Managing Research-Industry Collaboration in IT Innovation: An Interactive Learning Model

Abstract

We report experiences from collaboration in a large-scale, regional IT innovation program – ProcessIT Innovations – and investigate the management challenges involved in facilitating interactions between research and industrial practices. Building on engaged scholarship principles, we focus on how the IT innovation program was shaped in time and space, both in the hosting organization and in the wider context of customers, suppliers and involved research groups. Grounded in the reported longitudinal case study, we apply insights from the innovation literature to propose a process model of how learning unfolds during research-industry collaboration in IT innovation. The model suggests that collaboration projects are exposed to varying degrees of complexity and dynamics and hence call for different configurations of learning modes over time.

Introduction

IT innovation research has typically focused on single projects and their internal operations, but a more context-sensitive view focused on the broader dimensions of such projects is gradually emerging (Boland et al., 2007). The context-sensitive view on IT innovation projects focuses on actor groups within and around the project that might have an influence on outcomes (see e.g., Holmström and Robey, 2005). Paying attention to the context means going beyond the project itself to encompass its many interactions with other individuals, groups, and organizations. This implies a focus on boundary spanning activities, i.e. the passing of information and knowledge across the boundaries of the project, with boundary spanners functioning as agents between the project and its context (Bechky, 2003; Carlile, 2004; Levina & Vaast, 2005). However, the boundaries of IT innovation projects are typically blurred as information and knowledge have to be shared not only within individual projects, but also with other parallel projects within the organization as well as with actors outside the organization (Fichman and Kemerer, 1997). While this attention to interactions between individuals, groups, and organizations has for a long time been a key concern for Scandinavian IS research (e.g., Bødker et al. 1993; Ehn, 1988), to the best of our knowledge, this has not been examined in the context of Scandinavian regional IT innovation.

In this paper, we examine the ways in which diverse sets of providers, users and researchers interact and collaborate over time to drive processes forward and facilitate successful outcomes in regional IT innovation. Hence, considering the theoretical and practical significance of these interactions, we aim to address the research question: *How can collaborations be managed to successfully deliver competitive innovation outcomes valuable to researchers, providers, and users in regional IT innovation networks*?

We report the results from a comprehensive research-industry collaboration program – ProcessIT Innovations. In particular, the paper emphasizes the efforts in relating research activities with development and business activities in the realm of practitioners. ProcessIT builds on the idea of engaged scholarship, making an effort to produce results of interest to academia as well as to industry (Mathiassen & Nielsen, 2009; van de Ven, 2007). Indeed, the idea of stepping up academic involvement in technology-related innovation is anathema to universities that seek to participate more actively in shaping today's society (for a discussion see Cohen et al., 1998; Feller and Roessner, 1995; Kaufmann and Tödtling, 2001).

The remainder of the paper is organized as follows. Subsequently, we review the literature on innovation and research-industry collaboration resulting in a model of modes of innovation in collaborative R&D projects. This is followed by a description of the innovation processes and R&D efforts in ProcessIT. Then, we draw on the insights from the case to analyze the interaction and collaboration between academia and industry in relation to the identified modes of innovation and collaboration. We conclude by discussing contributions to and implications for research and practice.

Innovation and Research-industry Collaboration

The notion of innovation derives from Latin, meaning "to introduce something new to the existing realm and order of things." Rogers (1995) define technology related innovations as "an idea, practice, or object that is perceived as new by an individual or other unit of adoption." From an academic perspective, the innovation process could end here, with a technological component that is perceived as new. However, from a business perspective that is not enough. The new technological component must pass the commercialization stage with the establishment of a market niche or new market before it can be classified as an innovation (Carayannis and Wetter, 2004). From a business perspective, the utilization of the technology is thus just as important as the technology itself since business value must be created. Usually, there is more than one company involved in the value creation related to each technology-based innovation. Often, one firm focuses on developing and commodifying the technology, and another one creates business value through innovative and competitive use of the technology. Reflecting on the diffusion of IT innovations, Swanson and Ramiller (1997) depicted any IT innovation as an emergent phenomenon that originates from the ways in which a diverse inter-organizational community creates and elaborates an organizing vision for it.

