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The Organizational Innovation System: A systemic framework for radical innovation at the organizational level

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ABSTRACT

Most research on innovation management at the organizational level has typically been focused on one specific innovation project phase or innovation management concept. This has resulted in many valuable insights, though scattered in different (innovation) research fields and studies. With the development of the Organizational Innovation System (OIS), we bring together important insights from the Innovation Systems, Open Innovation and other related fields into a guiding concept useful for both innovation managers developing (radical) innovations and innovation scholars. In this paper, we define the OIS and its key structural components, and discuss the identified functions and categories of potential imperfections. With the OIS, we provide a holistic, hands-on concept currently lacking in the open innovation approach. From the conceptualization, a framework for analysis is put forward which provides structure to the study of ongoing and finished innovation processes. Additionally, the development of the OIS is a first step in the development of a currently underdeveloped micro-level within the innovation systems perspective. The insights in OISs and the future insights derived from analytical efforts, will not only be beneficial for the performance of innovating organizations and organizational innovation systems but also for the performance of the higher, interconnected system levels.

1. Introduction

Innovation is widely considered to be a key factor behind economic development and competitiveness for firms, regions, and nations (Frambach and Schilewaert, 2002; Reinders et al., 2010; Tödtling and Trippl, 2005). Furthermore, answering the rising demand for a transition towards an economy with more resource-efficient and sustainable production systems, fueled by global issues such as the increasing resource scarcity, the growing world population, land scarcity and global warming, requires numerous innovations of different magnitude. Minor changes to existing technologies or products, i.e. incremental innovations, are one piece of the puzzle, but the most important driver in this transition are more radical innovations, i.e. new-to-the-world concepts. Successfully implementing these new concepts involves alterations to the core dimensions of the existing socio-technical-system, i.e. the stable configuration of linked and aligned dimensions: technology, user practices and markets, industries, infrastructure, policy, and techno-scientific knowledge, as well as alterations to the linkages between these dimensions (Farla et al., 2010; Geels, 2002, 2005, 2006; Kirchen, 2012; Van Humbeeck, 2003). Consequently, these complex radical innovations have to be developed using innovation processes that take into account these multi-dimensional aspects (Bruns et al., 2010; Kroon et al., 2008).

However, the mindset of many (innovation) managers, researchers, policy makers and the general public is still dominated by innovation models stemming from approaches that either focus on a single dimension (the *push* and *pull* approaches) or on a very limited number of dimensions (the *coupled* approach) (Berkhout et al., 2010; Caetano and Amaral, 2011; Kroon et al. 2008; Rothwell, 1994; Tödtling and Trippl, 2005). These approaches and their uni-disciplinary models with closed boundaries and inflexible, linear trajectories without feedback (for an elaborate description of the approaches, see Rothwell, 1994) are ineffective and no longer sufficient to systematically succeed in cost-efficiently delivering (radical) innovations (Bigliardi et al., 2012; Han et al., 2012).

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One approach that is well suited as a theoretical background for the development of complex radical innovations is the *innovation systems (IS)* perspective because of its dynamic approach and holistic view on innovation (Budde et al., 2012). The innovation system construct has been developed to capture and understand the relations between producers, users, governments and institutions, and by doing so, helps to identify system failures and deadlocks, rather than mere market failures as reasons behind innovation failure (Faber and Hoppe, 2013). Consequently, within this paradigm, innovation is viewed as an evolutionary, non-linear and iterative learning process, which requires intense communication and collaboration between different actors in order to take into account the multi-dimensional aspects of innovation (Budde et al., 2012; Tödtling and Trippl, 2005; West and Bogers, 2013). Currently, research on innovation systems is mainly oriented towards the macro level (national innovation systems, NIS (e.g. Carlsson et al., 2002; Freeman, 1995)) and the meso level (regional innovation systems, RIS (e.g. Asheim et al., 2011; Cooke et al., 1997) and sectoral innovation systems, SIS (e.g. Faber and Hoppe; 2013; Malerba, 2002)). Another body of IS-research focusses on the system surrounding a particular technology (technological innovation system, TIS (e.g. Bergek et al., 2008; Carlsson, 1997)). Moreover, due to the globalizing economy, the international or global innovation system (IIS or GIS) is increasingly receiving attention (Balzat and Hanusch, 2004; Chung, 2002; Freeman, 2002; Fromhold-Eisebith, 2007; Walshok et al., 2014). The micro-level however, that of the innovating organization, has received very little attention within the innovation system perspective. As a result, micro-level innovation managers are in need of hands-on models for innovation development (Berkhout et al., 2010) that bring together the many valuable insights currently scattered in different studies and different (innovation) research fields (Alänge, 2013).

In this paper, we develop this innovation systems micro-level, the *Organizational Innovation System (OIS),* and develop a framework to analyze different organizational innovation systems. With the OIS, we aim to give a more holistic, comprehensive overview of important issues during a radical innovation project – from idea development to commercialization – based primarily on the innovation systems literature and open innovation literature, supplemented with insights from other related literature. Consequently, the organizational innovation system contributes to the innovation literature and practice in four important ways. First, the OIS provides the innovation systems perspective with a micro-level that is currently underdeveloped. Second, the OIS-concept provides innovation managers with a more comprehensive guiding model for the development of complex radical innovations within the multidimensional, multistakeholder innovation systems context. These types of models are currently lacking in both the innovation systems and open innovation perspective (Giannopoulou et al., 2011). Third, by developing a framework for analysis, innovation managers and scholars can study and compare OISs, potentially leading to further valuable insights to increase innovation efficiency and efficacy of innovation organizations. The importance of improving efficacy and efficiency of innovation processes will only increase due to shortening product life cycles, increasing research and development costs, continuously decreasing innovation times and technology becoming increasingly complex (Drechsler and Natter, 2012; Holl and Rama, 2012; Ritter and Gemünden, 2004; Van Haverbeke and Cloodt, 2006). Fourth, improved innovation performance on the organizational level will have a direct positive effect on the performance of related higher system levels, thus increasing growth of the related regions and nations. This is due to the interconnectedness and interdependence of the different system levels (Walshok et al., 2014) (Fig. 1).

