A method for assessing absorptive capacity of a regional innovation system

TUOMO UOTILA, VESA HARMAAKORPI AND HELINÄ MELKAS

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The present study focuses on two important dynamic capabilities in regional innovation systems: visionary capability and innovative capability. Visionary capability is based on the ability to acquire and assimilate future-oriented knowledge, and innovative capability on the ability to transform and exploit the acquired knowledge in the actual innovation processes. In the regional innovation system, innovation processes often take place in heterogeneous multi-actor innovation networks that set special demands for the absorptive capacity of the entire system. The present article sheds light on the aggregate process of generating and using foresight knowledge in regional innovation processes. Experiences gained by resource-based futures research and an "innovation session method" in the Lahti Region in Finland are described in a case study.

Tuomo Uotila, Helsinki University of Technology, Lahti Center, Saimaankatu 11, FI-15140 Lahti, Finland. E-mail: tuomo.uotila@tkk.fi.
Vesa Harmaakorpi, Lappeenranta University of Technology, Lahti Unit, Saimaankatu 11, FI-15140 Lahti, Finland. E-mail: vesa.harmaakorpi@lut.fi.
Helinä Melkas, Helsinki University of Technology, Lahti Center, Saimaankatu 11, FI-15140 Lahti, Finland. E-mail: helina.melkas@tkk.fi.

Introduction

According to the resource-based view, an actor's performance depends on its resources and capabilities (see e.g., Wernerfelt 1984). Valuable, rare, inimitable and non-substitutable resource configurations lay the basis for the competitiveness of an actor. This leads to strong path-dependency. The world is in continuous change, and the actors encounter the risk that the old resource-base becomes uncompetitive, which again leads to a declining performance. Therefore, the resource configurations need to be continuously renewed. The framework of dynamic capabilities (see Teece et al. 1997) offers a good basis to assess the capabilities needed in the transformation processes of an actor. An actor's dynamic capabilities can be defined as the actor's processes that use resources – specially the processes that integrate, reconfigure, gain and release resources – to match and even create market change. Dynamic capabilities are thus the organisational and strategic routines by which actors achieve new resource configurations as markets emerge, collide, split, evolve and die (Eisenhardt & Martin 2000). Actually, it is basically a question of an actor's capability to innovate, since "the production and use of knowledge is at the core of value-added activities, and innovation is at the core of firms' and nations' strategies for growth" (Archibugi & Michie 1995). Innovative capability can be defined as actor's ability to exploit and renew existing resource configurations in order to create sustainable competitive advantage by innovation activities (Harmaakorpi 2004).

The success of economic actors is strongly related to their adaptability to the emerging techno-economic environment. Decisions have to be made in a great insecurity. The insecurity can be reduced by the creation of future-oriented knowledge. Future-oriented knowledge is often very challenging to use in an actor's renewal process, since i) the possible futures are hard to outline, ii) future-oriented knowledge is even more abstract than tacit knowledge and iii) due to its nature, future-oriented knowledge is hard to adopt in an actor's organisational and strategic routines. To make use of future-oriented knowledge, economic actors need a special dynamic capability: visionary capability. In this context, visionary capability refers to an actor's ability to outline the potential development directions based on paths travelled – utilising the opportunities emerging from the changing techno-economic paradigm. In this present study, we aim to clarify, following Zahra and George (2002), the role of absorptive capacity as an important dynamic capability for an actor's success. Absorptive capacity includes features of both visionary and innovation capabilities. In order to use and absorb knowledge, an actor needs to be able both to explore future-oriented knowledge and exploit it in practical innovation processes.

