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Managing research and innovation networks: Evidence from a government sponsored cross-industry program

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ABSTRACT

Important innovations are increasingly produced based on research engagement and fertilization across industries. However, we know little about the challenges associated with managing innovation networks in specific contexts that involves researchers in cross-industry collaboration. Against this backdrop, we draw on theory on design and orchestration of innovation networks to analyze a large-scale government sponsored program, "*ProcessIT* Innovations" that was designed to increase competitiveness and accelerate economic growth in Northern Sweden. The program was initiated and led by firms from the traditionally strong local process industry and engaged local researchers and firms from the emerging IT industry. Based on our analyses, we offer two contributions. First, we provide a detailed analysis of the challenges related to configuration of the network, orchestration of partnerships between participants, and facilitation of innovation in dedicated development projects. Second, we propose a model of managing research and innovation networks through fertilization across industries and between firms and research institutions.

1. Introduction

Contemporary innovation processes do not necessarily take place within the boundaries of the firm or within single industries. Instead, they are increasingly distributed among a large number of networked actors (Jacobides and Billinger, 2006) with diverse and complementary capabilities (Asheim and Isaksen, 2002). Hence, networks of innovators (Pittaway et al., 2004; Vanhaverbeke and Cloodt, 2006) and cross-fertilization between firms and research institutions (Cooke et al., 2004; Asheim et al., 2007) have become significant contexts for innovation. Also, research on innovation systems (Lundvall, 1992) with a particular geographical focus (Storper, 1995; Padmore and Gibson, 1998) has been identified as important to policy makers trying to facilitate the emergence of such systems (Oughton et al., 2002; Asheim et al., 2007) and to firms striving for competitiveness through innovation and networking in a globalized world (Porter, 2000; Cooke et al., 2004). In particular, government sponsored research and innovation initiatives typically involve a large number of distributed and networked actors and they are launched when market mechanisms are not seen as enough to produce a change in innovation performance. Public interventions, in the shape and form of government sponsored initiatives, are intended to facilitate this transformation process, making it faster and more flowing.

Despite the upsurge in interest in supporting research and innovation, we know little about the challenges associated with managing networks that support cross-industry collaboration based on government sponsoring (Doeringer and Terkla, 1995). This holds true even if we include evidence from the fast growing stream of literature on technology and innovation management (Linton and Thongpapanl, 2004). Against this backdrop, we draw on theory on design and orchestration of innovation networks (Dhanaraj and Parkhe, 2006) to analyze a large-scale government sponsored research and innovation program, "ProcessIT Innovations" (in short, *ProcessIT*) that was initiated by the process industry and designed to increase competitiveness and accelerate economic growth in Northern Sweden. The program was launched in 2004 as a joint venture between commercial and public interests, and it engaged the traditionally strong local process industry as well as the emerging local IT industry in a network with many participating firms, public authorities, and local universities.

Grounded in the case and drawing on extant innovation research, we investigate the following research question: *what are the challenges associated with managing government sponsored research and innovation networks to improve firm competitiveness*

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and stimulate growth through cross-industry collaboration? Insights into this issue can contribute to current theory on research and innovation and provide useful guidance for firms seeking to increase their innovation capability as well as policy makers and funding agencies facilitating economic growth.

In the following, we review the literature on innovation and innovation management, followed by a presentation of the theoretical framing we used to analyze the case. Next, we present our research design, the context of the case and the results from the analyses. In conclusion, we discuss the challenges associated with designing and orchestrating the observed research and innovation network. In addition, we propose a model of managing innovation networks through fertilization across industries and between firms and research institutions.

2. Theoretical background

Van de Ven (1986, p. 590) pointed out that "few issues were characterized by as much agreement as the role of innovation and entrepreneurship for social and economic development". This statement echoes early work of Schumpeter (Schumpeter, 1942) about the outmost importance of innovation for firms and society as a whole. Today, this still holds true. In order to stay competitive, firms have to continuously find new ways to conduct and stimulate competitive innovation processes (Van de Ven et al., 1999; Chesbrough, 2003; Van de Ven, 2005; Chesbrough et al., 2006; Tidd and Bessant, 2009). Such efforts require collaboration with external partners (Van de Ven, 2005; Chesbrough and Schwartz, 2007; Chesbrough and Prencipe, 2008) in more open (Chesbrough, 2003; Chesbrough et al., 2006), diverse (Van de Ven, 2005), and distributed configurations (Coombs and Metcalfe, 2002; Boland et al., 2007). Hence, in order to stay competitive, firms must manage innovation processes in increasingly complex situations with growing numbers of diverse actors (Van de Ven, 1986; Roberts, 1998; Van de Ven et al., 1999).

Innovation that targets economic growth in a specific geographical area is typically constituted through ongoing interactions between industrial partners and supporting institutional infrastructures that include research, higher education, business associations, and technology transfer agencies (Asheim and Isaksen, 1997; Lundvall and Borrás, 1997). The value of such innovation systems depends on their ability to help firms address the dilemmas they face, for example when projects require extraordinary investments in situations where outcomes remain uncertain (Heidenreich, 2004). Such value may indeed be created because "close inter-firm communication, socio-cultural structures and institutional environments may stimulate socially and territorially embedded collective learning and continuous innovation" (Asheim and Isaksen, 2002, p. 83). Also, due to the geographical proximity dimension of the participants, firms within such systems can create, acquire, accumulate, and utilize knowledge faster than outside firms (Maskell and Malmberg, 1999) knowing it is difficult to transfer local capabilities built over time to other types of contexts (Lawson and Lorenz, 1999, p. 310).

Innovation research has in this way moved beyond the firm level to help understand the role of interdependencies between firms and how larger networked environments can facilitate innovation. This has exposed an inherent tension between local and global firms, and between the interest held by public policy makers and the commercial interest held by firms and venture capital. As firms increasingly collaborate and operate at national and international levels, locally created values increasingly transform into global values (Teece, 1986; Wright et al., 2005; Yamakawa et al., 2008). The increasing globalization has, at the same time, reinforced an interest in geographical innovation systems to help understand how unique types of local knowledge can help firms compete globally.

Accordingly, the increased appreciation of innovation systems relates to their importance to local and global economies (Porter, 1996, 1998, 2000) as well as to the competitiveness of the involved firms (Lundvall, 1992, 1994; Storper, 1995; Malmberg et al., 1996; Maskell and Malmberg, 1999; Ffowcs-Williams, 2000; Boschma, 2005). Extant research has combined disciplines such as regional science, policy studies, and innovation economies to focus on economic development and innovation performance across different parts of the world and to inform politicians and policymakers on how to handle innovation challenges (Cooke et al., 2004). However, few studies have examined how innovation can be managed from within particular collaboration configurations. Specifically, we found no studies that investigate the challenges associated with designing and orchestrating innovation in specific contexts that involves researchers in cross-industry collaboration.