An OIS is related to innovation systems at other levels in different ways. A TIS often cuts across several sectors, may have a geographical dimension but is often international in nature

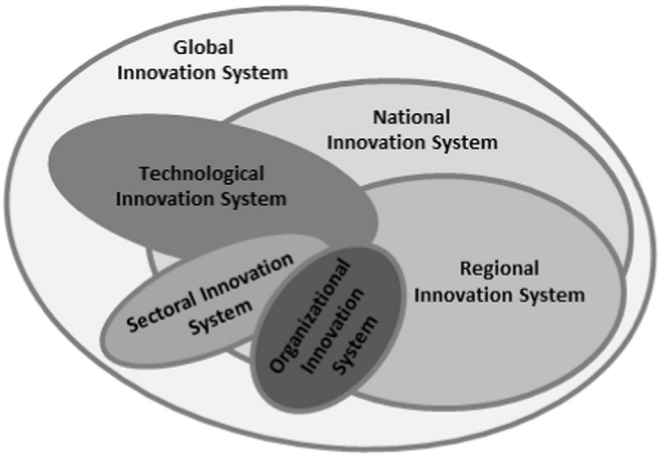

Fig. 1. Relationship between innovation systems levels (Adapted from Asheim et al. (2011)).

(Bergek, et al., 2008). A sectoral system is embedded in one or more RISs and the regional innovation system is a sub-system of one or more national innovation systems (Asheim et al., 2011; Chung, 2002). An OIS is part of one or more SIS, which can have regional or national bounds, but it can just as well be international.

The paper continues in Section 2 by defining the organizational innovation system and explaining how the OIS-concept is further conceptualized. Next, in Section 3, the OIS is further developed by elaborating on its main structural components. In Section 4, we define seven supporting functions of an OIS and in Section 5, ten groups of potential system imperfections are developed. Based on these different OIS elements, the framework for analysis is formulated in Section 6. The paper ends with a discussion on the implications of the OIS to theory and practice, potential paths for further research in Section 7 and concluding remarks.

2. Defining the Organizational Innovation System

In order to define the Organizational Innovation System, we examined how the innovation system is conceptualized at the higher system levels. A NIS is shaped by the interaction between various agents within a nation, bound by nation-specified institutions and policies that influence a nation's capability to generate, produce and diffuse innovation (Fromhold-Eisebith, 2007; Groenewegen and van der Steen, 2006; Wang et al., 2012). The regional innovation system can be defined as an interrelationship of innovation actors and institutions in a particular region that enables the generation, diffusion, and appropriation of innovation (Andersson, 2013; Chung, 2002; Fromhold-Eisebith, 2007). The SIS is conceptualized as a network of agents interacting in a specific economic or industrial area under a particular institutional infrastructure, which are involved in the generation, diffusion and utilization of innovation (Coenen and Diaz Lopez, 2010; Malerba, 2002). A technological innovation system (TIS) is a network of agents in a particular area of technology that, within the boundaries of institutions, generate, diffuse and utilize technology (Bergek et al., 2008; Carlsson, 1997).

These definitions across the different analytical levels have four communalities, allowing us to give a general definition of an innovation system: (i) a complex of diverse innovation actors (ii) that work in collaboration (iii) on the generation, development and utilization of innovation, (iv) shaped by a number of institutions (Bergek et al. 2008; Carlsson et al., 2002; Coenen and Diaz Lopez, 2010; Guan and Chen, 2012). In line with this general definition of an innovation system, the organizational innovation

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system can be defined as an innovation network of diverse actors, collaborating with a focal innovating organization in an innovation process, to generate, develop and commercialize a new concept, shaped by institutions.

The four main structural components, (i) the diverse actors, (ii) the innovation network, (iii) the innovation process and (iv) the institutions that contribute to the main goal of an OIS, i.e. the generation, development and commercialization of a new concept are further elaborated using insights from different relevant literature. We have collected findings of different scholars primarily from the innovation systems literature and open innovation literature. We selected the open innovation paradigm as a second primary theoretical background due to its complementarity to the innovation systems approach. This popular paradigm also places strong emphasis on the importance of a flexible and dynamic innovation process (Chesbrough, 2003; 2012). Additionally, open innovation strongly propagates collaboration, stressing the importance of opening up the organization to bring external knowledge and ideas into the organization, and also to commercialize internally developed ideas through outside channels (e.g. spin-offs, licensing) (ibid). Furthermore, open innovation is also viewed as a well suited approach to pursue the development of more radical types of innovation (Bigliardi et al., 2012). However, although the majority of research on open innovation focusses on the organizational level, it rarely looks at the innovation process as a whole (West and Bogers, 2013) but rather focusses on specific stages of the process (e.g. idea generation (Salter et al., 2015) or Research and Development (R&D) (Bruns et al., 2010)) or on specific aspects linked to innovation (e.g. knowledge sharing (Bogers, 2011) or absorptive capacity (Patterson and Ambrosini, 2015; Spithoven et al., 2010)), resulting in a lack of models explaining how an open innovation process should be executed (Giannopoulou et al., 2011).

To increase comprehensiveness of the OIS-concept, insights from other related perspectives and constructs such as the Multi-Level Perspective (MLP) (e.g. Geels, 2006; Geels and Schot, 2007), Business Models (e.g. Bocken et al., 2014; Osterwalder and Pigneur, 2005) and Innovation Adoption (e.g. Hameed et al., 2012; Rogers, 1995) were incorporated. Subsequently, these insights were also used to develop the framework for analysis of organizational innovation systems. The analyses on the organizational level, which should yield insights in OIS performance, is primarily based on the prevalence of a number of supporting functions and the prevalence of a number of system imperfections. This is in congruence with the analytic methods used at higher system levels. On these higher levels, the primary aim of a significant number of studies is to analyze and compare different innovation systems and formulate policy recommendations to improve the performance of the innovation system(s) under study (e.g. Collins and Pontikakis, 2006; Martin and Moodysson, 2013; Park and Lee, 2005). The performance is either judged on the ability to perform seven supporting functions: entrepreneurial activities, knowledge development, knowledge diffusion, guidance of the search, market formation, resources mobilization and creation of legitimacy (e.g. Bergek et al., 2008; Hekkert et al., 2007), or on the prevalence of a number of system imperfections such as infrastructural failure or weak network failure (e.g. Carlsson and Jacobsson, 1997; Woolthuis et al., 2005).

