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Opening up the innovation system framework towards new actors and institutions

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1 Summary

The paper revisits the established framework of the national and regional innovation system (NIS/RIS) in the light of recent insights from innovation research in order to increase its capacity for generating meaningful insights for policy makers and other actors wishing to influence innovation capacity of nations, regions or sectors. We review six research strands that challenge the classical NIS/RIS framework by pointing to a wider range of actors, institutions and innovation modes relevant for the innovation landscape: User innovation, social innovation, collaborative innovation, new innovation intermediaries, venture philanthropy, social and relational capital and non-R&D intensive industries. We find that each of these phenomena points to relevant contributions to national or regional innovation capacities that are not well captured by the established NIS/RIS framework. While some aspects could easily be integrated by adding some "arrows and boxes" in the graphics usually used for representing the framework, we find that several phenomena point to the need for a more fundamental revision of the innovation system framework. In particular it emerges that a distinctive assignment of actors to functions in the innovation process is no longer possible. Given, for example, the research insights on user innovation, social innovation and collaborative innovation, societal actors can no longer be assigned to the role of "demand articulation". Rather they actively contribute or sometimes even take over the generation of knowledge and innovation ideas as well as other functions such as financing, e.g. through crowdfunding activities. The broadened view on innovation also requires a wider understanding of the infrastructures and frameworks forming the enabling basis for innovation activities. Social and relational capital for instance that is deeply embedded in the cultural context of a region becomes a key enabler for trustful interactions of the diverse innovation actors such as low R&D intense firms that make huge contributions to innovation and employment but generate their knowledge through interaction with customers. The growing recognition of the economic and social relevance of collaborative and social innovation implies that collaboration platforms become as relevant infrastructures as classical technology transfer schemes. Finally the broadened view on innovation points to a wide range of intermediaries that form the backbone of an innovation system without necessarily seeing innovation as their primary purpose. As a consequence of these insights we suggest a revised innovation system framework. This system captures three types of contributions: Innovation supply and demand, innovation influx and innovation framework. Actors that may provide relevant contributions in one of these domains are grouped in open clouds, emphasizing the fluidity between functions and actors. We hope that this framework will allow for a more meaningful analysis of the innovation capacity of specific NIS/RIS systems.

2 Introduction

2.1 Basic elements of the innovation system framework

Starting in the mid 1970s, system approaches in innovation research gained considerable importance due to strong insights into the economics of innovation (e.g. in terms of innovation patterns of SMEs, the importance of technological trajectories, the cumulative character technological change), and the development of new ideas about the complexity and non-linearity of innovation processes (cf. Nelson and Winter 1977; Freeman 1982; Dosi 1982; 1988). Christopher Freeman is regarded as the 'father' of the concept of a "national system of innovation" (Freeman 1987). He considered it necessary that the national government promotes the technological infrastructure of a country and assumes that short-term strategies (such as wage or exchange rate changes) have only limited effects on the strengthening of the international competitiveness of an economy.

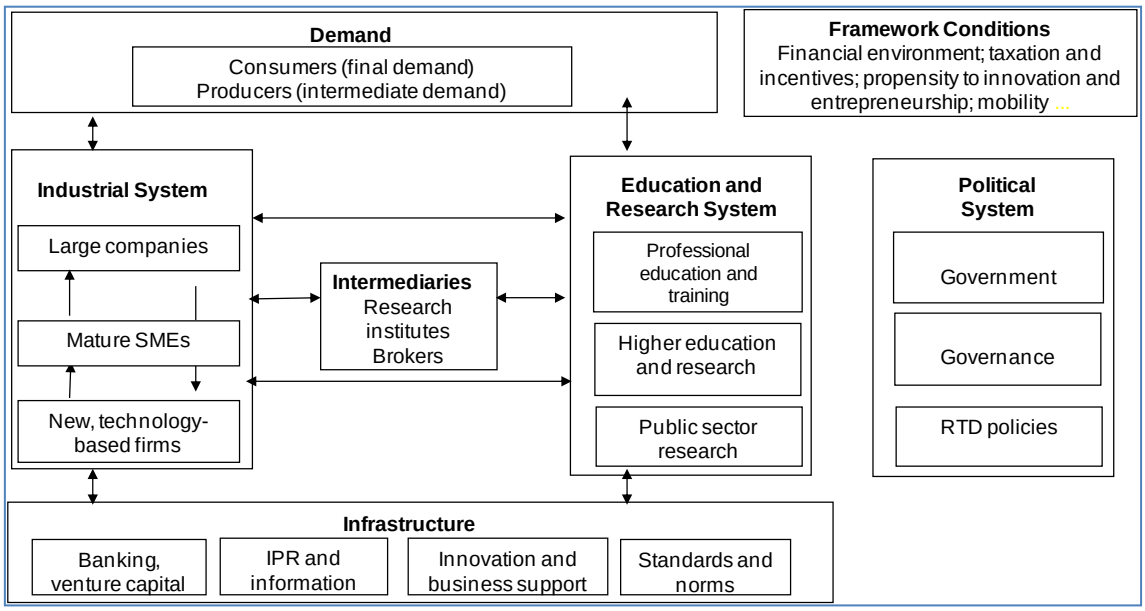
The most important characteristics of an innovation system are summarized in the definition by Edquist who wrote that innovation systems are defined by "... all important economic, social, political, organizational, institutional, and other factors that influence the development, diffusion, and use of innovation" (Edquist 2005: 182). During the late 1980s and especially during the 1990s, complex analyses of the national framework conditions for technology development and diffusion, on technical change, and on innovation and learning were carried out (e.g. Dosi et al. 1988).

According to Nelson (1993: 517-520) and Patel and Pavitt (1994), innovation systems are constituted by four main elements:

1. The institutional structures of a country, region or sector: They are formed by companies, universities, research and training organizations, norms, routines, networks, financial organizations, and the policy of promoting and regulating of technical change.
2. The incentive system of a country, region or sector. These include, among others, incentive systems for innovation, technology transfer, learning and qualification, for business formation and job mobility within and between organizations.
3. The skills and creativity of innovation and economic actors in a country, region or sector. Both between and within countries and between companies in a country there are great differences in the diversity and quality of products and services and opportunities to forge new paths of development.
4. The cultural peculiarities of a country, region or within a sector, which are reflected, for example, in different acceptances and user understandings of technologies.

For a long time, these central characteristics formed the basis of different interpretations of innovation systems and were usually adapted according to specific application needs (Koschatzky 2012). In many cases, heuristic models of innovation systems are built around the general institutional set-ups of countries, regions or sectors. An example of an innovation system model often used and extended in studies is the one developed by Kuhlmann and Arnold (2001) (cf. Figure 1). This model focuses on the two main sub-systems industry and education/research, and links them through the active role of intermediary organizations. These sub-systems are influenced and influence themselves the demand system, the framework conditions and the existing infrastructure system, and are shaped by the political system.

Figure 1: Innovation system framework



Source: Kuhlmann and Arnold (2001: 2)

In recent years it became clear that aspects like sustainability, globalization, the consideration of socio-cultural aspects, user demands, a new understanding of innovation like social innovation, open innovation, low-tech innovation, and service innovation question the traditional understanding of the structure and functions of an innovation system. Recent contributions to the innovation system literature developed multi-level conceptual frameworks for the comprehensive analysis of sectoral and technological innovation and for bridging the different territorial scales in innovation policies. Major impulses arose primarily from the articles by Geels (2004), Hekkert et al. (2007) and Bergek et al. (2008). Important new elements are the multi-level perspective (MLP) defined by landscape, regimes and niches and the extension of sectoral innovation system approaches by the integration of a socio-technical systems, mission- and de-

mand-oriented perspective as formulated by Geels (2004), the functional perspective of Hekkert et al. (2007) and Hekkert and Negro (2009), and the application of the functional approach in the context of technological innovation systems by Bergek et al. (2008). As an attempt of a synthesis between the socio-cultural multi-level approach and the function-based technological system approach, the paper by Markard and Truffer (2008) argues that technological innovation systems must be complemented by the multi-level perspective with landscape, regimes and niches.

2.2 Why is it still relevant, why does it need revision?

These new approaches complement and enlarge the understanding of functions and impacts of innovation systems and provide a better basis for conclusions about the governance implications of innovation system analyses. The classical institutional and organizational understanding of innovation systems is still a helpful tool to sketch the organizational structure of a country, sector or region and to identify strength or weaknesses in the innovation infrastructure and in the interaction between the different organizations or sub-systems. The new approaches are valuable to understand and explain the development of new technological regimes and are therefore often applied nowadays for analyzing and modeling the emergence of new technologies in a systems dynamic perspective (cf. Köhler et al. 2016).

Both approaches, old and new, miss a revised understanding of actors and actor constellations in innovation systems. Pointing to the new understanding of innovation and innovation processes (user-based innovation, open innovation etc.), it is insufficient to consider only groups like industry, research organizations, or the classical intermediaries like chambers or transfer offices. More and more is innovation triggered and influenced by civic engagement and new actors groups which emerged as a reaction to a specific problem. Additionally, cluster and network management organizations which support the specific interests of their members are a new form of intermediaries which did not exist at the time of the development of the innovation system approach. The actor perspective is also not included in the new functional approaches which, by definition, highlight different new functions of and in innovation systems - but not the role of specific actor groups.

In many cases the justification and design of innovation policy measures is still based on the classical understanding of the innovation system concept and its actors. Due to the fact that current forms and understandings of innovation are not reflected by at least the classical innovation system concept, policies based on this classical understanding miss new interpretations of innovation. As a matter of fact, there is an urgent need to review the innovation system concept in the light of the new findings and to

develop it further in a conceptual manner to effectively advise innovation policy and in particular mission-oriented strategies. Starting from the description and understanding of the mechanisms involved, the derivation of political needs and possible approaches and design options for policy instruments is required and also research about specific barriers and obstacles of such "new" innovation systems is necessary. The objective of this paper is to further develop the existing innovation system concept in a way that new forms of innovation and actor constellations can be mapped.