Thus, this present article takes a resource-based viewpoint of departure. As a change to the earlier research focusing on the internal resources, there is an increasing interest on the external resources and capabilities available to the actor through networks (Zaheer & Bell 2005). Accordingly, and following the teachings of non-linear multi-actor innovation processes, economic actors are not seen as isolated islands, but entities being parts of regional and interregional innovating networks. Therefore, the competitiveness securing resource configurations have to be considered at the level of innovation networks, individual actors being embedded in these networks. Absorptive capacity of future-oriented knowledge as a dynamic capability is seen as a crucial competitiveness factor of the individual actors and innovation networks. This article attempts to outline the principles and practical means for how absorptive capacity concerning future-oriented knowledge could be enhanced in the multi-actor innovation networks. Measures taken in the Lahti region, Finland, are used as a case study.

Futures research in regional contexts

The future is a central challenge in developing competitive advantage based on technology and knowledge. According to the results in a report for the Futures Committee of the Finnish Parliament, one of the main factors behind the ability to innovate is the ability to foresee technology development. Technology foresight has received growing attention among those involved in the shaping and implementation of science and technology (S&T) policies (Salmenkaita & Salo 2004). Earlier, more focus was laid on an approach that stressed outside objectivism during the foresight process, but nowadays those who will utilise or produce emerging technologies are also more involved in the technology foresight process in order to influence the shaping of those technologies (Eerola & Väyrynen 2002). Despite this development, a common finding in several recent studies has been that the foresight activities at national, regional and institutional levels ought to be better coordinated and that foresight activities at each level should be further strengthened. Besides the methodological competence, the importance of a problem-based approach is stressed (Eerola & Väyrynen 2002).

When discussing technology foresight at the regional level, an important basic problem is that when the process is not rooted deeply enough in already existing structures and competences, or more generally, existing resource configurations of a region, there is a danger that the results are not absorbed into the regional strategy making and development processes. This problematic phenomenon can be called "the black hole of regional strategy making". The birth of a black hole can be avoided by developing both the technological competencies and co-operative abilities of the potential users of new technology (companies and/or other organisations) and paying enough attention to communicating and managing the foresight process (Sotarauta et al. 2002). Thus, technology foresight processes cannot be treated separately from regional learning processes (Ronde 2003; Gertler & Wolfe 2004; List & Metcalfe 2004). Gertler and Wolfe (2004) even see learning dynamics as being fundamental to the ability of regional economies to achieve and sustain knowledge-based dynamism over the long run. They regard regional foresight processes to be, at their most fundamental level, socially organised learning processes involving learning by individuals, firms and institutions.

The key question for policymakers at the regional and local level is thus how to provide the right conditions for generating growth of more knowledge-intensive forms of economic activity within the context of dynamic innovation systems or learning regions. The concepts of path dependency and lock-in imply that the technological development directions of specific regions and localities are historically determined by the research and innovation capabilities developed by individuals and organisations over time (Gertler & Wolfe 2004). According to Ronde (2003), the development of a certain technological course is the outcome of the cumulative nature of learning processes, and hence, the generation of new knowledge builds upon what has been learned in the past.

Regional multi-actor innovation processes

Analysts in the field of innovation systems have abandoned simplistic models of how innovation and innovation processes work. It is increasingly recognized that the dynamics of innovation systems are complex and difficult to understand and that scientific and technological communities, not to mention the "users" of their products, face a number of challenges, both now and in the future (Kuhlman et al. 1999). Characterising innovation as a socially and economically embedded process raises the question of the socio-institutional environment, where the innovation processes are taking place. In a regional context, innovation is seen as a process embedded in a regional innovation system (RIS) (see e.g., Cooke et al. 1997; Storper 1997; Braczyk et al. 1998; de la Mothe & Paquet 1998; Doloreux 2002).

According to Autio, a RIS is composed of two subsystems: a knowledge generation and diffusion subsystem and a knowledge application and exploitation subsystem (see Fig. 1). The former consists of four main types of institutions, and all of them participate in the production and dissemination of both codified and tacit (technological) knowledge and (technical) skills. Key elements include public research institutions, technology mediating organizations, educational institutions and workforce mediating organizations. The knowledge application and exploitation subsystem, again, consists of four C's: companies, clients, contractors and competitors. Ideally, there should be horizontal and vertical linkages among the firms. Also dialogue and interactions between subsystems and actors within subsystems are a necessary prerequisite for RIS to operate sufficiently (Autio 1998; Tödtling & Trippl 2005).

