building support; generation and management of back- and foreground knowledge; idea and concept generation and management; concept evaluation and selection. An example is InnoJam, a discussion-based tool that can bring together large groups of people to connect them in an asynchronous way to empower the generation, evolution and evaluation of ideas. Another example is IDeM, a collaborative innovation support environment that uses the market metaphor to provide idea generation mechanisms, feedback, commenting and rating, and aggregation of the preferences of users to support idea selection. This approach fosters participation by exploiting a game-like process and providing incentives through idea competitions.

Innovation labs such as **living labs** are innovation process settings that bring together researchers, designers, developers, end-users and other stakeholders implementing a systematic process for product and service innovation, usually starting with the elicitation of user requirements and in initial concepts. Parts of the interaction settings usually are face-to-face (same time, same place) however normally the overall process consists of a sequence of different innovation-related activities across different places and times. E.g. based on initial design prototype discussed with user groups (designer – user interaction) a more elaborate design and engineering phase is initiated software development and engineering), followed by field tests with end-user communities (final stages of innovation).

Collaborative working tools. Team and community collaboration is in the heart of innovation, and web-based collaboration tools therefore form an important tool category. Computer-supported collaborative work (CSCW) tools such as collaborative workspaces, virtual worlds, group blog and videoconferencing enabling distributed teamwork are normal practice in most enterprises. In its basic form CSCW tools allow the creation and sharing of documents among (distributed) teams and communities. However, CSCW is a broad category as reflected in Fig. 1, and many cooperation workspaces integrate the search and finding of expertise and of people, presence awareness (who is on-line, with which electronic channel to reach) and other functionalities. Many of such functionalities are now part of common web tools such as Skype and Facebook. In the recent past, several projects in the 6th Framework Programme, such as ECOSPACE, CO-SPACES and Laboranova worked on collaboration environments for innovation including web 2.0 and semantic web tools

and explored their applicability in different cases such as creativity support, product innovation and distributed innovation teams.

Community-based innovation. On-line platforms and social media are currently seen as a promising area of community tools. On-line platforms for innovation jams (e.g. large-scale jams as used within IBM, but also small-scale team jams) and idea marketplaces (Nokia) or contests are early examples of interesting forms of such tools. An important category in engaging communities of people for innovation, which has met increasing interest, is **crowdsourcing**. This concept implies that creative solutions are harnessed from a distributed network of individuals through "open calls" (Howe, 2006). Crowdsourcing is increasingly popular as a way of attracting interested and motivated individuals who are capable of providing solutions that are superior both in terms of quality and quantity (compared to traditional forms, i.e. closed innovation), and the Web, and in particular **social media**, is imperative to this process. The benefits of crowdsourcing include the ability to interact with customers (both current and potential) and other interested individuals (e.g. developers) to reduce market uncertainty. It provides a way of identifying future needs, leads to a greater variety of ideas generated and allows access to a wider pool of technical expertise. Several authors have highlighted that crowdsourcing can be a valuable way of virtually integrating customers into the innovation process (Ebner, Leimeister, & Krcmar, 2009; Füller & Matzler, 2007). Nonetheless, crowdsourcing is not without challenges. Issues regarding intellectual property, lack of secrecy, legitimacy of expertise and the impact of product quality have been highly considered. Overall, there are many ways and means to utilise crowdsourcing and the outcomes from crowdsourcing are also varied and multiple. Within the IIT project we hope to be able to map the different ways and means by which companies in various sectors utilise crowdsourcing and understand the outcomes of such practices.

Crowdsourcing platforms. Nowadays many activities termed as crowdsourcing mostly are marketing tools, informing companies about customer preferences. However several initiatives have gone steps further to create crowdsourcing platforms engaging a range of people with different expertise contributing to the innovation. One of the forms is contests, which is especially useful in design stages, and today online platforms such as Quirky, HYVE, TopCoder, Kaggle, and InnoCentive provide crowd-contest services (Lakhani, 2013). Other crowdsourcing platforms can be found here: http://www.boardofinnovation.com/list-open-innovation-crowdsourcing-examples/. **InnoCentive** is a well-known example: an online platform for open innovation, crowdsourcing and the innovation contests. Another example is **NineSigma**, an open innovation service provider connecting clients with a global innovation network of experts. But also social media platforms such as Twitter and Facebook are crowdsourcing media, see also http://www.techipedia.com/2009/social-media-crowdsourcing/.

