Journal of the Association for Information Systems

Volume 18 | Issue 8 Article 2

8-31-2017

Using Information Systems in Innovation Networks: Uncovering Network Resources

Sven-Volker Rehm
WHU - Otto Beisheim School of Management, svrehm@gmail.com

Lakshmi Goel
University of North Florida, l.goel@unf.edu

Iris Junglas
Florida State University, ijunglas@fsu.edu

Recommended Citation

Rehm, Sven-Volker; Goel, Lakshmi; and Junglas, Iris (2017) "Using Information Systems in Innovation Networks: Uncovering Network Resources," *Journal of the Association for Information Systems*, 18(8), .
DOI: 10.17705/1jais.00465
Available at: https://aisel.aisnet.org/jais/vol18/iss8/2

Journal of the Association for Information Systems

Research Paper ISSN: 1536-9323

Using Information Systems in Innovation Networks: Uncovering Network Resources

Sven-Volker Rehm
WHU – Otto Beisheim School of Management
sven-volker.rehm@whu.edu

Lakshmi Goel
University of North Florida, USA

Iris Junglas
Florida State University, USA

Abstract:

In order to innovate, firms progressively combine complementary abilities through forming networks. Such innovation networks represent temporary assemblages of partners that, in collaboration, pursue new product developments. Existing theories suggest that successful participation in such networks depends on firms' having certain firm-level dynamic capabilities (i.e., skill in sensing the network and its environment, learning about the network, and coordinating and integrating individual resources across the network). In this paper, we argue that firms also have to develop particular networking capabilities (i.e., they have to understand who they are partnering with, what each partner can contribute, and how exactly each partner can cooperate with others across the network). We show that inter-organizational information systems (IS) are vital for facilitating the development of these networking capabilities. IS are also vital in developing unique constellations of resources (i.e., physical, human, and organizational resources) that we term IS-embedded network resources. These resources are manifested in the IS and are unique to the innovation network because they go beyond resources at the firm level. Using three innovation networks as case studies, we provide empiric evidence on how IS support networking capabilities to arrive at unique resource constellations embedded in IS and how the set of IS-embedded network resources is a determining factor for competitive advantage in innovation networks.

Keywords: Network Resource, Dynamic Capability, Networking Capability, Resource-based View, Innovation Network, New Product Development.

Mike Chiasson was the accepting senior editor. This paper was submitted on June 5, 2014, and went through two revisions.

1 Introduction

Organizations often try to innovate with the help of inter-organizational partnerships (Chesbrough, 2003a, 2003b; Davenport & Prusak, 2000; O'Reilly & Tushman, 2004; Nambisan & Sawhney, 2011). Current literature promotes the view of an ecosystem in which innovation networks represent temporary assemblages of partners who cooperatively pursue new product and service developments (NPD) (Adner & Kapoor, 2010; Nambisan, 2013; Schilling & Phelps, 2007; Cowan, Jonard, & Zimmemann, 2007). Innovation activities, which comprise researching and developing, designing, and marketing new products and services, involve not only internal resources but also a firm's external relationships for technological, strategic, and relational complementarities (Davenport, Leibold, & Voelpel, 2006; Emden, Calantone, & Droge, 2006; Pisano & Teece, 2007; Jacobides, Knudsen, & Augier, 2006). For collaborative innovation to succeed, a firm's internal resources, including its physical, human, and organizational capital (Barney, 1991), need to be aligned with those of its partners (Dyer & Singh, 1998).

Information systems (IS) are central to these innovation networks. Their capacity to support knowledge exchanges between firms (Nambisan, 2003, 2013) is vital because IS enable partners to enact their dynamic capabilities (i.e., their capability to sense, learn about, integrate, and coordinate across organizational boundaries) (Pavlou & El Sawy, 2006; Inkpen & Tsang, 2005). Although literature has recently addressed the role of IS in innovation networks and emphasized its significance as an enabler and facilitator, we lack understanding about how exactly information systems influence innovation processes in networks (e.g., Han et al., 2012; Nambisan, 2013; Whelan, Conboy, Crowston, Morgan, & Rossi, 2014).

Current theories about the benefits and pitfalls of sharing knowledge in partnerships have not yet convincingly elucidated how innovation occurs between organizations in an innovation network (Alexy, George, & Salter, 2013). While several well-established firm-level theories exist, we know comparatively little about the resources at the network level and the capabilities required to develop them. The resource-based view (RBV), for example, provides a firm-level explanation for competitive advantage of firms that possess rare, inimitable, and valuable resources (Barney, 1991). Likewise, the concept of dynamic capabilities, or "a firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments" (Teece, Pisano, & Shuen, 1997, p. 516), provides a firm-level explanation of the processes that have to take place for firms to achieve competitive advantage. While prior studies have extensively used both models, it seems conceivable that a network possesses attributes that go beyond those of the individual firms that participate in it. The relational view of the firm supports this position (Dyer & Singh, 1998). It seems conceivable that firms in an innovation network develop resources and capabilities that are specific to an innovation network, that are vital to achieve competitive advantage during the lifetime of the network, and that persist beyond the boundaries and lifetime of the network (Mesquita, Anand, & Brush, 2008; Schreyögg & Kliesch-Eberl, 2007).

In this paper, we demonstrate how IS enable firms in an innovation network to form resources and capabilities unique to a network and how they contribute to the competitive advantage of a network. We use the concepts of dynamic and networking capabilities (Pavlou & El Sawy, 2006; Mu & Benedetto, 2012) and study how firms cooperatively create network-level resources with the help of IS. Accordingly, we propose the concept of IS-embedded network resources to capture the unique constellation of resources that emerge through an alignment process that heavily depends on the successful use of IS. We provide empirical evidence for how IS enable networking capabilities across organizational boundaries and how they lead to network-level resources that one can view as IS-enabled assets.

We study three innovation networks and illustrate their use of IS for inter-organizational NPD projects. We develop an analysis framework for networking capabilities based on concepts drawn from prior literature. We contribute to research by suggesting a linkage between firm-level and network-level concepts through IS, and we contribute to practice by providing insights for partners on how to use IS for shaping and managing network-level resources and networking capabilities.

2 Theoretical Backdrop

Traditionally, researchers have viewed innovation predominantly as an intra-organizational endeavor. Increasingly, however, firms, especially small and medium-sized enterprises (SMEs), understand that, in order to innovate, they need to leverage external relationships. Accordingly, the most recent innovation models (Davenport et al., 2006; Emden et al., 2006; Pisano & Teece, 2007; Jacobides et al., 2006) view innovation as the outcome of a collaborative effort among organizations in which each partner contributes its own set of resources and capabilities. However, literature in this context focuses primarily on the set of shared innovation goals and is less specific about the resources and capabilities that individual firms have to bring to the network (Chesbrough, 2009).

2.1 Resources and Capabilities at the Firm Level

The resource-based view (RBV), a firm-level theory, provides substantial insights to this issue. The RBV model argues that organizations, in order to achieve a sustained competitive advantage, have to possess a unique set of resources that are valuable, rare, inimitable, and not substitutable (Wade & Hulland, 2004; Barney, 1991; Grant, 1991; Wernerfelt, 1984). Accordingly, RBV distinguishes between three types of resources an organization must focus on: physical, human, and organizational capital (Barney, 1991). Physical capital involves technologies, production lines and equipment, and access to raw materials. Human capital involves the skills, experiences, and judgments of managers and workers in the organization and those that come from business relationships. Organizational capital includes the governing structures, including the reporting, control, coordination, and planning processes in and across firm boundaries. While research has prominently and widely applied RBV, it has its drawbacks. For instance, researchers have often critiqued its static nature (Barney, 1991; Grant, 1991); the model ignores any changes, or reconfigurations, that an organization undertakes to ensure that its resources remain valuable, rare, inimitable, and without substitute.

To supplement the RBV model, researchers have introduced the concept of dynamic capabilities (Teece et al., 1997; Wade & Hulland, 2004; Baker, Jones, Cao, & Song, 2011; Spender, 1996; Zollo & Winter, 2002). Dynamic capabilities are competences that enable firms to create, reconfigure, and combine resources (Grant, 1991; Eisenhardt & Martin, 2000). Firms achieve competitive advantage through their ability to sense opportunities in the market and to seize these opportunities by adequately adapting and reconfiguring their core resources (Teece et al., 1997; Argote & Ren, 2012; Jarvenpaa & Leidner, 1998). Operationalized as processes, dynamic capabilities require a firm to continuously reconfigure its resources in order to better match the environment (Pavlou & El Sawy, 2006). More specifically, four processes determine a firm's ability to dynamically readjust to its surroundings: 1) a process that senses the market, 2) a process for learning, 3) a process that coordinates activities, and 4) a process that integrates interaction patterns (Pavlou & El Sawy, 2006). These four processes—learning, integration, coordination, and sensing—together constitute a firm-level NPD dynamic capability and are facilitated by IS.

The spectrum of IS that facilitate NPD processes, however, is rather diverse. It ranges from collaboration software for product design and development to project-management systems, resource- and knowledge-management systems, and cooperative work systems. For specific NPD activities, firms use specialized IS, such as product lifecycle management (PLM) systems, data mining tools, decision support systems, social media and virtual simulation tools (Banker, Bardhan, & Asdemir, 2006; Kleis, Chwelos, Ramirez, & Cockburn, 2012; Nambisan, 2013; Pavlou & El Sawy, 2006).

2.2 Resources at the Network Level

In contrast to firm-level theories, inter-organizational theories consider inter-firm relationships as a source of competitive advantage (Dyer & Singh, 1998). Simon (1947) points out that the interlinked and relationship-specific resources in a partnership are difficult to imitate, which hinders competitors from obtaining comparable advantages (Mesquita et al., 2008); the prospect of competitive advantage prompts partners to invest in building partnerships in the first place and, subsequently, to stick to them (Mesquita et al., 2008). The relational view model proposes that firms acquire capabilities as part of their relationships that they cannot develop in isolation. Collaborating firms can generate so-called "relational rents" through relationship-specific assets, knowledge-sharing routines, complementary resource endowments, and effective governance (Dyer & Singh, 1998; Mesquita et al., 2008). However, extant research does not discuss the processes needed to cooperatively reconfigure and align these resources at the network level and how IS can support them.