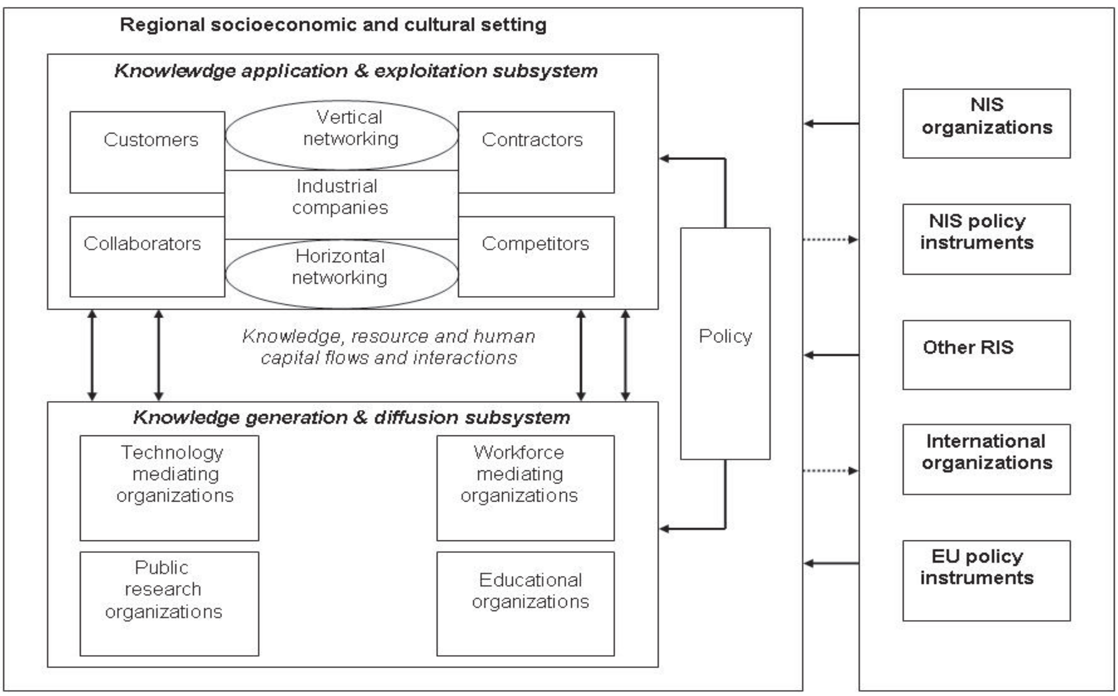

Fig. 1. Main structure of regional innovation systems (RIS) (Autio 1998; Tödtling & Trippl 2005).

Regional innovation system consists thus of innovative networks with different kinds of social relationships. Social structure, especially in the form of social networks, affects economical outcomes, since the networks affect the flow and the quality of the information (Granovetter 2005). Granovetter (1973) defines the concepts of strong ties and weak ties in social networks. The strength of a tie is a combination of the amount of time, the emotional intensity, the intimacy and the reciprocal services which characterize the tie (Granovetter 1973). Strong ties are characterized by common norms and high network density. These strong ties are easier for innovation, since they include normally a relatively high amount of trust, common aims and the same kind of language to communicate. However, weak ties are reported be more fruitful for innovations, because more novel information flows to the individuals through weak ties than through strong ties (Granovetter 2005). People in the same strong networks tend to share the same knowledge basis preventing the Schumpeterian knowledge-combining innovation processes to emerge (see Schumpeter 1942). Burt (2004) has developed the "strength of weak ties" argument further by arguing that innovations are most likely to be found in the structural holes between the dense network structures (see also Burt 1992; Walker et al. 1997; Zaheer & Bell 2005). An actor able to span across the structural holes in a social structure is at a higher "risk" of having good ideas: new ideas emerge from selection and synthesis across the structural holes between groups (Burt 2004). A regional innovation system rich in structural holes offers a lot of opportunities for new networked innovation processes.