In the following section we will discuss five strands of innovation thinking that we feel should be to be recognized by the innovation system framework. In chapter 4 we will then introduce our suggestion for a revised innovation system heuristics doing better justice to this wider perspective on actors and institutions relevant for analyzing innovation landscapes.

3 Innovation phenomena challenging the established innovation system framework

3.1 User innovation

3.1.1 Key aspects

Already in the 1970s and 1980s some researchers started to point out the role users and customers play for successful innovations. In 1976 Eric von Hippel, the "father of user innovation", identified the role of users for innovations in the scientific instrument industry revealing that many users provided product ideas and even created product innovations by themselves to adapt products to the specific needs (von Hippel 1976). He concluded that "the information needed to innovate in important ways is widely distributed" (von Hippel 2005: 14). In 1978 von Hippel distinguished between the „Manufacturing-active" and the „Customer-active paradigm" (von Hippel 1978). In von Hippel (1986) he pointed out that a specific small group of customers, called Lead Users, in a very early stage anticipate market needs and are willing to provide ideas for the development of new products or even develop new or modify existing products. Lead users can improve the approximation of product attributes to heterogeneous users' needs. Even more, these lead users often share their information within the entire sector. This phenomenon was also called "free revealing" (von Hippel 2005: 77 ff.).

A lead user is no average user but much more an extreme user with more expectations and benefits in case of an innovation. The main incentive to innovate is the direct use (self-use) benefit from a design, a product, or a service and the willingness to solve the own needs (Piller and West 2014). Lead Users face specific requirements in particular

when markets are fast-paced and the desired product or services are not available on the market (ibid.).

In the 1990s the term "user innovation" has emerged to describe the phenomenon where users innovate by themselves. Notions such as customers-as-innovators or user driven innovations have become widespread. In this context, many studies have found that user innovators have often lead user characteristics. The Lead User Method (von Hippel 1986; 2005) or the development of products using (web-based) user toolkits (Dahan and Hauser 2001) was proposed to support user innovations. While the lead user concept proposes the physical integration of customers at the leading edge of the target market in the development process, user toolkits enable them to design their own products supported by tools within a certain solution space. Toolkits have the advantage over the lead user concept that at the end of a user-design phase, neither market appeal, nor management priorities have to be tested at the manufacturers' side. However, some toolkits provide rather small solution spaces which allow just to "superficially" design their own products. Such toolkits are considered to be instruments for mass-customization rather than true user integration (Piller and Reichwald 2006).

A couple of studies investigated the incentives and motivations for companies or individuals to actively engage in the innovation process and showed user innovations are of particular relevance in situations with highly heterogeneous user requirements. In such situations despite a fine segmentation of the market, user needs are often not fulfilled entirely by the products offered by manufacturers.

In recent years case studies of user innovation have often focused on specific industries. They include diverse domains like extreme sports industries, such as mountain biking (Lüthje et al. 2002), kite surfing (von Hippel 2005: 103), kayaking (Hienerth 2006), software development (Morrison et al. 2000; Franke and von Hippel 2003), or high-tech industries like the semiconductor and electronic manufacturing equipment producers (Urban and von Hippel 1988). Herstatt and von Hippel (1992) described the application of the Lead User method at Hilti AG, and Lilien et al. (2002) reported a case study at 3M. The emergence of user created content has fundamentally changed the dominant modes of content creation and diffusion in the creative content sector in particular books, music, audiovisual (film and television), video games and cultural spaces sub-sectors (Mateos-Garcia et al 2007; OECD 2006a). In addition to the Lead User method the phenomenon of creative consumers has gained in importance in the low-tech and high-tech industries and has been extensively discussed in the literature in the recent years (McCarthy 2014). A creative consumer is defined as "an individual or group who adapts, modifies, or transforms a proprietary offering, such as a product or service" (Pierre et al. 2007). One early example of creative consumers is the T Ford

which was adapted by farmers as a power source for driving generators, mills and lathes. Pierre et al. (2007) place the creative consumer, called "underground consumer", in opposition to the Lead User, thus his needs often remain personal and not necessarily become general. However, Tsinopoulos and Al-Zu'bi (2014) describe the Lead User as a specific type of creative consumer.

3.1.2 Relevance

There is a large amount of literature studying the various roles of customers within the innovation process and its impact on innovation performance. Studies delivered rich empirical evidence for different forms of involvement of users, the lead user approach and the use of user innovation toolkits (for an overview see e.g. von Hippel 2005). Most studies corroborate that user innovations have a higher success rate on the market (Blättel-Mink and Menez 2015). More general, empirical studies based on CIS data have shown that customers are the most important external information source and that the share of companies which co-operate with customers has increased in the last decade (OECD 2008). Laursen and Salter (2006) are amongst those authors who delivered evidence that the use of customer information is positively related to the innovation performance. Recently, three national surveys of representative samples of users have revealed that millions of users collectively spend billions of dollars annually developing and modifying consumer products to serve their own needs. Consumer product development seems to be a major activity among citizens acting alone and in collaborative teams (Hienerth et al. 2014).

3.1.3 Implications for the innovation system framework

As outlined above, user innovation has become a major innovation mode with high economic and social relevance. It goes beyond the traditional customer orientation as propagated by marketing and market research that sees the consumer as a passive object of market research. Rather in the extreme cases, the full product development is "outsourced" to the customer who creates his or her own products, while the manufacturer is providing the tools for the product development and adaptation by the customer. It is even no longer necessary to understand what the customer wants. Instead of trying to understand users' needs, those parts of the process, where costly information on needs is usually integrated, are undertaken by the user.

The obvious conclusion from the insights of user innovation studies is the need to provide a more active role for the users of innovation both for companies (B2B) and consumers (B2C). Instead of being just passive carriers of "needs", users become active and knowledgeable contributors of ideas and even – in the case of the lead users –

fully fledged innovators. Moreover, user communities fulfill an important function in innovation systems and should thus be visible in the framework.

Beyond these immediate implications however the user innovation perspective challenges the attempt to assign clear roles to certain groups on a more fundamental level. It becomes clear that actors take different roles depending on the context.

3.2 Social innovation

3.2.1 Key aspects

For some years now, "social innovation" is high on the agenda of innovation research and increasingly receives attention in innovation policy circles. Nevertheless, the very concept remains contested (Moulaert et al. 2013; Howaldt and Schwarz 2010). Two main groups of perspectives on social innovation prevail.

The first group distinguishes social innovation from other innovation types through its positive impact on society. For example, the EU project TEPSIE defines "social innovation" as follows*: "Social innovations are new solutions (products, services, models, markets, processes etc.) that simultaneously meet a social need (more effectively than existing solutions) and lead to new or improved capabilities and relationships and/or better use of assets and resources. In other words, social innovations are both good for society and enhance society's capacity to act"* (The Young Foundation 2012: 18).

This definition comprises all sorts of innovation media such as technologies, services and processes.

The other group of scholars such as Howaldt and Schwarz (2010) distinguishes social innovation by its medium rather than its purpose. They see social innovations as novel configurations of *social practices* with the purpose of fulfilling the innovators' own needs.[1] In this understanding social innovations are different from technological innovations because they involve novel practices (i.e. ways of doing) rather than novel technologies or products. At the same time they differ from classical innovations in services, processes or business models as they do not primarily target market implemen-

1 "The substantive distinction between social and technical innovations can be found in their immaterial intangible structure. The innovation does not occur in the medium of technical artifact but at the level of social practice. A social innovation is new combination and/or new configuration of social practices in certain areas of action or social contexts prompted by certain actors or constellations of actors in an intentional targeted manner with the goal of better satisfying or answering needs and problems than is possible on the basis of established practices" (Howaldt and Schwarz 2010: 21).

tation but rather address needs and problems. Adopting this definition implies that social innovations are socially desirable from the point of view of the social innovators but not necessarily good for the whole society and may also have negative impacts.

Another concept related to social innovation is "social entrepreneurship". The OECD defines social enterprises as "any private activity conducted in the public interest, organized with an entrepreneurial strategy, but whose main purpose is not the maximization of profit but the attainment of certain economic and social goals …" (OECD 2013: 3). In Europe the concept of social enterprise is rooted in the tradition of social economy and which gathers entities with various legal forms such as co-operatives, associations, mutuals and foundations. Social enterprises can be distinguished from voluntary organizations by several criteria including a continuous activity producing goods and/or selling services and a minimum amount of paid work (ibid.: 4).

3.2.2 Relevance

Social innovators often operate in a hybrid space between non-profit/voluntary, public and for-profit/business sector (Berglund et al. 2012: 34 ff.; Bjerke and Karlsson 2013: 25; Defourny and Nyssens 2013: 49). In spite of their limited or non-profit orientation social enterprises generate substantial economic overturn and employment. In all Western societies a growing share of people is employed in the "third (or citizen) sector" and the "social economy" (Bjerke and Karlsson 2013: 41; OECD 2013: 12). At the same time social innovators and social enterprises contribute to delivery of good quality social welfare services, inclusion and local economic development. As several authors point out this relevance is bound to grow in the face of the crisis of many European welfare systems (Defourny and Nyssens 2013: 43). Finally, as stressed by a vast deal of literature, addressing societal challenges such as demographic change, health and sustainability requires social innovations to complement technological ones (Howaldt and Schwarz 2010; Young Foundation 2012). For all these reasons policy actors from several domains such as health, aging, environment and education are looking for ways to underpin social innovation capacities and to provide beneficial framework conditions for this kind of innovation. For this purpose they require information on these actors and their function within the innovation system. In particular however for mission oriented innovation policy strategies that aim at addressing societal challenges through innovation it is crucial to include social innovators into the picture as one of the key enablers of transformative socio-technical innovations. To sum up there are a number of good arguments for integrating social innovation as a relevant element of innovation systems be it on national, regional or local level.