Business ecosystem platforms. A related but more company-controlled engagement approach is to create a platform ecosystem around a firms' product and service base engaging suppliers, customer, technology providers, developers and other communities in collaborative product or service development. Well-known examples of innovation and business models based on platform ecosystems are those of Apple, Facebook, Google, Microsoft. Specifically, the role of open innovation and crowdsourcing in relation to Amazon Mechanical Turk and Apple iOS platforms has been studied by Bergvall-Kareborn and Howcroft (2013). Platform ecosystems can be found in ICT-based but also in other industries, such as automotive and aerospace.

In recent years collecting and analysing **Big Data** has become more and more important for companies developing strategies for future innovation. These data are not only gained by social media in sectors like ICT

but also within traditional industries from “traditional” production processes, and within urban settings to stimulate the “idea flow” of innovators and co-creators, and understand patterns of innovation within communities (Pentland, 2014).

Adoption and use of web-enabled tools in innovation practice

Surprisingly little systematic scientific evidence is available regarding the adoption, use and effectiveness of web-enabled tools in the innovation process. Most of the literature just presents or proposes tool solutions and much is part of grey literature of consultant reports, and case studies. Also, a large part of the web tools are fully accepted as essential part of company’s computing infrastructure. Some of the findings are the following.

Piller et al. (2012) is an important study; it discusses the impact of social media on customer co-creation in the innovation process. Social media may enhance the effectiveness and efficiency of co-creation by lowering cost of interaction and allowing a larger number of participants. Social media may also change the character of co-creation, turning it into social exchange relations.

Holzblatt, Tierney (2011) concluded that incorporating social media into the Enterprise is a key opportunity as well as critical challenge facing many organizations today. They found that tantamount in decision-making about social media implementation is the question of 'value'. Their research examines the deployment of an online innovation management platform to execute an annual research and development proposal competition over two cycles of usage. Their findings suggest strategies for monitoring and measuring the effectiveness of social media's impact to an existing innovation process within the context of a business strategy.

Blomberg (2013) presents the results of a survey of 18 ICT tools addressing various phases of new product development. The findings suggest that “most companies involve customers and suppliers in their development activities. The extent of usage of new media and social media open innovation tools is lower than traditional tools (e.g. Email). Next to that, ICT tool usage differs across phases. Total ICT usage appears to be higher in the discovery and development phase compared to the commercialization phase. The antecedent ICT infrastructure was found to have most significant effect on the use of ICT, though not always as expected. While a better ICT infrastructure has a positive impact on process and project management tools and Social media tools, it has a negative effect on traditional tools. This suggests that a better IT infrastructure causes a shift in the type of tools used in a company. Furthermore, social media tools (e.g. Social Networking tools) have a positive impact on Process Performance, while using Traditional tools in the commercialization phase can negatively influence Process Performance.”

Al-Hasan a.o. (2013) studied open innovation crowdsourcing contests. Their findings show that open innovation contests are subject to significant informational spillovers relating to submissions that benefit later entrants. They also found that the benefits of informational spillovers from feedback provided to early entries depend on the type of feedback provided.

Bergvall-Kareborn and Howcroft (2013) investigated the role of open innovation and crowdsourcing in relation to Amazon Mechanical Turk and Apple iOS platforms, digital platforms which enable to open up the company’s boundary to external labour. They found that introducing open innovation and crowdsourcing in platform contexts transforms the business model of the companies involved. The attractive business model innovation (from firm perspective) does not necessarily translate into positive benefits throughout the value chain as control is centralised in the platforms and benefits do not reach labour. This in turn might negatively

affect the future sustainability of crowdsourcing in this context, in particular the ability of firms to attract highly-skilled external workers. The authors also raise questions as to whether crowdsourcing platforms could potentially subsume existing industries, such as data entry, technical support and software development, leading to more precarious working practices.