In an attempt to overcome the shortcomings of RBV as a firm-focused model, studies have suggested incorporating the relational view into RBV as an inter-firm extension (Mesquita et al., 2008). Related studies suggest that the core assumption in the RBV that firms need to have exclusive ownership and control over resources to achieve competitive advantages is incorrect. Instead, access to a partner's resources—typically complementary in nature—may create mutual benefits (Lavie, 2006; Penrose, 1959). Other studies, such as Lorenzoni and Lipparini (1999), show that firms can learn from building partnerships by developing a relational capability—a capability that entails interacting with other firms to access, transfer, and integrate knowledge. Studies that examine strategic alliances suggest that the resources of individual partners "influence the competitive advantage of the interconnected firm" (Lavie, 2006). In this context, Gulati (1999) considers the concept of firm network resources as a specific form of a firm-level resource that "firms can use to conceive of and implement their strategies" (Gulati, 1999, cited in Barney, 1991, p. 101). They emerge "from the informational advantages they obtain from their participation in interfirm networks that channel valuable information" (Gulati, 1999, p. 399). In other words, these studies view network resources as informational advantages that accumulate as the alliance develops; they might even act as enablers for future cooperations (Gulati, 1999; Gulati, Nohria, & Zaheer, 2000; Lavie, 2006; Lee, 2007). Extant research, however, has failed to address how firms can exercise access to partners' complementary resources through, for example, using inter-organizational IS.

Expanding on the conceptualizations above, we infer that IS enable informational support that is vital in developing constellations of resources (i.e., physical, human, and organizational resources) at the network level. These network-level constellations are unique to the innovation network and go beyond resources at the firm level. We term these constellations IS-embedded network resources and suggest that they exhibit competitive advantages through their capacity to integrate their owner's capabilities and activities (see also Mu & Benedetto, 2012, p. 8).

2.3 IS-embedded Network Resources: Resource Constellations in Innovation Networks

While the RBV and related literatures only hint at the possibility of firms' including outside resources and suggest the role of informational advantages in accessing partner resources, we explicitly adopt this underlying tenet in the context of innovation networks. Innovation networks depend not only on a partner's internal firm resources but also on resources that are newly created or recombined at the network level. Firms in a network that use IS, particularly inter-organizational systems (IOS), create new opportunities to define, access, and mutually control these new, shared resources.

In this paper, we propose the notion of an IS-embedded network resource as a new concept that represents the unique resource constellations that manifest in IOS and that network partners use. We understand resource constellations as unique sets, or arrangements, of resources that individual network partners own. Firms develop and define their arrangements over time. As such, network resources provide competitive advantage in the context of innovation networks.

Not unlike the RBV model, we suggest that network resources in an innovation network require information about relevant firm-level resources of the network's partners, including information about 1) which machines, equipment, and production facilities are available in the network (physical capital); 2) who in the network can provide what expertise, knowledge, and development services (human capital); and 3) how activities are best coordinated given the experience and strategic/market orientation of network partners (organizational capital). Former research supports this tripartite distinction in noting that a firm's unique pattern of relationships has the potential to confer competitive advantage (relating to physical capital), that the right choice of partnerships significantly affects future partnering opportunities (relating to human capital), and that the ways in which firms implement their cooperation (often termed tie modality) impact firm performance (relating to organizational capital) (Gulati et al., 2000).

2.4 Linking Firm and Network Levels: Networking Capabilities

Extant research describes the term networking capability in relation to a firm's ability to exploit its existing ties and to explore new ties to achieve resource reconfigurations for competitive advantage (Capaldo, 2007; Mu & Benedetto, 2012; Mu, 2014). Studies have conceptualized it as a firm's ability to manage inter-firm relationships (see, for example, Mu's (2014) review) and have shown that it contributes to successful NPD endeavors—particularly in innovation networks (Mu & Benedetto, 2012; Mu 2014; Ozcan & Eisenhardt, 2009). A networking capability embraces various factors, such as connecting resources available in a network of partners, generating knowledge across boundaries, systematically exploring opportunities between partners, and reducing costs by enhancing the transparency across partners and improving coordination (Mu & Benedetto, 2012; Burt, 2004; Dubini & Aldrich, 1991; Dhanaraj & Parkhe, 2006).

Building a networking capability requires significant effort and time (Hayes, Pisano, & Upton, 1996; Mort & Weerawardena, 2006). It involves establishing and managing network relationships and leveraging network opportunities (Mu & Benedetto, 2012; Gulati, 1998; Capaldo, 2007). Accordingly, studies have pointed out that, in order to achieve networking capabilities, firms need to connect partner resources, develop routines across network partners, and attain resource constellations (Eisenhardt & Martin, 2000; Ritter, Wilkinson, & Johnston, 2002; Mort & Weerawardena, 2006).

In this paper, we extend extant research by suggesting that a networking capability involves not only building, reconfiguring, adding, or deleting firm-owned resources (Mort & Weerawardena, 2006) but also managing the process to achieve resource constellations across network partners. We argue that IS can substantially enable this alignment process. As part of this paper, we study particular characteristics of IS that contribute to this process.

2.5 Analysis Framework: Types of Resources, Capabilities, and IS

We build on earlier research (Mort & Weerawardena, 2006) and capture the activities and efforts involved in creating a networking capability based on the dynamic capabilities perspective. We use the four enabling processes of NPD dynamic capability (Pavlou & El Sawy, 2006) to study how firms use IS to learn, integrate with and coordinate between each other, and sense their environment to reconfigure resources.

In addition, and as informed by the RBV, we study how networking capabilities in the context of innovation networks evolve with respect to resources. We observe how firms use IS to capture information about partners' resources that are available in the innovation network (i.e., physical capital, denoted as "P"), who is involved in the network's partnerships and who provides what expertise (i.e., human capital, denoted as "H"), and how partners design and implement processes within the innovation network (i.e., organizational capital, denoted as "O"). Table 1 provides our analytical framework by formulating capabilities as informational requirements for IS at the network level.

Table 1. Analysis Framework

NPD dynamic capability: reconfigures firm resources to match the firm's environment	**Networking capability**: involves capabilities for learning about network partners, integrating knowledge across boundaries, connecting to partner resources, and exploring opportunities between partners, in order to achieve unique resource constellations
Enabling processes (as defined by Pavlou & El Sawy, 2006)	**Informational requirements**
Learning process: drives innovative thinking and knowledge generation to enhance existing resources (i.e., the process of acquiring, assimilating, transforming, and exploiting existing resources to generate new knowledge) (aka. absorptive capacity).	• Capability to exploit partners' resources in the network (P) • Capability to capture and represent knowledge about partners in the network and to leverage partners' capabilities (H) • Capability to implement processes to incorporate knowledge from the network (O)
Integration process: supports the implementation of new operational competences by developing required patterns of interaction (i.e., the process of creating and implementing new ways of performing activities) (aka. collective mind)	• Capability to compile operative planning information about the distribution of resources amongst network partners (P) • Capability to approach network partners about the status of resources and to establish mutual arrangements (H) • Capability to investigate and apply procedures to access shared resources and facilitate collaborative activities in the network (O)
Coordination process: helps to allocate resources, assigns tasks, and synchronizes activities (i.e., the process of managing dependencies among resources and tasks) (aka. coordination capability)	• Capability to judge the complementarity of resources amongst network partners (P) • Capability to adopt new partners into the network (H) • Capability to define project- and network-level mechanisms and synchronize resource usage (O)
Sensing process: aids management's understanding of the environment, business needs, and opportunity identification (i.e., the process of generating, disseminating, and responding to market intelligence for proposing a product/service) (aka. market orientation)	• Capability to identify and review relevant NPD options arising from the network (P) • Capability to change partnerships based on market needs (H) • Capability to alter and adapt to new business models with network partners (O)

While the enabling processes of dynamic capabilities are inherent to the firm level, we suggest that executing networking capability becomes observable at the network level as an innovation project progresses. An alignment process emerges at the network-level between the partners of an innovation network who intend to align resources and form unique constellations in order to match the innovation network's goals. This alignment process represents the networking capability that manifests itself in IS, which we focus on in this paper. The alignment process involves creating and reconfiguring shared network-level goals and resource constellations (i.e., IS-embedded network resources). While research has investigated reconfiguration processes at the firm level before (e.g., Pavlou & El Sawy, 2006), it has not widely considered them at the network level.

We conceptualize IS-embedded network resources as determining factors of competitive advantage in innovation networks. We conduct our enquiry as follows. First, we examine how firms use IS to exercise networking capabilities to cooperatively create unique resource constellations as IS-embedded assets at the network level. Second, we explicate the role of IS as facilitators of the alignment process on network level and highlight relevant IS functionalities in the innovation network context to managerial practice.

3 Research Method

Over a three-year period, we followed three innovation networks of SMEs. Each conducted an NPD project that targeted specific bundles of innovative products and services. We used the case study method (Stake, 2005; Yin, 2003), which concurs with earlier studies that have looked at networking capabilities and their generative mechanisms and resulting processes among partners (Eisenhardt, 1989; Mort & Weerawardena, 2006). To observe how firms exercise networking capabilities (i.e., how two or more cooperating partners mutually adapt and balance between goals, processes, and resource allocations and explicate their complex interactions), we took an interpretive stance (Myers, 1997). We accompanied the partners' deployment and use of IS and analyzed how processes between network partners manifested themselves in IS (Klein & Myers, 1999; Walsham, 1993). We predominantly used episodic interviews as a form of narrative inquiry (Denzin & Lincoln, 2005; Myers & Newman, 2007) in addition to secondary data. During the interviews, we tried to capture the current status quo of the ongoing NPD and identified episodes that were momentous in changing the cooperation. We did so in accordance with prior literature that suggests the significance of dialogues in inter-firm collaborations (Majchrzak, More, Philip, & Faraj, 2012)

3.1 Case Selection: Three Innovation Networks

All three networks were part of a joint cooperative research project called SmartNets that the European Commission partly funded. The networks all started out with a similar set of IT resources (in particular, a wiki-based collaborative work environment (CWE)) that supported their alliance. However, during the course of their projects, each network developed specific IT artifacts as instruments for their NPD projects by configuring IS functionality in the CWE for their specific purposes.

The first network, which we refer to as the "Motorbike Helmet Network" (MHN), focused on testing the application of a new type of dampening material for motorbike helmets. The innovation network comprised three core partners: a helmet manufacturer tasked with externally designing the helmet and its mechanical parts; a material manufacturer, which had developed the dampening material and, thus, caused new requirements for the production processes; and an engineering services provider, which managed design tasks associated with the changed production processes (inside design) and also acted as a coordinator in the network. Others, including a consulting and engineering services firm and a research agency, provided supplemental services for the innovation network. The three core partners started the project with only a rough idea about the material's potential in the automotive market. The progression of the project substantiated this idea and, finally, targeted a comprehensive design and processing framework for industrial production. The superiority of the material (especially with regards to safety and quality when compared to other products) in the market was validated during various tests, which assured partners to continue with the developments.