3.2.3 Implications for the innovation system framework

From the point of view of the innovation system there are two major aspects arising from including social innovations and social enterprises independently from which of the two definitions is adopted. Firstly, the focus on *innovation in social practices* needs to be added to the established understanding of the innovation system which is very much focusing on technological innovation and does only marginally cover even commercially oriented soft innovations such as service innovation. Innovation in social practices and in particular those that are not primarily aiming at market introduction are not recognized by the established system. Accordingly, the respective social innovators, i.e. actors who develop new practices for addressing problems and needs, are hardly viewed as relevant innovation actors in the established framework. Integrating social innovation into the innovation system concept would therefore mean including the actors, infrastructures and institutions involved in innovation of social practices.

Secondly, both definitions point to *innovators in the third sector or citizen sector* (Bjerke and Karlsson 2013: 24) who are neither operating within a business environment nor employed in the public sector. These "citizen entrepreneurs" are sometimes seen as a subgroup of social entrepreneurs (Bjerke and Karlsson 2013: 43), a wider group that also includes business innovators with social purposes and public sector innovators. Similar to the case of user innovation one consequence of including social innovation is to allow a more active and innovating role for "ordinary citizens". In contrast to user innovators, however, social innovators do not turn to companies to feed in their ideas but rather act themselves to address the perceived need through new practice. Therefore, they need to be placed on an equal level to companies.

3.3 Collaborative innovation

3.3.1 Key aspects

A number of concepts in the current academic debate address the emergence of internet-based large- and medium-scale collaborations among individuals as a new mode of innovation, production and consumption.

One of the most prominent concepts is the notion of *"commons-based peer-production"* proposed by Yoachi Benkler from Yale Law School (Benkler 2002; 2004; 2006; 2011; 2013; Benkler and Nissenbaum 2006). Peer production is defined as a form of open creation and sharing performed by groups online that set and execute goals in a decentralized manner, harness a diverse range of participant motivations, particularly non-monetary motivations, and separate governance and management relations from

exclusive forms of property and relational contracts. The two core characteristics of commons-based peer production are decentralization and the use of social cues and motivations for coordination instead of pricing or hierarchies.

This definition explicitly excludes systems where the definition of the problem and setting of the goals is done by one central actor such as the InnoCentive platform or ones that rest primarily of financial motivations and narrowly focus on optimizing systems such as Amazon's Mechanical Turk and collective intelligence within firms where participants and resources are bound by contracts (Benkler 2013).

Benkler stresses that commons-based peer production as a socio-economic system of production has always played an important role, but is bound to gain even more relevance in digitally networked environments where coordination costs are significantly lowered: "*Facilitated by the technical infrastructure of the internet, the hallmark of this socio-technical system is the large scale collaboration of individuals [...] who cooperate effectively to provide information, knowledge or cultural goods without relying on either market pricing or managerial hierarchies to coordinate their common enterprise*" (Benkler and Nissenbaum 2006: 394).

While the model first emerged within the context of software production, this is but one instance of a more general phenomenon: "*At its core, peer production is a model of social production, emerging alongside contract- and market based, managerial-firm based and state based production*" (ibid.: 400). Benkler argues that, in certain cases, the commons-based peer production model is superior to the other two models due to information and allocation gains: "*the widely distributed model of information production will better identify who is the right person to produce a specific component of a project, all availability and to work on a specific module within a specific timeframe considered*" (Benkler 2006: 111). He states that in the particular conditions of the digitally networked knowledge economy, these conditions apply to an increasing number of production tasks. Benkler proposes three key preconditions for the applicability of commons-based peer production: Modularity of the objects, fine granularity of the modules and availability of low cost integration mechanisms and quality control. In his recent work he argues that the core benefit of commons based peer production, its ability to elicit self directed action from diverse sources of human talent and diverse motivations without the formalization losses of market based interactions, is particularly beneficial in highly uncertain and dynamic environments (Benkler 2013). Benkler's work was taken up and further developed in a number of publications both in academic and business realm (Bauwens et al. 2012; Wittke and Hanekop 2011b). A concept very much in line with the notion of commons-based peer production, but more focused on innovation is "*Open source innovation (OSI)"* (Raasch et al. 2008). The term is characterizing

a new innovation model emerging from the generalization of open source software development (OSS) and the transfer of this principle to industries. OSI refers to "innovation, which is (1) generated through volunteer contributions and (2) characterized by a non-market transfer of knowledge between the actors involved in invention and those involved in exploitation. Actors involved in invention provide open access to their results for anyone wishing to exploit them, allowing utilization, modification, and redistribution" (Raasch et al. 2008: 4). The OSI concept is not restricted to user communities but encompasses companies or intrinsically motivated volunteers.

A third concept related to collaborative innovation is the notion of *collaborative consumption*. This is a socio-economic model that is based on the shared usage of commodities (Piscicelli et al. 2015). In contrast to commons-based peer-production, the focus of this perspective is on the model of consumption rather than of innovation or production. Collaborative consumption is enabled by a specific type of "product service systems" (PSS), i.e. value propositions oriented to fulfill needs and provide satisfaction to consumers (or users) through delivery of an integrated system of products and services. PSS that enable collaborative consumption can be classified as use oriented or result oriented (Tukker 2006). The uptake of such models is often advocated for reasons of reducing the environmental footprint of production and consumption by increasing resource efficiency and reducing waste. A concept related to collaborative consumption that has received growing attention is the so called "sharing economy" (Botsman and Rogers 2010; Schor 2014). There is a wide range of activities discussed under the notion of the "sharing economy". At one end of the spectrum there are classical access-oriented business models that charge product use rather than selling product ownership such as leasing schemes. On the other end there are community based non-profit initiatives such as time banks or solidarity initiatives. With respect to the type of "sharing" activities Schor (2014: 2) distinguishes four broad categories of sharing economy: recirculation of goods, increased utilization of durable assets, exchange of services and sharing of productive assets. All four types can either be done for-profit or non-for-profit. They may be organized fully among individuals (peers) or be driven by a company. In his detailed analysis of a wide range of "sharing" practices Belk (2014) points out that only few of these practices really involve sharing in an anthropological sense. In particular practices such as short and long term renting and leasing as well as online mediated bartering are not really sharing practices but rather specific types of business relationships. He does however single out four "true" sharing practices (ibid: 14 ff.):

- Intentional online sharing of ephemera (opinions, expertise, photos, videos) as part of a group of others doing the same thing and thereby creating and recreating a community.

- Online facilitated offline sharing i.e. borrowing and lending without any fees involved such as e.g. non-profit tool libraries.
- Non commercial peer to peer online sharing such as Kickstarter.
- Non-profit online facilitated hospitality such as CouchSurfing.

While sharing is a very old social practice the fast spreading of collaborative services among very large groups of people is "enabled by a number of technological developments that have simplified sharing of both physical and non physical goods and services through the availability of various information systems on the internet" (Hamari et al. 2015: 2). Several empirical studies are under way, that are looking at the motivations of actors participating in collaborative consumption or sharing activities (Wittke and Hanekop 2011b). First results indicate that while value orientations play a major role studies should look at practices (Piscicelli et al. 2015) and extrinsic motivations (Hamari et al. 2015) as well.

3.3.2 Relevance

All three phenomena discussed above (commons based peer production, open source innovation and collaborative consumption) have a clear **economic relevance**. Commons-based peer production and in particular the free/libre and open source software (FLOSS) movement have developed highly successful innovations such as the GNU/Linux operating system or the Apache web server. Many established companies such as IBM, Google, HP and Oracle adopted FLOSS products and approaches in major parts of their technology business. Hybrid business models where commercial companies offer complementary services to FLOSS software or platforms for peer production activities abound and are highly successful. The collaboratively developed internet encyclopedia Wikipedia is one of the most used websites of the world, with its articles of a comparable quality to the Encyclopedia Britannica. Several peer produced sites such as TripAdvisor or Yelp are more successful than proprietary alternatives (Benkler 2013: 6 ff).

In the case of open software development, Bonaccorsi and Rossi (2003: 1252) argue that the license agreements used by the FLOSS developers have transformed software from a private to a non excludable and non rivalry collective good with major benefits for the overall innovation system. They stress that in general "in contexts where there is knowledge-intensive innovation, the goods no longer have a fixed nature but are to different degrees *both* private and appropriable, and public and universal" (ibid: 1257). This implies that collaborative innovation may have major advantages over company driven innovation in a knowledge intensive context with the consequence that basic

preconditions of the innovation system framework that rests on a clear distinction between these types of goods may have to be revised.

For the case of collaborative consumption economic relevance is also obvious. Several analysts and consultancies declare emphasizing the high profit potential of the "sharing economy". According to Geron (2013: 1) "FORBES estimates the revenue flowing through the share economy directly into people's wallets will surpass $3.5 billion this year, with growth exceeding 25%". The two most well known for-profit sharing platform such as Airbnb and Uber are valued at 10 and 18bn dollars respectively. At the same time most of the for-profit endeavors discussed under the heading of the "sharing economy" are a subset of service oriented business models such as e.g. renting or leasing i.e. non-technological innovations that have always been part of the innovation system in particular with the increasing service orientation of the last decades (Miles 2005).