We choose to develop the OIS-concept with both a number of supporting function and system imperfection categories for two reasons. First, this method of structuring and analyzing has already yielded valuable insights and policy recommendations in studies on higher system levels. Second, thinking in terms of beneficial general functions within an organizational innovation system and disrupting imperfections, allows us to better bring together the many fragmented important aspects of innovation management into a limited amount of aggregated categories of importance. Consequently, a clearer, less complicated overview of important aspects throughout the whole innovation process can be developed, whereas other methods summing up every fragmented beneficial aspect would result in less hands-on, more complex models and concepts.

3. The structural components of the Organizational Innovation System

In the definition of an OIS established above, four main structural components are derived: (i) the innovation process, (ii) the actors, (iii) the innovation network and (iv) the institutions. Since the 1980s, a significant increase in organizations engaging in external collaboration has been observed, causing organizational boundaries to blur (Gulati et al., 2012). Therefore, before exploring the structural components of the OIS, some elaboration on the focal point of the OIS, the innovating organization, is required. We consider an organization to be a legal entity consisting of individuals, employed to achieve a collective goal (Coase 1937; Kogut and Zander, 1996). All persons with an employment relationship and all official business units or subsidiaries are considered part of the innovating organization. Consequently, in congruence with work on Meta-Organizations (Gulati et al., 2012), we consider all entities or individuals not employed by the organization to be external agents outside of the organizational boundaries (Dahlander and Gann, 2010). Innovating organizations can be firms, research institutes, governmental agencies or other institutes.

In order for an innovating organization to successfully develop (radical) innovations, the innovation process should be a non-linear and iterative learning process with intense communication and collaboration between different actors to take into account the multi-dimensional aspects of innovation (Budde et al., 2012; Coenen and Diaz Lopez, 2010; Tödtling and Trippl, 2005). The innovation process within the OIS concept is divided in three main process phases, as derived from the general consensus on the definition of innovation across the innovation literature. Innovation stems from an innovative idea, which is developed into an invention, and this invention cannot be called an innovation as long as the invention is not incorporated into the organization or introduced to and adopted by the market (Bogers and West, 2012; Bruns et al., 2010; Kroon et al., 2008; Pullen et al., 2012; Van Haverbeke and Cloodt, 2006). Therefore, the three main innovation process phases are the idea development phase, the invention phase and the commercialization phase.

Each main phase contains a number of subphases. The idea development phase can be separated in activities that involve identifying potential sources of innovations, generating innovative ideas to exploit these trends and opportunities, judging the feasibility of these ideas and selecting the most attractive ideas for further development. The subphases with more emphasis on techno-scientific aspects, from project design to real life testing of proof of concepts, are bundled in the invention phase. The commercialization phase entails the more socio-economic phases towards end-user adoption such as demonstration activities and determining the marketing strategy. Fig. 2 gives an overview of the three main phases with their subphases.

The relevant actors of the OIS are those groups or individuals who affect or are affected by the innovation process, i.e. those who have a certain stake in the innovation process (Freeman, 1984). These stakeholders can be divided into different stakeholder groups. The potentially relevant stakeholders for innovation projects include competitors, suppliers, intermediate users, end-users, industry associations, financial partners, universities and (private) research institutions, network organizations, government bodies,

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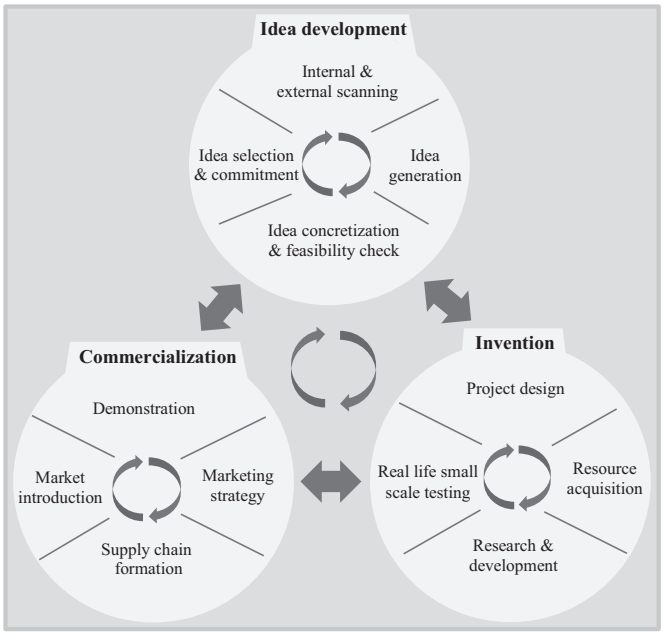

Fig. 2. Main and subphases innovation process.

non-governmental organizations (NGOs), expert consultants, knowledge brokers, and firms from unrelated industries (Bogers and West, 2012; Bruns et al., 2010; Chesbrough, 2003; 2012; Huizingh, 2011; Laursen and Salter, 2006; Lichtenthaler, 2011; Nowotny et al., 2003; Pohl, 2005; 2011; Sarkar and Costa, 2008).