Government sponsored research and innovation efforts are common, especially in Europe. As a result of the importance of firm-level innovation for economic development, they are politically relevant for governments. Therefore, governments grant subsidies to help firms overcome market imperfections (Schwartz and Clements, 1999). These subsidies are typically aimed at supporting research and innovation activities and reducing existing financing gaps. By doing so, governments attempt to stimulate the economy and ensure economic development. The granted subsidies are expected to have higher social returns than the funds invested by governments (Kleer, 2010), justifying the expenditures of governments on subsidies for firm-level innovation. Schwartz and Clements developed the following definition of subsidy:

> In most general terms, a subsidy can be defined as any government assistance that (i) allows consumers to purchase goods and services at prices lower than those offered by a perfectly competitive private sector, or (ii) raises producers' incomes beyond those that would be earned without this intervention (Schwartz and Clements, 1999, p. 120).

This definition distinguishes two kinds of subsidy recipients: consumers and producers, and gives a very broad description of subsidies: any government assistance. As governments try to encourage private expenditures on research and innovation by offering public subsidies (Gonzalez and Pazó, 2008), they may actually experience the opposite: public expenditures reduce private expenditures because firms use public funds as a replacement for their own investments, a phenomenon known as 'crowding out' (Cumming and MacIntosh, 2006). As a result, researchers have investigated the effects of public subsidies on private research and innovation expenditures (Clausen, 2009).

Turning to the general literature on innovation management, we also found limited focus on fostering innovation in specific contexts by involving researchers in cross-industry collaboration. Parts of this literature discuss innovation management in open innovation processes and innovation networks, but the perspective taken is almost exclusively from the view of single firms (Tidd, 2001; Chesbrough, 2004; Dhanaraj and Parkhe, 2006; Vanhaverbeke and Cloodt, 2006; Ojasalo, 2008) rather than from broader geographical systems of innovation. Some notable exceptions include Tidd (2001) who argues for the need to take a broader view on innovation management, and Vanhaverbeke and Cloodt (2006) who discuss aspects of innovation in dyadic and inter-organizational settings. More specifically, Tidd and Bessant (2009) provide four major arguments to why organizations might want to push for greater levels of networking in their innovation processes. These arguments relate to collective efficiency, collective learning, collective risk taking and the intersection of different knowledge sets. Also, a review of characteristics of high value innovation networks in the UK identified the following success factors: highly diverse partners, third-party gatekeepers, financial leverage, and proactive partner engagement

(Pittaway et al., 2004). Finally, the challenges related to the building and leveraging new innovation networks include finding the right partners to interact with, forming competitive partnership collaborations with prospective partners, and performing effective and efficient innovation processes in the partnerships that emerge (Birkinshaw et al., 2007; Tidd and Bessant, 2009).

Against this backdrop, our goal is to contribute to our understanding of how the diverse actions and decisions of distributed actors can contribute to successful collaborations in research and innovation networks (Dahlander and McKelvey, 2005). Specifically, we draw on the concept of innovation networks (Pittaway et al., 2004; Dhanaraj and Parkhe, 2006; Vanhaverbeke and Cloodt, 2006; Chesbrough and Prencipe, 2008; Ojasalo, 2008) to understand how research and innovation configurations may be managed and how collaboration between participating firms, research institutions and public authorities may be facilitated (Sieg et al., 2010).

3. Analytical framework

Dhanaraj and Parkhe (2006) present a framework for management of innovation networks and for understanding how different kinds of management efforts can enable innovation outcomes. The framework focuses on how a hub as coordinator can improve outcomes by facilitating interactions between the involved firms and institutions. Drawing on network theory and its focus on structures, relations, and outcomes (Dhanaraj and Parkhe, 2006), the framework addresses the essential process-structure duality that in many ways defines a network's ability to facilitate innovation. In fact, the outcome of a network is equally dependent on the interactions between independent members of the network as it is on the network's structure:

> Networks are more than just relationships that govern the diffusion of innovations and norms, or explain the variability of access to information across competing firms. Because they are the outcome of generative rules of coordination, networks constitute capabilities that augment the value of firms. These capabilities, e.g., speed to market, generate rents that are subject to private appropriation. It is through an understanding of networks as knowledge encoding coordination within and between specialized firms in specific cooperative and competitive structures that the "missing" sources of value can be found (Kogut, 2000, p. 423).

As illustrated in Fig. 1, Dhanaraj and Parkhe relate the concept of orchestration to the subtle leadership of facilitating interaction between independent members of the network. Orchestration is performed by a hub as it pulls together and leverages the dispersed resources and capabilities of network members. The hub can influence network outcome by affecting how the network is designed and how processes within the network are established, stimulated, and unfold. Similar innovation management roles can be found in research on the "anchor tenant firm" (Agrawal and Cockburn, 2003) and research on the production of network externalities for smaller firms (Feldman, 2003).

3.1. Network design

There are three challenges related to network design: membership, structure, and position (Dhanaraj and Parkhe, 2006). Network membership defines size and diversity of the network and the value and knowledge potential to its members. Through recruitment activities and by learning about what kinds of members and interactions foster promising value constellations, the hub can affect network membership and make new players and current members more aware of and attracted to the opportunities offered within the network.

Network structure defines density and autonomy and the ties that connect members in different ways. Density refers to the degree of formal and informal relations amongst members that keep the network together. A hub can change network density by affecting the strength and flourishing of existing relations, by establishing new promising relations, and, by recruiting new organizations already having relations to existing members. Autonomy refers to the degree to which members can take actions without the permission of someone in control of the network and it impacts the degree to which individual members can affect network structure. A hub can impact network autonomy through the way members are recruited and by designing structures that enable collaboration.

Finally, network position refers to the centrality, confidence and status ascribed to the hub by the network members. These qualities are primarily reflected in the network members' perception of the hub's performance as network designer and orchestrator. Hence, the hub can impact its position by effectively communicating the virtues of the network and the value-adding role the hub is playing as designer and orchestrator of the network.

3.2. Network orchestration

The challenges related to network orchestration is rooted in knowledge mobility, innovation appropriability and network stability (Dhanaraj and Parkhe, 2006). Knowledge mobility is defined as "the ease with which knowledge is shared, acquired, and deployed within the network" (p. 660). Knowledge mobility can be improved through knowledge absorption, network identification, and inter-organizational socialization. Since innovation arises out of new combinations of existing capabilities within the network (Schumpeter, 1942; Kogut and Zander, 1996), the hub can

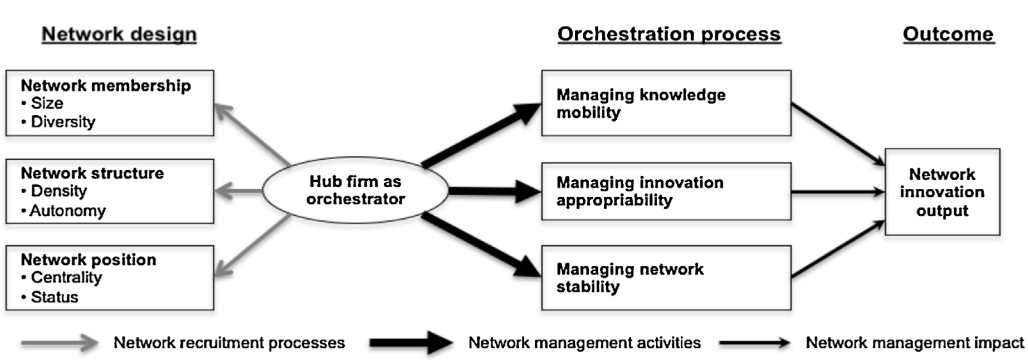

Fig. 1. Network orchestration framework (Dhanaraj and Parkhe, 2006).

impact knowledge mobility by increasing each member's absorptive capacity to identify, assimilate, and exploit knowledge from other network members (Cohen and Levinthal, 1989, 1990; Lyles and Salk, 1996; Simonin, 1999). Hubs can also enhance knowledge mobility by reinforcing a common identity that facilitates knowledge sharing (Dyer and Nobeoka, 2000), creates a "logic of confidence and good faith" (Meyer and Rowan, 1977), and, provides the "cohesive force" (Orton and Weick, 1990) necessary for enabling knowledge flow. In addition, the serendipitous nature of innovations makes it impossible to predict exactly which innovative ideas will turn-up and when they will do so. Hence, hubs can promote knowledge mobility by fostering inter-organizational socialization through different forms of exchange forums and communication channels thereby increasing the network's social and relational capital.