Organizations innovating with IT undertake learning to bridge the gap between what they already know and what the new technology requires them to know (Fichman and Kemerer, 1997). An organization innovating with IT not only learns through its own learning-by-doing experience, but also from interpretations of the innovation that becomes available through information channels that reach across the organization's boundaries. Empirical studies of IT innovations usually portray learning as learning-by-doing, which often begins when an organization adopts an IT innovation (e.g., Ang et al., 1997; Salaway, 1987). However, even before an organization adopts an innovation, a learning challenge exists because of lack of knowledge about innovation characteristics, its potential benefits, and the demands posed by its implementation and utilization. The multiplicity of knowledge sources available to organizations innovating and seeking to learn about an IT innovation emphasizes the heterogeneous and interdependent interests involved.

A key to succeed in aligning these heterogeneous and interdependent interests is to overcome the theory-practice gap. This can be done through collaborative R&D projects where both academics and practitioners participate. The Scandinavian approach, which has evolved over more than 30 years, has such direct collaboration at its core. The aim has been to give users a voice in development projects, and at the same time enhance the quality of the resulting innovation (e.g. Ehn, 1988). The Scandinavian approach in the 70's was formulated as a co-operation between researchers, developers, users and union representatives of unskilled labor and blue-collar workers. The aim was resource building by educating users to take part in work place negotiations. The approach evolved over time, and during the 80's a new strategy gradually evolved based on development of alternative technologies in collaboration with workers (Bansler, 1989; Bjerknes, 1992; Bjerknes and Bratteteig, 1995; Ehn, 1989). During the 90's, collaborative design went through several transformations along with changes in

both society and technology as the development of multimedia, internet-based communication, and new user groups, e.g. knowledge workers, emerged. While many aspects of research-industry collaboration have been addressed over the years, Scandinavian IS research has just recently started to address the topic in the context of regional IT innovation (Holmström et al., 2010). In these cases, the main discourse is associated with the challenge of integrating highly diverse sets of IT users, IT providers and IT researcher in a regional setting by configuring research-industry collaborations on both the network and project levels. Seeking to integrate these diverse sets of actors, the guiding idea has been to open up the learning processes from idea generation to commercialization and utilization in open innovation landscapes.

Innovation can be characterized as learning processes (March, 1991) distinguishing between the exploration of new technologies or services on the one hand, and the exploitation of old technologies or a services on the other hand. While the explorative mode essentially has to do with learning about and mapping uncharted territory, the exploitative mode has to do with leveraging the capabilities of the territory. Hence, the reference point for innovation in this view is the cumulative tradition – what we know and what we don't know. Innovation, from an academic perspective, can thus be distinguished between the extreme points of exploiting that which is well known, or exploring that which is not yet known. Technology-related innovation in the industry setting, on the other hand, is always acting with reference to the market. If the market does not accept a new technology the commercialization stage will not succeed. The rate of the innovation is thus influenced by market pull and market push factors (Chau and Tam, 2000). Market pull is categorized by unfulfilled needs of the consumers. However, these needs may be latent, because consumers have not been able to define them clearly. The opposite phenomenon, market push, is categorized by what the manufacturer wants the customers to have. What the market wants – or what we want it to want – is thus of central importance in the industrial view of innovation (Carayannis and Wetter, 2004), and 'market push' and 'market pull' captures well the driving force.

In the model presented in Figure 1, technology exploration, technology exploitation, market pull, and market push represent modes of innovation. During technology exploration, researchers play the key role with their interest in generic knowledge production; but, providers and users also contribute with in-depth knowledge of potential solutions and needs. During market pull, users play the key role with their interest in finding solutions for identified needs; but, providers also contribute with knowledge of potential solutions and researchers contribute with their ability to critique and scrutinize identified needs and potential solutions. During market push, providers play the key role with their key interest in commodifying and commercializing competitive solutions; but, users also contribute with in-depth application knowledge and researchers contribute knowledge of specific technologies and generic use patterns. During technology exploitation, the interaction between providers and users is the key process since the aim is to optimize the fit between identified solutions and needs; but researchers can also contribute with generic knowledge on use patterns and abilities to scrutinize identified needs and solutions.