Several of the tools discussed above aim at enhancing collaboration (cocreation) capabilities in networks and communities rather than supporting individuals and teams. The role of Web 2.0 - based tools to enhance collaborative innovation in various settings (idea marketplaces, customer innovation, participation platforms, platform ecosystems and other) has met a high level of interest, and attention has shifted to forms of "mass collaboration" and collaboration in "collaborative innovation networks" which also has changed innovation in the workplace (Tapscott and Williams, 2006; Gloor, 2008). While the importance of such tools has been widely recognized there is still a lack of empirical studies as regards their actual impact on collaboration and innovation.

Trends and developments for the future

Regarding the adoption of web-enabled tools we should take into account the trends in open, collaborative innovation. Open innovation has been growing and it can be expected to further evolve. Thus, it can be expected a continuing adoption of web-enabled tools and platforms to support the innovation process, in particular web-based tools such as social media and crowdsourcing platforms. External collaboration platforms will build gateways or even merge with internal idea management platforms. Additionally the range of tools to choose from will increase. It also can be expected a much higher level of cross-industry collaboration, requiring new effective and efficient forms of innovation support. See: http://www.innovationmanagement.se/2013/09/02/10-prospects-and-trends-for-open-and-collaborative-innovation/.

Implications for data collection and analysis

Although there is a large body of literature describing a variety of web-enabled tools supporting the innovation process (and supporting collaborative, open innovation), literature about actual adoption, use (for particular parts of the innovation process and management), effectiveness and also problems of such tools is relatively scarce. Equally there is little scientific evidence regarding the effectiveness and adoption of specific social media oriented tools such as crowdsourcing solutions. The IIT survey can shed light on these issues. Furthermore there remain a number of fundamental issues in relation to access, openness and control and distribution of benefits of web-enabled platform tools when utilized across the boundaries of the company. A number of questions throughout the questionnaire address the use of web-enabled tools:

- How important are web-enabled innovation tools for your innovation process? What are the experiences?
- Do you seek to expand the market prospects for innovations after initial introduction to the market?
    - What are the roles of … social media, crowd-sourcing etc.?
- Do you 'map' the innovation environment for your firm If so, which aspects?
    - If so what methods do you use? What is the value of these to your mapping?
    - … , analysis of social media, crowdsourcing, …

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4.3 Innovation Management and Strategy

Issue description

Innovation management is a complex and multidimensional practice, and draws on many disciplines that traditionally have been studied separately (Tidd, 2001). Consequently, the field contains several research streams, such as studies on organizational learning, project management, and top management teams, which are to some extent independent (Crossan and Apaydin, 2010). This shows in textbooks and various review articles of the field (e.g., Hidalgo and Albors, 2008; Adam, Bessant and Phelps, 2006);To further develop this research field, a more systemic understanding and a holistic view has been called for, in order to better understand the relationships between existing theoretical constructs and streams of research. Also from the practitioner's perspective, holistic studies are considered highly valuable (e.g. Herstatt et al., 2007; Medcof, 2008).

As shown by Crossan and Apaydin (2010), innovation processes touch upon different organizational levels, are based on different drivers, move in different structural directions, draw on different sources, and focus on different loci. Similarly, innovation management practices can be seen as configurations consisting of a vast range of managerial tasks in different hierarchical levels, taking into consideration issues such as strategy, structure, and culture, for which different tools, guidelines and concepts have been developed. From this perspective, we understand innovation more specifically as a process where micro-level activities in different subfields gradually become interlinked and tightly coupled. In our project, we will focus on these innovation processes and the ways these are managed and structured.

Given that innovation management and strategy are two very well researched areas, our review cannot do justice to the full range of literature available. Furthermore, a large part of the literature is mainly concerned with internal processes, while the interest of IIT is also on how internal processes of innovation management relate to or are affected by how a company interacts with its environment. Thus, we will focus on the question how the particular type of innovation practice as open or closed, embedded into ecosystems, incremental or radical is or needs to be reflected in innovation management and strategy.