The weak links or structural holes enabling the biggest innovation potential are somewhat problematic for innovation processes. In order to be able to utilise the innovation potential in these structural holes, information should often be transferred between very research-oriented and practise-oriented partners – as well as partners of totally different horizontal knowledge interest (interdisciplinarity). The potential innovating partners in different sub-systems might not be able even to begin the processes, as the common rules for communication are lacking. Even in the same technological field, the language in basic research is so different from practice-based innovation processes that an innovation process could end before it has started, even if the innovation potential in the structural hole is obvious. The situation is the same between different technological disciplines. The situation is most complicated when there is a desire to span the structural hole between a partner with research-oriented knowledge interest in one technological field and a partner with practice-oriented knowledge interest in another technological field.

A remarkable part of difficulties between the potential innovating partners stems from the information asymmetry on the different sides of a structural hole (see e.g., Montgomery 1991). The partners on the opposite sides of the structural hole have information of different quality and achieved for their own purposes. The difference is often so big that a special interpretation function is needed. Burt writes about this special function as information brokerage in the structural hole. A structural hole is an opportunity to broker the flow of information between people and control the form of co-operation that brings together people from opposite sides of the hole (Burt 1997).

Absorptive capacity in multi-actor innovation networks

Absorptive capacity was originally defined by Cohen and Levinthal (1990) as an organisation's ability to value, assimilate and apply new knowledge. Kim (1998) argues that absorptive capacity requires learning capability and develops problem-solving skills; learning capability, again, is the capacity to assimilate the knowledge for imitation and problem-solving skills to create new knowledge for innovation. Moreover, Zahra and George (2002) define two different types of absorptive capacity giving good point of departure for this study: potential absorptive capacity that is important in acquiring and assimilating external knowledge, whereas realized absorptive capacity refers to the functions of transformation and exploitation of the knowledge collected. Both are, naturally, important in regional innovation processes: potential absorptive capacity enables the exploration of knowledge (often) over the weak ties of the innovation system, and realized absorptive capacity secures the exploitation (often) in the strong ties of the networks. Absorptive capacity is crucial when pondering questions about future-oriented knowledge adaptation in regional innovation networks; higher absorptive capacity enables the easier crossing of structural holes in the innovation system.

To understand better the characteristics of absorptive capacity as a dynamic capability we have to take a closer look at its different parts: acquisition, assimilation, transformation and exploitation. Acquisition refers to an actor's capability to identify and acquire externally generated knowledge that is critical to its operations. Assimilation refers to the actor's routines and processes that allow it to analyse, process, interpret and understand the information obtained from external sources. Transformation denotes an actor's capability to develop and refine the routines that facilitate combining existing knowledge and the newly acquired and assimilated knowledge. Exploitation as a capability is based on the routines that allow actors to refine, extend and leverage existing competencies or to create new ones by incorporating acquired and transformed knowledge to their operations (Zahra & George 2002). According to these definitions, absorptive capacity is like a funnel, where potential absorptive capacity (visionary capability) secures the newness and diversity of the knowledge needed, whereas realised absorptive capacity (innovative capability) stands for operationalization of the new knowledge in the existing processes in order to make the actual innovation processes to take place.

However, the difference between potential (PACAP) and realised (RACAP) absorptive capacity is blurry. According to Zahra and George (2000), PACAP could theoretically be equal with RACAP, but in most cases PACAP is larger than RACAP. Zahra and George (2002) also suggest that there is a special need for a social interaction mechanism between assimilation and transformation processes. In the following case study, we focus on these phases of the absorptive capacity in regional innovation networks. Assessment includes both potential and realised absorptive capacity; however, exploitation is left for further research. The key question in the case study is: how could acquisition, assimilation and transformation processes (absorptive capacity) be aided in regional innovation networks? The research focus is depicted in Fig. 2.