IT provider perspective			
	No identified solution	Technology exploration	Market pull
	Identified solution	Market push	Technology exploitation
		No identified need	*Identified need*

IT user perspective

Figure 1: Modes of innovation maturity

Taken together, the model in Figure 1 captures not only distinctive modes of innovation based on research-industry interaction, it also illustrates how the modes complement and follows from each other. In this model, innovation processes start with technology exploration (no identified needs or solutions), followed by market pull (identified needs but no identified solutions) or market push (no identified needs but identified solutions), and finalize with technology exploitation (with identified potential needs and solutions). The model built on a provider versus a user perspective, and on what these groups of actors bring to R&D collaborations facilitated through researcher engagements. At the same time, the model captures the modes of innovation, i.e. technology exploration and exploitation. From a research point of view, the exploration mode is typically regarded as the mode with the highest claim for innovation. Similarly, from an industry point of view, the market push mode is typically regarded as the mode most clearly associated with innovation. For such an innovative process to be successful, however, it requires a well-organized collaboration between research and industry.

Further, the individual activities during innovation processes can roughly be up-stream or down-stream oriented (Teece, 1992). While up-stream activities focus primarily on technology and its inherent capabilities, down-stream activities focus primarily on business value and the contextual implications of technology. Up-stream activities imply a great interest in understanding the possibilities and shortcomings inherent in the technology and they are therefore opportunity oriented. In contrast, down-stream activities imply an interest in the values and implications to business and the social contexts in which the technology is to be used and they are therefore value oriented. In the presented model, innovation processes characterized as opportunity-oriented are initiated in the market push stage, while value-oriented are initiated in the market pull stage. Both opportunity-oriented and value-oriented activities are highly relevant to research as well as industry. While the research in technical universities clearly illustrates an up-stream focus, the research in business schools illustrates a more down-stream oriented focus. And, relating to the distinction between organizations focusing on providing versus using technology, IT-providers can be seen as primarily opportunity oriented with clear interests in commodifying technologies while organization like banks and processing industries are primarily oriented towards technology-enabled value creation.

Research Method

In order to investigate how research and industry organizations collaborated through different modes of learning in the ProcessIT initiative, a longitudinal case study was conducted from 2005 to 2009. On an annual basis, representatives from the involved stakeholders were interviewed, mainly on site at each respondent's work place. The rationale behind selecting this group was their willingness to cooperate and their insights into ProcessIT in general and the projects carried out within the scope of ProcessIT in particular. The group consisted of representatives from all key stakeholder groups e.g. IT users, IT vendors and IT researchers. The focus for each year's round of interviews was the experiences and expectations of the collaboration each stakeholder held, even though there also was a specific focus for each interview. In 2005, special attention was on early expectations and ideas of possible outcomes. In 2006, this focus shifted towards outcomes and the role of the program in relation to these outcomes. In 2007, specific interest was directed towards experiences of ProcessIT as an actor facilitating research and industry collaborations. Finally, in 2008 collaborative processes on an overall level were emphasized. From a research perspective, we are interested

in studying technology-enabled innovation and the use of technology in a practical setting while the involved companies are interested in deploying the innovations into their business in a fruitful way. To bridge these dual goals, we adopted Mathiassen's (2002) recommendation to organize projects as a loosely coupled system of agendas – as a shared space in which research efforts and practice initiatives can blend in a fruitful way.

Data was collected by the second author through a mixture of these semi-structured interviews and document reviews (Yin 1989). In total, we performed 42 interviews with people from all group of stakeholders, i.e. processing industry firms, IT firms, universities, and public authorities. Each interview was conducted on site and took between one and two hours. The respondents ranged from large industry CEOs and county governors to researchers and engineers at small and medium sized enterprises. The interviews had one structured part with questions related to our readings of the progress reports produced for each year, and one unstructured part with follow up questions emerging from previous interviews and meetings. When examining progress reports and other documents from internal meetings, data was read through and cross-analyzed before being coded into categories concerning expectations and experiences of the collaboration.

The data were gathered, analyzed, and discussed with the participants within an interpretivist paradigm. This interpretivist approach, with its goal of revealing the participant's views of reality, allowed the underlying reasons for actions in innovation practice to be elicited. The interviews, which were audio recorded and transcribed, were between 30 and 90 minutes long and conducted by the second author. With respect to use of theoretical constructs to guide theory-building research, we worked within the explicit conceptual framework presented in Figure 1. Such a framework becomes a 'researcher's first cut at making some explicit theoretical statements' (Miles & Huberman, 1994, p. 91).