The second network, which we refer to as the "Medical Device Network" (MDN), began with the intent to develop a cardiovascular "stent graft" made of new materials superior in functionality and lifespan to industry standards. A stent graft is a tube-like form that comprises a textile mesh (graft) that a metallic wire grid (stent) stabilizes. The innovation network comprised five core partners: a device manufacturer (stent graft producer), which managed the assembly and marketing of the final product; two submanufacturers, one responsible for providing the graft and another responsible for covering the metallic wire with Polyester; a processing service provider specialized in round-weaving narrow fabrics, which supported the graft processing; and an academic institution, which conducted research regarding the base material and its functionality. Others, including a consulting and engineering services provider and an industrial research agency provided supplemental services. Legal regulations impose high requirements on the quality of medical devices; thus, the firms paid meticulous attention to the product's functionality and quality adherence. They also focused on ensuring intellectual property rights and conducted base research on in-body conditions. At the time of reporting, the project had reached a prototypical design with acceptable functional characteristics.

The third network, which we refer to as the "Textile Coating Network" (TCN), began in response to an idea of a large customer in the furniture industry. The developed sol-gel coating increased scratch and abrasion resistance for textile surfaces and extended heat deflection and chemical resistance. The network comprised three main players: a chemical company that provided the coating, an industrial research agency that developed the coating in close cooperation with the chemical company, and an interior textile manufacturer that applied the chemical coating to its fabrics. Interestingly, while a large customer triggered the NPD, this company itself was not part of the innovation network. Two industrial research agencies provided supplementary services to the innovation network: one specialized in the area of engineering and environmental regulations, the other in project-management services. Sol-gel had reached considerable maturity when, due to a market change, the target customer lost interest in the project. As a result, the innovation network changed direction and developed a new product, an "easy clean" coating that prevented fabrics from staining. Cleaning only required wiping off the dirt, a differentiating feature of "easy clean" when compared to competitors' offerings.

We deemed these three innovation networks representative cases for our enquiries and suitable for several reasons. First, each NPD project targeted highly innovative products and services in which the technology, base material, or design presented a disruptive force in the market. Second, each network included five or more partners who were open to sustaining partnerships beyond the lifetime of the NPD project. Third, each network faced challenging issues during their NPD projects both from technical and managerial perspectives. At times, firms needed to reevaluate the project and its boundary conditions, which provided a rich opportunity to study the strengths and critical issues about the partnerships and their operative processes. And last, we received permission to closely follow each project and to interact with all NPD team members at any point in time; we also had access to all relevant working documents, information repositories, and IS. Table 2 summarizes and compares the three innovation networks. While the size of the partnering organizations, the overall team size, and the number of resulting task types in the CWE were all similar, each case belonged to a different industry and context.

Table 1. Innovation Networks' Summary

	Medical Device Network (MDN)	Motorbike Helmet Network (MHN)	Textile Coating Network (TCN)
NPD project summary	Cardiovascular stent graft involving innovative materials; improve in-body application and product reliability	Motorbike safety helmet using a novel dampening material; improve safety parameters	Sol-gel coating for furniture; later: easy-clean coating, which provided novel product functionalities
Network size (i.e., number of participating organizations)	7	6	5
Geographic range	Czech Republic, Germany, Italy	Italy, United Kingdom, Germany	Belgium, Germany, Italy
Industry sectors	Healthcare, technical textiles, textile processing, textile machinery, physics, engineering, consulting	Automotive, chemical, engineering, consulting	Chemical, textile, home textiles, furniture, engineering, consulting
NPD team size (CWE users)	36	25	32
Number of interviewees	16	10	10

3.2 Data Collection

During a three-year period, we regularly attended project meetings of all three networks, including more than 30 full-day meetings and numerous workshop meetings. We observed the projects' team members use and discuss IS in operative work situations. At the time of reporting, we had carried out more than 50 semi-structured interviews that, on average, lasted approximately 75 minutes. We followed and spoke with about ten people in each network, including both operative and management roles (for more detail, see Table A1). Appendix A shows sample questions of our semi-structured interviews (Table A2). Our questions focused on the changes each network partner had to undergo and the actions they took in order to align with each other and achieve resource constellations. Questions mimicked the three resource types of the RBV, tapped into dynamic and networking capabilities, and inquired about goals and reconfigurations. While we based our initial questions on our theoretical lens, the course of the interviews guided our follow-up questions. Overall, from conducting the interviews, we identified central themes and found evidence of resource reconfigurations, mutual alignment, and IS use.

In order to validate our findings, we included further materials in our analysis that documented project progress and results. These materials included more than 1,100 pages of project reports and documentations, 425 pages of public documents, project reports, technical documentations in a Web-based team space, various collected brochures, (Web) catalogues, and more than 100 pages of personal research notes. We also analyzed several videos (tutorials, promotional material for public presentation, or those about technical content) prepared during the project. We conducted interviews and collected material when the projects began and continued for more than three years. As of this writing, the projects still continue (with marketization).

3.3 Coding Procedure

After we transcribed the data, we performed the coding independently of each other. In a first descriptive phase (Yardley, 2008), the first and second authors familiarized themselves with the interviews and developed a coding frame. This frame assured we captured relevant narratives with respect to the study's objective. In a second interpretative phase, we all connected the narratives to the theoretical lens regarding resource reconfiguration, dynamic and networking capabilities (along the four enabling processes), and efforts to achieve resource constellations. The interpretation process was iterative. We compared our interpretation against the theoretical concepts by sharing and (re-)evaluating comments (Klein & Myers, 1999) to ensure that our coding was in line with what the concepts meant.

We started by looking for evidence of resource reconfigurations that resulted from mutual alignment efforts. Thus, our unit of analysis was the reconfiguration we observed in the networks. During interviews, individual members brought up these reconfigurations and recounted them from their personal perspective. We looked for corroborating evidence for such incidents in interviews with partners and in secondary data to triangulate the same episode from multiple perspectives. In this way, we could look at the knowledge exchanges that IS supported and identify associated resources, exercised capabilities, and alignment efforts. We classified data by looking for evidence for each of the four enabling process (listed in Table 1). As an example, we classified data related to "awareness of the markets" as "sensing" and data related to "awareness of partners" as evidence of "learning". In a subsequent step, we classified according to the type of resource being reconfigured (i.e. human, physical, or organizational; see Appendix A2). We looked for keywords that provided evidence for the type of resource. For example, we classified "awareness" about "skills" and "competences" in a network as "learning: human capital". At each level of coding, we also documented the role of IS involved. In addition, we also used participant feedback in order to validate our analysis (Yardley, 2008; Silverman, 2014), which not only ensured participants' engagement in our research but also avoided our misrepresenting their views.

4 Analysis

In this section, we present qualitative evidence about how the firms of the innovation networks used IS to reconfigure and align various types of resources with each other at the network level. We relied on the analysis framework (see Table 1) to classify narratives by enabling processes (i.e., learning, integrating, coordinating, and sensing) and resource types (i.e., human, physical, and organizational capital). We particularly focus on how firms used IS in this context. Table 3 provides a schematic overview of the evidence presented (see also Table B1 in Appendix B for an overview of the selection process).

Table 3. Schematic Structure of Evidence

Enabling process/ NPD dynamic capability	Human capital	Physical capital	Organizational capital
Learning process	"Learning about partners" / all three networks	"Learning about opportunities" / all three networks	"Learning how to cooperate" / all three networks
Integration process	"Integrating partners" / Motorbike Helmet Network	"Integrating contributions" / Motorbike Helmet Network	"Integrating routines" / Motorbike Helmet Network

Table 3. Schematic Structure of Evidence

Coordination process	"Coordinating between partners" / Motorbike Helmet Network	"Coordinating/synchronizing contributions" / Medical Device Network	"Coordinating/synchronizing procedures/routines" / Medical Device Network
Sensing process	"Sensing others" / Textile Coating Network	"Sensing structures" / Textile Coating Network	"Sensing processes" / Textile Coating Network

4.1 Learning in the Innovation Network

We could observe the learning process in the knowledge generated through partners' attentiveness towards capturing and representing information about others in the network, awareness about potential obtainability of physical resources in the network, and alertness towards organizational processes for determining, evaluating, and incorporating knowledge from the network.

4.1.1 Human Capital: Learning about Partners

Since the partners had not worked together in these groups before, they had to first learn about each other—particularly their expertise and competences (i.e., the human capital available in the network). These efforts entailed developing attentiveness and becoming aware of the network as comprising a collective of partnerships. An entrepreneur of the MHN expressed the significance of capturing knowledge about the partners in the networks in partnership repositories:

> *First is the [network] modeling. This took the longest time. Because it was not easy for SMEs as we all are, to understand. We spent a lot of time to understand what is the [network]…. For SMEs it is not always automatic to be aware about the [network], its own [network]. That is the first job, to understand that there is a [network] that must be regulated. Now, as SMEs, knowing that a [network] is existing, allows us to systematically apply (this knowledge) to our relationships with the others.* (Owner of Service Provider, MHN)

Firms joined the innovation networks because the entrepreneurs and experts involved deemed their constellation of competences promising. In the early stages of the projects, the involved partners needed to validate this expectation and formalize tasks. None of the involved partners could anticipate, or even manage, the entirety of the product development single-handedly. As fundamental components of the targeted product lay beyond the core competences of each partner, they had to find a way to identify those partners with the complementary knowledge and expertise for the network. Thus, all partners needed to create awareness and representation of information about the other partners and particular competencies. Maps that identified knowledge and expertise of current and potential partners created by open source business process-modeling tools helped in this respect. Besides individual competencies (displayed in expertise maps), the partners captured network level strategy information through business ecosystem maps and project strategy maps. A product designer mentioned using the mapping tools to model the network knowledge:

> *So, first of all, the [network] knowledge is the most important; it is the foundation, and it is the base on which we base further evolutions, thanks to the tools, thanks to all the analysis methods, and so on. So, the [network] knowledge is the first and the most important tool.* (Product Designer, MHN)

During the first year of the projects, the maps comprised partnership repositories that depicted value chain structures, types of partners, their specific knowledge and expertise, and services or manufacturing potentials with regard to the ongoing cooperation.

4.1.2 Physical Capital: Learning about Opportunities and Potential Contributions

Partners also needed to learn to identify what physical capital each partner could potentially offer to the network, including machines, equipment, and other facilities such as laboratories. They needed to represent the availability of these facilities in an understandable format. For some partners, identifying other partners' physical capital represented the first time they could reflect and pinpoint what they themselves could actually contribute to the innovation network. As the following quote shows, a service provider achieved awareness and subsequent learning about physical resources with respect to the network:

> *What is firstly changed is basically awareness about real skills, real capabilities, real knowledge of our own structure, split into all key aspects of the company life, that means real knowledge, real competences, and which degree of each parameter, how. And this helped the company to well-structure the internal process, in terms of methods, in terms of information flows, management, in terms of awareness, and also the relationships with potential external partners being advisors or suppliers or partners.* (Owner of service provider, MHN)

This newly created awareness included partners identifying tasks to collaboratively work on, sharing resources, and, eventually, reconfiguring machine set-ups to meet with the defined tasks. As a product designer in the MHN said: “every task has been dedicated to the involved partners following the [available resources and expertise]...not because I like to do aramid analysis” (Product Designer, MHN).