Key insights on impact on innovation practices and performance

Rather than aiming for one best way to manage innovation, IIT aims to provide insights into effective organizational configurations in different contexts. Different contexts may require different organizational structures and processes (Tidd, 2001). In earlier sections, industrial sectors, ecosystems, types of innovation such as open and closed innovation, and demand-based innovation have been elaborated as relevant contingencies, which pose specific challenges for innovation strategies and the management and organization of innovation processes, including not only internal processes but also external relationships and the flows of knowledge and other resources. In this section we will elaborate another central contingency in innovation management: the radicalness of the firm's innovations. This radicalness of innovations is considered to have a significant influence on the effectiveness of different innovation management practices, on a strategic, organizational and process level, which has received ample attention in innovation management literature (e.g., Afuah and Tucci, 2003; Crossan and Apaydin, 2010).

Incremental innovations remain close to the firm's technological competences, existing customer base and current business models, while radical innovations entail novel technologies (Ahuja & Lampert, 2001), changing customer preferences (Bower and Christensen, 1996), new complementary assets (Tripsas, 1997), and/or innovative business models (Teece, 2010). Incremental vs. radical is not a dichotomy, but a

multidimensional scale. However, companies can choose to focus more on either incremental or radical innovations (Miles, Snow, Meyer and Coleman, 1978). These strategies are risky. Sole attention for improving current products and services may lead to success traps (Levinthal and March, 1993) and severe problems in times of transition. On the other hand, mere investment in radical innovations may lead to vicious cycles and failure traps (Levinthal and March, 1993) and loss of competitive position. Therefore, ambidextrous strategies, in which short-term incremental innovations are combined with radical innovations, seem preferable for firm success on the short and longer term (O'Reilly and Tushman, 2004). However, there are different ways to implement an ambidextrous strategy and literature is inconclusive under which circumstances which strategies work best. Firms could alternate their focus on radical and incremental innovations, or pursue them in parallel, or strive for a division of innovative labour with other firms in the innovation ecosystem (Van Looy, Martens, Debackere, 2005; Gupta, Smith and Shalley, 2006; Lavie, Stettner and Tushman, 2010).

Next to a strategic dimension, ambidexterity also has an internal and external organizational dimension. Radical and incremental innovation require differences in process (Veryzer, 1998), team structures (De Visser, De Weerd-Nederhof, Faems, Song, Van Looy and Visscher, 2010) and collaborations (Rothaermel and Deeds, 2003; Lavie and Rosenkopf, 2006). Whether to separate or integrate incremental and radical innovation processes organizationally is also an important debate in literature. Some authors favour a strict separation through spin-offs (Christensen and Raynor, 2003), which foster an entrepreneurial spirit and prevent a venture from being crushed by existing business units. Others, however, argue that spin-offs have difficulties with upscaling their activities in a later stadium, as they cannot use the mother company's production and marketing resources (Iansiti, McFarlan and Westerman, 2003). Besides, future integration with the mother company is problematic. Internal corporate ventures are better at fostering integration (Burgelman, 1983), but may limit entrepreneurial freedom. Hybrid forms such as structurally ambidextrous organizations (O'Reilly and Tushman, 2004) and contextually ambidextrous organizations (Gibson and Birkinshaw, 2004) have been proposed to deal with these tensions between differentiation and integration. However, under which circumstances these forms of organizing are effective is still a debated issue (Markides and Charitou, 2004; Van Looy et al., 2005; Tushman, Smith, Wood, Westerman and O'Reilly, 2010). The same goes for the external organization of incremental and radical innovations. While incremental innovations involve more collaboration in the supply chain, and radical innovations entail more cooperation with outsiders and knowledge institutes (Faems, Van Looy, Debackere, 2005), it is still under debate how different open innovation practices are related to different kinds of innovations (see e.g., Bengtsson, Lakemond, Lazzarotti, Manzini, Pellegrini and Tell, 2015).