While early identification of possible constructs allows them to be explicitly used in the interview context (Eisenhardt, 1989), it is equally important to recognize that the identification of constructs is tentative in theory-building research. We found this to be true as new factors were found during data collection that needed to be added to the analysis. An important issue to resolve for reaching closure is when to stop conducting interviews. Ideally, researchers should stop adding cases when theoretical saturation is reached (Eisenhardt, 1989). Theoretical saturation is the point at which learning becomes minimal because the researchers are observing phenomena seen before (Glaser & Strauss, 1967). In practice, we decided to stop conducting interviews when new interviews did not add to what we already knew.

In addition to the interviews, we collected more than 300 documents relevant to the present study, including organizational charts, annual reports, special reports, and administrative documents. 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 theoretical saturation was reached. Data analysis was based on the three types of coding suggested by Strauss & Corbin (1990): open, axial, and selective. The data analysis process was facilitated by using Atlas.ti software, which was designed for managing complex data and supporting qualitative analysis. We first identified 35 codes, each supported by two or more text segments in the data set, during the open coding stage. During this stage, we drew on the modes of innovation maturity (Figure 1) for guidance. 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 innovation practices. Following an initial coding effort, additional data collection and coding efforts were made until theoretical saturation was reached. To verify the plausibility of identified concepts, we further reviewed the data set for corroboratory evidence to ensure the validity of our

findings (Miles & Huberman, 1994).

Experiences from ProcessIT Innovations

In late 2004, ProcessIT, a large-scale, long-term R&D program and innovation network focused on IT in processing industries, was honored ten years of substantial funding from the national Swedish R&D funding agency Vinnova. The program resulted from discussions between stakeholders from industry, public authorities, and universities in the north of Sweden since years back. The board that had been formed to manage the application process, dominated by representatives from regional industry, started to build the R&D program. The board appointed the person who had led the application project as CEO, focusing on the establishment of ProcessIT as an innovation network and as part of an emerging regional innovation system focused on IT challenges in processing industries.

ProcessIT was built on a strategic idea of how to conduct R&D projects in order to support sustainable growth and effective innovations processes. The strategy guiding the design and management of the network was to bring together plant owners from processing industries using IT in their processes, IT firms providing processing industry with solutions based on IT, and, IT research groups from both technical and business oriented faculties, and on that basis build collaborative R&D activities with actors involving all three groups of stakeholders. The idea was presented as a three-part R&D project strategy. By means of projects built on this collaboration approach, ProcessIT aimed at meeting IT related needs of plant owners, support IT firms prepared to develop, commodify and maintain products and services meeting these needs, and strengthen IT research groups ready to support these industries with innovative findings and research. In this section, the development of ProcessIT and the associated shifts concerning stages and modes of innovation in the program will be presented.

Period 1 (2005-2006): Building Trust

The three-part R&D project strategy was identified as necessary to serve the interests of each group of stakeholder. To learn how the strategy could be translated into practice, it was elaborated, experimented with, and evaluated during this period. To IT users, i.e. plant owners, the IT firms could offer a long-term product responsibility and the research groups could contribute with height in innovation. To IT providers, the plant owners represented a first potential customer and the research groups represented potential knowledge to some specific problem in the identified product. To research groups, the plant owners provided access to a very demanding industry context and the IT firms were potential partners willing to commercialize their research findings. The three-part project strategy fits well with the innovation model presented in this paper, and to the management of ProcessIT the question was if the project strategy would bring the identified actors together in such a way as to realize the targeted synergies.

Setting up R&D projects following the strategy became the key issue of the early phases of ProcessIT, and in order to succeed in this, management identified trust as a key element. The degree to which different stakeholders would be interested in investing time and energy in projects were considered highly dependent of whether they trusted, on the one hand, potential project partners, and, on the other hand, the strategic idea of ProcessIT in itself. To this end, the projects themselves became the means to start building the requisite level of trust. Hence, during this period management continuously stressed the significance of identifying and clarifying the needs of processing industries, and the importance of building R&D projects accordingly. The need analyses and building of projects were mainly led by researchers and

could, following the model presented in this paper, be described as activities conducted during *the technology exploration stage* (Figure 1).

From the beginning of ProcessIT, it was obvious that the ideas of what ProcessIT should be, and what a regional innovation system was, differed considerably among key stakeholders. Among researchers the idea of ProcessIT as an ordinary funding agency was widespread, and a lot of IT firms had problems in conceiving ProcessIT as something other than a consultancy broker. To ProcessIT management, these ideas were clearly identified as misinterpretations obstructing the intended building of collaborative R&D activities and trust, hence a lot of energy was put into discussions with people having ideas like these. Taken together, the differences in perceptions of ProcessIT did slow down the creation of trust, but they also initiated a lot of activities that helped frame the overall collaboration.