The partners used the network models in project strategy maps to describe these constellations of their physical capital.

4.1.3 Organizational Capital: Learning How to Cooperate

After learning about the others’ potential contributions in terms of human and physical capital, the partners needed to establish appropriate organizational processes. Reconfiguring internal processes and adapting them to the network required learning about the specific ways firm-level innovation processes worked and then organizing them into cooperative processes. Doing so included establishing communication processes with partners to achieve a sustained alertness about their processes. Business process models helped partners to describe, discuss, define, and revise the operations during the ongoing project. For example, a product designer in the MHN said:

> *If you don't have the way [i.e., the business process models] to deeply split every profile and [each partner’s] skills in a certain way, giving a priority, if there is an overlapping area profile of the partners, you can't drive information and responsibilities in a good way, an effective way. So… when we build our information flow management, and our tasks, we do not drive by intuition, but following the [process models], going through all the schemes, the graphics, we had from the [network] analysis. Who does what? When? Why? It is all already written.*

Network reference processes mapped task distribution and offered workflow functionality between partners. A network reference library provided a central semantic repository of technical terms and metadata regarding resources, products, and services.

Firms crucially needed to learn about the different aspects—their partners, their resources, and organizational processes—in the early stages of each innovation network. This knowledge provided a shared view on the structure of relationships between the partners and served later stages of the project as a reference framework when, for example, they needed to extend the network.

4.2 Integrating the Innovation Network

We found evidence of the integration process in the partners’ readiness to develop and implement new configurations of operational competences and required patterns of interaction. This integration process entailed a readiness to plan the distribution of resources and tasks between the network partners; a pro-activeness to inform partners on the status of resources, tasks, and activities in the network; and a willingness to investigate and apply procedures to access shared resources and facilitate collaborative activities in the network.

4.2.1 Human Capital: Integrating Partners

Partners’ readiness to share information and knowledge in the NPD teams included monitoring and evaluating the project status and proactively updating partners about achieved results. This way of sharing became important for, for instance, the MHN’s success. In the collaborative work environment (CWE) that the NPD teams collectively used, the MHN had created a project workspace for overseeing the activities of project team members that integrated the results each expert obtained; it also provided easy-to-adapt informational structures, such as wiki pages, and semantic directories of tags and attributes that the NPD experts maintained themselves. Partners’ sharing their work documentations and reports in the project workspace formed the basis for them to align their operations. Incidents that occurred in the NPD process triggered operation reconfigurations, such as when an engineer obtained surprising testing results, which the below quote illustrates:

> *<Laughs> We took a look on the table [of test results] and started wondering "how is it possible" and so on. So we decided to plan—of course—all the different testing activities that we'll have to be performing in order to warrant that our product will be able to sustain such (tests) in the best way.* (Industrial engineer, MHN)

Firms also reconfigured the experts' cooperative work when they needed to add new partners. This reconfiguration entailed re-evaluating partnerships and proactively informing partners about the project status. Each partner needed to integrate flexibly with new partners as an involved entrepreneur described:

> *[Usually] there are several meetings when [we] try to discover which is the mechanism inside that allows to have a fluent and a smooth [exchange] between…both teams, between engineering, the design, the prototyping and so on…which is the information flow…. In my small service company, I bring in the information [about the partnership] and I manage it within the "circle of mechanisms" that I have built within the company.* (Owner of service provider, MHN)

For example, during a later phase of the helmet development, a technical problem occurred that necessitated adding a new partner. Since the network sought to develop a manufacturing scheme for the helmet and to sell this scheme to a licensee for industrial production, it needed to develop a comprehensive blueprint for all manufacturing and logistical processes involved upfront. One of the problems concerned transporting materials in shipping containers. The transportation process would expose the materials to high temperatures and humidity for an extended time, which would cause changes in their physico-chemical properties. Since the network partners could not find a solution to circumvent this impact on their own, they tried to identify partners who could provide solutions to the problem through a partner-profiling procedure. This procedure, however, required divulging (sometimes secret) knowledge about the product. The network had to ensure that it shared only relevant, but not critical, information with the external contacts. In the project workspace, the MHN NPD team grouped various wiki pages and reports to ensure limited, controlled access to the existing information resources through adequate access rights as one of the managers commented: "Because you need to analyze just one time and you have information ready for all other cases automatically" (Product Designer). Eventually, after several attempts to find a solution with external companies, the network managed to identify a solution on its own. They nevertheless kept a close relationship with the established contacts in prospect of future collaboration.

4.2.2 Physical Capital: Integrating Value Contributions

Because the network partners could not plan the overall NPD process a priori due to the fact that it involved exploratory development along several directions, integrating value contributions necessitated the network to continually monitor the project's scope, time, cost, negotiated agreements, and intermediate results. The project workspace helped all partners capture project-management information, including project plans, assigned responsibilities among partners, and partners' contributions. The partners then used the workspace to support and monitor project progress and to navigate technical complexities. In the MHN, the workspace increased the team's perceived responsiveness because the partners used it to proactively approach network partners for aligning their work, which the following quote illustrates:

> *There is the analysis of the situation, of the new results, trying to deeply understand what they mean. And then there is a normal phase where we discuss future activities… perspectives, and so on…If we use the instruments in the analytical part of the discussion, let's say, which can be by meeting or conference, or else. It can be extremely useful for the successive definition of future perspectives, possibilities and so on.* (Industrial engineer, MHN)

The project workspace allowed network partners to track who did what using wikis, task lists, flow charts, and Gantt charts. It enabled the partners to track information on machine settings and laboratory parameters applied and, thus, provided them with a tool to align and integrate physical activities.

In addition, the networks used systematic methodologies, such as quality function deployment and product potential analysis, to cooperatively explore reasonable next steps and resources needed for decisions on project continuation, which the following quote illustrates:

> *When we apply [systematic innovation procedures], you well know how to move your company in terms of profiles, in terms of competences, okay? Inside that specific procedure, [we know what] to contribute… We provide a series of activities and information fully dedicated to that specific part of the [network].* (Owner of service provider, MHN)

A collection of such procedures and the blueprints to operationalize them in the CWE formed an innovation procedure toolkit of relevant methods for all networks to elaborate on ideas and designs or to quantify impacts of changing market requirements.

4.2.3 Organizational Capital: Integrating Processes and Routines

Integration between partners also involved their identifying, implementing, and adapting organizational processes. This was particularly evident when partners developed work routines in the MHN to continuously and systematically exchange information. The network partners sought to facilitate information exchanges on a regular basis while avoiding overloading each other with information and, thus, facilitate collaborative activities in the network, which the following quote illustrates:

> *Generally I inform them with a short call or a short message via Skype in order to check if they have interest in the topic with two phrases or something like that. And if they are interested I am going to email. Just not waste time, explaining things that they are not interested in or to hide information they could be interested in.* (Industrial engineer)

The project workspace in the CWE comprised collaborative tools for chatting, telephony, instant messaging, screen sharing, and so on, which allowed partners to develop a common understanding of the market, product, and business contexts. It formed the basis for a systematic approach to react to any event that could occur during the course of the project, which the following quote illustrates: "[Now we can] speak the same language…, work in the same know-how storage system…, speak about the same scheduling…, and every time [we] have a systematic approach" (Product designer, MHN).

By establishing a common understanding, the team could reflect on how it used the project workspace to suit the network's working style, which the following quotes illustrate:

> *And the [partners] are really able to exchange all information without any huge problem and staying fully informed in real time. (Chemical engineer, MHN)*

> *Today we discussed that. We would like to have the possibility to re-order the discussion, the chat by arguments, not by time. [One team member] told me there are tools for that.* (Chemical engineer, MHN)

This way, the project workspace of the CWE enabled partners to implement and adapt operational work by integrating all aspects about partners and their resources and organizational processes in the network.

4.3 Coordinating the Innovation Network

We found evidence of coordination in how the network partners allocated resources, service,s and task assignments and in how they synchronized activities. Firms achieved such coordination through an awareness about their partners' complementary resources and services, a readiness to align their own strategies and services to new needs arising in the network or environment, and a willingness to define project- or network-level mechanisms and to synchronize resource usage, tasks, and activities.

4.3.1 Human Capital: Coordinating between Partners

Most of the SMEs in the innovation networks lacked long-term strategic partners. As our interviewees recounted from their previous experiences, few strategic partnerships had emerged from cooperative projects. The firms had found it difficult to recognize complementarities and disjoints regarding resources, expertise, corporate culture, and skillset.

One entrepreneur of the MHN explained how he had learned to view his own capabilities as services and not as problem solutions that arose from "hidden" expertise. By embracing the service notion, his perspective on coordination efforts in partnerships changed drastically during the NPD project. He stated:

> *And now I understand the possibility to extend the models, the system to exchange information, to a network. For me it is a step ahead, because I have to change my approach to exchange knowledge. Because I have to speak with different people and [now need] to organize all the information in a different way than in my mind.* (Chemical engineer and company owner)

Expert profiles on professional social network websites (PSN) played an important role in firms' generating the capacity to coordinate with their partners. These websites allowed firms to identify and connect with potentially promising new contacts and to sustain existing business relationships, which the following quotes illustrate:

> *I saw that if you meet people—speaking with another brain that is not yours—you increase your possibilities and ideas and develop [more ideas than] if I stay in my laboratory.* (Chemical engineer and company owner)

> *I am on LinkedIn but I never tried to find something special; I linked with [some related groups]. But now I try to see if it's possible to get contacts for [developing] new ideas.* (Chemical engineer and company owner)

Numerous product and service ideas resulted from the service mind shift. We observed how partners became aware about each other and about potential future partners—a process that facilitated coordination in the network. A service-oriented offering soon became part of the profiles that partners supplied to their network, which the following quote illustrates:

> *Didn't change the task, but changed involved profiles… Because having the correct profile not only allows us to call the specific need but also to have the knowledge and the skills fully dedicated to that need.* (Owner of service provider, MHN)

This mind shift eventually led to taking up activities that focused on reaching outside partners. Activities included interacting with special interest groups on PSNs, posting videos on product design and services on YouTube, or participating in public events with interactive product and service demonstrators.