Innovation appropriability is an important concern for the hub to ensure value is distributed equitably and perceived as such by network members. Free riding and opportunism can lead to decreased commitment and obstruct value creation within a network. The hub can ensure innovation appropriability and an equitable distribution of value through trust, procedural justice, and joint asset ownership. In fact, the strength of an appropriability regime does not rest so much on lengthy formal contracts as on social interaction between partner firms. Principles of procedural justice like "bilateral communications, ability to refute decisions, full account of the final decisions and consistency in the decision-making process" (Dhanaraj and Parkhe, 2006, p. 663) are examples of how the hub can support knowledge mobility by strengthening innovation appropriability.

Finally, ensuring reasonable network stability is a critical task for the hub since a network in disintegration hardly promotes the required value creation. The hub can increase this quality by enhancing network reputation, by managing expectations, and by building multiplicity. Network reputation is increased by signaling trustworthiness and by communicating what future benefits a network member can anticipate. Member expectations are a key to manage how the future can cast shadows back into present network performance. Moreover, by encouraging members to join other members in projects, a hub can support network stability by relying on multiplicity. With members interacting more broadly and deeply to develop an increasing understanding of the capabilities and peculiarities of each other, the ties connecting them will be reinforced and more resistant to unraveling.

4. Research design

4.1. Case study

The project was organized as collaborative practice research (Mathiassen, 2002) allowing the first author to engage fully in practical management of *ProcessIT* while at the same time researching innovation in collaboration with the other two authors (McKay and Marshall, 2001). The research started in 2004 when *ProcessIT*, a research and innovation program focused on IT enabled process innovations for process and manufacturing industries in Northern Sweden, received substantial financial support from the national agency Vinnova. Reported as a case study, our research has focused on the management of the program and how this contributed to economic growth and increased competitiveness in the participating firms. We have been particularly interested in how the hub of the regional innovation network facilitated participation and coordination.

We decided to adopt the case study method based on a number of considerations. First, multiple data sources and theory driven data analysis are key characteristics of case study research (Yin, 2003), and we had access to very rich data about the design and orchestration of the network. Second, the case study method has a distinct advantage in situations when "how" or "why" questions are being asked about events over which the investigator has little or no control (Yin, 2003). Our investigation was driven by such a question based on retrospective analysis of events that had shaped *ProcessIT*. We ensured credibility by making our research project an explicit part of the ongoing innovation efforts in *ProcessIT* and by having *ProcessIT* managers critique relevant parts of our analysis. To facilitate transferability of results, we related our findings to current theory on network orchestration (Dhanaraj and Parkhe, 2006) and provided detailed accounts of the context of *ProcessIT* to enable judgment of how contextual factors had shaped the program.

4.2. Data collection

Informed by contextualism (Pettigrew, 1990; Howcroft et al., 2004), our research aimed at developing a rich understanding of *ProcessIT* by reconstructing its history, investigating different stakeholders' activities and opinions, and, examining the context in which activities occurred. A longitudinal design and direct access to multiple data sources allowed us to gain a comprehensive and rich understanding of the context and the associated behavioral consequences and of how actions and perceptions of different actor groups evolved over time (Walsham and Sahay, 1999).

Among the primary data sources are audio recordings of management meetings and interviews with key stakeholders. We documented more than 190 meetings over the period. The purpose of these meetings was to monitor progress, discuss plans, and coordinate implementation. We also had unlimited access to more than 300 documents, including project status reports, minutes of meetings, plans, and project reports. In addition, the first author was involved as strategic support to the managers of the network, while the second author was engaged as researcher in a couple of the projects carried out within the network. Specifically, the first author has since 2004 observed and participated in monthly meetings of the steering group, about six times a year in board meetings, and together with the second author in eight annual workshops evaluating and planning research and innovation projects and activities.

Data were collected from May 2004 to January 2012 following a specific routine for each year. Based on participatory observation, extensive project documentation, observations at meetings and workshops, and continuous discussions with participants, interviews with key stakeholders were conducted annually at the end of each year. These annual interviews focused on how the network developed, the actions taken by management, and ideas about future initiatives. A total of 64 interviews with informants representing the program were conducted on an annual basis from 2004 to 2011: eight with program representatives, 12 with public authorities, 26 with industry representatives, and 18 with university representatives. These annual interviews made it possible to build an understanding of the relations between the outcomes produced and orchestration activities carried out each year and to give each interviewee an opportunity to provide feedback as well as thoughts about where the network should go. All interviews were conducted on the site of each interviewee, they took about one hour, and they were either recorded and transcribed, or carefully noted down on paper.

4.3. Data analysis

All three authors analyzed the data in multiple discussion sessions following the recommended procedures for qualitative research and grounded theory (Strauss and Corbin, 1990).

Specifically, we adopted the "Straussian" approach toward grounded theory which permits researchers' exposure to related literature to guide the data analysis process (Eisenhardt, 1989). We followed an iterative coding process that involved identifying the emerging concepts, examining empirical evidence for support, consolidating similar concepts to create more refined ideas, and collecting more data until reaching theoretical saturation. The data analysis process was supported by Atlas.ti software to help manage data complexity and support qualitative analysis. During the coding process, we strived to integrate the identified codes and formulate a storyline that offered a coherent and insightful account of *ProcessIT*. Additional effort in terms of data collection and coding were performed until reaching theoretical saturation.

Data analysis was based on the three types of coding suggested by Strauss and Corbin (Strauss and Corbin, 1990): open, axial, and selective. We first identified 63 codes, each supported by two or more text segments, during the open coding stage. During this stage, we drew on the network orchestration framework (Dhanaraj and Parkhe, 2006) for guidance, and focused on identifying possible links between innovation outcomes and managerial actions taken. During the axial coding stage we consolidated codes that were conceptually similar. Finally, during the selective coding we strove to integrate the identified codes and formulate a storyline that offered a coherent and insightful account of the development of *ProcessIT*. This third stage was again guided in large part by the network orchestration framework as we were looking for evidence of social constructions and the social definitions of meanings for what was to be design or orchestration in the network.