During the first years of the ProcessIT program, the main parts of the projects were built by researchers, and after a while a couple of projects were seen as successful to all of the involved stakeholders. These projects came to be recognized as important role models, providing evidence that the three-part project strategy worked, and being used as showcases to clarify to stakeholders how to use the program in valuable ways but also to help guide ProcessIT management in facilitating the formation of new projects.

To smoothen relations to key stakeholders, and to better understand the conditions of each group of stakeholder, ProcessIT hired practitioners to handle the relations to industry, and academics to handle the relations to universities. This contributed to the network in the intended way, and stakeholders from especially industry recurrently stressed the value of this. They were also positive to ProcessIT working with three-year activity plans, and thus handling changes of directions cautiously. As an overall observation, though, management concluded at the end of this period that the share of projects with strong industry commitment was fairly low.

Period 2: (2007-2008): Encouraging Entrepreneurs

During the first period ProcessIT did well in accomplishing its goal of building trust between the key stakeholders. At the same time, it became clear that the pace with which ProcessIT identified, initiated and conducted projects was too low. In most cases the process of establishing new projects had been led by researchers from the universities, but the projects that were identified as most successful were the ones initiated and led by IT providers, trying to push for a specific idea of solution. These projects showed how IT firms were managing innovation processes in very entrepreneurial manners, but also how actors from this group were able to verify their solutions in relation to potential needs in IT user organizations within the process industry. Because of this, ProcessIT started to favor project proposals put forward by IT firms and encourage people from these firms to propose and take charge of new projects. These actions helped increase the pace of establishing projects valuable to the IT firms as well as to the plant owners and the research groups, and helped establish appropriate collaborations within ProcessIT. According to the innovation model in Figure 1, the projects that were perceived as stronger by all stakeholders represent projects initiated in *the market push stage.*

For organizations to commit to and invest in ProcessIT projects it was also identified as important to find appropriate and fair ways to handle outcomes. Organizations planning to take part in projects had to be confident that the value created through the activities was to be distributed equitably, and that the potential commercialization was not dealt with unfairly. Besides encouraging IT firms to engage in projects, ProcessIT management therefore put great efforts in developing transparent project procedures, incorporating explicit notions of

fairness in the relation between project partners. Situations with firms suspecting other firms to capitalize on commonly produced values without letting the others gaining anything from the collaboration were considered as key risks. This helped reduce some concerns that prevented actors from taking part in specific projects.

In 2008, ProcessIT hired two project officers to continuously visit industry sites and serve as brokers, focused on identifying new and promising matches between needs and solutions, and by that, be able to build new strong collaborative R&D projects. Through this structure, ProcessIT was able to increase its number of projects, and clearly improve the pace and quality of the overall innovation process by more efficiently handling the cycle of needs-meeting-ideas-of-solutions. This change on the program can be seen as a step taken to encourage the transformation of projects to move towards *the technology exploitation stage* (Figure 1).

In designing the network structures of ProcessIT, the management had to take into consideration the importance of time-to-market regarding IT innovations. After some years they also realized the serendipitous nature of innovations, and started to think about ways to handle this. In order to maximize the number of boundary spanning activities between stakeholders further, ProcessIT decided to increase its financial support on pre-studies and meetings, and thus let the stakeholders involved in each R&D projects take a larger share of this cost. The management started to perform many different forms of brokering activities, helping organizations identify ideas and promising partners to collaborate with, and thus help in the initiation of projects in the stages of market pull, market push and technology exploitation.

Period 3: (2009-2010): Increasing Relevance

In 2009, a new period in the development of ProcessIT took off. Additional and substantial funding was allocated and the board decided on a new activity plan. According to this plan, a shift in focus was implemented, in which a key element was knowledge mobility, based on both needs pull and solutions push. Important activities were to better organize the different groups of stakeholders to identify more relevant needs and technologies with potential to produce new areas of IT solutions to processing industry. During 2009, ProcessIT established two industry councils (one in pulp & paper and one in mining) and two technology clusters (one in vision based measurement and one in interaction technologies). These councils and clusters substantially increased the number of industry relevant projects and were received in very positive ways by industry. Through these councils and clusters, firms and research groups with clear interests in these areas could focus on the most challenging needs and promising technology areas to their organizations, and identify and define strong and relevant ProcessIT projects accordingly. The organizing of these councils and clusters can, following the model in Figure 1, be seen as actions taken to produce stronger projects within *the market pull and market push stages*, establishing further relationships to drive innovation processes towards successful outcomes.