The case study thus aims to outline the principles and practical means for how absorptive capacity concerning future-oriented knowledge could be enhanced in multi-actor innovation networks by looking into measures taken in the Lahti region, Finland. Our underlying hypothesis is that absorptive capacity is crucial when pondering questions about future-oriented knowledge adaptation in regional innovation networks; with successful operationalization of new knowledge in the existing processes, actual innovation processes are aided. The method to address this is to take a closer look at the different parts of absorptive capacity within the case study environment – and by doing this, a "test" of the validity of our theoretical considerations is also undertaken.

The case study: a resource-based foresight process in the Lahti region innovation system

The Lahti region has set a goal to be the leading area in practice-based innovation activities in Finland, and the framework of network-facilitating innovation policy has been adopted in the region in order to promote innovation activities. The Lahti region's future competitiveness is seen to be greatly dependent on its ability to promote practice-based innovations, due to the absence of a whole university and very low research inputs in the region. The yearly research input in 2004 in the Lahti region was only 255 euros per capita compared to 1800 euros in the Helsinki region and 2530 euros in the Tampere region. This tells something of the knowledge-intensity of the region. However,

Fig. 2. Absorptive capacity of future-oriented knowledge in innovation processes (following Zahra & George 2002).

the Lahti region has a favourable logistic setting: it lies only 100 km from two remarkable research centres, Helsinki and Tampere, enabling the relatively easy transfer of scientific knowledge to the practice-based innovation processes.

The situation in the Lahti region has forced it to develop new tools to trigger innovation processes. One aim of the network-facilitating innovation policy is to search for structural holes between the regional knowledge-base and the future-oriented knowledge-base found in the surrounding research centres; that is, to absorb the surrounding future-oriented knowledge to the regional innovation system. Therefore, as part of the regional innovation policy, a resource-based technology foresight process was carried out in 2005 (the results of which will be reported on later, in other articles). In general, the existing resource configurations in a region set the basis for future development, and, therefore, regional foresight processes have to be tightly connected with an audit of the region's resource base (Harmaakorpi & Uotila 2006). Bearing this in mind, the technology foresight process was planned to be carried out in three phases:

- Phase 1: Defining the regional development platforms and clusters to be assessed and identifying the related technologies
- Phase 2: Exploring the future opportunities for the clusters and technologies using the Delphi process
- Phase 3: Organising future-oriented innovation sessions in order to disseminate the results of the Delphi process within the clusters

In the Lahti region, the cluster-based development strategy was adopted during 2004–2005. Strong current clusters in the region are mechatronics, environmental, grain, wood, furniture and plastics clusters. The development resources during the coming years will mainly be allocated to the development of these clusters, and especially the environmental cluster. The aim of our regional technology foresight was to create an open, exploratory foresight process, the limits of which are drawn on the basis of the regional cluster strategy. The focus was on mechatronics, environmental and plastics clusters. The actual process is depicted in Fig. 3.