During all phases of an innovation project, the process should be systematically open to an innovation network consisting of representatives of these various relevant stakeholder groups, in order to access their different expert knowledge and other resources (Chesbrough, 2003; Gallagher et al., 2012; Malerba, 2002; Westergren and Holmström, 2012). However, participation with an innovation network is not a binary choice between essentially closed or completely open innovation. There is a spectrum of possible collaborative arrangements between those two extremes (Bahemia and squire, 2010; Chesbrough, 2003; Huizingh, 2011). The innovating organization should employ a dynamic, layered collaboration strategy. The layeredness entails that the innovation network can consist of two layers. The first layer is a smaller core group of stakeholders with whom the organization works in close collaboration, sharing knowledge openly (Bogers, 2011). The second layer consists of a larger periphery of diverse stakeholders that are less involved, though participate in the innovation process, with whom not all information is shared (ibid). The layered strategy allows organizations to have a large heterogeneous network which has a positive effect on the development of (radical) innovation (Bahemia and Squire, 2010; Berkhout et al., 2010; Westergren and Holmström, 2012), while allowing a more closed approach to networking, proven to have a beneficial effect on innovation performance (Pullen et al., 2012). This layeredness is dynamic in time, depending on the stage of the innovation process. In an early stage, participation with the innovation network will be more open to the broad innovation network in order to maximally explore its knowledge and other resources, whereas stages of the innovation process involving more confidentiality necessitate more closed approaches to optimally exploit the knowledge and other resources (Bahemia and squire, 2010; Cooke et al., 1997). Besides the level of openness to the network, which stakeholders should be part of the core group and which belong in the periphery layer, is also dynamic and function of the innovation stage. For instance, during stages of invention, technology providers and innovative upstream companies will be closely involved, whereas during commercialization stages, downstream players come to the foreground to get the innovation to market (Van Haverbeke and Cloodt 2006). However, the periphery of the innovation network should be regularly consulted by sharing non-confidential information about the innovation. By doing so, the innovation network can act as a reference group, suggesting adjustments to be made to the innovation to better fit the external expectations. Furthermore, the whole innovation network, including the peripheral stakeholders, should help create legitimacy and support for the innovation. The process of *legitimation* entails the efforts and strategies to overcome the liability of newness of the innovation. These efforts can range from adjusting the innovation to fit the existing institutional framework (e.g. choosing to follow an established product standard or legislation) to creating a new institutional framework that fits the innovation specificities under development (e.g. establish new product standards or lobby for changes in legislation) (Bergek et al., 2008; Spencer, 2003).

Institutions form a key factor in systems theory that envisions the institutional context as a defining and structuring element of the system (Woolthuis et al., 2005). The dynamic layered collaboration scheme requires strong institutions within the OIS to efficiently and effectively collaborate with the stakeholders, as institutions shape the interactions between them, providing the stakeholders some sort of stability in the light of the intrinsic risk connected to innovation activities (Coenen and Diaz Lopez, 2010; Faber and Hoppe, 2013; Kaiser and Prange, 2004; Malerba, 2002). A commonly used and accepted distinction is made between formal and informal institutions (Coenen and Diaz Lopez, 2010; Kaiser and Prange, 2004). Informal institutions influence social and economic life in a subtle, often intangible way (Coenen and Diaz Lopez, 2010). Examples include trust, habits, norms and values, beliefs, conventions, traditions, routines, and preferences (Coenen and Diaz Lopez, 2010; Faber and Hoppe, 2013; Geels, 2005; Huang et al., 2014). Formal institution are more formal and tangible, such as laws, regulations, contracts, standards, product specifications, and property rights (Coenen and Diaz Lopez, 2010; Faber and Hoppe, 2013; Huang et al., 2014; Kaiser and Prange, 2004). Hard institutions in the OIS level would include non-disclosure agreements, collaboration contracts, intellectual property (IP)-arrangements, written agreements about the distributions of the developed value, etc. that can facilitate the open sharing of knowledge and resources between the stakeholders (Bogers, 2011; Melese et al., 2009). Also, there needs to be an alignment in soft institutions such as beliefs, norms and values, and expectations between the different collaborating partners, supplemented by a certain level of trust.

Besides the importance of institutions on the OIS-level, the institutions of national (e.g. patent system, laws), sectoral (e.g. sectoral labor market) or other system levels can also influence how the innovating organization is shaped, how the relationships between organizations are formed and which innovative ideas are viable, consequently influencing the innovation process and the OIS as a whole (Malerba, 2002). In addition to these contextual institutions, other contextual factors such as the dimensions of the dominant socio-technical system, e.g. scientific, technical, political, cultural, industrial, and market aspects (Geels, 2005), and networks formed within the higher system-levels of which the organizational innovation system is a part, are linked and aligned to the existing technology (Geels, 2002), potentially influencing the OIS. Therefore, innovation efforts that do not take the interdependency between these different dimensions into account will face a number of barriers to market adoption (Farla et al., 2010). Such barriers, but also triggers for innovation processes may exist in each of the system levels (Faber and Hoppe, 2013).

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Consequently, innovation within the system perspective is seen as a multidisciplinary activity which has to take these different dimensions into account from the beginning of the process and throughout the whole innovation process (Kroon et al., 2008). To optimally do so, linkages should be made across disciplinary boundaries and between theoretical development and professional practice, transcending academic disciplinary structure (Hadorn et al., 2006; Pohl, 2005; 2011; Nowotny et al., 2003; Veldkamp et al., 2009).

In this multistakeholder, multidimensional setting, learning between collaborating partners plays a vital role, necessitating a process with frequent iteration and feedback in order to be able to repeat process stages to undertake corrections, adjust to unforeseen developments and correct mistakes (Bruns et al., 2010; Fetterhoff and Voelkel, 2006; Gallagher et al. 2012; Hermans, 2011; Van der Duin et al., 2007; Veldkamp et al., 2009). Therefore, the innovation process should be organized in a non-linear, iterative, flexible fashion with interconnected cycles (Arnold and Barth, 2012; Berkhout et al., 2010; Bruns et al., 2010; Gallagher et al., 2012; Kroon et al., 2008; Pullen et al., 2012; Van der Duin et al., 2007). To emphasize this non-linear, iterative character of the innovation process, it is depicted in Fig. 2 using looping and double arrows. Furthermore, to highlight that innovation processes do not consist of a fixed number of phases that follow each other seamlessly, the phases are placed in circles and depicted in a non-sequential order. Fig. 3 shows a schematic overview of the OIS and its main structural components, within the higher system levels' contextual aspects which form its contextual boundaries.

4. The supporting functions of the Organizational Innovation System

Seven supporting functions of an organizational innovation system are identified and developed, allowing a better understanding of how an OIS should be configured to maximize the chances of a successful outcome and facilitating the analysis of the performance of an OIS. These seven functions are: (i) provide opportunities, trends and ideas, (ii) reduce uncertainty about the innovative idea, (iii) provide complementary human and financial resources, (iv) act as a reference group during the innovation process, (v) create awareness, legitimacy and support for the innovation, (vi) facilitate market formation and (vii) aid in supply chain formation. The further elaborating of the seven supporting functions is linked to the main innovation process stage in which the fulfillment of the respective function is most important. However, this does not imply that functions important in later phases should not be taken into account during earlier phases of the innovation process and vice versa.