To further increase the interest from stakeholders, ProcessIT management put a lot of effort in defining and communicating goals for the whole program to each group of stakeholders to achieve two objectives: 1) helping stakeholders see the network as an extension and amplification of their own every day performance, and 2) facilitating integration of the diverse interests of each group. To research groups, management made clear that both opportunity and value oriented research was highly encouraged even though goals like that traditionally were more tempting to industry. To IT firms, management continued to pursue the policy favoring their project proposals but at the same time emphasized the need to set goals attractive to researchers and processing firms. To plant owners, the message was the

need for the program to go all the way until utilization led to business value, and the efficiency and effectiveness to achieve this if both providers and researchers were to take part. Management wanted, in terms of the model in Figure 1, to encourage stakeholders to identify project goals and activities that would lead to *a successful technology exploitation stage*, and do so by pushing the unique opportunities related to research-industry collaboration during all four stages of the innovation process.

In order to take into consideration the serendipitous nature of innovation and increase the level of knowledge mobility, ProcessIT management tried to identify activities supporting an inter-organizational socialization between individuals of the participating organizations. Social events received increased attention during meetings and activities, and were accomplished very much in order to support a culture characterized by openness, curiosity and informal relations. Individuals from different organizations should better get to know each other because of these events, and by that, be able to identify promising needs and solutions. This could, based on the model in Figure 1, be seen as another action taken to encourage project proposals *building on all four stages of innovation*.

Until 2009, most of the projects conducted within ProcessIT had met identified R&D project goals, but hardly touched upon the more business critical challenges facing the involved processing industry of IT users. The IT providers and research groups had not really been able to identify, build and conduct projects that moved the processing industry forward. An explanation presented by ProcessIT management related to differences in size. The IT users within the processing industries were all global players with turnovers from one billion Euros, while the IT providers were local players with turnovers somewhere around one million Euros. At the beginning of 2010 though, ABB, the world leader in IT-related automation for processing industry, were invited to take part in the industry councils to help identify key challenges and needs together with each processing industry. While still in an early stage of development, the intention is to make possible the identification of R&D projects with potentials to create new value and move these industries forward. Interpreted through the model in Figure 1, this action represents an attempt to find a better match between the needs identified by the global processing industries of ProcessIT and the possible solutions from the engaged ABB supported by local IT firms. A global player as ABB, competing on a world market, is better equipped to address the strategic needs of global processing firms than IT firms primarily competing on local markets.

Discussion

Grounded in a detailed case study of the ProcessIT program, we have addressed the research question: *How can collaborations be managed to successfully deliver competitive innovation outcomes valuable to researchers, providers, and users in regional IT innovation networks*? In doing so, we have seen innovation as a process 'where interaction is the critical element' (Tidd et al, 1997: 29). At the heart of the question of how to cultivate innovation is therefore an understanding of how these interactions take place. In the ProcessIT program, diverse stakeholders interacted in order to co-innovate. The project strategy involving three groups – IT users within the process industry, IT providers, and research groups – has been governing the project since the outset. However, the evolution of the program shows how the innovation process shifted over time as the strategy became adapted to the different and independent interests of the many stakeholders. This insight is based on our observation of the transitions and interactions between different types of learning modes during ProcessIT (cf., Figure 1).

The challenges associated with the transitions and interactions between different configurations of learning modes illustrate how innovation processes in large-scale innovation

programs cannot be rushed. Initial improvement projects with few underpinning interests were gradually replaced with project with higher innovation ambitions and more complex associated interest profiles. After a period of exploration it also became critical to exploit the innovations. Exploration alone is not enough from a business perspective. Any new technological component or technology-related service must pass the commercialization stage with the establishment of a market niche or new market before it can be classified as an innovation (Carayannis and Wetter, 2004). Moreover, to mediate this transformation, various thrusts to increase market push and market push were implemented.