4.3.2 Physical Capital: Synchronizing Value Contributions

All three networks—but particularly the Medical Device Network (MDN)—contained efforts to synchronize resources, tasks, and activities as challenges arose. Partners in the MDN contributed for different reasons. For instance, with the stent graft, surgeons placed heavy weight on the implanting process and their past experiences and personal preferences; regarding design, the product construction and materials needed to fit each other; regarding biomedical functionality, one could implant the product only into a human body after certification bodies had endorsed its biomedical parameters. The network understood that, in order for the product to be successful, the technical descriptions had to be translated into parameters describing its behavior in in-body conditions—a task, which had not been considered before. An engineer explained it this way: "There are different expectations, the technician says 'doable', the principal engineer wants it 'as thin as possible', the customer—we don't know" (translated).

As a result, partners had to drive forward their developments with different contributions that covered physics, material science, textile engineering, mechanical engineering, surgery, and biomedical sciences, which led major challenges in synchronizing partner contributions.

For example, all partners involved in the MDN network had to comprehensively document all materials and development steps to ensure regulatory compliance and ease market entry. As the stent graft included numerous new materials from different partners in the network, the materials and production processes had to undergo a rigorous assessment before certification bodies could finally approve it for production. On one occasion, one partner supplied a material to another. Both partners, independently of each other, analyzed the material's quality with a different focus, which resulted not only in redundant efforts but also in contradictory documentation captured in unrelated files as part of the partners' respective quality management systems. Per requirements, the partners needed to merge these documents into a comprehensive test report. As a solution, they created a framework for synchronizing their contributions with each other in a network reference library. One interviewee said it was "a transformation from a creative "tinker" world into systematic NPD processes and quality-certified production" (Industrial Engineering Consultant, translated).

The quote hints at the "transformation" that each network partner required to undergo to become aware of its own competences and to consequently align and synchronize with network partners. The partners formed the basis of this transformation by introducing systematic innovation procedures, such as failure mode and effects analysis (FMEA). They implemented FMEA and other systematic procedures for innovation in the CWE to form an innovation procedure toolkit. Using these procedures allowed the partners to align their strategies, physical capital, and contributions and to adapt to new arising needs. They later made these procedures available as templates for other contexts.

4.3.3 Organizational Capital: Synchronizing Routines and Processes

The partners also needed to coordinate to ensure the new process competences aligned with the network. One particular challenge entailed synchronizing data dictionaries. The partners had to describe the various parts of the final product with relevant parameters that stemmed from different contexts, which led to a multitude of data structures that they needed to match to reliably exchange information with each other. As a consequence, they had to continuously synchronize naming conventions, evolving data structures, and data compatibility, which the following quotes illustrate:

> *We had to invent a new data structure…, translate it into our own terminology…, and even invent names for the [prototypical] machines we used in our tests.* (Industrial engineering consultant, translated, MDN)

> *It is not an interface problem, but a problem of knowledge structures.* (Industrial engineering consultant, translated, MDN)

A network reference library helped partners to create conventions for naming their new developments. Partners used network architecture maps to document the compatibility of required "interfaces" between their IS that they had to consider (e.g., quality management systems).

4.4 Sensing the Environment of the Innovation Network

We found evidence of the sensing process in partners' efforts to evaluate the environment and leverage potential business opportunities in the face of change. Doing so primarily involved shifting their perspective of the business and market environment. Several factors enabled sensing: an openness to adjust to new business models with network partners, a willingness to identify and review relevant NPD options that firms identified collaboratively, and a willingness to engage in dialogues to adapt or alter how network partners implemented business and market strategies with each other.

4.4.1 Human Capital: Sensing New Network Partners

We found evidence that partners reconfigured the network based on sensing the environment across all three networks but particularly in the TCN. It entailed their formulating specific perspectives about the market environment and having the openness to adjust to new business models with the help of partners.

The TCN's original idea focused on a novel finishing technique ("sol-gel") for a large customer in the furniture market. This customer had not been part of the innovation network and, at a certain point of the project, signaled disinterest. This change of target market expectations put an end to the primary product idea, which forced the network to re-evaluate its product and re-orient the partnership goals in the network. The following quote illustrates the situation:

> *Unfortunately [the customer] decided to stop [its activities in the] upholstery market and to go only into the curtain market now…. So, it's not about the product, because they say that it's really interesting…. We did not stop the sol-gel project because we did not have results.* (Textile engineer)

Despite the change in market expectations, the network partners agreed to go ahead and license the technology. Early in the project, the NPD team had started to collect and share interesting articles about potential markets for their coating service. Partners shared relevant articles and reports on the project workspace, which allowed them to attain vital knowledge about their collaborators' work context and potential target markets. Only a few months after loss of the original customer, one of the partners who had engaged in promoting the technology identified and won a new customer.

4.4.2 Physical Capital: Sensing New Value Contributions

As we saw in the TCN, the network's raison d'être had vanished when the target customer decided to pull out of the development. This incident meant the partners had to rethink the arrangement of value contributions in the network. Since the cooperation between network partners had been exceptional and the technical infrastructure was already in place, the partners were eager to leverage both to their advantage and find a new strategy. Instead of sol-gel (which provided a scratch- and abrasion-resistant coating for textiles), the network partners identified an alternative product idea called easy-clean. Easy-clean, like sol-gel, also provided a coating but also prevented fabrics from staining. Cleaning a textile with easy-clean coating equaled wiping off dirt. The following quote illustrates how the partners reconfigured their contributions:

> *I think the real big change was when we changed to work on the easy-to-clean project [instead] of the sol-gel project.... It was after a lot of discussion with the [new textile customer] and a request from them to work on these properties…. They are really excited by working on that. We see that the collaboration is really better and we know that all partners have a goal. We work really well on this new project.* (Textile engineer)

The overall partnership and the interaction processes created in the partnership repository and the project workspace remained more or less stable. By concurrently elaborating on how they could integrate technical work content with the new NPD and market strategy, the partners re-evaluated and re-aligned their resources and contributions.

4.4.3 Organizational Capital: Sensing New Processes and Routines

Before the TCN changed direction from sol-gel to easy-clean, the partners had much dialogue on how to systematically approach a new product development, including a new market strategy. The partnerships in place were the core asset they sought to exploit along with the complementary expertise and experience already existing in the network. The innovation procedure toolkit that included methodologies, such as product potential analysis as a procedure for identifying market opportunities, helped improve the partners' market focus, which the following quote illustrates:

> *So he suggested, "…to try the Product Potential Analysis method". And then…he sent a questionnaire to the two companies, I don't know, let's say a week before we had a meeting. And then we had a meeting, with him, with the three (network) partners. And then we went over the filled out questionnaires and he explained a bit to the companies, and they explained their answers, so that was really a useful day.* (Textile engineering service provider)

The loss of the original customer necessitated the network to reconfigure its existing procedures. For the follow-up project, easy-clean, the network initiated a close cooperation with the newly identified target customer to gain early feedback on the prototype. Hence, by sensing, the network adapted its procedures to minimize future negative impacts from external events in the market, which the following quote illustrates:

> *We can totally use all the information that we have now…. Yes, we will use it and we already started to work with another customer to develop some tests to see where we can go, who is interested…. [Also] for the chemical company this first step is not [lost]…. It's really nice for the chemical company to have, so no problem to continue.* (Textile engineer)

The network partners needed to sense the different aspects, partners, their (potential) contributions, and their resources and organizational processes to better understand the environment, business needs, and opportunities.

5 Discussion

5.1 Evidence of Networking Capabilities

Applying the framework in Table 1 to identify characteristic elements of networking capabilities led to our collected evidence in Table 4. More specifically, Table 4 shows how each of the four enabling processes contributed to the network partners' developing and exerting networking capabilities. We identified distinct competences. Firms needed to expand significant effort to exercise these competences to capturing information about both their own and their partners' internal resources (e.g., descriptions of machines, processes, services, functional competences, experiences, etc.). Firms needed to make this information available to their network partners, and, thus, they needed to encode, store, maintain, and eventually include it in operational processes for retrieving and applying it in cooperative NPD. Moreover, the competences we identified were interrelated (e.g., firms' efforts to identify their partners' expertise (learning process: human capital) affected their awareness of their own competences (coordination process: physical capital)).

Research has often focused on the "optimal" IS support for distinct NPD activities and suggested that firms use decision support systems (DSS), computer-aided design, or virtual simulation tools (Nambisan, 2013; Pavlou & El Sawy, 2006). In the context of our case studies, we witnessed that the role of IS become an enabler of highly specific arrangements between innovation network partners that answered to the distinct requirements of the NPD process. We observed this enabling mechanism when network partners used the CWE as a foundation for configuring their own specific IT artifacts.

We also observed that combining IS functionalities into network-specific instruments satisfies the informational requirements (Table 1) associated with exerting networking capabilities and accomplishing enabling processes. Moreover, it helps network partners to form a unique set of synergistically aligned resources and capabilities.

IS helped network partners to link their dynamic and networking capabilities and enabled an alignment process between them. For instance, to cooperatively define tasks (integration), the CWE provided project documents (coordination), business process models (learning), and process blueprints (sensing). Network partners then operationalized this information through maps of the business ecosystem (learning), which revealed gaps in the value chain structure and helped the partners search for new ones on social networking platforms to fill these gaps (sensing). Partners operationalized dynamic capabilities in the CWE, which provided central repositories and an environment to support processes.

5.2 Evidence of Informational Purposes in the Alignment Process

In our analysis, we focused on how resource constellations in innovation networks emerge and what role IS play in the alignment process. We witnessed a variety of ways in which IS helped network partners exert networking capabilities and alignment processes.

From the evidence we collected, four informational purposes arose that each comprised several IS functionalities and that together enabled the alignment process. We conceptualize these informational purposes as: representation, sharing, architecture, and reach. These informational purposes represent assemblages of IS functionalities that can relate to all types of resources and enabling processes (see Table 5).

Representation involves functionalities that help one to analyze, collect, and model information about resources and capabilities (past and present) that are relevant for current or future cooperations. In our case study, we found evidence for firms' using IS for representation in partnership repositories, maps, and expert profiles that informed the learning process and provided inputs for integration and coordination between partners. Representation also helped identify gaps or needs with respect to resources and capabilities in a partnership and, thus, was part of the sensing process. Representations facilitate network partners' ability to track changes in resource constellations in the network and present capabilities to potential partners outside the network.

Sharing involves functionalities that allow network partners to cooperatively collect, distribute, and retrieve information that can provide input for them to reconfigure and align resources at an operative level. By sharing information in common workspaces (that particularly comprise collaborative work functionalities), network partners support learning. Also, a set of integration and coordination processes between partners typically accompanies this information sharing. Sharing also informs sensing processes (e.g., when a partner takes on the distinct role of a mediator between other partners).