Several authors however point out the potential **societal relevance** of collaborative innovation. Some authors expect major benefits for social welfare (Baldwin and von Hippel 2010). Others argue that peer production enhances the individuals' capacities to do more things for/by themselves and for/with others (Bauwens et al. 2012: 173). Jeremy Rifkin (2014) sees collaborative innovation as a key mechanism in his "zero margin cost society" with a substantially reduced environmental footprint. Benkler (2013) stresses that peer production may be able to generate solutions that could not have been achieved otherwise such as catering to highly diverse tastes and interests, mobilizing tacit knowledge and addressing situations of high uncertainty: "*A system that allows agents to explore their environment for problems and solutions, experiment, learn, and iterate on solutions and refinement without requiring intermediate formalizations to permit and fund the process will have an advantage to a system that does require those formalizations; and that advantage will grow as the uncertainty of what path to follow, who is best situated to follow it, and what class of solution approaches are most promising becomes less clearly defined*." (ibid: 10).

It seems that such situations of high uncertainty and complexity are especially relevant in the context of the "grand challenges" our societies are facing. Finally, as mentioned above, collaborative consumption is often seen as a key element of a sustainable economy due to its potential of increasing resource efficiency and reducing waste (Tukker 2006). At the same time scholars emphasize possible positive effects on social inclusion (Schor 2014) but also warn of possible dangers of certain concepts.

Several scholars stress that the growing relevance of collaborative innovation poses new research challenges to innovation studies. (Baldwin and von Hippel 2010: 30)

even call for a "paradigm shift" in innovation research: "*Taken in combination we think the patterns and findings we have described represents significant change in the "problem field" of innovation research, policymaking and practice*". The core questions highlighted evolve around better understanding the dynamics of collaboration (motivation, governance) and its enabling factors: "*How can autonomous, highly decentralized activities of large numbers of actors be coordinated and integrated into the highly divided production of sophisticated products and services? The critical point here is that collaborative production is a new kind of collective action that is socially embedded in internet communities. The specifics of this social embeddedness have received less attention in the debate"* (Wittke and Hanekop 2011a: 11).

"Another [avenue for future theoretical research] is to explore further the technological and institutional factors needed for collaborative non-rivalrous innovation to become an important contributor to technological progress and economic development" (Baldwin and von Hippel 2010: 31). A number of scholars call for substantial research efforts on cooperative human system design. The high number of ongoing failed and successful projects offers a unique possibility to study motivational drivers across communities and several empirical studies are already available such as (Hamari et al. 2015) who mapped 254 collaborative consumption websites. Bonaccorsi and Rossi (2003) suggest the collective action framework and the concept of critical mass to study the evolution of Open Source software.

Another key research domain is the combination of classical firm-driven and collaborative innovation activities: "*The critical question here is how can collective action of autonomous actors be successfully combined with the value-creation activities of companies? This is a controversial issue in the current debate*" (Wittke and Hanekop 2011a: 11).

3.3.3 Implication for the innovation system framework

Even if we apply a broad definition of innovation as the generation of novel solutions that are adopted by society rather than only the market, not all phenomena described above are innovation activities but rather production, service provision, development or consumption. Still, in all these cases the collaborative mode of providing these activities can be seen as a substantial organizational innovation often complemented by a series of groundbreaking institutional innovations such as the FLOSS licensing agreements. At the same time, there certainly is a substantial part of commons-based-peers production, Open Software Innovation and collaborative consumption truly dedicated to innovation such as e.g. open design initiatives and software development. In addition, as argued above, more and more classical innovation activities are combined with col-

laborative innovation modes. As several scholars stress, the number of innovation domains where collaborative modes prove superior to firm based ones is bound to grow. Thus it seems relevant for the innovation systems approach to consider its suitability for underpinning the investigation of collaborative innovation and supporting policy strategies. At first sight there are three key implications:

Broaden the notion of key innovation actors

Collaborative innovation projects involve hundreds of individuals with diverse motivations coordinating with each other. This raises the question whether individual innovators need to be recognized as innovation system actors. Secondly, communities of actors ranging from Neighborhood-Innovators (Schor 2014: 3) to programmer circles and hackerspaces become key nodes of the innovation ecosystem as argued by Bauwens et al. (2012: 4): "*Two main agents of transformation guide this work. One is the* emergence of community dynamics as an essential ingredient of doing business*. It is no longer a matter of autonomous and separated corporations marketing to essentially isolated consumers, it is now a matter of deeply inter-networked economic actors involved in vocal and productive communities*." Finally, according to some researchers, actors of the social economy (Rifkin 2014: 17 ff.) play a major role in collaborative innovation.

Recognize diverse innovation motivations

Classical innovation system theory is mainly preoccupied with market based innovation that is driven by profit incentives. Several policy measures focus on counteracting the effects of distorted market signals (market failure) and restoring these financial incentives. Collaborative innovation does by definition harness a wide range of motivations (Benkler et al. 2013: 11) many of them non monetary such as e.g. desire to advance the social wellbeing of humanity (Rifkin 2014: 21 ff.), serve needs at community scale (Schor 2014: 5), enhancement of reputation or just pleasure. Innovation systems aiming at mobilizing this type of innovation capacity would need to understand and mobilize this diverse mix of motivation.

Consider new enabling infrastructures and institutions

Collaborative innovation activities require specific enabling infrastructures. One key aspect that is emphasized in the literature (e.g. Strandburg 2008; Baldwin von Hippel 2010; Bauwens et al. 2012) is the provision of adequate forms of intellectual property rights. "*The combined effect of digital reproduction and the increasingly 'socialized' production of value, makes the individual and corporate privatization of 'intellectual'*

property if not untenable, then certainly more difficult, and in all likelihood, ultimately unproductive. Hence the combined development of community-oriented and 'open' business models, which rely on more 'social' forms of intellectual property" (Bauwens et al. 2012: 4).

Other aspects of enabling infrastructures for collaborative innovation mentioned by various authors are public sharing platforms (Rifkin 2014; Schor 2014), Internet/Internet of things (secure neutral, protected, collaborative/p2p (Rifkin 2014), reliable reputation mechanisms (Schor 2014: 8), intellectual infrastructure (e.g. Open Science) (Frischmann 2012).

3.4 New innovation intermediaries

3.4.1 Key aspects

The innovation system concept based on Kuhlmann and Arnold (2001) includes the group of intermediaries that mediate between "education and research" and the "industrial system" (cf. Figure 1). When the increasing complexity of innovation systems is taken into account, the perspective on intermediary actors and actor groups in innovation systems should be broadened to include further actors beyond research institutes and brokers (given as examples in the above-cited concept). In addition, the group of intermediary actors should be further investigated in order to obtain a more detailed picture on their characteristics, activities and relationships with other players. Relevant issues comprise questions like: Which actors or stakeholders are associated with and summarized under the label of "intermediaries"? Which functions, goals, influence and impact do intermediaries have? Is this group of intermediaries comparatively stable over time or does it involve more and/or different stakeholders in the course of the evolution of innovation systems? Which relationships with further actors in the innovation system do exist (see also Koschatzky et al. 2014)?

The initial innovation system concept assigns intermediaries a mediating function between education, qualification and research on the one hand and private businesses on the other hand. Intermediaries thus assume the role of transferring knowledge generated in the science and research system to private companies where it is applied and exploited for innovation (Meißner 2001). Conversely, companies may transfer their need for research via intermediaries to the science system. From this rationale follows that intermediaries "translate" knowledge between science and industry actors, proceed, adapt and transfer it between them. Their function could be described as brokering, bridging, mediating, or transferring knowledge (Howells 2006; Klerkx and Leeuwis 2009; Stewart 2008). Examples for those intermediary actors are for instance applied

research institutes or development providers. In parallel, it is assumed that the knowledge production and knowledge exploitation parts of the innovation system maintain direct relationships.

With the increasing degree of interrelated innovation processes that involve various different actors this picture seems very simplified. Further actors enter the scene: besides (public or private) research institutes service providers, networks, clusters, public agencies etc. are involved in knowledge transfer and intermediation (cf. Nauwelaers 2011). Part of these functions can also be standardized and delivered for instance through internet portals or platforms. In addition, the institutional structure of intermediaries seems to become increasingly blurred: Besides organizations with a formal structure that exclusively work on innovation mediation, there are for instance departments within universities that fulfill intermediary functions towards industry (cf. Smedlund 2006). Finally, the intermediation function is not restricted to bridging between science and industry; there are also bridging actors within those sub-systems, with the policy area, with users and further elements of the innovation system (Nauwelaers 2011).

Intermediaries can hence be described as a heterogeneous and dynamic element in innovation systems. Evolutions and modifications may affect functions and tasks, but also the composition of actors: new intermediaries may emerge, while established ones may disappear or – more probably – turn to other fields of activities (Koschatzky et al. 2014). Further, it can be assumed that the general framework conditions for innovation as well as the political system and its shaping function also have an impact on the types and numbers of intermediaries (see the aspects of coordination and governance in the Varieties of Capitalism approach, Hall and Soskice 2001).

Investigating innovation systems and their individual characteristics leads to consider intermediaries under different perspectives. In the case cited above, i.e. actors whose primary function is to broker and transfer knowledge within the innovation system, intermediaries' activities can be considered as deliberate or intentional processes that aim at facilitating innovation. However, there are further actors whose activities can be considered as by-product of their primary function (e.g. research-liaison offices at universities, cf. Nilsson and Sia-Ljungström 2013: 165), or whose activities do not primarily target innovation, but have an indirect impact on innovation. Various examples can be cited in this respect: non-researching firms that focus on development activities, solution providers mandated by their (industrial) clients, or individuals who express their vision on future developments, technological pioneers, clubs and lobby groups that express their clients' interests (cf. van Lente et al. 2003). Consumer advisors, technical advisors (such as Chaos Computer Club, technology assessment), employers' interest groups such as trade unions, but also the 'crowd', i.e. the critical public,

have an important role to play in this context, since many of their activities have an indirect impact on the innovation system. As a consequence, we propose to broaden the definition of 'intermediaries' and to include (1) mediating bodies that fulfill a deliberate function in innovation systems by coordinating two or more actors or actor groups and (2) actors that do not primarily target innovation, but whose activities have an impact on parts of or the whole innovation system. This includes associations as defined by Koschatzky et al. (2014), but also individuals and interest groups that are composed (often for a limited time) to defend a specific topic that has implications on innovation and the innovation system.