Following an initial coding effort, additional data collection and coding efforts were made in late 2011 until theoretical saturation was reached. To verify the plausibility of identified concepts, we further reviewed the dataset for corroboratory evidence and used data from different sources and methods for results triangulation to ensure the validity of our findings (Miles and Huberman, 1994). Hence, we triangulated between different speakers, we compared and contrasted with meeting notes, plans and other documents, and we checked factual information with key stakeholders within *ProcessIT*. Throughout the analyses, issues were discussed among the authors until consensus was reached on a particular interpretation, or a decision was made to revisit the data. As information gaps were identified, we searched the material in an iterative fashion for clarifying or complementary expressions. Finally, as the write-up evolved, relevant parts were read and commented on by key stakeholders in *ProcessIT* and adjusted accordingly. As a result, our analysis illuminates key relations between network activities and innovation outcomes in the observed research and innovation program with a particular focus on how network design and orchestration were enacted (Dhanaraj and Parkhe, 2006).

5. Research context

The region of *ProcessIT* covers the northern counties of Norrbotten and Västerbotten of Sweden. It is built on century old capabilities to refine natural assets of timber, water, and minerals through process industries in forestry, energy, and mining, which represent about 30 percent of the regional growth production. Following the development of these industries, the region has also fostered a growing manufacturing industry, for example in forestry and mining machines, different kinds of construction equipment. This industry represents about 20 percent of the same economy. The IT industry is not as significant, but the public-private IT collaborations are growing. Public authorities and the two local universities have collaborated to create plans for IT development, universities and firms have organized a considerable portfolio of joint innovation projects, industry has funded research projects, and, research groups have conducted several projects on industry sites.

ProcessIT origins from discussions back in 2003 when a group of representatives from IT industry, universities, and public authorities tried to launch a research and innovation program focused on IT within the dominant process and manufacturing industries of the region. The aim was to support innovation with participants from industry, universities, and public authorities in order to accelerate industry growth and increase firm competitiveness based on research driven IT innovation. This made a good fit with one of the major firms in Northern Sweden, a world leader in mining. They saw the program initiative as a brilliant idea, addressing one of their key innovation challenges, namely their ability to attract talent and partners to support IT-enabled process innovations. The firm accepted the role as a key industry stakeholder, making it clear that their future competitiveness depended on how well initiatives like this would stimulate local universities and IT suppliers to come up with solutions and competencies relevant to their industry. They saw *ProcessIT* as a means to improve their innovation capability and to secure sustainable development within the local mining industry.

During 2003–2004 a raw model of *ProcessIT* was developed and a project was established to secure federal funding. A few firms, representatives from public authorities, and a small group of researchers worked on developing a proposal to the national agency Vinnova and potentially guaranteeing substantial national funding for 10 years. The final application for the research and innovation program involved seven plants, a handful of IT firms, two county administrative boards, four municipalities, and about ten researchers. In late 2004, *ProcessIT* was provided long-term funding from Vinnova. Representatives from industry dominated the board that had been formed to supervise the application process. The board appointed the person who led the application project to managing director. As soon as the program launched, participation increased. By mid-2005, the program involved fifteen large process and manufacturing firms, fifteen IT firms, and about 30 researchers.

6. Results

The strategic idea guiding *ProcessIT*, first proposed by the mining firm and built on cross-industry principles, was to incubate boundary-spanning research and innovation projects, later called *ProcessIT* projects, with needs owners from process and manufacturing industry, solution providers from IT and automation industry, and researchers from universities. The assumption was that industry growth and firm competitiveness is stimulated by initiating, establishing and implementing such research and innovation projects because they bring critical knowledge about innovation and strategy to the participants in each project. *ProcessIT* was hence based on four different, mutually reinforcing value propositions: (1) strengthen the competitiveness of the local process- and manufacturing industries; (2) help IT firms develop globally competitive solutions; (3) offer research groups challenging cases to develop world class research; and (4) accelerate growth. The network should include a diversity of actors to offer promising value constellations for each network member, support the serendipitous nature of innovation processes, and, respond to the time-to-market pressure in IT innovation. To plant owners, IT firms offered long-term solution responsibility and research groups stimulated innovation. To IT firms, plant owners constituted potential joint ventures and customers and research groups could help develop solutions to identified problems. To research groups, plant owners meant access to challenging industrial contexts and IT firms were partners interested in commercializing

Table 1
Funding, participation and project activities per year.

	Funding of the network from 2005*						Number of partners involved in ProcessIT					Ongoing projects	
	External project funding			Public funding		Revenues	Industry partners			Public partners			
	Fund. agencies	Industry cash	Industry time	National publ.	Regional publ.	Total	Process & manufact.	IT firms suppliers	Total	University Staff	Public authorities	Pre-studies	Full projects
2005	130	15	219	450	185	999	15	15	30	30	6	8	5
2006	163	75	384	600	666	1887	18	30	48	72	6	17	9
2007	365	75	499	674	420	2032	19	35	54	78	6	15	12
2008	456	75	588	319	741	2180	24	33	57	59	6	25	11
2009	599	69	1392	557	1,263	3878	26	34	60	69	6	19	16
2010	650	68	1653	596	1,485	4452	29	38	67	57	6	28	19
2011	535	316	1468	549	1,869	4737	32	37	69	61	7	32	20

* Figures concerning funding are in thousands of Euros.

research findings. Public authorities received an opportunity to influence a well-recognized development area in this particular part of Sweden.

6.1. Network design

To ensure a critical mass of diverse participants, the management of *ProcessIT* conducted a series of meetings communicating the strategic idea and its project incubation offerings. It encouraged partners to engage in *ProcessIT* projects, and thus to draw from the values associated with the research and innovation network. Early on, it was a key activity to continuously identify partners with overlapping objectives that could be "talked into" new collaborations, was a key activity. In 2011, management had encouraged a large number of firms to engage in its project activities, making the network include almost 70 firms (see Table 1) from process industries in mining, pulp and paper, energy, and steel, and manufacturing and IT industries focused on forest harvesters and forwarders, milling and drilling equipment, test and measuring equipment, engineering tools, monitoring and control systems, actuation systems and solutions, manufacturing execution systems, and decision support systems. Within the process and manufacturing industries, the involved firms were significant global players with a diversity that offered several interesting boundary spanning opportunities across the industries. Regarding the IT industry, the network was dominated by SMEs, with only few exceptions.

In the beginning, the motives for joining the network varied from innovation opportunities and local goodwill ("we thought of *ProcessIT* as something good for both us and the region"), to group behavior ("we decided to join because the others had"), and to see *ProcessIT* as "easy money". Like the managing director phrased it, "they saw there was money in the system." Management considered this line of reasoning as counterproductive and worked hard to encourage partners to engage in projects. This resulted in a large number of pre-studies. For example, an activity focused on drying efficiency with a manufacturer of drying fans, involved a sawmill owner and a process optimization research group. The same research group got involved in a project with a manufacturer of burners and an energy company producing heating pellets for this kind of burners. In the same manner, a research group in informatics got involved in a pre-study together an IT firm focused on decision making and the flow of information at a pulp and paper mill. Together with a research group in interaction technologies and a mining company, a firm manufacturing conveyor belts engaged in a pre-study focusing on alternative ways to visualize the way rocks behave when loaded in different ways onto conveyor belts.