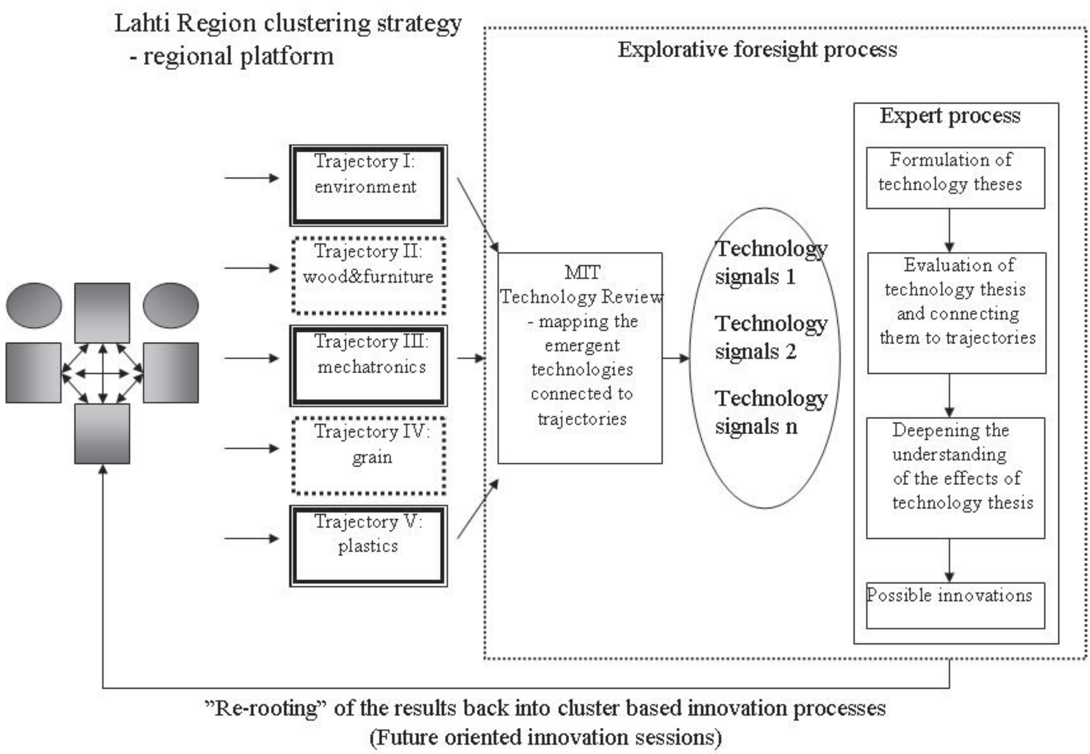

Fig. 3. Technology foresight process in the Lahti region (Ahlqvist et al., forthcoming). More detailed results of that research process will be reported on later in other articles by Ahlqvist, Uotila, Harmaakorpi & Melkas.

The idea of the regional technology foresight process in this case was to identify and evaluate technology signals related to nano-, bio- and ICT technologies that may have significance for the three clusters focused on in this foresight process. The definition of technology signal is analogical to that of weak signal (see e.g., Vapaavuori & von Bruun 2003; Mannermaa 2004), but implicating that the content of the signal is related to technology (hence the name technology signal). Potential technology signals were identified from several sources, out of which *The MIT Technology Review* was the most important. Around 200 potential signals were ″muddled through″, grouped and pre-evaluated. Finally around 30 signals were selected to the Delphi process, one selection criteria being the potential link to the cluster strategy in the Lahti region. After the selection, the signals were written in the form of "technology theses" (for example, as follows: "Silicon-based nanosensors that detect atomic motion. Silicon-based nanosensors can be utilized as highly precise measurement devices, for example in measuring the smoothness of a surface."). The purpose of this reformulation was to indicate the possible use of a certain technology signal so that the experts could more easily evaluate the potentiality and application areas of that technology signal.

Delphi relies on the "informed intuitive opinions of specialists" (Helmer 1983). This collective judgement of experts, although made up of subjective opinions, is considered to be more reliable than individual statements – and thus more objective in its outcomes (Johnson & King 1988; Masini 1993). One of the most challenging phases of the Delphi process is building up the expert panel (see Kuusi 1999; European Commission 2002). It is of critical importance that the panel members really are experts in the subject areas. In this research, the panel was build up by muddling through web-pages of those organizations – mainly universities or other research organizations – that are doing research in the area of the selected technology signals and by choosing the potential respondents from those pages. The composition of this panel is thus very research and science oriented. All in all 300 potential respondents were selected to participate in the panel, from Finland and abroad. This kind of a procedure serves also the purpose of mobilizing expertise from outside of the region into the regional foresight process, which is of vital importance, since outside expertise is important in breaking possible mental lock-ins existing in a region (Harmaakorpi & Uotila 2006).