Also regarding to the innovation process, the radicalness of innovation makes a difference. Traditionally, literature on innovation process management has been dominated by stage-gate models (Cooper, 1990), defining phases and decision points to structure and control innovation processes. Stage-gate models fit incremental innovation processes, but there also have been attempts to adapt these models to suit radical innovation processes (Veryzer, 1998; Bers, Dismukes, Mehserle and Rowe, 2014), for instance by treating the fuzzy front end differently (Van der Duin, Ortt and Aarts, 2014). Although these models still receive ample attention in literature and have shown their value in practice, for instance as a basis for standardization, several recent contributions to the innovation process literature, especially in the software industry, depart from the stage-gate logic and stress agility, flexibility, and intensive stakeholder involvement (Thomke and Reinertsen, 1998; Buijs, 2003; Nerur, Mahapatra and Mangalaraj, 2005). These agile processes bear promises of being quicker and more creative, of making better use of the innovation ecosystem, and of being more

suitable for radical innovations, but the conditions under which they are effective and their applicability outside software innovations processes are still under research (e.g., Conforto, Salum, Amaral, da Silva and de Almeida, 2014).

Implications for data collection and data analysis

Drawing on the above outlined framework on innovation management, a key research gap lies in specifying the multiple ways in which the interlinkages within the innovation management practices actually emerge and materialize in the changed landscape. In particular, we wish to uncover the interlinkages between innovation strategies, design choices on internal and external organization structures, and the management of innovation processes. We want to uncover patterns in these linkages and find out how and why these linkages were constructed or evolved. Special attention goes to the questions if and how innovation management needs to be adapted to different types of innovation practices, the strategic considerations related to choosing for different types of innovation practices, such as balancing between open and closed or radical and incremental innovations, and how these choices have implications for internal organization, external collaboration and innovation processes. A question on the background is how these choices and processes are related to perceptions of and possibilities in the innovation ecosystem.

These issues will be mainly addressed in the 'Innovation management and practice' section of the questionnaire, and partly in the 'Business environment and company strategy' section. In particular the following questions are relevant:

- How would you describe your innovation strategy (scope and concept)?
  - organized around technologies, functionality, product areas/markets, affiliations/locations, customer needs?
  - what are your firm's core technological competences?
  - has the balance between technical and non-technical innovation changed over the last few years?
- Please outline the main stages of an innovation project within your firm from conception to market?
  - What are the main factors involved in beginning an innovation project? What are the main points of handover between the main stages you have identified?
  - How do you manage the progression the progression of a project (e.g. stage-gate, agile, customer-driven, other…)?
  - Do you use any other 'formal' methods (e.g. innovation management standards) to manage your innovation process?
  - Which parts/functions of the company are involved? If cross-functional teams are involved how are these coordinated?
  - Do you differentiate between incremental and radical innovations in you management structure or processes?
  - How important are web-enabled innovation tools for your innovation process? What are the experiences?
  -
- How do you report on and assess the overall innovation progress in your company?
  - What are the reporting lines?
  - What are the main performance criteria? Any formal processes?
  - Are stock market expectations taken into account when innovation strategy is formulated
- Has your firm's approach to innovation management (organisation, processes and tools) changed in the last 5 or 10 years?
  - If so how?
  - What has the effect of these changes been?
  - What were the drivers of these changes?

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5 Summary and perspectives

The previous chapters presented an overview and analysis of developments in innovation practices, from three different perspectives. The first perspective, addressed in sections 2.1 and 2.2, is the context of company innovation practices, where we highlighted the role of innovation ecosystems and also looked into the sectoral patterns of innovation. The second perspective has been to understand the key trends in innovation practices, in particular open innovation and demand-based innovation, in sections 3.1 and 3.2. The third perspective was the actual shaping of innovation practices by the companies themselves, in particular the processes involved in managing innovation, the role of foresight and intelligence, and the new Web-enabled tools supporting collaborative innovation discussed in sections 4.1, 4.2 and 4.3.

The role of **innovation ecosystems**, including newer forms such as business platforms, has become more and more relevant for company's innovation practices. Benefiting from interactions and collaborative relations with actors within the company ecosystem is nowadays a key success factor. This also brings new challenges such as agreeing on actor roles, on the trade-off between openness and control, and on the innovation management principles applicable to innovation in networks.