How to define these new actors?

Recent literature has to an increasing extent included innovation intermediaries into the discussion of innovation activities and innovation systems (Howells 2006; Koschatzky et al. 2014; Nauwelaers 2011; Stewart 2008; van Lente et al. 2003). Theoretical and conceptual discussions are enriched by case studies (see for instance Dalziel and Parjanen 2012; Howells 2006; Nilsson and Sia-Ljungström 2013). Watkins et al. (2014) focus on industry associations as institutional intermediaries in innovation systems, particularly in developing countries, van Lente et al. (2003) discuss "systemic intermediaries" in contrast to "traditional intermediaries" and their focus on bilateral operations, while Bennett (1998a; 1999; 2000) and Bennett and Ramsden (2007) focus on business associations and trade organizations.

According to Dalziel (2010: 1), innovation intermediaries are "... organizations or groups within organizations that work to enable innovation, either directly by enabling the innovativeness of one or more firms, or indirectly by enhancing the innovative capacity of regions, nations, or sectors" (cf. also Smedlund 2006; van Lente et al. 2003). This definition refers to the above-mentioned first type of actors with immediate and deliberate effects on firms' innovation activities. Intermediaries of this type may be of public, private or mixed nature (van Lente et al. 2003). Following this definition, all organizations and actors that pursue the goal to enable innovation would be included in the group of innovation intermediaries. They can be identified and described on the basis of their activities and functions. In addition however there are actors that fulfill a different primary goal, but whose activities also have an impact on innovation and the innovation system.[2] This includes individuals or groups of individuals who might act on their own, but might also be connected through different degrees of formalization (tem-

2 In addition, there are hybrid cases such as technology transfer offices at universities (Dalziel 2010).

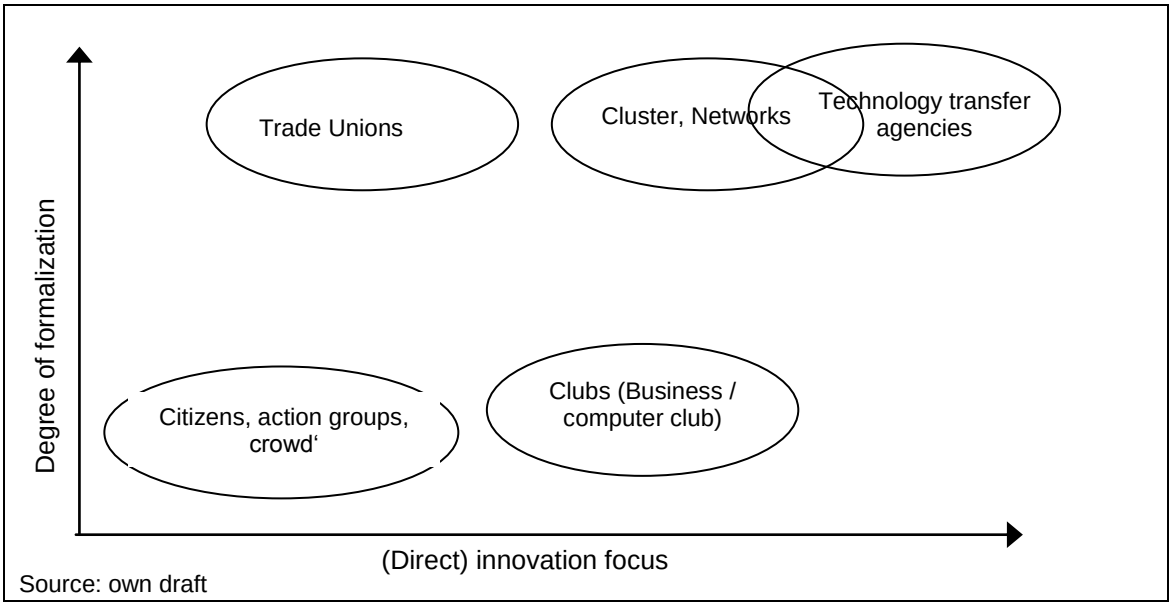
porary relations, advocating specific interests or ideas vs. relations in a long-term perspective as registered association).

This shows that the group of "intermediaries" consists of a core of actors with well-defined and innovation-focused functions and activities, encircled by divergent actors whose activities are to a decreasing extent directly focusing on innovation and whose organizational structure becomes less uniform and formalized. Hence the picture becomes increasingly blurred; "new intermediaries" belong to this outer circle. Identifying and analyzing this latter type seems to be (1) very specific in individual innovation systems, (2) hardly possible through directly innovation-related functions and activities, and (3) relying on qualitative information and good knowledge of the innovation system under analysis. Figure 2 tries to capture this by illustrating some examples in a matrix shaped by the innovation focus and the degree of formalization.

Summarizing, "new intermediary actors" are individuals or associations that so far have not explicitly been integrated in innovation studies because of their limited direct relation to innovation. These actors' motivations focus on fields outside the innovation process, but have implications on innovation. Examples are trade unions (main focus on representing employees, labor conditions, etc.), business clubs (main focus on representing their clients' interests) or computer clubs (mediation technical/ social development) or citizens (expression of interests in selected technology-related fields) (cf. Figure 2). Their main activities are in representation of interests, lobbying or awareness rising, which might have an impact on technology and innovation development or prevention.

In addition, intermediaries might also act as 'bridges' beyond knowledge producers and knowledge users, e.g. with the political system. Innovation dialogue processes and platforms as well as (regional) conferences could be cited as examples.

Figure 2: Selected intermediaries, their degree of formalization and (direct) focus on innovation (schematic overview



Source: own draft

3.4.2 Relevance

Intermediaries have been considered in innovation system concepts based on their direct knowledge and technology their intermediation between knowledge of different parts of the system. In the last years, a rising awareness for additional actors/ processes / functions and interrelations could be observed. It becomes obvious that the intermediary segment is much broader than initially conceived, and that it shapes various parts and facets of an innovation system. Since innovation becomes increasingly complex and comprehensive, not considering these actors and activities would give an incomplete picture. The investigation of "new intermediaries" in the concrete case is very specific to the innovation system in question, because their number, characteristic and degree of freedom highly depend on the legal and institutional framework conditions. However, due to their high (and increasing?) presence and specific mediating functions, it is indispensable to include them in the innovation system concept. As intermediaries in the "traditional" understanding, they may have important (direct or indirect) impacts on innovation and the innovation system – some of them rather in the long-term perspective – and should thus be considered in innovation system analyses.

3.4.3 Implications for the innovation system framework

The broadening of the notion of innovation mediators implies that one box with one specific mediation function e.g. between universities and companies is no longer sufficient. As a consequence, we propose to broaden the view related (1) to the specific

actors to be considered and (2) to the interlinkages they organize. The first notion refers to actors that have previously not been considered in innovation system analyses and/or actors with less innovation-oriented primary functions, while the second notion emphasizes the linkages that those intermediaries occupy. In terms of actors to be considered, the new innovation system model should broaden the notion of intermediaries and include representatives of relevant actors such as (business) associations and clubs, actor interfaces such as networks and clusters, representatives of co-workers in (innovating) companies such as trade unions, in addition to (industry-oriented) research institutes, transfer agencies, etc. In terms of interlinkages, the new model should go beyond relating the industrial and the research system and broaden the view to mediating activities within and between all sub-systems of the innovation system model. This view broadens the initial concept of brokering scientific and technological knowledge, and includes knowledge flows leading to non-technological innovation and embraces actors that were not at the core of previous innovation system analyses, such as for instance specialized service providers, agencies that focus on creative industries, but also platforms relating citizens and social actors with business and research actors. This full spectrum of intermediary actors and mediation functions leads us to consider mediators as "background cloud" in the new innovation system model.

3.5 Venture philanthropy

3.5.1 Key aspects

Along with the rise of social entrepreneurship in the mid 1990s, the mode of financing social projects changed significantly. Promoted as a way to revolutionize grantmaking, "venture philanthropy" developed significantly in the US in the mid 1990s, took hold in the UK from 2002 and since 2010 and is expanding into continental Europe. According to Moody (2008) venture philanthropy grantmakers borrow the venture capital funding model, which has been used to nurture and grow start-up businesses in the "new economy", and adopt and adapt the model for philanthropic funding. Due to its role in providing finance and professional services to social purpose organizations – helping them expand their social impact – venture philanthropy and social entrepreneurship are in many ways two side of one coin: "The rise of social entrepreneurship and the changing face of philanthropy are reshaping the social sector in tandem" (Martin 2004: 21).

Venture philanthropy is an approach to charitable giving that applies venture capital principles, such as long-term investment and hands-on support to the social economy. Venture philanthropists work in partnership with a wide range of organizations that

have a clear social objective. These organizations may be charities, social enterprises or socially driven commercial businesses, with the precise organizational form subject to country-specific legal and cultural norms. According to John (2006) key characteristics of venture philanthropy are:

High engagement: Venture philanthropists have a close hands-on relationship with the social entrepreneurs and ventures they support, driving innovative and scalable models of social change. Some may take board places on these organizations, and all are far more intimately involved at strategic and operational levels than are traditional non-profit funders.

Multi-year support: Venture philanthropists provide substantial and sustained financial support to a limited number of organizations. Support typically lasts at least three-to-five years, with an objective of helping the organization to become financially self-sustaining by the end of the funding period.

Tailored financing: As in venture capital, venture philanthropists take an investment approach to determine the most appropriate financing for each organization. Depending on their own missions and the ventures they choose to support, venture philanthropists can operate across the spectrum of investment returns. Some offer non- returnable grants (and thus accept a purely social return), while others use loan, mezzanine or quasi-equity finance (thus blending risk-adjusted financial and social returns).