Table 4. Evidence from Three Case Studies in Relation to Networking Capability

Enabling process at the firm level	Competences belonging to networking capability that contribute to creating resource constellations at the network level		
	Human capital	Physical capital	Organizational capital
Learning process: connects to partners' competences for identifying and leveraging complementary value contributions	• Identifying expertise and competences of each partner in the network	• Determining (potential) value contributions of a network partner	• Establishing processes to evaluate potential partners • Identifying knowledge gaps and overlaps in partnerships
Integration process: uses information, means and procedures available in the network to implement shared modes of working and to operatively manage collaborations	• Providing information for project planning • Monitoring project progress • Preparing for partner integration at a later stage • Monitoring project progress for re-evaluating project status and technical objectives	• Providing information for aligning tasks • Re-evaluating partner contributions through systematic innovation procedures • Re-evaluating technical objectives, task planning, team composition, and task distribution	• Establishing operative working infrastructures and team spirit • Responding to new technical developments concurrently
Coordination process: defines boundary conditions and procedures to synchronize collaborations in the network	• Re-orienting the service and product portfolio towards new markets through widening the readiness and ability to engage in different types of businesses • Adopting new approaches to partnering • Representing own capabilities as "services"	• Adapting own organization and services to the network • Altering awareness of own core competences • Developing and providing frameworks to synchronize contributions and assure fair resource use on methodical and technological basis	• Providing systematic processes and tools for synchronizing information and exchanging knowledge • Increasing reach through using new approaches to tasks • Increasing reach through using new communication channels (SMEs)
Sensing process: builds on network partners' expertise and market relations/views to identify new business opportunities and shared goals	• Re-orienting partnership goals • Finding new ways to approach the market through reconfiguration of partnerships (e.g., licensing options)	• Identifying complementary contributions • Leveraging existing network infrastructures as an asset • Concurrently elaborating NPD objectives to align with partner contributions and to better target at market demands	• Applying systematic procedures for innovation • Keeping close contact with partners in view of markets

Architecture relates to systems and reference models that support network partners in defining and implementing a joint infrastructure with regards to information systems, processes, informational structures, conventions, and so on. It comprises functionalities for defining taxonomies, modeling processes, and instantiating process templates as workflows. A common architecture establishes the foundation for configuring IT artifacts that help network partners to integrate and interact with each other.

Reach comprises functionalities that help network partners take up activities with new ones (e.g., when extending the network or extending the scope of activities through promoting partners' capabilities to the public). In and across the network, knowledge spaces that contain tutorials or demonstrations of products and services can serve as inputs for learning and, if shared, can become vital means for integrating and sensing.

Our conceptualization of the four informational purposes builds on the IT artifacts that the NPD projects of the three networks configured. In Tables 5 and 6, we characterize these resulting IT artifacts with the help of generic names and outline how the network partners used them with respect to different types of resources. The IT artifacts created allowed innovation network partners to align with one another; they also persisted as concurrently developed assets throughout the projects.

Table 5. Evidence of IS Support for Networking Capability: IS Functionalities

Informational purpose	IS functionalities*	Role in supporting networking capability
Representation: involves functionalities that allow network partners to present their own and others' resources and capabilities	• Business process modeling (BPM) • Professional social networking websites (PSN)	• Capturing and modeling network partners' expertise and experience from past projects and partnerships (H) • Presenting own (person-related) competences to the network (H) • Identifying and acquiring external expert knowledge (H) • Analyzing potential value contributions (identifying knowledge and service gaps/overlaps) (P) • Fostering a service-oriented approach to collaborating on the operative level (P) • Documenting implemented processes and process blueprints (O) • Leveraging contacts throughout and beyond the network for adjusting own strategies and directions with competitors and the network partners (O)
Sharing: involves functionalities that allow network partners to cooperatively collect, distribute, and retrieve information or to automatically generate analytical interpretations	• Collaboration software (chatting, telephony, screen sharing, etc.) • Collaborative work environment (CWE) • Project-management software (task lists, flow charts, Gantt charts, etc.) • Shared databases • Wikis, blogs	• Documenting and monitoring the status of operative work (H) • Representing and evaluating project plans (H) • Provision of a shared information repository allowing for selective information sharing (H) • Scheduling tasks and arranging contributions (P) • Adapting task structures in relation to shared goals, i.e. provision of functionality to analyze the consequences on the overall task structure and other goals (P) • Providing functionality for adjusting information on group awareness (e.g., presence, reaction to network partners' activities, development of shared work routines and mental models, easier switch from individual to group work, context definition) (P) • Defining complex tasks that comprise a multitude of contributions from several partners as one entity (O) • Providing adaptable work processes (e.g., online/offline, synchronous/asynchronous, desktop-based/mobile, etc.) (O) • Providing exchange of impressions, opinions, doubts, and so on (e.g., instant messaging, blogging, commenting, ratings) (O)
Architecture: involves functionalities that help network partners establish joint processes and conventions	• BPM • CWE • Wikis • Workflow-management systems	• Documenting shared goals, which allows for an intermediate definition of (preliminary) tasks (requirements) (H) • Documenting objectives, individual goals, and (intended) contributions (H) • Compiling libraries of technical terms (naming conventions) and of elements of the available technical infrastructures (P) • Collecting and sharing information on resources (status) (P) • Providing frameworks guiding decisions on project progress (e.g. best practice or reference frameworks of innovation methods/processes) (P) • Providing guidelines for (applying) systematic innovation procedures (O) • Providing process blueprints (O)
Reach: involves functionalities that help network partners take up activities with new ones	• CWE • PSN • Wikis	• Connecting to and engaging in professional social networks (H) • Creating tutorials as a way to reflect on and distribute own competences and capabilities (H) • Learning from others through regularly scanning for expertise existing in the network and outside (H) • Publishing interest and competence areas, e.g. through tutorials and demonstrator videos etc. (P) • Illustrating overall goal not only in text but also in multi-media to extend expression possibilities (O) • Providing knowledge repositories on expertise existing in the business ecosystem surrounding the innovation network (O) • Identifying and connecting to potentially promising new contacts and adjusting with known partners (O)

* These are exemplary functionalities and system types that we found in our case studies. Further functionalities and systems might provide comparable support.

Table 6. Evidence of IS Support for Networking Capability: IT Artifacts

Informational purpose	Characterization of enabling IT artifacts*
Representation: involves functionalities that allow network partners to present their own and others' resources and capabilities	• **Partnership repository** Overviews partnerships, performed projects, and established processes. Use for reviewing and re-orienting partnerships towards customer and market needs and for managing types of partnerships. • **Business ecosystem map** Overviews (detailed) technical competences and expertise of partners, list of available services, outline of NPD areas potentially interesting to partners. Use for aligning competency and partnership strategy. • **Expertise map/expert profiles** Firm and expert profiles to present best practice expertise in technical fields. Describes in detail expertise (person-specific "white pages") and related capacities in closed (network-wide) groups. Publication of tutorials and demonstrators to the network and eventually to the public. • **Project strategy map** Plans the overall NPD project, task distribution lists, and technical responsibilities, which includes blueprints for project phases. Use for collectively managing task distributions and developing global understanding of the project as a whole.
Sharing: involves functionalities that allow network partners to cooperatively collect, distribute, and retrieve information or to automatically generate analytical interpretations	• **Project workspace: project management** Documents the overall NPD process, task lists, technical responsibilities, and activities. Use for collectively managing tasks; addressing situational demands; mutually sharing developments in time; developing global understanding of each other's fields, actions, contexts, specialized skills, and relevant knowledge. • **Project workspace: collaboration** Provides multiple communication channels, tracking and documenting of team interactions (conversations), retrieval functionality (e.g., tagging of single information items), collaborative work space (e.g., incl. wiki, blog functionalities). Use for creating a work environment fostering immersion into the collaboration and for developing shared work routines. • **Project workspace: analytics** Provides an automated process capture and analysis in a recommender system. Use to control project progress, identify lags and gaps in developments, and make recommendations for upcoming plans/activities.
Architecture: involves functionalities that help network partners establish joint processes and conventions	• **Network reference library** Provides a library of technical terms, numbers, and identifiers from the NPD process. Provides an overview of (names/types of) network resources and novel products and services and their descriptive parameters (e.g., based on a semantic model). • **Network architecture map** Overviews the network's IS infrastructure (e.g., enterprise architecture functionality). Use as a "clearing house" for managing naming conventions, for managing compatibility of interim solutions and resource development, and for managing the network IS infrastructure. • **Innovation procedure toolkit** Lists relevant methods to elaborate ideas and designs and to quantify impacts of changes including method blueprints. For synthesizing promising approaches to new products and services; a toolbox. Note: several websites offer method descriptions in the public domain. • **Network reference processes** Provides task coordination or workflow functionality and, eventually, ad hoc work flow blueprints for frequent cases/types of interaction. Use for setting up effective workflows in quick response to occurring changes and to link these workflows with relevant information items and, if possible, the innovation procedure toolkit.
Reach: involves functionalities that help network partners take up activities with new ones	• **Network knowledge space** Space for publishing tutorials and demonstrators (eventually to the public, including YouTube posts); interactive presentations of new products and services, or current NPD projects. • **Network interaction groups** Space to contribute to discussions on expert topics (e.g., incl. white papers, on PSN). • **Project workspace: markets** Collection of news and information from publications, magazines, and corporate networks to identify new business opportunities. Use for identifying and elaborating promising ideas on new products and services.

* These are exemplary IT artifacts that we found in our case studies. Other ways of implementing and grouping functionalities might provide comparable support.

5.3 Evidence of the Role of the Alignment Process in Creating IS-embedded Network Resources

In their efforts to align with each other, innovation network partners create IS-embedded network resources as assets at the network level that hold the potential for achieving a competitive advantage. These partners synergistically interlink human, physical, and organizational capital through informational representations embedded in IS; thus, unique resource constellations across network partners arise. The constellations are specific configurations of IT artifacts that combine partners' resources and capabilities.

For example, the business ecosystem map of an NPD network can provide a network resource for its partners to gain competitive advantage through learning. The ecosystem map contains information about relevant partners and their innovation capabilities, services, and market interests. Network partners can then use this resource to align their competencies and strategies and to re-orient the network when markets change or when new opportunities arise. In the MHN, for example, partners used their ecosystem map to identify promising additional markets for the novel material they developed. Among others, they discovered wind wheels and car bodies as promising future markets and could reach out to new partners based on this new insight.