4.1. Functions during the idea development phase

During the idea development phase, the OIS can play an important facilitating role. Firstly, regular interaction with diverse stakeholders will enable the organization to constantly and efficiently scan the external factors in search of inspiration for innovation (Börjesson et al., 2006; Maine et al., 2014). Furthermore, the network can aid in translating trends and opportunities into more and better ideas for innovation projects (Brettel and Cleven, 2011; Hansen and Birkinshaw, 2007; Sandulli et al., 2012). Third, stakeholders, by looking at an idea from their diverse expertize, can help identify the potential technical and socio-economic bottlenecks and inducing factors that will determine the attractiveness and feasibility of the ideas. Fourth, during the selection stage, the OIS can help safeguard that the idea with the highest value and potential win-win for the entire value chain and society is selected, rather than an idea with the highest added value for the single, innovating organization. The OIS should thus provide the innovating organization with insights in external opportunities and trends, more and better ideas to choose from and a multidisciplinary viewpoint on the feasibility of the ideas. This allows us to formulate the first two functions of the organizational innovation system; first, provide opportunities, trends and ideas for innovation projects and second, reduce uncertainty about the

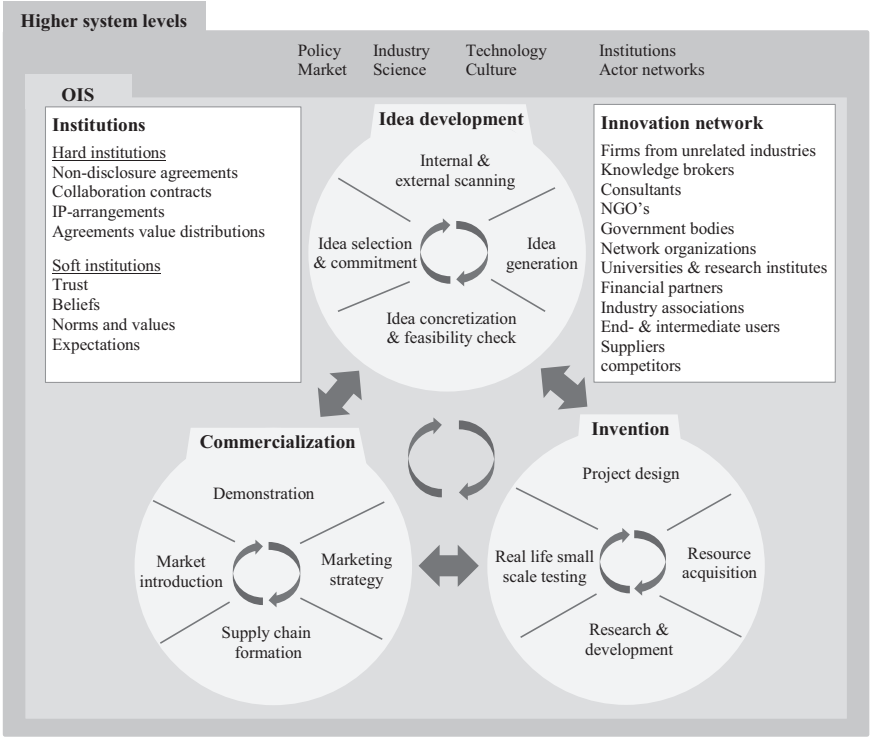

Fig. 3. Main structural components of the organizational innovation system.

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selected innovation idea and subsequent innovation project.

4.2. Functions during the invention phase

During the invention phase, the innovative idea is first translated into a project design. From this project design, it becomes fully clear which resources will be required to develop the innovation. These resources can be financial resources such as capital, infrastructure, machinery, lab equipment, etc. or human resources, i.e. people with the multidisciplinary knowledge, skills and/or knowhow to successfully develop a feasible idea into a marketable invention (Bigliardi et al., 2012; Holl and Rama, 2012; Rampersad et al., 2010; Sandulli et al., 2012). The OIS can play a significant role in the invention phase by providing the resources the innovating organization is lacking (Brettel and Cleven, 2011). This type of collaboration requires well formulated hard institutions with a clear division of tasks, roles, and responsibilities between the collaborating partners, as well as complementary soft institutions such as beliefs, expectations and trust. The third function of the organizational innovation system is thus to provide the complementary financial and human resources required to develop the invention. The fourth function of the OIS is a reference function. The periphery stakeholders should be used as a reference group to check if the development of the innovation proceeds in congruence with the wishes and needs of downstream stakeholders, the market and society.

4.3. Functions during the commercialization phase

The commercialization phase entails a number of actions with the ultimate goal to maximally increase the chances of market adoption, i.e. the decision of an individual or organization to make use of an innovation (Frambach and Schilewaert, 2002). The innovation characteristics that have a positive effect on the adoption decision include the perceived relative advantage of the innovation over the existing concepts, the perceived compatibility of the innovation with existing values, past experiences and needs of potential adopters, the perceived observability of the results of the innovation and the perceived trialability of the innovation. Negative effects on adoption include the perceived complexity, difficulty to understand and use the innovation, and the perceived uncertainty regarding the innovation (Arts et al., 2011; Frambach and Schilewaert, 2002; Frambach et al., 1998; Nooteboom, 1989; Rogers, 1995). Consequently, efforts should be made to emphasize the relative advantage of the innovation, increase its compatibility, observability, and trialability, as well as reduce as much uncertainty and complexity as possible.

A way to increase compatibility is to take into account the needs and wants of the users and other stakeholders from the beginning of the process, in the idea development phase and throughout the invention process. Another important aspect to increase adoption chance is to organize demonstration and dissemination events on a regular basis. During these events, information about the innovation specifications, e.g. how it will work and what the benefits are or will be, are shared with the general public to reduce uncertainty and complexity of the innovation while also absorbing the feedback received from these events to further improve the fit of the innovation. Providing early and timely information is particularly important for highly innovative and discontinues new concepts to avoid harsh judgment by the market (Berkhout et al., 2010). These demonstration and dissemination events should also be organized as early as possible during the process and throughout the process. Apart from helping to reduce uncertainty, these events also help to create awareness for the innovation, and, with the correct communication, assures a certain familiarity with and acceptance of the new concept before it is even launched to market (Arnold and Barth, 2012; Spencer, 2003), which helps create legitimacy for the innovation. These type of activities, together with activities that help shape certain institutions in favor of the developing innovation, are all part of the OIS's fifth function; creating legitimacy from the innovation.