In 2008, management conducted an analysis identifying twenty key firms with innovation processes purposefully aligned to the strategic idea of *ProcessIT*, and with good potential to exploit the opportunities offered by the network (see Table 2). The outcomes from projects conducted by this group of key firms were clearly stronger than the rest (see Table 3), and among these the IT firms were very pleased with *ProcessIT*. The process industries did though raise issues related to low impact and project relevance. During 2010, *ProcessIT* identified critical gaps in the supply-chains of the process industries, related to a lack of significant supplier firms in the region. In early 2011, this led *ProcessIT* to more actively approach firms from other regions both within and outside the boarders of Sweden. In 2012, *ProcessIT* got public funding to explore the opportunities to apply its strategic idea on a national level, primarily to strengthen its networks through expansion and diversity.

Another challenge was structuring activities and providing governance that could positively affect existing and new relations. Therefore, the network was established with an industry led board of directors representing key stakeholders, a steering group led by the managing director, an industry advisory council, and a research council. In the beginning, the plan was for the research council to conduct needs inventories and produce project proposals to the steering group that would then prepare proposals to the board. However, this procedure did not work, mainly because the research council and the board became bottlenecks. Instead, from mid-2005 all stakeholders could present proposals to the steering group and the steering group was mandated to decide on pre-study proposals not exceeding 30 thousand Euros. In 2007, *ProcessIT* also hired a project officer to continuously visit firms and research groups and serve as broker identifying new promising relations and activities between network members. Enabled by these structural changes, *ProcessIT* could increase the number of project activities and relations more efficiently (see Table 1). Due to the regional supply-chain gaps related to the process industries, *ProcessIT* took initiative to coordinate activities with other industry clusters in Sweden and Europe in 2011. This was well received by the process industries, and resulted in a proposal describing new structures to coordinate activities between these clusters.

Another management challenge was to establish legitimate leadership within the network and position *ProcessIT* as central and valuable to its members and other local interests. Therefore, it was important to have significant stakeholders play key roles in network management and to adjust network objectives and

Table 2
Industrial co-funding in project activities in 2008.

Project statistics 2008	No	Co-fund.*	In kind*	%
All companies involved in ProcessIT in 2008**	57	136	567	100
Key companies	20	122	464	83
Non-key companies	37	15	103	17

* The figures are in thousands of Euros, related to ongoing projects in 2008.
** Since 2005 a total of 77 companies had been involved in ProcessIT.

Table 3
Outcomes related to conducted project activities and involved firms.

Outcomes from project activities conducted between 2005 and 2011							
	No of activities	Research publications	New products	New companies	New installations	New project activities	New jobs
From all project activities	***129***	**111**	**32**	**6**	**37**	**64**	**47**
From prestudies	*91*	39	15	2	12	47	15
From projects	*38*	72	17	4	25	17	32
Outcomes from project activities with key/non-key companies involved							
With key companies involved	*87*	79	26	4	32	38	38
With no key company involved	*42*	32	6	2	5	26	9

value propositions in dialogue with all stakeholders. Hence, representatives from the most influential local organizations, both from industry and public sector, were recruited to the industry led board of *ProcessIT*. This enabled the network to stay aligned with the interests of these influential organizations and with other local development initiatives. The strong board also afforded considerable legitimacy and credibility to help build and maintain both local and global relations. Still, the knowledge gaps in the supply-chain still made the process industries consider *ProcessIT* as promising, but with unleashed potential related to their innovation challenges.

6.2. Network orchestration

To improve knowledge mobility amongst its members, management of *ProcessIT* focused on increasing the flow of strong project proposals and facilitating knowledge sharing throughout and beyond the project incubation process. At the core of this orchestration were cross-industry gatherings of plant owners, solution providers, and IT researchers leading to collaborations and knowledge sharing that would otherwise not have taken place. For key firms, the project incubation model and strategic idea was experienced as significantly increasing the speed of innovation and reducing the time-to-market by encouraging project stakeholders to organize and learn in parallel projects.

A project focused on a training simulator for crane operators can serve as illustration. A small IT firm had discussions with a large manufacturer of overhead travelling cranes and a large steel firm concerning a simulator. The crane firm found the product interesting, but they were not convinced of its value to their customers and doubted it would be realistic enough for training purposes. At that stage, the IT firm put forward a project proposal to *ProcessIT*, having both the crane and the steel firm as partners in defining the requirements and a group of researchers from physics, mathematics and computing science to help investigate how to make the simulated crane act realistically. To the researchers, the challenge was to design efficient real time algorithms that could simulate the cables in the cranes (Servin and Lacoursiére, 2008).

Faced with this proposal, the management of *ProcessIT* decided to finance a pre-study, letting the project group investigate technical options, but also the marketing potential, and the values that such a training simulator could bring to the steel industry. The pre-study was successful and the research group quickly produced a working prototype. This made the IT firm and the crane firm eager to go for the next step well ahead of plan. At that time, less than four months after initiation of the pre-study, the IT firm and the crane firm produced a revised project plan and received continued support from the management of *ProcessIT*. During this second phase, the project focused on development of the technical platform, on development of a first prototype of the training simulator demonstrating a majority of the planned features, and on planning the initial crane market penetration. In the third and last phase, the IT firm produced the first commercially available version of the simulator, allowing the crane firm to start selling it. During the pre-study, *ProcessIT* was the main source of funds. During the second and third phase, the firms handled the main part of the project budget themselves.

The project produced a commercialized product that strengthened the crane firm's business offerings and provided the IT firm with revenues of more than one million Euros during the first year. It also helped the IT firm develop a whole new business area. Furthermore, the researchers that produced the algorithms for the cables in the simulator started a new firm focused on algorithms for real time physics. In less than a year, this new firm hired more than ten people, mainly from computing science and mathematics.

The crane simulator project illustrates how the strategic idea promoted knowledge mobility and network outcomes. Through the process of project incubation, the idea promoted by the IT firm could be developed enough to help the crane firm see its potential, and by that, take decision to speedily push the implementation of the following research and innovation project. In addition, the project enabled important strategic learning for the participating firms. To increase the speed of innovation and the number of project activities in *ProcessIT* as a whole, management also started to favor funding of pre-studies. This increased the number of ongoing pre-studies significantly without a corresponding decrease in projects (see Table 4). The management explained the reason to why the number of projects could be preserved by quoting a manager at a large firm, "for good project proposals, there will always be money." By supporting pre-studies, the management of *ProcessIT* increased boundary-spanning activities and provided opportunities for more organizations to reduce risk, to learn, and go into investigations of ideas that would otherwise have died. Even though some firms did not actively utilize the opportunities of *ProcessIT*, the network was highly appreciated by all groups of stakeholders for this swift approach to transform vague ideas into project proposals, attracting both money and stakeholders to subsequent activities. A manager at one manufacturing firm said "without *ProcessIT* we would never have taken this step, but it is obvious that the stake is a risk worth taking."

A project focused on a multi-touch interaction display at a pulp and paper mill is another example of the project incubation process. In 2009, management identified an overlap of objectives between a pulp and paper company pushing a lean production project, and a research group and a small IT firm experimenting with new kinds of interaction technologies such as multi-touch, gesture, and large display techniques. The management of *ProcessIT* suggested that the firms and the research group should initiate a *ProcessIT*

Table 4
Annual budget allocations for project activities.