The first round of the Delphi process was carried out in April 2005, and the second round in July–August 2005. The main purpose of the first round was to collect expert opinions concerning the issue of which of the technology signals are so-called emerging technologies. The second round was somewhat more focused, and it concentrated on five technology signals, which were found to be the most promising during the first round. The main idea was to deepen the understanding of those product, process or business innovations that could utilize the technology signals focused on. Altogether 63 experts responded to the first round and 49 to the second round questionnaire.

Using Delphi in this context is, however, not enough. The results of the Delphi process must be again rooted back into the clusters to support practical innovation processes in companies. This is done in part three of the foresight process. The opportunities emerging from the Delphi assessment should take a practical form in regional development activities. It is also important to form creative social capital to exploit the resource configurations effectively (Tura & Harmaakorpi 2005). This can be done by organising future-oriented thematic innovation sessions. The aim is to organize altogether 60 sessions in the Lahti region during the period 2005–2006, out of which 40 sessions have already been held. Thus, in the future-oriented innovation sessions, the aim is to assimilate and transform the foresight information gained during the Delphi process to future-oriented innovation knowledge to be exploited by companies (see Fig. 4). This task is not easy to fulfil. It has often been seen how difficult it is to reach a fruitful dialogue between the participants of the innovation sessions, since the knowledge interests are too far from each other, which threatens the spanning of the structural hole. The innovation potential is clear, but the innovation processes are inadequate due to the lack of communication.

Normally, we conceptualise three archetypes of participants in an innovation session: (i) future-oriented knowledge producers, (ii) practical knowledge exploiters (usually representing a company, but sometimes also its customers/suppliers) and (iii) intermediators. Reaching a common understanding of the problem by the efforts of knowledge producers and knowledge exploiters has proven to be problematic in many cases. The rela-

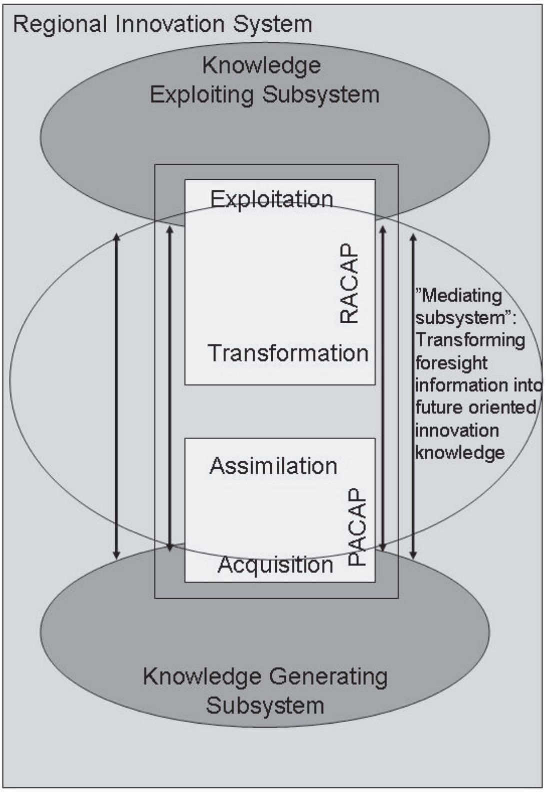

Fig. 4. Absorptive capacity in the context of a regional innovation system.

tionship between future-oriented nanotechnology knowledge and practical innovation processes in the plastics industry can be given as an example of that. The innovation potential is clear, but the innovation processes are inadequate due to the lacking ways of communication. The adoption of future-oriented knowledge in the practical innovation processes is difficult but crucial in this kind of an environment.