A sixth function related to the commercialization of the innovation is to facilitate market formation. Although some radical innovations could be directly diffused to the mass market, most will have to find their way to the mass market through a niche. These niches are markets where selection criteria are different from the dominant socio-technical regime (Geels, 2002; Hermans et al., 2013). There are two distinct types of niches: the *technological niche* and the *market niche*. A technological niche is deliberately created by actors to have spaces for experiments, pilot and demonstration projects, and often a first market for the developed new concept (Schot and Geels, 2007). Market niches are a select number of innovators and early adopters that have a positive attitude towards innovative features and can benefit from the innovation (Rogers, 1995; Walter et al., 2012). These niches serve as nursing markets which, through the spread of information, interaction and contamination effects, help bridge *the chasm* that exists between the niche markets and the mass markets (Bergek et al., 2008; Frambach et al., 1998; Moore, 1991). One example is T-City, Friedrichshafen in Germany. This city is a large test market and showcase for new technology from Deutsche Telekom (Rohrbeck et al., 2009). It is the task of the OIS to aid in setting up a technological niche and/or to help identify market niches, thus facilitating market formation.

The seventh and final function of the organizational innovation system is the facilitation of the supply chain formation. A lean supply chain that can effectively and efficiently assure quality products is beneficial for the adoption of the innovation. This supply chain can be formed with downstream stakeholders from the innovation network, or actors provided by stakeholders in the innovation network.

5. Organizational system failures

When an OIS-supported innovation project fails to get the new concept to market, this can be due to certain failures or imperfections in the organizational innovation system. Although some of the system imperfection categories on the OIS level are similar to the ones at higher system levels, their conceptualisation has to be altered to better fit the micro-level. The potential failures on the organizational level are manifold, but can be categorised into ten different groups of imperfections (Table 1), related to the one of the main structural components of the OIS or one of its supporting functions.

The first two groups of failures relate to the organization of the innovation process. The first failure that can occur is that the innovation process was organized and ran without taking into account all system dimensions, thereby creating unsurmountable bottleneck(s), preventing the project to succeed. For instance, unidentified legislation or poorly investigated market demand can respectively make a potential innovation illegal or not attractive enough for potential adopters. Also, analyses of best practices in many firms and industries shows that aspects that become more important in later stages of the process (e.g. marketing and launch planning in the commercialization phase), should already be taken into account at an early stage of the project and should be monitored throughout the whole process (Börjesson et al., 2006; Guiltinan, 1999). We categorize the overlooking and underinvestigating of one or more dimensions of the innovation system, or taking innovation aspects into account too late into the process

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Table 1
Summary of the possible organizational innovation system failure groups.

OIS failure groups	Explanation
Dimensional blindness failure	Overlooking of one or more dimensions or not focusing on one or more dimensions soon enough
Iteration failure	Improper balance between too much iterativety and too little feedback loops
Resource failure	Too few financial resources or human resources within the OIS to successfully generate, develop and diffuse the innovation
Representativeness failure	Improper stakeholdergroup representativeness, non-representative organization or individual for the group, or non-representative individual for the organization
Openness failure	Improper balance between consulting and participating with too many stakeholders and too few
Cooperation failure	Too few strong ties in the innovation network, leading to, for example, trust issues and difficulties in cooperation
Lock-in failure	Too many strong ties, leading to, for example, 'group think', resulting in myopia and inertia within the innovation network
Hard institutional failure	The lack or underdevelopment of formal arrangements, e.g. collaboration contracts, IP-arrangements and non-disclosure agreements
Soft institutional failure	The lack or non-alignment of informal arrangements, e.g. shared vision, social values, culture and norms, mutual trust, goals of the different partners and business models
Capacity failure	The lack of certain capacities of the innovation organization to maximally profit from the OIS, e.g. absorptive capacity or network management capacity

'dimensional blindness failure'. Second, the flexible and iterative nature of the process could also cause problems. Too little iteration can be harmful and deadlock the innovation process or have it yield a suboptimal result. For instance, too little iteration during the idea development phase can cause the selection of a subfeasible idea. This is due to the inseparability of the idea generation and idea concretization subphase, necessitating iteration (Koen et al., 2001). The feedback loops may take significant time but they typically shorten the total innovation project time because integrating the multidisciplinary knowledge helps to identify bottlenecks early, which in turn helps prevent late and costly changes, or even worse, product failures (Börjesson et al., 2006; Koen et al., 2001; Sandmeier et al., 2012). But iteration and flexibility between the main phases is just as important; when an idea proves not accomplishable during R&D, additional idea development should be organized to overcome the deadlock. However, too much iteration, for instance during the idea development phase with the goal to exhaustively check the feasibility of the idea, can cost precious time to market (Koen et al., 2001). Consequently, innovation projects can fail when the right balance in iteration is not found, causing an 'iteration failure'.

The third category of imperfections is related to the function of the OIS to provide complementary human & financial resources necessary for the innovation process to succeed. The provision of the skills, knowledge and expertize (human resources) is of particular importance during the idea development and the invention phase whereas providing the necessary financial capital is most important during the invention and commercialization phase. If the project is faced with a shortage of either of these resources, it can fail. We labeled these failures the 'resource failure'.