Organizational capacity-building: Venture philanthropists focus on building the operational capacity and long-term viability of the organizations in their portfolios, rather than funding individual projects or programs. They recognize the importance of funding core operating costs to help these organizations achieve greater social impact and operational efficiency.

Non-financial support: In addition to financial support, venture philanthropists provide value-added services such as strategic planning, marketing and communications, executive coaching, human resource advice and access to other networks and potential funders.

Performance measurement: Venture philanthropy investment is performance-based, placing emphasis on good business planning, measurable outcomes, achievement of milestones, and high levels of financial accountability and management competence.

Basically, venture philanthropy is about the concentration of financial resources to a few selected organizations, which are considered as efficient and effective. These organizations are supported over a long period of time with the necessary resources. Therefore, the social entrepreneur will not only receive financing but also management

support, social networks and contacts. The term "high engagement philanthropy" has been created to describe this kind of activity (Venture Philanthropy Partners and Community Wealth Ventures 2004).

The specific financing modes applied by venture philanthropy are similar to those known from the classic venture capital funding: donation, grants, soft loans, guarantees and equity (Achleitner 2007). However, in compared to classic venture capital funding, donation is the most important element in venture philanthropy (John 2006).

3.5.2 Relevance

The expansion of social entrepreneurship and venture philanthropy results in the establishment of new intermediaries. Given the fact that social entrepreneurs spend most of the time with fund raising, new actors or organizations can strengthen the efficiency of the whole sector (Drayton 2006). At the same time foundations and donors devote a large part of their resources on the identification and selection of projects, Meehan et al. (2004) come to the following conclusion: "*That means that in the social capital market, the cost of raising capital consumes roughly 22 to 43 percent of the funds raised, a dreadfully inefficient process*".

Worldwide, not only in the US and UK, creative approaches have been developed to establish a philanthropic version of most of the areas of the capitalist market system: Social Investment Banking, Social Investment Management, a conversion of private banking, information brokers and analysts and rating agencies are according to Maitland (2004) typical concepts of this trend. Like the "normal" capital markets, which require intermediary organizations to be efficient, they are similarly significant for the private financing of the social sector.

The relevance of venture philanthropy for adapting the innovation system concept lies in the fact that respective intermediary organizations can be regarded as a new and increasingly important group of actors, which have the potential to improve the framework conditions for innovation. However, their importance varies between the different countries. The US is clearly a pioneer in this field – based on decades of experience in the area of classic venture capital funding and the importance of philanthropy in general. In Germany for instance, opportunities for venture philanthropy may arise as the federal state leaves more and more room for social activities (Achleitner 2007). Therefore, social entrepreneurship receives more and more support. New organizations like "Ashoka – Innovators for the Public", BonVenture (the first venture philanthropy fund in Germany, founded in 2003) or the Schwab Foundation for Social Entrepreneurship are examples for new models to support social entrepreneurship. However, when speaking

of innovation as the main "output" of innovation systems, the project portfolio of the relevant organization has to be analyzed in detail, in order to assess the "innovative content" of the (social) projects funded.

3.5.3 Implications for the innovation system framework

The emergence of venture philanthropy in the innovation field is increasing the diversity of funding sources. In particular when integrating social innovation into the system view, it seems crucial to consider this type of funding in addition to more traditional sources. At the same time the function is different from classical financing as there is a normative component in the selection of projects so next to finances also orientations are injected into the system.

3.6 Social and relational capital

3.6.1 Key aspects

When introducing the actor perspective in the innovation system concept, a relation to the socio-cultural dimension of innovation, defined as social and not only as technical process (cf. section 3.2), is necessary. In this respect, two sociological concepts are of relevance: social and relational capital.

Regarding social capital, a distinction is made between the collective perspective by Bourdieu (1979), and the more individualistic perspective by Coleman (1988). When the analytic view is on actors, both perspectives are relevant, because an actor in an innovation system not only acts for himself, but has to be considered in the systemic and interactive innovation perspective. In this respect, social capital *"...consists of the stock of active connections among people: the trust, mutual understanding, and shared values and behaviors that bind members of human networks and communities and make cooperative action possible*" (Cohen and Prusak 2001: 4). Social capital does not only consist of active connections, but also of their content. This content can be expressed by obligations and expectations, information channels and social norms (Coleman 1988). Nevertheless, the individual absorptive capacity of social contacts and the making use of them are as well important. Therefore authors like Charmes (1998) or Mahieu (1998) emphasize that social capital is an individual and not only a collective asset.

In the economic context, which is of great relevance for an innovation system, Putnam describes social capital as "*features of social life – networks, norms, and trust – that enable participants to act together more effectively to pursue shared objectives... So-*

cial capital, in short, refers to social connections and the attendant norms and trust" (Putnam 1995: 664-665). Here we find the collective character of social capital and the importance of networking in attaining it. Also Paldam (2000: 630) states that "*social capital deals with cooperation in groups and networks within groups of people*". He concludes that it is a micro concept, which may be aggregated to the national level (and thus to the regional level as well).

Summarizing this short reflection, it becomes clear that social capital is constituted by general components like trust, norms, values, attitudes and understandings and is attained through the process of social interaction. Since social interaction plays an important role, the dimension of social capital is not only individualistic, but has a strong collective feature. Social capital can be regarded as public good, but since networks might not be open to everybody and groups are able to control the access of other individuals to the group, it could also have the character of a club good.

A typical club good is relational capital. It stresses the importance of interactions. According to Capello and Faggian (2005: 77) it is defined as *"...the set of all relationships – market relationships, power relationships and cooperation – established between firms, institutions and people that stem from a strong sense of belonging and a highly developed capacity of cooperation, typical of culturally similar people and institutions".* Relational capital is therefore associated with social capital, because it is "...the sum of the actual and potential resources embedded within, available through, and derived from the network of relationships" (Nahapiet and Goshal 1998: 243).

Building on available social and relational capital, collective actions by more than one actor become possible. According to the collective action framework literature, organizations in the form of groups or clubs emerge as response to the need of joint action (i.e. collective interests) and the supply of collective goods (Olson 1985). This again stresses that not only single actors need a stronger focus in innovation system analyses, but groups of actors pursuing joint interests.

3.6.2 Relevance

Actors and actor groups can act as collective bodies between individual and state action (Bennett 1998a) and be regarded as an outcome to the need of collective action. Their range of activities is quite broad and includes collective bargaining (e.g. trade unions), self-regulation (e.g. development and protection of standards), representation and lobbying, as well as forum or club activities (e.g. social exchange and informal networking) (Bennett 1998b). In this respect, actors in an individualistic and in a group perspective can be related to social as well as relational capital. In the case actors in-

tend to perform intermediary functions, which are a typical activity within innovation systems, relational capital and thus the underlying amount and quality of relations among relational actors is a key factor for successful collective action. Relational capital implies a capability for interaction and collective learning, and is therefore an important input and outcome of innovative activities (Capello and Faggian 2005; Maskell 2000).

3.6.3 Implications for the innovation system framework

Both relational and social capital are closely related to social interaction and thus to social proximity and embeddedness. Proximity is an important factor in innovation processes and innovation systems, especially regarding the exchange of tacit, locally-bound knowledge and expertise (Carrincazeaux and Coris 2011). Embeddedness, which was introduced by Granovetter (1973; 1985) into the scholarly debate, is especially similar to social proximity. Among the five different forms of proximity (cognitive, organizational, social, institutional, geographical), social proximity reflects *"…economic relations (that) are ... embedded in a social context*" (Boschma 2005: 66). It is therefore necessary to emphasize the relevance of proximity relations between innovation actors, e.g. through non-transferable person-embodied knowledge, in the innovation system concept (Asheim and Coenen 2005; Asheim and Gertler 2005). Due to the fact that innovation activities strongly rely on the creation of new, so far unknown knowledge, the immediate framework in which innovation takes place has to be elaborated and the innovation system approach adapted to the specific actor constellations.

Another implication is the focus on actors and actor groups which pursue joint interests. In analyses it should be made clear who are the most important (or relevant) actors or actor groups, how are they related and what are their major interests and collective action channels. Without this knowledge a sound analysis of the efficiency of an innovation system will not be possible.

3.7 Non R&D-intensive industries

3.7.1 Key aspects

Arundel et al. (2008) found that the half of the surveyed firms in the Community Innovation Survey does not conduct any research or development at all. Drawing from the innovation and research policy debate, research and development (R&D) is just one possibility in which innovativeness can be attained. Thus, there are many firms which can be innovative without R&D and the levels of economic performance do not differ (Hirsch-Kreinsen 2008a). However, by what are these firms characterized?

Manufacturing industries can classified into the divisions "high-tech", "medium-tech" and "low-tech" by their sectors' average share of R&D expenditures (Hirsch-Kreinsen et al. 2005; von Tunzelmann and Acha 2005). The OECD classification established in 1994 consists of four thresholds instead of just three, and was modified by Legler and Frietsch in 2007. Sectors with a less than 3%, respectively less than 2.5% (Legler and Frietsch 2007) share of R&D expenditures in turnover are classified as non-R&D-intensive or low-tech sectors (OECD 1994). Industries such as textiles, clothing, leather products, furniture, and metal products belong to this category. Industries such as aerospace, computers, semiconductors, telecommunications, pharmaceuticals and instruments are commonly classified as "high-tech" with more than 7% share of R&D expenditures in turnover. Medium-tech sectors, like electrical and non-electrical machinery, transport equipment and parts of the chemical industries possess a share of R&D expenditures in turnover between 2.5% and 7%.