Allocation of project activity budget annually							
Year	2005	2006	2007	2008	2009	2010	2011
In prestudies (%)	22	24	23	39	46	52	54
In projects (%)	78	76	77	61	54	48	46

pre-study, partly financed by *ProcessIT*. The project took off, and after three month of studies the project team knew how to frame the challenge, formulated a plan, and returned to *ProcessIT* with a new project proposal. This time, focused on a prototype to be tested within one of the production lines at the mill. To the management of *ProcessIT* the proposal was considered promising, and a decision was taken to support this project stage as well. This time though, with a lower financial engagement from *ProcessIT*. Four month later a first prototype of an interactive multi-touch display was installed, giving the operators and maintenance staff opportunities to try it out in production.

After a few month of prototype testing a lot of things started to happen. The people working at the focused work place in the pulp and paper mill didn't want the prototype to be removed, the IT firm started a product development project based on its findings, and a global manufacturer of control systems decided to adopt the concept and develop it to have it included in its global product portfolio. Through the project incubation process the management of *ProcessIT* could reduce the risk enough for each partner to make them interested in pursuing a next step of innovation that would otherwise not have taken place. As the results were getting more and more positive, the need for *ProcessIT* decreased.

In 2007, management decided to establish technology and industry councils to further push knowledge mobility. Technology councils were seen as a means to engage people interested and specialized in specific technologies. At the end of 2011, two industry councils had been launched, with another two emerging. Industry councils were intended to involve managers from industries focused on IT challenges and solutions for their specific industry. The first industry council in pulp and paper was formed in 2007 and the second in mining launched in 2009. From these councils, more than 50 proposals were developed leading to project activities funded with more than one million Euros in public funding.

However, not all firms were successful in utilizing the opportunities in *ProcessIT*. In 2008, the firms identified as best aligned with the strategic idea of *ProcessIT* accounted for 83% of the industrial co-funding (see Table 2). They represented one third of the firms involved in the network that year, and until 2011 they had produced the greater part of the outcomes relevant to industry (see Table 3), i.e., products, firms, installations, and jobs. It also proved difficult for new network partners to "enter the inner circle of the network." Management took two initiatives to address this issue: hiring the project officer to conduct brokering activities and encouraging solution providers to come up with project proposals. Management also communicated showcases and success stories and put a lot of effort into reinforcing a shared network identity.

Due to the lack of interest in commercializing the solutions from process industries, innovation appropriability was not a critical issue. To ensure that the values created through the activities were shared and distributed equitably though, management developed principles, procedures, and activities through the whole period. The requirement of a written project agreement between the stakeholders of each project was central, and so was project monitoring to keep track of and address emerging tensions, and the claim for co-funding to validate the stakeholders' faith in the ideas and willingness to share risk in the projects.

The 10-year funding from Vinnova was the basis for the commitment in *ProcessIT* to all of the founding local organizations. Stability and sustainability of the network was thus a prerequisite to all of its key members, and management focused on how to support and maintain a reasonable level throughout. Specifically, management actively balanced the project portfolio and arranged inter-organizational events that stimulated the emergence and strength of network ties. Also, management encouraged larger organizations to create their own project portfolios in the network thereby making the network a more significant part of their innovation efforts. Still, stakeholders continued to raise issues concerning the relatively low knowledge and awareness of *ProcessIT*, making interactions with other local stakeholders more difficult.

6.3. Network innovation

Concerning the overall innovation outcome of *ProcessIT*, the interviewed stakeholders were pleased with what *ProcessIT* had delivered and how the research and innovation network as a whole had developed. The interviews and project documents reveal three distinct deliverables: (1) promising overall results from the initiative as a whole, (2) promising knowledge mobilization in key areas, and (3) an enhanced capacity to transform ideas and needs to project activities with multi-purpose objectives. Concerning the overall results, *ProcessIT* launched 129 project activities, including 91 pre-studies and 38 projects from 2005 to 2011. From these projects, the network resulted in 32 new products, six new IT firms, 37 installations in process and manufacturing industries, and at least 47 new jobs in the IT industry (see Table 3). These are good results for the IT firms, but less significant to the process industries. It is the production of good results for the IT firms and the incorporation of more relevant supply-chain actors for the process industries that make the overall outcomes promising. In 2012, the project incubation that had been done on a European level resulted in the largest research and innovation project in process automation so far within the European Union with 80 partners from 14 different countries and a project budget on 69 million Euros.

Related to mobilization of knowledge, *ProcessIT* has involved about 60 researchers and 60 firms annually since 2006, increased the annual revenues from one million Euros in 2005 to more than 4.7 million Euros in 2011, and during the same period increased industry funding of projects from 234.000 Euros to more than 1.7 million Euros (see Table 1). There has thus been a steady growth both in funding of the network and financial commitments from industry. Concerning the project portfolio, the engagement of funding agencies and industry has grown with between 10% and 30% for every year since 2005, even though 2009 was a tough year for industry. Between 22% and 54% of the total budget has been spent on pre-studies, and 46–78% has been allocated to research and innovation projects (see Table 4) with a shift between 2007 and 2008 when management decided to favor pre-studies at the expense of other projects. Considering increased mobilization, the industry council in pulp & paper engaged all the local and globally competing firms in the industry. The technology council focused on vision-based measurement has attracted more than twenty organizations, all with a strong interest and commitment to develop solutions relevant to process- and manufacturing industry.

The enhanced local capacity to transform ideas and needs into projects is documented by the number of pre-studies and projects, but also by statements from the stakeholders. A CEO from an IT firm said "*ProcessIT* means action instead of the usual series of endless discussions of how to initiate and manage collaboration", and a researcher said "*ProcessIT* has given our research group a fantastic opportunity to improve and grow, primarily because of the swiftness in finding partners and building project activities." However, not all organizations involved in the network have experienced such values. Table 2 and Table 3 indicate the impacts of this divide. Of the 77 firms involved in the activities of the network since the beginning, the eight firms founding the network and another 12 identified as mature innovators turned out to be the key players. Of the outcomes relevant to industry, only a few products, installations, and jobs relates to projects without involvement of one of these key firms (see Table 3); similarly, 83% of the industry funding in 2008 came from these organizations (Table 2).

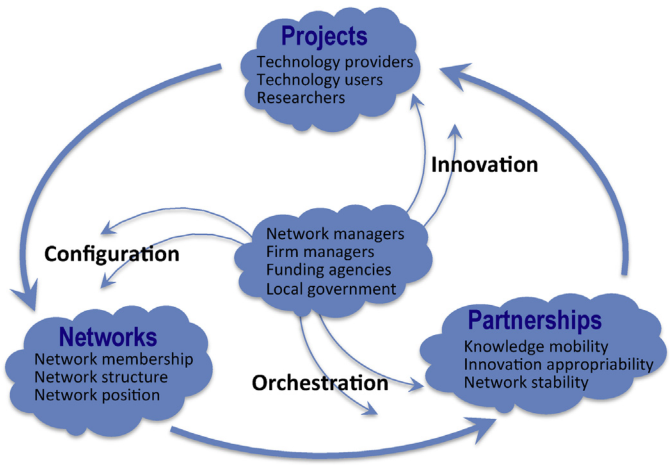

Fig. 2. A model of managing research and innovation networks.