The role of information brokers has proven to be essential in making the participants innovate. The task of these intermediators is very challenging, since they need to understand the processed substance knowledge, as well as have the social abilities to work in very diverse groups. To secure a successful innovation session, intermediators need to be able to set questions and deliberative arguments that, for example, enable (i) the people on both sides of the structural hole to become aware of the interests and difficulties of the other group, (ii) transferring the best practices between the groups, (iii) drawing analogies between groups ostensibly irrelevant to one another, and (iv) making a synthesis of the knowledge interests (Burt 2004). In order to do this, each session must be prepared very carefully. Although the session usually lasts for one day, the preparation time can last for up to two months or even longer. During that time, the intermediators try to learn as much as possible about business logics in the industry the company is operating in, about technology used, current knowledge base of the company and also knowledge needs for the future, etc.

The brokers need new methodology in order to succeed in their challenging task. The experiences gained in innovation sessions show that the familiar brain-storming methods, for example, do not suit very well to such sessions. The knowledge interests of the innovating partners often remain too distant to enable an active multi-actor innovation network to emerge. After many experiments, it became clear that the right questions set in the group work in the innovation sessions could open up the way for successful innovation processes. This development course led us to find the interrogative model of inquiry, i.e., a general method to generate knowledge and skills by question-answer-processes (see Sintonen 2006) as a possible methodological approach to use in the networked innovation processes that aim at spanning the structural holes (see Harmaakorpi & Mutanen, forthcoming). The model being developed in the field of theoretical philosophy poses a fascinating intellectual challenge – to apply the model in the context of innovation systems.

Conclusions

The present article took a resource-based view of regional development. The resource-based view emphasizes the renewal of existing resource configurations by dynamic capabilities. Two important dynamic capabilities in promoting regional innovation systems were defined: visionary capability and innovative capability. Visionary capability refers to the regional innovation systems' ability to explore diverse future-oriented knowledge, and innovative capability to the systems' ability to use the knowledge in the actual networked multi-actor innovation processes.

The main question in this research is: how can these capabilities be promoted in a regional innovation system? The question was assessed with the concept of absorptive capacity. Absorptive capacity was defined to be a dynamic capability including two elements: potential absorptive capacity and realized absorptive capacity. Potential absorptive capacity is strongly related to visionary capability, and realized absorptive capacity to innovative capability.

The article reported on the approach used in the Lahti region in Finland. Experiences gained from a regional technology foresight process to identify and evaluate technology signals related to nano-, bio- and ICT technologies were introduced. The article also sheds light on the so-called innovation sessions that are used to root future-oriented information and knowledge back into the region. Innovation sessions methodologies are under development, as described in the article.

This article concentrated on a thorough description of the background and probably raises more questions than it answers, as the research is in progress. In further research, important issues to be taken into account are, at least:

- The re-rooting of the results of the foresight process described in the article was characterized by the inclusion of SMEs with limited resources for (futures) research, in mostly traditional and usually less research intensive industries, in a region without major research organizations supporting SMEs. This is one case, interesting and challenging, but not enough for "universal" conclusions.
- How could absorptive capacity be measured in innovation networks?

In the Lahti region, the direction is towards using the interrogative model of inquiry in regional innovation promotion activities. Although application of the model is still in its embryonic phase, it has proven to have potential for further development. The first experiences emphasize heavily the role of intermediate organizations – information brokers – in a successful questioning process. So far, the actors in these organizations seem to lack the qualifications needed to process questions and deliberative arguments in the inquiry process (see Harmaakorpi & Mutanen, forthcoming). Therefore, the next steps in making the interrogative model of inquiry really work in the innovation processes in the region are (i) to develop the model to better suit to the practical work by trying different kinds of inquiry scenarios in the innovation sessions and (ii) to educate the actors in the intermediate organizations to use the interrogative model of inquiry in the information brokerage of the innovation sessions.

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