Based on this classification, low-tech and medium-low-tech sectors account for the largest part of manufacturing output and employment in OECD and European economies, and their preponderance is decreasing only at a very slow rate (Sandven et al. 2005; Bender 2006; Gehrke and Legler 2010; Som et al. 2010; Hahn 2009). Non-R&D-intensive firms generally perform more weakly with regard to product innovation compared to R&D-intensive firms (Huang et al. 2010; Arundel et al. 2008; Heidenreich 2009), but low-tech and medium-low-tech firms are key customers of innovation generated in high-tech industries and are also involved in knowledge-creating activities (Robertson and Patel 2007). Hauknes and Knell (2009) revealed the direct and indirect flows of knowledge between different R&D-intensive industries in several countries in Europe. Furthermore, Pavitt (1984) showed that technology flows between high-tech and low-tech industries are dominated by the flows into low-tech sectors. Besides low-tech industries stimulate or even influence new innovation activities in high-tech sectors, either by giving customer feedback on their practical experiences with high-tech products or by acting as suppliers to high-tech industries (Mendonça 2009).

Even though innovative product-related services are often developed in close association with a new product, non R&D-intensive industries also show weaker performance in the field of product-related services (Kirner et al. 2008, 2009b). Thus, innovation in low-tech firms is assumed to be mostly in the form of improvements to existing products (Raymond and St-Pierre 2010). These results also correspond with the taxonomy of Pavitt (1984) who argued that firms of traditional (= non R&D-intensive) sectors of manufacturing consist largely of small, "supplier dominated firms" with weak in-house R&D and weak engineering capabilities.

3.7.2 Relevance

In the classical linear understanding of the innovation process, R&D plays a leading role (Godin 2006). R&D investments are expected to lead to the creation and development of prototypes and to the introduction of new products to the market (Saviotti and Nooteboom 2000). This linear R&D-based innovation paradigm has been challenged from different perspectives. Firstly, innovation is often in practice a non-linear, rather complex, collaborative and multi-level process which is embedded in innovation systems (Lundvall 1992). Secondly, non-technological forms of innovation are also increasingly recognized as distinct innovation paths which can contribute to a firm's economic success (Damanpour and Evan 1984; Piva and Vivarelli 2002; OECD 2005). Innovation is also linked to complex mechanisms of knowledge distribution (Edquist 1997) and can arise through different innovation modes.

Given the different modes of innovation, the interdependent nature of innovation processes and their embeddedness into innovation systems, innovation can be assumed to be a diverse phenomenon with R&D forming only one of many possible sources. According to Schumpeter, innovation is a means to an end, the end being economic success, increased competitiveness or growth (Schumpeter 1934). Besides developing new products, manufacturing firms can also develop new product-related services, introduce innovative manufacturing technologies or implement innovative organizational concepts. Each of these innovation types can be a source of competitive advantage in itself.

But today, the majority of scholarly research, policy documents and instruments on innovation is still based on neoclassical models of mainstream innovation research (Arundel 2007), however, other methods that firms can use to innovate increase slowly. If only R&D indicators are used to measure innovation capability, firms without R&D will not be captured adequately and in consequence they will be classified as non-innovative or even be excluded from innovation studies. Firms that do not perform formal R&D have been largely neglected by academic research and the policy community.

Non-R&D-intensive firms are definitely able to successfully develop new products or even market innovations (Kirner et al. 2009a) and new process innovation (Evangelista et al. 2002; Nascia and Perani 2002). Innovation activities of non-R&D-intensive firms are often more focused on production efficiency, product differentiation and marketing (von Tunzelmann and Acha 2005; Heidenreich 2009) by process and organizational innovations (Som 2012).

A source of innovation for non-R&D-intensive firms are the acquisition and purchase of innovative machinery and equipment or intermediate goods from external sources (Bender 2006; Bargegil et al. 2008). They are thereby relatively more dependent on the diffusion of external knowledge than R&D-performing firms (Arundel et al. 2008; Heidenreich 2009). The development and availability of absorptive capacity plays a major role, as it enables them to manage and implement technology adoption successfully (Bender and Laestadius 2005; Hirsch-Kreinsen 2008b; Hauknes and Knell 2009). Non-or-less-R&D-performing firms gain innovation success from external knowledge sourcing or formal cooperation with external partners, particularly with customers, suppliers and competitors (Huang et al. 2010; Rammer et al. 2009).

Creativity and innovation-enabling capabilities through customer-related and practical knowledge are furthermore a key source for innovation in non-R&D-intensive firms (Bender and Laestadius 2005; Hirsch-Kreinsen 2004, 2008a). For instance, non-R&D innovators, like production engineers, design staff or low- and unskilled production employees are alternative sources of knowledge generation and accumulation than science-based modes of expert knowledge (Arundel et al. 2008; Kirner et al. 2009b). Internal organizational practices, knowledge management and personnel policy, in particular, play a vital role for innovation and the innovation performance of low-tech firms (Bender 2006; Hirsch-Kreinsen 2008b; Rammer et al. 2009).

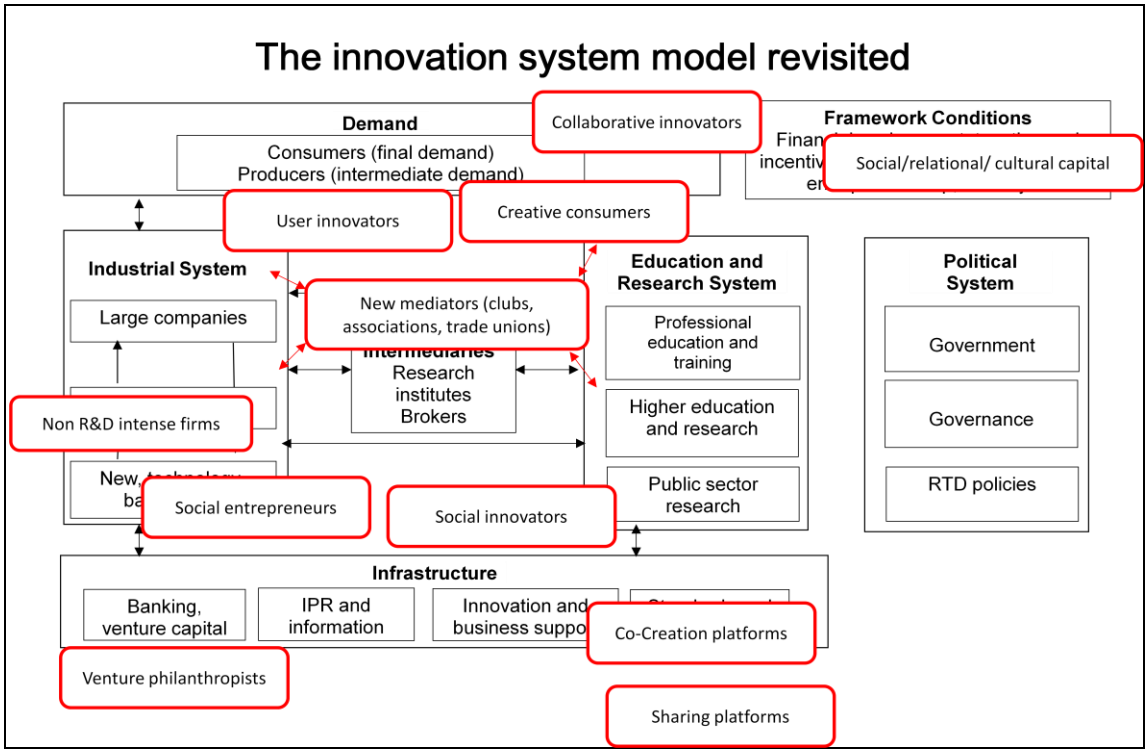
3.7.3 Implications for the innovation system framework

Innovation in non-R&D intensive industries does not fundamentally question the established notion of the innovation system. Rather, the respective companies can be seen as an important part of the industrial system. Nevertheless, it is obvious that the established perception was very much focused on high- or at least medium-tech companies. The transfer of scientific knowledge from universities and research organizations was viewed as the main mode of knowledge transfer relevant for innovation. As shown above, however, non R&D intensive innovation builds on different ways of knowledge exchange and also rest on different knowledge types such as non formalized tacit knowledge. Therefore, explicitly including this sector of industry seems crucial in order to increase the relevance of the heuristics for large parts of the innovation landscape.

4 Conclusions – Towards a broadened innovation system framework

As the discussions in the last sections have revealed, recent innovation debates imply a number of revisions of the innovation system concept. The innovation system framework needs to cover a wide range of new actors and institutions in order to allow for an analysis of the capacity of a system to generate novel solutions (cf. Figure 3).

Figure 3: New elements in the innovation system framework



Source: Adapted from Kuhlmann and Arnold (2001)

When reviewing the phenomena discussed above, it becomes apparent however that adding a few new boxes and arrows will not do justice to the new perspectives.

Several of the phenomena discussed above such as collaborative consumption, user innovation and the role of social and relational capital point to a more fundamental blurring of clear boundaries between actors roles and functions.

In addition it becomes obvious that it is no longer possible to make a distinct assignment of functions[3] in the innovation process to certain actors and vice versa:

- The function of **knowledge generation** can no longer be primarily situated at the research system. Other actors such as user innovators, customers, new intermediaries, collaborative innovators and citizen innovators make substantial contributions especially to the newly recognized innovation types such as low tech innovation and social innovation, but also to classical product innovation.
- For the function of **resource mobilization** industry remains the main contributor for classical product innovations. When looking at the broader range of innovation activities in the public and third sector, however, the contributions of other actors such as venture philanthropists, third sector institutions, governments, cities and individual citizens become ever more relevant.
- **Consumers and customers** can no longer be assigned to the function of "market formation". Rather they make key contributions to knowledge generation, diffusion and resource mobilization.