The fourth category is the 'representativeness failure', one of the four groups linked to the innovation network. This type of failure can manifest itself in three ways. One, the network has to consist of an adequate number of stakeholders from all relevant stakeholder groups. Two, these stakeholders have to be representative for their group in terms of characteristics and opinions. Three, when the stakeholder is an organization, the individual representing the organization should be someone who articulates the opinion and actions of the organization (and not his own) and have a certain decision power within the organization. If this is not the case, the idea selection can, for instance, be based on opinions not shared by all stakeholders within the stakeholdergroup. Besides the representativeness of the stakeholders in the innovation network, the amount of participating stakeholders can also influence the successful outcome of the innovation project. Research shows that organizations that open up their boundaries to search for knowledge with a wide variety of stakeholders tend to be more innovative (Berchicci, 2013). However, at a certain point, due to increasing searching- and information costs, bargaining- and decision costs, and policing- and enforcement costs (Bruns et al., 2010), diminishing returns of this openness set in (Berchicci, 2013; Laursen and Salter, 2006). Thus, a balance has to be found between consulting and participating with too many stakeholders, resulting in too much lost time and resources, and consulting with too few stakeholders, which can lead to incomplete information or suboptimal partnerships. We label a failure to find this balance, resulting in a suboptimal OIS, an 'openness failure', the fifth category of imperfections. Two more possible network failures lay in an imbalance in the network between stakeholders with whom the innovation organization habitually cooperates and stakeholders with whom it is not or less familiar. The presence of familiar stakeholders helps to build trust and allows the network to gain new members, while new stakeholders bring in new ideas and impulses (Bahemia and Squire, 2010). Bahemia and Squire (2010) advocate a network consisting of small group of weak ties (at least 20% of the network) and a large group of strong ties to generate better and more radical innovations. Too few strong ties will lead to the sixth imperfection labeled 'cooperation failure', which include trust issues and difficulties in cooperation. On the other hand, too many strong ties will lead to lock-ins in thinking due to 'group think', resulting in myopia and inertia within the network (Nooteboom, 2000), which we name 'lock-in failure', imperfection number seven.

An additional source of potential failure in the organizational innovation system lies in contradicting hard and soft institutions. The hard institutions are deliberately created, on-paper rules that regulate the collaboration within the OIS (Edquist et al., 1998). For the OIS, these can be collaboration contracts, IP-arrangements and non-disclosure agreements. The absence of hard, formal institutions or inadequately developed hard institutions can, for instance, hinder the open sharing of knowledge between partners or the exchange of other resources and can lead to opportunistic behavior. In congruence with Carlsson and Jacobsson (1997) and Woolthuis et al. (2005), we label the lack of or underdevelopment of hard institutions in the OIS 'hard institutional failure', the eight category of imperfection. The ninth failure group is the 'Soft institutional failure', which refers to the lack of commonality between the actors in the innovation network in less formal institutional aspects. Examples of these soft institutional failures are a lack of shared vision, different social values, culture and norms, a lack of trust in one another, no alignment in the goals of the different partners and incongruence in business models (Carlsson and Jacobsson, 1997; Chesbrough and Schwartz, 2007; Pullen et al., 2012; Woolthuis et al., 2005).

The tenth and final group of failures are the 'capacity failures'. This group holds all shortcomings of the innovation organization in its capacity to innovate together with the innovation network. A first possible shortcoming is a lack of absorptive capacity,

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impeding the innovating organization to recognize and absorb external valuable resources. Absorptive capacity is defined as the capacity of an organization to recognize the value of new, external information and apply it to commercial ends (Spithoven et al., 2010; West and Gallagher, 2006). Organizations can develop this absorptive capacity by internally developing prior (technological) knowledge and expertize (Berchicci, 2013; Lichtenthaler, 2011). Another example can be the lack of network management capacity or relational capability (Sisodiya et al., 2013). The innovation organization needs to have the competences to build an innovation network, grow it, recruit potential partners and manage the different relationships between the actors (Bahemia and Squire, 2010; Mu, 2014; Ritter and Gemunden, 2004). The innovating organization can take this role on herself, or if she should lack these competences, employ a stakeholder that takes on the role of broker. These brokers are actors that grease the wheels of the innovation systems. They function as a bridging agent in the network, facilitating resource sharing between the different collaborating actors (Klerkx and Leeuwis, 2009; Lichtenthaler, 2013). If the innovation organization neither has the network management capacities, nor recruits an organization that has, this form of capacity failure can hinder the success of the OIS.

6. Framework for analysis of the Organizational Innovation System

Based on the developed facilitating functions and system imperfection groups, organizational innovation systems can be analyzed to acquire insights on how to improve or adjust the systems under study. Conducted from the viewpoint of the focal organization in the innovation network, the innovating organization, the OIS can be studied using the framework depicted in Fig. 4.

This seven step framework for analysis can be used to study an OIS both during an ongoing innovation process to make alterations to the OIS based on the resulting insights, as well as when the innovation project is finished to analyze the reasons for failure or success, resulting in insights useful in future projects. In the first step of the analysis, the innovation project to be studied is selected. In step two, the success of the project (thus far) is reviewed based on the predetermined key performance indicators (KPIs) such as time to market, number of products sold in first few months after launch, R&D costs, etc. In step three, the structural components of the OIS are described. Then, in step 4, an analysis is made of which functions were developed, underdeveloped and undeveloped. In step five, the project is reviewed to find system imperfections which have let to the un(der)development of certain functions, ultimately resulting in meeting or not meeting the KPIs or perhaps the failure of the innovation project. From the insights gathered in these previous steps, innovation management recommendations are formulated in step 6 and the OIS is altered accordingly should the project still be ongoing in step 7. Then, this process can be repeated starting from step 3 to further monitor the projects progress.

7. Discussion

Changes in environmental conditions occur ever faster and product life cycles continue to shorten (Drechsler and Natter, 2012), making innovation efforts crucial to the survival of organizations. However, given the multidisciplinary nature of innovation (Kroon et al., 2008), the increasing complexity of technology (Holl and Rama, 2012; Ritter and Gemünden, 2004) and the tendency of firms and other organizations to focus on their core competences (Gulati et al., 2012), organizations are and will increasingly continue to open up their innovation processes to external stakeholders (Chesbrough, 2012). Therefore, in this paper, we developed the organizational innovation system concept to facilitate the execution and study of such open, collective innovation processes. An organizational innovation system contains a dynamic, layered innovation network of diverse relevant stakeholders, shaped by a set of formal and informal institutions. Through an iterative innovation process, it aids the focal innovating organization in generating, developing and commercializing innovations by providing the required supporting functions. However, diverse system imperfection can cause a suboptimal innovation process or even failure. Based on the structural