Attaining resource constellations requires an alignment process at the network level. We found evidence for at least four informational purposes that characterize this alignment process. All firms in our case studies used specific IS functionalities to establish a common information basis and handle information and business process models (i.e., representation), specific IS functionalities to integrate interactions and information through common processes and routines (i.e., sharing), specific IS functionalities to create a shared infrastructure to design and execute processes (i.e., architecture), and specific IS functionalities to increase reach through displaying market intentions and professional social networking (i.e., reach). Network partners can implement these informational purposes with help of dedicated IT artifacts that help them exert their networking capability, which enables them to generate knowledge about the relevance of each other's resources in the market (i.e., sensing), about understanding the value of each other's resources (i.e., learning), about using and exploring resources together (i.e., coordinating), and about facilitating shared resource use (i.e., integrating). This enabling mechanism permits the network partners to create and align their network resources as IS-enabled networking capabilities.

As we illustrate in our analysis, attention towards network resources helped the network partners we examined to develop their networking capability, which extends and complements the known set of functional competences (i.e., customer, technical, and managerial competences that Pavlou and El Sawy (2006) define) that firms need to achieve dynamic capabilities. In this sense, we demonstrate that the four enabling processes also contribute to generating and reconfiguring network resources.

At the network level, firm-level resources enter the IS in complex combinations: the informational purposes (i.e., representation, sharing, architecture, and reach) provide patterns for how network partners generate such complex combinations. We also found that IS play an important role for establishing an "innovation infrastructure" (Nambisan, 2013) for innovation networks—in other words, IS are levers for developing particular configurations of network resources.

Using the term "resource" is important because firms should understand network resources as unique assets. Just like firm-level resources, firms need to manage network resources (i.e., plan, shape, implement, maintain, monitor, and evaluate them). Network resources represent constellations of resources that exhibit unique characteristics and, as the RBV suggests, comprise the factors of value, rareness, inimitability, and persistence. In the context of our study, we found, for example, that bundles of services and products can emerge that stem from a rare (and, in many cases, unique) constellation of network partners. These network resources may be difficult to imitate and constitute an exclusive opportunity for a specified market. Highly specified innovations are possible along with a high return and an unlikely prospect of substitution due to the distinct interplay of network resources.

We also observed that the constellations of resources persist (i.e., once specific configurations are in place, they are relatively stable and can be included in the scope of functional competences (Pavlou & El Sawy, 2006)—at least for the duration of the project). Thus, we propose that, by paying attention to network resources, firms can reap substantial benefits from engaging in innovation networks.

As we show in this paper, network partners build on these resources, yet they differ from organizational resources. While we focus on technical functionalities of IS that enable network partners to form these unique resources, the social subsystem of the IS may also play a role. For example, integrating different structures of power may result in complex combinations such that resultant network-level resources supersede heterogeneous cultures and organizational forms. While we saw some evidence of such a result in our sample of SMEs that differed in national culture, language, and organizational structures, we need future research to fully explore how people and organizational structures (i.e., the social subsystem of socio-technical systems) enable network partners to form IS-embedded network resources.

With regards to the relational view, the alignment process (for establishing network resources as inter-firm resources) substantializes the processes involved in generating specific inter-firm assets (Dyer & Singh, 1998; Mesquita et al., 2008). Our research extends the literature by connecting a firm's NPD dynamic capabilities (i.e., how innovation happens in an organization) with the network's alignment process (i.e., how innovation happens between organizations).

Prior literature has also pointed at the relevance of a firm's "embeddedness" in an innovation network (Cowan et al., 2007), including knowledge retained from previous cooperations (i.e., relational embeddedness) and knowledge about potential partners (i.e., structural embeddedness). Our study explicates how firms can practically achieve this embeddedness. We believe that, if firms orient their innovation efforts toward network resources, they will be able to create innovation infrastructures as part of an ecosystem of partners that can support multiple networks simultaneously. In this sense, network resources can provide pooled information resources to an innovation ecosystem (Robey, Im, & Wareham, 2008).

6 Limitations

Our study has limitations inherent to our research question and design. For example, while we acknowledge the relevance of individual level analyses for investigating the role of IS in NPD activities, we concentrated our analysis at the firm and network level. We did not investigate effects that appeared in teams or changes in individual-level behaviors (Majchrzak, Wagner, & Yates, 2013). Research in this direction might shed further light on the performance of inter-organizational NPD teams.

Further, as an interpretive study of three SME networks, our study can only provide analytical conceptualizations. The data we collected from studying three networks in depth limits our findings. Future research could use our concepts to look for evidence in a larger, possibly more varied, sample of innovation networks.

Acknowledgments

This work was partly funded by the European Commission through the project SmartNets: The Transformation from Collaborative Knowledge Exploration Networks into Cross Sectoral and Service Oriented Integrated Value Systems (grant agreement no. 262806). We acknowledge the commission's contribution and expressly thank all the SmartNets project partners for their support.

References

Adner, R., & Kapoor, R. (2010). Value creation in innovation ecosystems: how the structure of technological interdependence affects firm performance in new technology generations. *Strategic Management Journal*, *31*(3), 306-333.

Alexy, O., George, G., & Salter, A. I. (2013). Cui bono? The selective revealing of knowledge and its implications for innovative activity. *Academy of Management Review*, *38*(2), 270-291.

Argote, L., & Ren, Y. (2012). Transactive memory systems: A microfoundation of dynamic capabilities. *Journal of Management Studies*, *49*(8), 1375-1382.

Baker, J., Jones, D. R., Cao, Q., & Song, J. (2011). Conceptualizing the dynamic strategic alignment competency. *Journal of the Association for Information Systems*, *12*(4), 299-322.

Banker, R. D., Bardhan, I., & Asdemir, O. (2006). Understanding the impact of collaboration software on product design and development. *Information Systems Research*, *17*(4), 352-373.

Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management*, *17*(1), 99-120.

Burt, R. S. (2004). Structural holes and good ideas. *The American Journal of Sociology*, *110*(2), 349-399.

Capaldo, A. (2007). Network structure and innovation: The leveraging of a dual network as a distinctive relational capability. *Strategic Management Journal*, *28*(6), 585-608.

Chesbrough, H. W. (2003a). *Open innovation: The new imperative for creating and profiting from technology.* Boston, MA: Harvard Business School Press.

Chesbrough, H. W. (2003b). The era of open innovation. *MIT Sloan Management Review*, *44*(3), 35-41.

Chesbrough, H. W. (2009). Constructing and managing innovation in business networks. In J. Word (Ed.), *Business network transformation. Strategies to reconfigure your business relationships for competitive advantage: 179–19*8 (1st ed.). San Francisco, CA: Jossey-Bass.

Cowan, R., Jonard, N., & Zimmermann, J.-B. (2007). Bilateral collaboration and the emergence of innovation networks: Bilateral collaboration and the emergence of innovation networks. *Management Science*, 53(7), 1051-1067.

Davenport, T. H., & Prusak, L. (2000). *Working knowledge: How organizations manage what they know.* Boston, MA: Harvard Business School Press.

Davenport, T. H., Leibold, M., & Voelpel, S. (2006). *Strategic management in the innovation economy: Strategy approaches and tools for dynamic innovation capabilities*. Erlangen: Publicis.

Denzin, N. K., & Lincoln, Y. S. (Eds.). (2005). *The SAGE handbook of qualitative research* (3rd ed.). Thousand Oaks: Sage.

Dhanaraj, C., & Parkhe, A. (2006). Orchestrating innovation networks. *Academy of Management Review*, *31*(3), 659-669.

Dubini, P., & Aldrich, H. (1991). Personal and extended networks are central to the entrepreneurial process. *Journal of Business Venturing*, *6*(5), 305-313.

Dyer, J. H., & Singh, H. (1998). The relational view: cooperative strategy and sources of interorganizational competitive advantage. *Academy of Management Review*, 23(4), 660-679.

Eisenhardt, K. M. (1989). Building theories from case study research. *The Academy of Management Review*, *14*(4), 532–550.

Eisenhardt, K. M., & Martin, J. A. (2000). Dynamic capabilities: What are they? *Strategic Management Journal*, *21*(10/11), 1105–1121.

Emden, Z., Calantone, R. J., & Droge, C. (2006). Collaborating for new product development: Selecting the partner with maximum potential to create value. *Journal of Product Innovation Management*, *23*(4), 330-341.

Grant, R. M. (1991). The resource-based theory of competitive advantage: Implications for strategy formulation. *California Management Review*, *33*(3), 114-135.

Gulati R. (1999). Network location and learning: the influence of network resources and firm capabilities on alliance formation. *Strategic Management Journal, 20*(5), 397-420.

Gulati R., Nohria N., & Zaheer A. (2000). Strategic networks. *Strategic Management Journal 21*(3), 203-215.

Gulati, R. (1998). Alliances and networks. *Strategic Management Journal*, *19*(4), 293-317.

Han, K., Oh, W., Im, K. S., Oh, H., Pinsonneault, A., & Chang, R. M. (2012). Value cocreation and wealth spillover in open innovation alliances. *MIS Quarterly*, *36*(1), 291-316.

Hayes, R. H., Pisano, G. P., & Upton, D. M. (1996). *Strategic operations: Competing through capabilities*. New York: Free Press.

Inkpen, A. C., & Tsang, E. W. K. (2005). Social capital, networks, and knowledge transfer. *The Academy of Management Review*, *30*(1), 146-165.

Jacobides, M. G., Knudsen, T., & Augier, M. (2006). Benefiting from innovation: Value creation, value appropriation and the role of industry architectures. *Research Policy*, *35*(8), 1200-1221.

Jarvenpaa, S. L., & Leidner, D. E. (1998). An information company in Mexico: Extending the resource-based view of the firm to a developing country context. *Information Systems Research*, *9*(4), 342-361.

Klein, H. K., & Myers, M. D. (1999). A set of principles for conducting and evaluating interpretive field studies in information systems. *MIS Quarterly*, *23*(1), 67-93.

Kleis, L., Chwelos, P., Ramirez, R. V., & Cockburn, I. (2012). Information technology and intangible output: The impact of IT investment on innovation productivity. *Information Systems Research*, *23*(1), 42-59.

Lavie, D. (2006). The competitive advantage of interconnected firms: An extension of the resource-based view. The Academy of Management Review, 31(3), 638-658.

Lee, G. K. (2007). The significance of network resources in the race to enter emerging product markets: The convergence of telephony communications and computer networking, 1989-2001. *Strategic Management Journal*, *28*(1), 17-37.

Lorenzoni, G., & Lipparini, A. (1999). The leveraging of interfirm relationships as a distinctive organizational capability: A longitudinal study. *Strategic Management Journal*, 20(4), 317-338.

Majchrzak, A., More, Philip H. B., & Faraj, S. (2012). Transcending knowledge differences in cross-functional teams. *Organization Science*, *23*(4), 951-970.