7. Discussion

While there is increasing focus on innovation systems in the literature (Lundvall, 1992, 1994; Porter, 1998, 2000), there is increasing evidence that the management of these systems is important to both firm competitiveness and industry growth (Van de Ven, 1986; Van de Ven et al., 1999; Tidd, 2001; Chesbrough, 2004; Birkinshaw et al., 2007; Tidd and Bessant, 2009). Against this backdrop, we have examined how a large-scale government sponsored research and innovation program, *ProcessIT*, in Northern Sweden was designed and orchestrated in order to provide value to the participating firms and stimulate economic growth. Specifically, we have drawn on the notion of innovation network orchestration (Dhanaraj and Parkhe, 2006) to analyze how close collaboration between academia, industry, and public authorities was managed in this context. As a result, we contribute to current knowledge by providing a detailed account of the management of this large-scale research and innovation program; and, by adapting innovation network theory to present a model of managing research and innovation networks, including key constructs and propositions (see Fig. 2 and Table 6).

7.1. A detailed account of ProcessIT

Related to our first contribution, the framework of Dhanaraj and Parkhe (2006) helped us understand *ProcessIT* as an innovation infrastructure that engaged local firms and institutions to jointly develop and subsequently extract value from the network (Cooke et al., 2004). The framework underscores how network design affects network membership, network structure, and position of the hub organization, whereas orchestration is rooted in knowledge mobility, innovation appropriability, and network stability (see Fig. 1). Our analyses demonstrate how *ProcessIT* developed value for the region as well as individual firms by leveraging network diversity to promote new project combinations, foster learning, and enable faster diffusion (Tuomi, 2002). At the core was the strategic idea of combining the needs for IT-enabled process innovations within the process and manufacturing industry, the capability to develop solutions within IT firms, and, expertise in relevant IT knowledge areas from universities. These basic constituents served as feeders into an incubation process of proposal development, pre-studies, and full-blown research and innovation projects. Table 5 summarizes these analyses by relating each of the six components of the network orchestration framework (Dhanaraj and Parkhe, 2006) to (1) the challenges faced by *ProcessIT*, (2) the responses taken to address these challenges, and (3) the outcomes of the adopted network design and subsequent orchestration efforts.

These analyses demonstrate how the general network orchestration framework translates well into understanding the specific challenges faced by *ProcessIT*. Beyond achieving critical mass and establishing initial network structure and leadership, challenges were mainly caused by the adopted strategic idea of constantly creating collaboration between diverse actors each having their own understanding of technology (Davidson, 2006) and often conflicting interests (Boland and Tenkasi, 1995). Our analyses document that the management of *ProcessIT* was appreciative of this challenge and the subsequent orchestration efforts were to some extent shaped to address them.

The analyses also reveal the many different ways in which the *ProcessIT* network was designed and subsequently orchestrated. The responses to challenges (see Table 5) reflect recommendations given in Dhanaraj and Parkhe (2006) and basic assumptions in the innovation literature, e.g., that effective innovation networks leverage capabilities distributed across a range of organizations (Coombs and Metcalfe, 2002; Boland et al., 2007) by sharing partner knowledge (Jonsson et al., 2008; Westergren and Holmström, 2012) and customer knowledge (Gibbert et al., 2002). As we saw in *ProcessIT*, such knowledge sharing was instrumental in generating relevant proposals and developing useful project outcomes. Consistent with the innovation literature's emphasis on network effects, messiness, ambiguity, and combinability (Lyytinen and Damsgaard, 2001; Tuomi, 2002; Van de Ven, 2005), the analyses also reveal how management of *ProcessIT* demonstrated resourcefulness in implementing creative accommodations and adjustments to facilitate unexpected project configurations and outcomes.

Additionally, our analyses documented important *ProcessIT* outcomes. Besides being successful in launching projects and creating IT solutions, management sponsored many pre-studies. This approach to stimulate innovation and learning is consistent with the insight that innovation situations with uncertain outcomes require extraordinary investments (Heidenreich, 2004). Also, management's emphasis on technology and industry councils strongly engaged people and organizations to quickly generate new proposals and projects. This outcome reflects how enduring competitive advantage increasingly lays in local characteristics that distant competitors cannot match (Porter, 1998) and in cross-fertilization between firms and research institutions (Lundvall and Borrás, 1997). Overall, the positive outcomes of the *ProcessIT* network are in concert with the insight that distributed innovation emphasizes "inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation" (Chesbrough et al., 2006, p. 1).

However, our analyses also reveal that the *ProcessIT* network continued to face challenges related to effectively engaging local players without any innovation experience and collaboration tradition with other firms and researchers. More effectively addressing these challenges will likely depend on whether or not management will find ways to successfully increase the social and relational capital of the network (Dhanaraj and Parkhe, 2006).

7.2. A model of managing research and innovation networks

As a second contribution, we adapt and extend the analytical framework by Dhanaraj and Parkhe (2006) to a research and innovation context. Although the framework focuses on innovation networks from the point of view of individual firms, its constructs were useful in making sense of *ProcessIT*. At the same time, there are important observations from the case that go beyond the initial framework. Combining these observations with the orchestration framework leads to a new model of managing research and

Table 5
Summary of orchestration challenges, responses and outcomes in ProcessIT.

Theoretical framework	ProcessIT challenges	ProcessIT responses	ProcessIT outcomes
Network membership	How to ensure critical mass and diversity of stakeholders in the network?	Recruit stakeholders by communicating the strategic idea and the long-term value propositions of ProcessIT	The number of involved people and organizations has increased for seven consecutive years
		Identify and communicate showcases illustrating ways to understand and utilize ProcessIT	The firms have constantly increased their level of co-funding
		To address experienced gaps in the supply-chains ProcessIT has started to approach national and international firms	But: Recruitment activities have revealed regional gaps in the supply-chains of the process industries, causing firms to complain about the impact and relevance of ProcessIT projects
Network structure	How to organize the activities and governance of ProcessIT to facilitate new and strengthen existing relations?	Establish board of directors representing key regional and business stakeholders	The key stakeholders have strengthened their relations because of the network
		Establish technology clusters and industry councils to focus on key process and technology challenges	Technology and industry councils have been successful in engaging people and organizations in exploring key challenges
		Hire project officers to facilitate collaboration and increase network presence among the regional, as well as national and international stakeholders	The active brokering between stakeholders has helped develop relations to address new innovation opportunities
			But: To build relations with high impact the regional focus has been limiting
Network position	How to establish legitimate leadership within the network and in relation to the region?	Make sure the most significant stakeholders play key roles in board of directors, steering group, technology and industry councils	The majority of its stakeholders has appreciated ProcessIT as important, and increasingly experienced it as a partner that can help them achieve their goals
	How to position the network in relation to each stakeholder's strategies?	Continuously adjust and communicate objectives and value propositions held by the network through dialogue with all stakeholders	But: The structures for pushing collaborations with firms outside the region were insufficient
Knowledge mobility	How to increase the flow of strong project proposals within the network through knowledge mobility between its stakeholders?	Incubate cross-industry project proposals through pre-studies, and efficiently turn selected proposals into collaborative projects.	Solution providers have increasingly engaged in the activities promoted by ProcessIT
	How to facilitate knowledge sharing between stakeholders during research and innovation projects and beyond?	Share knowledge through technology and industry councils, and by having project officers conduct brokering activities	Key stakeholders have appreciated ProcessIT's regional coordination of projects and networks due to increased knowledge mobility, reduced risk in projects, and increased speed of innovation
		Encourage solution providers to come up with project proposals and to manage projects	But: Involved actors put restrictions on what it is possible to achieve through collaboration
		Communicate success stories to help stakeholders understand how to better utilize ProcessIT for own objectives	
		Give solution providers and researchers access to process industries for tests and experiments	
Innovation appropriability	How to ensure that the values created in the projects are shared and distributed equitably, and perceived as such by the stakeholders?	Develop signed project agreements between project partners and claim co-funding from the industry partners in research and innovation projects	Key participants have expressed satisfaction with the creation and sharing of value across the network, and the claim for co-funding as part of each research and innovation project
	How to make each stakeholder feel confident that challenges will be addressed with similar engagement across stakeholders?	Identify and address emerging project tensions through open discourse amongst participants	There have been no explicit conflicts over value sharing in specific project activities
		Communicate success stories of value sharing publicly, and consider new project proposals in relation to the overall project portfolio	But: Some firms have expressed difficulties getting access into the inner circle of the network and thus ability to share values from the network
Network stability	How to ensure strong long-term commitment from each new ProcessIT participant, and specifically from key local stakeholders?	Align the project portfolio to common local challenges and across diverse stakeholders, and continuously communicate the long-term value proposition of ProcessIT	ProcessIT has increased its turnover, number of projects, and diversity of participants for seven consecutive years
		Support groups of members to raise funds and develop project portfolios within the network of ProcessIT	The participating process industries, universities and public authorities are discussing ways to strengthen their roles and responsibilities in ProcessIT
			But: Participants have recurrently raised issues about the low visibility of ProcessIT and its offerings