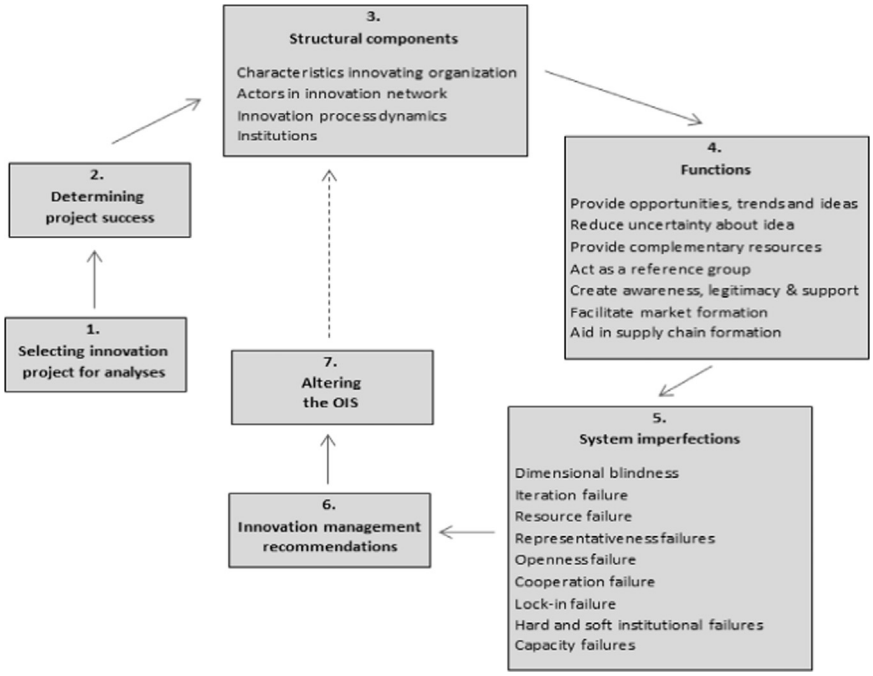

Fig. 4. Framework for analysis of organizational innovation system.

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components and functions of the OIS, ten categories of these potential imperfections are put forward. Furthermore, the elaborate conceptualization of the OIS concept allowed for the development of a framework for analysis of organizational innovation systems.

With the development of the OIS concept, we contribute to the innovation management theory, in particular the Open Innovation and Innovation Systems perspective, in several important ways. First, we have made a synthesis of the innovation management insights which are currently scattered in numerous (empirical) studies and dispersed across different research fields (Open Innovation, Innovation Systems and other related concepts) and bring them together into a single, inclusive concept. Second, to the authors' knowledge, the organizational innovation system is among the first concepts that elaborates on innovation network configuration, institutional arrangements, and innovation process characteristics, while also commenting on the interconnection and interdependence between these different key innovation management aspects for the entire innovation process. Third, conceptualizing the OIS in congruence with the development of higher system levels (e.g. Woolthuis et al., 2005; Bergek et al., 2008), i.e. by using structural components, supporting functions, and groups of system imperfections, allows for a clear and accessible, though inclusive concept with a high level of comprehensiveness in the aggregated OIS-elements. Fourth, the organizational innovation system concept presented, offers a first step into the development of a currently largely overlooked and lacking micro-level in the innovation systems perspective, while simultaneously providing the open innovation perspective with a concept explaining how radical innovation processes in a multidimensional, multistakeholder context should be executed. Fifth, in addition to the conceptualization of the organizational innovation system, we further contribute to the innovation management theory through a framework for analysis, which provides a stepping stone for scholars who wish to study open, collective innovation processes from idea development to commercialization in an inclusive manner.

Besides these theoretical implications, the organizational innovation system presented also offers a number of practical contributions and implications. The OIS-concept can serve as a guiding concept or model for innovation managers to ex-ante organize their innovation processes. Guided by the OIS-model, innovation managers will look at the innovation process from a more holistic point of view. They will see the process as an iterative learning loop and will develop an innovation network with a layered innovation strategy to maximize both exploration and exploitation opportunities, while minimizing chances of negative externalities. The concept urges them to consider which stakeholders should be in the network and to which layer they belong, taking into account the phase of the innovation process and which supporting functions the innovating organization requires. Furthermore, innovation managers are encouraged to tailor their use of formal and informal institutions to best fit the situation. Furthermore, the groups of imperfections provide the managers with accessible categories of potential red flags. Using these imperfection categories in conjunction with the rest of the framework for analysis, innovation managers can critically analyze their ongoing innovation projects to rectify imperfections and other inefficiencies, or study past projects in search of best practices or lessons learned to increase efficiency and efficacy of future innovation efforts.

However, this study is not without its limits. Although efforts were made to maximize the comprehensiveness of the aggregated system elements, the vast amount of innovation management studies in the numerous relevant research fields made it impossible for a completely comprehensive overview, especially in the elaboration on each system element. Therefore, the OIS can benefit from both further theoretical and empirical research on the topic. One valuable line of research could be on the further development of the different system elements, e.g. research on which aspects relate to *capacity failure* or which OIS activities can be labeled as part of the *facilitating market formation* function. Additionally, further research, especially empirical work, will be beneficial to not only illustrate and validate, but also to further develop the OIS-concept. Future research should also aim to critically review the different system elements as they are currently developed and will potentially reveal additional structural components, supporting functions, or failure groups. Furthermore, empirical research on organizational innovation systems will test the developed framework for analysis and contribute to its usability. Another research path on OIS can focus on the connection and interdependence between the different developed system elements, especially between the different functions and groups of systemic failures. Additionally, high potential lies in the development of archetypes of OIS. Similar to typologies of meta-organizations (Gulati et al., 2012), modes of open innovation (Lazzarotti and Manzini, 2009), or archetypes of open innovation users (Keupp and Gassman, 2009), these archetypes of organizational innovation systems could be differentiated by differences in innovating organization characteristics (e.g. type, size, industry), innovation network structure, institutions used, or prevalent functions. Finally, although the link between the micro-level of OIS and the higher system levels has been established in this work, future research can enrich the understanding on how the OIS influences the performance of the connected other systems and vice versa.

8. Conclusion

Many organizations are already implementing collaborative, open innovation activities with external partners. Although many success stories exists and these type of open innovation activities are associated with a substantial number of potential benefits, collaborating with external stakeholders often proves challenging. With the Organizational Innovation System, we provide a holistic concept that offers insights in stakeholder groups, network strategy, and institutional arrangements across the different innovation process phases. With the development of seven OIS functions, ten groups of potential OIS failure, and the framework for analysis, we aimed to further amplify the comprehensiveness and usability of the concept. The OIS can guide both (innovation) managers and scholars in the set-up of projects as well as in the analysis of ongoing and finished innovation efforts to help maximize the benefits and minimize the risk associated with open innovation.

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