The **sectoral perspective on innovation** is still relevant as there are great differences among sectoral innovation patterns in terms of R&D expenditure and propensity to innovate, as well as how innovation is organised (e.g. user-producer relations, the role of key actors). For example there are great differences between retail and automotive sectors. The sectoral view of innovation provides an understanding of the contextual factors affecting innovation practice.

Open innovation has been on the forefront of innovation discussions since a decade. A considerable number of firms confirm to apply open innovation concepts, however it remains unclear which concepts, how they are adopted and to what extent, what the impact has been, and how innovation processes are managed in open contexts.

Demand-based innovation equally is a highly important trend which has transformed company innovation practice as well as national innovation policies. Still there remain gaps in our insight as regards how companies' innovation practices respond or anticipate to changes on the demand side (customers and sectors), and more in general how companies interact with their environment in developing and adapting their innovation strategies and creating mechanisms of co-innovation, thus linking back to the role of broader innovation ecosystems.

This issue is also addressed in the section on **mapping the environment**. A wide spectrum of approaches are in use to generate intelligence regarding technologies, markets and competition as well as societal trends. Interactions between the company and external actors (customers, suppliers) have also increased, giving companies a more direct interface and leading to forms of networked or community-based foresight.

Increasingly, **Web-enabled tools and platforms** are in use to support company innovation practice. Besides the more well-known collaboration tools, new forms have emerged such as social media and crowdsourcing platforms. Such tools also play a key role in creating innovation communities around companies' innovation practices. The level of adoption and impact of using such tools and platforms on actual innovation practice and on innovation performance is still largely unknown.

Finally, under the influence of the developments sketched above, **innovation management** as a practice has transformed from a company-internal process towards a more open process that includes actors beyond the company boundaries, and different types of innovation pose different challenges to innovation management. A challenge for innovation strategy is to find the right mix of different types of innovation and establish organizational structures appropriate for them.

The conceptual elements and insights on current developments in innovation practices assembled in this framework are used to inform the central empirical study in the IIT project, a large-scale qualitative interview-based survey of 800 European companies aimed at creating an understanding of current best practices of innovation (WP 2). The framework provides implications for the sectoral sampling of the companies to be interviewed, the topics to be addressed and the questions to be posed (Task 2.2). Furthermore, the framework will guide the data analysis by informing the coding and the analytic lens to be applied to the empirical material (Task 2.4). Finally, following the large scale survey, in-depth company case studies will be conducted, which allow for a more thorough analysis of innovation practices in the companies (Task 3.3). The set-up and specification of the case study design will draw both on the insights gained in the survey and the conceptual framework.

Appendix

Table 5: Pavitt's taxonomy

Characteristics		Typical Sectors	Type	Sources of technology	Technological trajectories	Source of process technology	Relative size of innovating firms	Industrial organization
Supplier dominated firms	• Active in traditional industries • Firms innovate by acquiring machinery and equipment • Distinctive and significant technological trajectory • External sources of innovation	Textiles, Potteries, Furniture, Machinery, Agriculture, Housing	Manu-facturing	Suppliers, Research extension services	Cost-cutting	suppliers	small	Growing importance of small manufacturing firms
Specialized suppliers	• Specialized in capital goods and equipment • Live in symbiosis with their customers • Produce technology that is an intermediate product to other enterprises • Demand-pull innovation (static interpretation) • Separation between supplier-dominated and specialized suppliers firms (dynamic interpretation)	Mechanical engineering, Steel and Coal	Manu-facturing	Design and development users	Product design	In-house; Customers	small	Separation between producers of capital and consumption goods
Science-based firms	• Exploit new scientific discoveries • In-house RTD • RTD outsourced to universities • Development of new products or pocesses • Technology-push innovation (static interpretation) • Grow in size much more than other firms (dynamic interpretation)	Electronics, Chemicals, Pharmaceuticals, Aerospace, Engineering	Manu-facturing	RTD Public science Production Engineering	mixed	In-house suppliers	large	Emergence of large firms
Scale-intensive firms	• Mass production • Cost cutting trajectories • Internal and external sources of innovation • Advantage is based on economies of scale (dynamic interpretation)	Automobiles, Synthetic products, Consumer durables	Manu-facturing	Suppliers RTD Production Engineering	Cost-cutting	In house suppliers	large	Oligopolistic competition for mass consumption
Information-intensive firms	• Main source of technological accumulation in the advanced processing of data • Based on intensive analysis and the use of data-processing (dynamic interpretation)	Banking, Retailing, Tourism, Telecoms, Software Microelectronics	Service					Networks of firms, strong user-produces interactions