Table 6
Propositions for managing research and innovation networks.

Proposition 1 Configuration and orchestration of a network for research and innovation requires a hub with dedicated management resources and representation of key stakeholders
Proposition 2 Configuration of a network for research and innovation depends on how the hub recruits members and structure relations between them and on how members in turn perceive the position of the hub
Proposition 3 Orchestration of partnerships in a network for research and innovation depends on how the hub manages knowledge mobility, innovation appropriability and network stability
Proposition 4 Participant value and economic growth from research and innovation networks are generated through dedicated projects in which technology provider firms develop solutions for technology user firms supported by research groups
Proposition 5 Orchestration of a portfolio of innovation projects depends on how the hub manages available funding to engage partnerships in pre-studies and to attract additonal funding to consequential commercialization projects

innovation networks, with key constructs and propositions (see Fig. 2 and Table 6).

Drawing on Dhanaraj and Parkhe's (2006) original framework, our observations of *ProcessIT* led to identification of three distinct stages of managing research and innovation networks: configuration of the network, orchestration of partnerships between participants, and innovation in dedicated development projects (Fig. 2). This elaborate account reflects the complexity involved as corroborated by Tidd and Bessant's (2009) three-stage process of innovation management. Consistent with our proposed model, Tidd and Bessant suggest the challenges related to building and leveraging research and innovation networks are finding the right partners to interact with, forming competitive partnership collaborations with prospective partners, and performing effective and efficient innovation processes in the partnerships that emerge.

Management of research and innovation networks requires careful configuration and orchestration through a dedicated hub. Besides having requisite resources to engage, the hub must leverage local options and therefore be representative of key stakeholder interests (Proposition 1, Table 6), including network management, universities, local governments, involved firms, and funding agencies. Most studies analyzing research and innovation subsidies concentrate on their effects at a firm level (see e.g., Brouwer et al., 1993; Czarnitzki et al., 2007). Less attention has been focused on the networked character of innovation processes and potential firm-spanning effects of policy programs such as *ProcessIT*. There is, however, an increasing awareness that the position of firms in innovation networks – as well as their selection of innovation partners – affects their innovation activities. Our findings show how innovation networks, such as *ProcessIT*, can be effective instruments to implement government sponsored initiatives because of their proximity with local public and private actors in charge of innovation processes and their facilitator role with a central position to enhance innovation partnerships. In the case of *ProcessIT*, the management team and the board of executives were the key actors in the hub, but network management was also enacted through a portfolio of meetings focused on different high-level issues and involving universities, industry, local government, and funding agencies. Research and innovation networks hold the potential for both thriving and declining, and the ongoing effort in managing them is a key to avoid network decline.

Network configuration depends on how the hub recruits members and structure relations between them and on how members in turn perceive the position of the hub (Proposition 2, Table 6). Configuration of the network is an ongoing activity that should take into consideration the local history and traditions and leverage these into attractive opportunities for value creation and economic growth. In *ProcessIT*, the importance of history was evident in the willingness of the actors to support the program with its focus on the century old process industry. Development of partnerships through network orchestration depends on how the hub manages knowledge mobility, innovation appropriability and network stability (Proposition 3, Table 6). In *ProcessIT*, we saw again how the historic strengths of the local process industry were used to partner with the young and emerging IT industry. So, the combination of process industries as users of technology, IT firms as technology providers, and researchers as technology explorers turned out as a configuration with attractive project opportunities attached (Proposition 4, Table 6). Research and innovation networks can emphasize inherent dependencies and shared opportunities between the participants and use such insights as drivers for the orchestration efforts to effectively pull together and leverage the dispersed resources and capabilities of network members. In *ProcessIT*, the dependencies and shared opportunities of the region helped build the necessary support and commitment to project ideas during early stages of the incubation process in which public sponsoring of project proposals allowed the strongest to move forward as pre-studies towards commercially focused projects with increased private funding (Proposition 5, Table 6).

Considering innovation outcomes, our model emphasizes that although it is important to provide value to the participating firms, it is equally important to stimulate economic growth. Otherwise, the necessary support from key stakeholders is likely to fade out. In *ProcessIT*, outcomes in terms of both participant value and economic growth continuously materialized, leading to a constantly increased interest in and commitment to participate in the network. When local government, universities, and funding agencies collaborated in the funding of new research initiatives with clear relevance to *ProcessIT*, it stimulated economic growth, provided future value to the participants, and, further reinforced their belief in *ProcessIT*'s capacity to appropriate value. Indeed, as some regions host networks of firms that do not collaborate (e.g., Lissoni and Pagani, 2003) we need to be sensitive towards the fact that networks of firms only collaborate on certain topics, and only when these networks are carefully orchestrated.

8. Conclusion

In conclusion, it is important to stress that our study involved limitations that can be attributed to issues of generalization and choice of theoretical framework. First, our research is based on a single case study within the process industry in Northern Sweden. However, this does not rule out the possibility of generalizing from description to theory (Lee and Baskerville, 2003) by relying on analytic generalization as opposed to statistical generalization (Yin, 2003). Second, our choice of Dhanaraj and Parkhe's (2006) framework limited our empirical explanations and theoretical contributions by focusing the analyses on specific issues while ignoring others. Still, our empirical account of *ProcessIT* and the proposed model of managing research and innovation networks demonstrate that innovation is a complex activity involving a diverse group of constituents in network configuration, orchestration of partnerships, and joint innovation projects. Such complex activity definitely requires concerted management attention.

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