Majchrzak, A., Wagner, C., & Yates, D. (2013). The impact of shaping on knowledge reuse for organizational improvement with wikis. *MIS Quarterly*, *37*(2), 455-A12.

Mesquita, L. F., Anand, J., & Brush, T. H. (2008). Comparing the resource-based and relational views: Knowledge transfer and spillover in vertical alliances. *Strategic Management Journal*, *29*(9), 913-941.

Mort, G.S., & Weerawardena, J. (2006). Networking capability and international entrepreneurship: How networks function in Australian born global firms. *International Marketing Review*, *23*(5), 549-572.

Mu, J. (2014). Networking capability, network structure, and new product development performance. *IEEE Transactions on Engineering Management*, *61*(4), 599-609.

Mu, J., & Di Benedetto, A. (2012). Networking capability and new product development. *IEEE Transactions on Engineering Management*, *59*(1), 4-19.

Myers, M. D. (1997). Qualitative research in information systems. *MIS Quarterly*, *21*(2), 241-242.

Myers, M. D., & Newman, M. (2007). The qualitative interview in IS research: Examining the craft. *Information and Organization*, 17(1), 2-26.

Nambisan, S. (2003). Information systems as a reference discipline for new product development. *MIS Quarterly*, 27(1), 1-18.

Nambisan, S. (2013). Information technology and product/service innovation: A brief assessment and some suggestions for future research. *Journal of the Association for Information Systems*, *14*(4), 215-226.

Nambisan, S., & Sawhney, M. (2011). Orchestration processes in network-centric innovation: Evidence from the field. *Academy of Management Perspectives*, *25*(3), 40-57.

O'Reilly, C. A., III., & Tushman, M. L. (2004). The ambidextrous organization. *Harvard Business Review*, *82*(4), 74–81.

Ozcan, P., & Eisenhardt, K. M. (2009). Origin of alliance portfolios: Entrepreneurs, network strategies, and firm performance. *Academy of Management Journal*, *52*(2).

Pavlou, P. A., & El Sawy, O. A. (2006). From IT leveraging competence to competitive advantage in turbulent environments: The case of new product development. *Information Systems Research*, 17(3), 198–227.

Penrose, E. T. (1959). *The theory of the growth of the firm*. New York: Wiley.

Pisano, G. P., & Teece, D. J. (2007). How to capture value from innovation: Shaping intellectual property and industry architecture. *California Management Review*, *50*(1), 278-296.

Ritter, T., Wilkinson, I. F., & Johnston, W. J. (2002). Measuring network competence: Some international evidence. *Journal of Business & Industrial Marketing*, *17*(2/3), 119-138.

Robey, D., Im, G., & Wareham, J. D. (2008). Theoretical foundations of empirical research on interorganizational systems: Assessing past contributions and guiding future directions. *Journal of the Association for Information Systems*, *9*(9), 497–518.

Schilling, M. A., & Phelps, C. C. (2007). Interfirm collaboration networks: The impact of large-scale network structure on firm innovation. *Management Science*, *53*(7), 1113-1126.

Schreyögg, G., & Kliesch-Eberl, M. (2007). How dynamic can organizational capabilities be? Towards a dual-process model of capability dynamization. *Strategic Management Journal*, *28*(9), 913–933.

Silverman, D. (2014). *Interpreting qualitative data* (5th ed.). Los Angeles, CA: Sage.

Simon, H. A. (1947). *Administrative behavior: A study of decision-making processes in administrative organizations* (4th ed.). New York, NY: Free Press.

Spender, J.-C. (1996). Making knowledge the basis of a dynamic theory of the firm. *Strategic Management Journal*, *17*, 45-62.

Stake, R. E. (2005). Qualitative case studies. In N. K. Denzin & Y. S. Lincoln (Eds.), *The SAGE handbook of qualitative research* (3rd ed., pp. 443-466). Thousand Oaks, CA: Sage.

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal*, *18*(7), 509–533.

Wade, M., & Hulland, J. (2004). The resource-based view and information systems research: Review, extension, and suggestions for future research. *MIS Quarterly*, *28*(1), 107-142.

Walsham, G. (1993). *Interpreting information systems in organizations*. New York: Wiley.

Wernerfelt, B. (1984). A resource-based view of the firm. *Strategic Management Journal*, *5*(2), 171-180.

Whelan, E., Conboy, K., Crowston, K., Morgan, L., & Rossi, M. (2014). Editorial: The role of information systems in enabling open innovation. *Journal of the Association for Information Systems*, *15*(11), Article 4.

Yardley, L. (2008). Demonstrating validity in qualitative psychology. In J. A. Smith (Ed.), *Qualitative psychology*: *A practical guide to research methods* (pp. 235-251). Los, Angeles, CA: Sage.

Yin, R. K. (2003). *Case study research: Design and methods* (3rd). Thousand Oaks, CA: Sage.

Zollo, M., & Winter, S. G. (2002). Deliberate learning and the evolution of dynamic capabilities. *Organization Science*, *13*(3), 339-351.

Appendix A

Table A1. Overview of Interviewees

Organization (*)	Interviewee number and title (experience level in years)	
Medical Device Network (MDN)		
Medical device producer (9)	1	Director (20+)
	2/3	R&D managers (20+/15+)
	4/5	Engineers (medical products) (15+/15+)
Research services provider (physics) (2)	6/7	Researchers (material engineering) (20+/5+)
Textile processing services provider (wire covering) (6)	8	General manager (20+)
	9	Process manager (15+)
Technical textiles producer (graft) (4)	10	Engineer (technical textiles) (15+)
Textile machinery service provider (8)	11	R&D manager (15+)
Consulting & engineering services provider (3)	12/13	Management consultants (5+/5+)
Industrial research institute (6)	14	Project manager (5+)
	15/16	Management consultants, industrial processes (20+/<5)
Motorbike Helmet Network (MHN)		
Chemical company (3)	1	Chemist, business owner (20+)
Engineering services provider (8)	2	Process engineer, project manager (10+)
	3	Lead product designer, project manager (10+)
	4	General manager (15+)
Product design & manufacturing company (2)	5	R&D manager, business owner (20+)
Consulting & engineering services provider (3)	6/7/8	Management consultants (15+/5+/5+)
Industrial research institute (6)	9	Project manager (5+)
	10	Management consultant, industrial processes (20+/<5)
Textile Coating Network (TCN)		
Interior textiles producer (5)	1	Sales manager (10+)
Coating producer (5)	2	R&D manager, business owner (20+)
	3	R&D engineer (10+)
Textile research services provider (9)	4	Research manager (20+)
	5/6	Researcher (textile engineering) (10+/5+)
Consulting & engineering services provider (3)	7/8	Management consultants (5+/5+)
Industrial research institute (6)	9	Project manager (5+)
	10	Management consultant, industrial processes (20+/<5)

* We indicate the number of team members in brackets. For MHN, there are 3, for TCN 4 further team members from other firms which have not been included to interviews.

Table A2. List of Sample Questions for Semi-structured Interviews

Aspect	Question(s)
Networking goals	
	• Was there recently a change of goals in the network? • Did single partners change their goals and/or contributions recently? • Did the project take a new direction?
Dynamic and networking capabilities	
Aspects of human capital in the network	• Was there a change in the team composition? Did team members assume new roles? Did new people join or leave the team? If yes, why, and with what effects? • To your knowledge and experience, have team members developed new competences? Do you have the impression team work changed recently? What caused this change? How do you react to it? • In your opinion, which competences are missing in your team/ in the network? Have you changed your way of working? Have you gained new competences recently?
Aspects of physical capital in the network	• Was there a need arising for new, additional types of value contributions recently, e.g. due to technical requirements? Could you provide them within the network? Did you have to seek additional contributions from outside the network? • Which resources are employed in your network? Who provides them? • Have new resources been employed in the network recently? To what effect? • Have there been technical problems recently? How were they overcome?
Aspects of organizational capital in the network	• Have there been any incidents recently that changed the project plans? If there have been changes, what were the reactions of project partners? During this change, how did the process of finding an agreement/ a consensus/ a common strategy proceed? • Which role did the applied IS play in this respect, if any?

Appendix A

Table B1. Overview of Vignettes

Enabling process / NPD dynamic capability*	Human capital	Physical capital	Organizational capital
Learning process	V1.1* (all three networks)	V1.2 (all three networks)	V1.3 (all three networks)
Integration process	V2.1 (Motorbike Helmet Network)	V2.2 (Motorbike Helmet Network)	V2.3 (Motorbike Helmet Network)
Coordination process	V3 (Motorbike Helmet Network)	V4.1 (Medical Device Network)	V4.2 (Medical Device Network)
Sensing process	V5.1 (Textile Coating Network)	V5.2 (Textile Coating Network)	V5.3 (Textile Coating Network)

* Numbering of vignettes relates to the sequence as they appear in the text.

From a total of 12 significant vignettes about resource configurations that we found during our analysis, we identified 32 occurrences of correlations between enabling processes and resource types. Each of these occurrences provided evidence for elements of networking capability included in Table 4. We selected vignettes to cover all correlations and to comprehensively re-narrate developments in the networks.

About the Authors

Sven-Volker Rehm holds the Chair of Business Information Science and Information Management at WHU – Otto Beisheim School of Management, Germany, as interim professor. His research sits at the intersection of communication, technology, and organizing, and focuses on the digital transformation in innovation and entrepreneurship. He has published work in outlets, such as *Information & Management*, *Information and Organization*, *MIS Quarterly Executive*, *International Journal of Information Management*, and others. He holds lecturing positions at the University of Strasbourg, France, and at the University of Stuttgart, Germany. He assisted the European Commission as an independent expert in the field of integrative technologies for industrial applications. He is also a board member of the Society for Managerial and Social Cybernetics.

Iris Junglas is an Associate Professor in the Department of Business Analytics, Information Systems and Supply Chain at Florida State University, USA. Her research interest captures technology innovation and business analytics. Iris' work has been published in the *European Journal of Information Systems, Information Systems Journal*, *Journal of Strategic Information Systems*, *Journal of the Association of Information Systems*, *Management Information Systems Quarterly*, and various others. She is an Associate Editor for the *European Journal of Information Systems* and *Communications of the Association of Information Systems*, and an editorial board member of the *Journal of Strategic Information Systems* and *Management Information Systems Quarterly Executive*.

Lakshmi Goel is currently working as Associate Professor of Information Systems at the Coggin College of Business, University of North Florida. Her research works are published in various conferences such as International Conference on Information Systems, Americas Conference on Information Systems, Academy of Management, Hawaii International Conference on System Sciences, and European Conference on Information Systems; and journals such as *Management Information Systems Quarterly*, *Journal of the Association for Information Systems*, *Decision Support Systems*, *Information & Management*, *Information and Organization*, and *Information Systems Journal*.