Source: Pavitt (1984, 1994), Author's (MP) illustration

Table 6: Castellacci's Taxonomy

Sectoral category	Sectoral category Sub-groups within each category	Typical core sectors	Major function and relationship to technological paradigms	Technological regimes	Technological trajectories
Advanced knowledge providers	Knowledge-intensive business services	Software; RTD; engineering; consultancy	The supporting knowledge base of the ICT paradigm	Opportunity levels: very high External sources: users and universities Appropriability: know-how; copyright Dominant firm size: SMEs	Type of innovation: new services; organizational innovation Innovation expenditures andstrategy: RTD; training; Cooperations
Mass production goods	Specialized suppliers manufacturing	Machinery; instruments	The supporting knowledge base of the Fordist paradigm	Opportunity levels: high External sources: users Appropriability: patents; design know-how Dominant firm size: SMEs	Type of innovation: new products Innovation expenditures and strategy: RTD; acquisition of machinery; software purchase
	Science-based manufacturing	Electronics	The carrier industries of the ICT paradigm	Opportunity levels: high External sources: universities and Users Appropriability: patents; design; copyright Dominant firm size: large	Type of innovation: new products; organizational innovation Innovation expenditures and strategy: RTD; cooperations
	Scale-intensive manufacturing	Motor vehicles	The carrier industries of the Fordist paradigm	Opportunity levels: medium Opportunity levels: medium External sources: suppliers and users Appropriability: design; process secrecy Dominant firm size: large	Type of innovation: mixed products and process innovation Innovation expenditures and strategy: RTD; acquisition of machinery
Supporting infrastructure services	Network infrastructure services	Tele-communications; finance	The supporting infrastructure of the ICT paradigm	Opportunity levels: medium External sources: suppliers and users Appropriability: standards; norms; design Dominant firm size: large	Type of innovation: mixed process, service and organizational innovation Innovation expenditures and strategy: RTD; acquisition of software; training
	Physical infrastructure services	Transport; wholesale trade	The supporting infrastructure of the Fordist paradigm	Opportunity levels: low External sources: suppliers Appropriability: standards; norms; design Dominant firm size: large	Type of innovation: process Innovation expenditures and strategy: acquisition of machinery and software
Personal goods and services	Supplier-dominated goods	Textiles and clothing	They enhance the quality of final products and services by acquiring and embodying technologies related to different paradigms	Opportunity levels: medium External sources: suppliers and end users Appropriability: Trademarks; design Know-how Dominant firm size: SMEs	Type of innovation: process Innovation expenditures and strategy: acquisition of machinery
	Supplier-dominated services	Hotels and restaurants		Opportunity levels: low External sources: suppliers Appropriability: non-technical means Dominant firm size: SMEs	Type of innovation: process Innovation expenditures and strategy: acquisition of machinery; training