Learning was indeed a central task that the involved organizations had to accomplish to innovate successfully. IT innovation research has shown how IT innovation can be depicted as an emergent phenomenon that originates from the ways in which a diverse inter-organizational community creates and elaborates an organizing vision for it. The learning undertaken by any prospective adopter, according to this theory, is tied to the learning unfolding in the larger community. Our perspective on learning modes makes a contribution in this regard. Specifically, we identify particular learning modes and outline the dynamics of their sequencing as large-scale R&D projects evolve over time. We suggest that learning modes play an instrumental role as the complexities of social interaction grow over time in large-scale R&D projects there interactions facilitates the translation of ideas across space and time in the key parts of the innovation process. These ideas extend prior research that has called attention to the specific role of learning in collaborative projects by specifying how learning is accomplished in research-industry based innovation practices.

We also extend research on the role of brokering that is central to innovation. Many have suggested that individuals often serve as brokers by connecting pockets of knowledge to enable recombinant innovation (cf. Hargadon and Sutton 1997). Our discussion has focused on how learning modes interact to effectively share ideas and stimulate activity among stakeholders with diverse and independent interests. The role of broker in this context does not remain located within a specific individual. Rather, brokering in the perspective proposed in this paper is very much co-created by the stakeholders involved and only enabled by program management. An implication of this perspective is that the transition between learning modes continue to result in "generative impulses" (Bartel and Garud, 2009) for innovation as changed circumstances give rise to new opportunities for innovation.

At the beginning of the ProcessIT program, the strategic idea was that each R&D project should bring together people from each of the three stakeholder groups: IT users, IT providers, and IT researchers. Through experimentation and learning, it became obvious this strategy didn't have all the answers to what innovation activities to conduct, and how to relate different activities to each other to really make the involved stakeholders committed to projects. To initially put the IT providers, with their interest in opportunity investigation and commercialization of identified technologies, in the center of R&D projects represented one such learning. Other key adaptations include: hiring practitioners to handle the relations to industry and academics to handle the relations to universities; developing transparent project procedures and incorporating explicit notions of fairness in the relation between project partners; engaging two project officers to continuously visit industry sites and serve as brokers by identifying new and promising matches between needs and solutions; increasing financial support for pre-studies and meetings and thus letting the stakeholders involved in each R&D projects take a larger share of this cost; and, establishing two industry councils and two technology clusters to increase interactions and partnership formation across stakeholder groups.

Our findings show how innovation processes grow outside of a central control and live their own life. In fact, attempts to centralize control of innovation processes can result in failures (Ciborra 2000). Innovations should be nurtured and cultivated step-by-step in a process that is

co-constructed by the key actors involved. We agree with Ciborra's argument that such cultivation is based on frequent misfits between organizations and their technologies. Cultivation, hence, is about "destabilizing current strategy" and "creating imbalances with the current level of technology." (Ciborra 1997, p. 75) We believe that an engaged scholarship approach offers an approach by which such cultivation is possible.

Conclusions

In this paper, we have explored some key challenges that lie in the establishment of large-scale innovation projects based on research-industry collaboration. We have identified and theorized around some central analytical and methodological issues relevant to these projects, drawing from innovation theory and proposing a process framework of science-industry innovation that incorporates a typology of innovation modes. In the context of Scandinavian IS research, these findings contribute to the long-standing tradition of research-industry collaboration (Mathiassen & Nielsen, 2009) extending the discourse to the context of regional IT innovation where the main challenge is to integrate highly diverse sets of users, providers and researcher by configuring research-industry collaborations on both the network and project levels.

The notion of engaged scholarship (van de Ven, 2007) is proposed as a way to organize collaboration between academics and practitioners to ensure that innovation processes develop in a way that draws from the competencies from both camps. We have identified particular innovation modes and outlined the dynamics of their sequencing as large-scale R&D projects evolve over time. Building on experiences from the ProcessIT program we assert that learning modes play an instrumental role in the evolution of large-scale R&D projects. The ProcessIT program illustrates how innovation modes facilitate the translation of ideas across space and time during the innovation process. These findings extend prior research that has called attention to the specific role of innovation in collaborative practice projects by specifying how learning is accomplished.

The contribution of academy to technical innovation in industry can take on many different forms. It should be noted, however, that although there are apparent benefits to be reaped mutual suspicion can be found in both camps. Such suspicions need to be addressed and turned into mutual trust, particularly in view of the benefits we can expect from a deepened collaboration. The identification of some central issues relevant to the establishment of innovation systems in this paper can hopefully contribute to such creation of more efficient and worthwhile innovation projects.

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