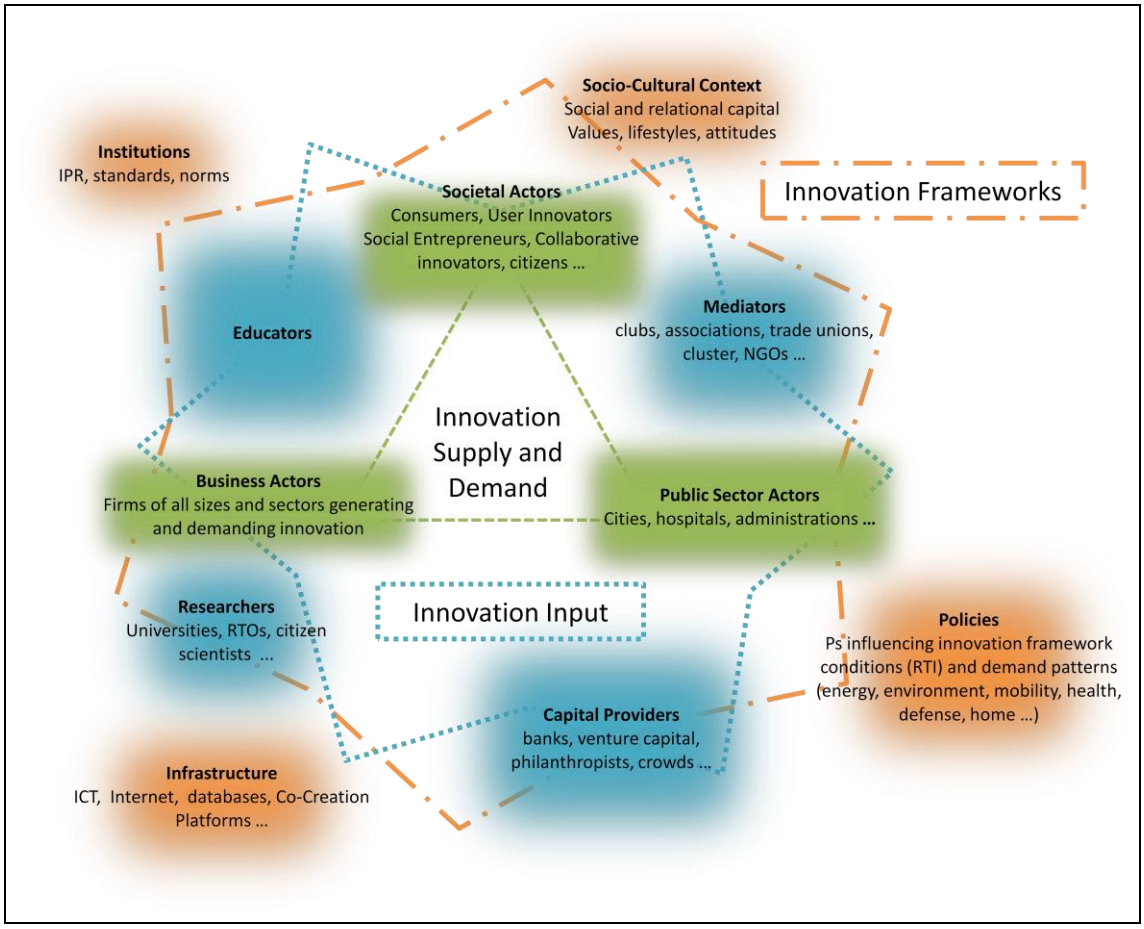
These considerations point to the need for a more radical revision of the innovation system analytical construct. Firstly, an analytical framework for the innovation system is required that captures the broadest possible notion of innovation as "novel solutions" that are successfully embedded into society be it new technologies, products, social practices, processes and concepts. Market uptake is one of the possible pathways for such an embedding, but others such as e.g. implementation in a public sector organization such as a hospital or uptake of a social innovation in several communities are equally covered. Secondly, the framework should not fix any assignment of actors and functions but rather allow for multiple roles of actors groups (e.g. companies as providing, demanding and financing innovation) as well as fulfillment of functions by several different actor groups.

In order to fulfill these requirements we have developed the analytical framework depicted in Figure 4.

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3 Innovation systems are considered to provide certain functions for the innovation process. Typologies differ slightly but the main functions discussed in literature are knowledge generation, knowledge diffusion, guidance for the direction of search, entrepreneurial experimentation, market formation, legitimation and resource mobilization (Köhler et al. 2016).

Figure 4: Revised innovation system analytical framework



Source: own drawing

We distinguish three types of contributions to innovation processes symbolized by the dotted lines. Actors that may contribute to the respective innovation types are listed in the colored clouds. The fuzziness of the clouds emphasizes that the actual list of actors is open so new actors may contribute here at any time.

Situated **at the core** of the analytical framework is **innovation supply and demand** (in grey). This type of direct contribution to the dynamics of innovation can be fulfilled by a wide range of diverse actors from civil society, business and the public sector who are immediately engaged into the innovation process through generating, requesting or embedding innovations.

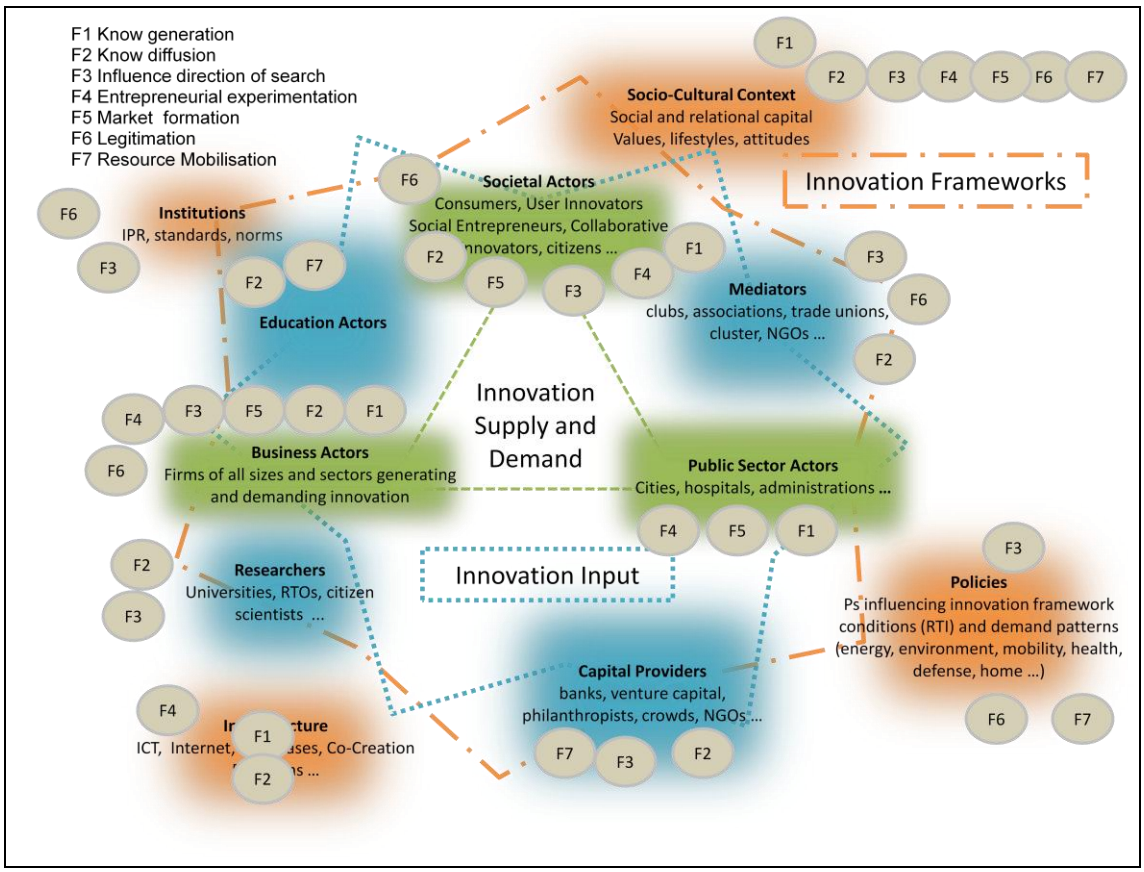
On a **second level, innovation input** (in green), are the actor groups that feed the innovation process by providing crucial inputs such as research organizations providing scientific knowledge, education providing competent innovators and users and financers providing financial resources. Actors from the first level may contribute here as well of course as is indicated by the grey clouds outreach.

Finally, at the **third level** we place the **innovation frameworks** (in purple). One core element here is provided by basic enabling infrastructures for the different types of innovation ranging from fast internet to co-creation platforms. Also crucial for the framework are fundamental institutions such as intellectual property rights as well as standards and norms. Finally, innovation frameworks are provided by the cultural context with its social and relational capital as well as by various policies among them research and innovation policies but also other fields such as social policy, health and transport that impact on innovation framework condition.

Just like the established system depicted in Figure 1, our advanced framework does not attempt to depict one specific innovation system. Rather it is meant as an analytical framework guiding the analysis of any spatial (national, regional) innovation system to identify its specificities and support policy makers in advancing the system's capacities. We do hope however that our broadened concept will allow for an analysis that reveals a more diverse set of innovation types and thereby underpins innovation policy strategies seeking to extent support to a wider range of innovation types as it is increasingly the case.

Important avenues for further research are the testing of our newly developed framework by case studies. Another important avenue for further research is the linkage between spatial innovation systems (NIS, RIS) and technological innovation systems (TIS). For the TIS analysis it is common practice to derive the actors that could potentially fulfill a certain function for a specific technology from the NIS framework (e.g. Hekkert et al. 2011). We feel that the advanced framework may provide a useful widening of the range of actors to be considered. Figure 5 provides an example how TIS functions could be fulfilled by the actors and institutions in our framework. Both case studies and an analysis of the innovation system of wind power in Germany using our advanced innovation system framework are the next steps in our research.

Figure 5: Locating the TIS functions in a spatial innovation system framework



Source: own drawing

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