Source: Castellacci (2008), Author's (MP) illustration

Table 7: Taxonomy of technologies on the basis of Schumpeter Mark I and II

	Schumpeter Mark I	Schumpeter Mark II
	CREATIVE DESTRUCTION	**CREATIVE ACCUMULATION**
Knowledge characteristics	• High technological opportunities • Low knowledge accumulation • Knowledge exploration • Low knowledge appropriability	• High technological opportunities • High knowledge accumulation • Knowledge exploitation • High knowledge appropriability
Sector characterisitcs	• Low concentration of innovation • Low asymmetry • Small firms • Low stability in hierarchy • High rate of market entries	• High concentration of innovation • High asymmetry • Large firms • High stability in hierarchy • Low rate of market entries
Sectors/Technologies	Clothing and shoes, Furniture, Agriculture, Chemicals, Physical processes, Medical preparation, Chemical processes for food and tobacco, Machine tools, Industrial automation, Industrial machinery and equipment, Railways and ships, Material handling apparatus, Civil engineering and infrastructure, Mechanical engineering, Mechanical and electric technologies, Household electric appliances, Lighting systems, Measurement and control instruments, Sport and toys	Gas, hydrocarbons, Organic chemicals, Macromolecular compounds, Biochemicals, Aircraft, Engines, turbines, Laser technology, Optics and photography, Computers and office equipment, Electronics components, Telecommunications, Multimedia systems, Ammunition and weapons, Nuclear technology

Source: Malerba et al. (1997), Author's (MP) illustration

Table 8: Taxonomy of Sectoral Regimes by Marsili and Verspagen

Regime	Characteristics	Typical Sectors
science based (SB) regime	• high levels of technological opportunity • technological richness (due to the universal nature of scientific knowledge, the regime is able to continuously introduce new products), • high technological entry barriers • cumulativeness of innovation • firms are homogenous in their rates and directions of innovation • regime is devoted to product innovations and benefits directly from the advances made in academic research	pharmaceutical electronical/electronics industries
fundamental-process (FP) regime	• medium levels of technological opportunity • High technological entry barriers • heavy persistence • process innovation • regime benefits quite substantially from the scientific advances made in academic research	chemical and petroleum industries
complex systems (CS) regime	• knowledge base combining the mechanical, electrical/electronic, and transportation technologies • medium to high levels of technological opportunity • entry barriers in knowledge and scale • persistence on innovation • high degree of differentiation of technological competencies developed by firms and of external sources of knowledge including important, but indirect, contributions by academic research	aerospace motor vehicle industries
product-engineering (PE) regime	• mechanical engineering technologies • medium to high levels of technological opportunity • low entry barriers to innovation	Mechanical engineering

Regime	Characteristics	Typical Sectors
	• not very high persistence of innovation • A distinctive feature of this regime is the high diversity of technological trajectories explored by firms • The regime has an emphasis on product innovation which benefits from external contributions	
the continuous-process (CP) regime	• The knowledge base is characterized by the combination of chemical/metallurgical processes with mechanical/electrical technologies • low technological opportunities • low entry barriers • low innovation persistence • Firms are technologically heterogeneous and their knowledge base is, on the whole, differentiated among technological fields • Main innovative efforts are in processes which benefit from capital-embodied knowledge.	metallurgical industries metals and building materials chemical process industries textiles paper food and tobacco

Source: Marsili et al. (2002), Clausen T.H. (2004); Author's (MP) illustration

Table 9: Castellacci taxonomy related to IIT-research sectors

Castellacci taxonomy/ prioritized fields	**Advanced knowledge providers**		**Mass production goods**		**Supporting infrastructure and services**		**Personal goods and services**	
	Knowledge-intensive business services	**Specialized suppliers manufacturing**	**Science-based manufacturing**	**Scale-intensive manufacturing**	**Network infrastructure services**	**Physical infrastructure services**	**Supplier dominated goods**	**Supplier dominated services**
ICT and services	Software companies		Consumer electronics (e.g. smartphones or tablets)		Data-transfer (broadband, fibre optics services, internetproviders)			Telecare technologies.
Manufacturing	Engineering office	Measurement equipment (e.g. advanced microscopes, research tools)	Aerospace	Vehicles, ships		Construction companies	Smart textiles	Maintenance of heating installations in housing
Biopharma	Labs, contract research organizations		Biopharmaceutical products (e.g. drugs)					
Agro-food		Deboning equipment, food and drinks production and processing equipment					Food & drinks sector	restaurants
Clean technologies		Purification/treatment technologies		Recycling industry		Automated transport, energy providers		