MANAGING MULTILAYERED INNOVATION PROCESSES: CHALLENGES RELATED TO EMBEDDEDNESS IN TIME AND SPACE

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ABSTRACT
From organizational theory we know that firms tend to prioritize problems that are close in time and space. This paper develops a framework in order to understand how an innovation process is embedded into four different contexts that are drifting. These contexts are identified by introducing embeddedness in time and space as two basic dimensions, and combining these with organizational and technical resources as two types. We illustrate our theoretical ideas with an in-depth case study, taken from the Swedish biotech industry. The firm Pyrosequencing was in 2000 a success story, a spin-off from the Royal Institute of Technology, and attracted venture capitalists and prominent board members. However, the firm was in the end merged with two other biotech firms, only three years after its founding. We analyze the role of control in this innovation process. The paper concludes that control is supporting close activities in time and space but has harder to capture signals that are more long term and takes place in distant spaces in a network surrounding an innovation.

Keywords: Innovation, resource, embeddedness, controls, business relationship, business network

INTRODUCTION

An innovation needs to be managed in relation to a technological and an organizational level (e.g., Dosi, 1988; Håkansson and Waluszewski, 2002). In both a short- and a long-term perspective, any innovation builds on, and contributes to, an organizational and technical structure, both close and farther away from a single organization. Hence, an innovation also needs to be managed in relation to time and space as two dimensions (e.g., Rosenberg, 1976; von Hippel, 1988).

From organizational theory we know that firms tend to prioritize problems that are close in time and space (March, 1991; Levinthal and March, 1993). However, so far have the consequences of this for the management of innovation has not been studied in-depth. The tensions and balance between short and long time problems and their solutions are crucial for firms that are trying to survive. Short term solutions that seem to be right and successful might be devastating for the long term survival. Further, solutions to problems that are close to the firm, either internal problem or stakeholders that are close to the firm, might be right in the "close" space around the firm. However, the solution might not "fit in" in the wider network of actors and resources. Our argument is that innovation is a multilayered phenomenon that has be managed and controlled in such a way, where both time and space are critical dimensions and the innovation is dependent upon its present and future embeddedness in social as well as technical resource contexts. The purpose of this paper is to develop a framework to elaborate on the embeddedness of an innovation. More specifically, this is done by focusing on the organizational and technical resources in time and space that embed an innovation. Related to innovation as embedded in a multilayered context of organizational and technical resources in time and space, we will discuss the role of control and the possible problems arising from focusing on the close technical and organizational space and time. By doing so, the paper aims at contributing to our knowledge about innovation processes as multilayered phenomena. The concept of embeddedness deals with connections to a context, or structures of social relations (Granovetter, 1985). Embeddedness can be seen as a core issue within network research, and is often implicitly acknowledged in the sense that companies embedded in networks of interdependent business relationships (Halinen and Törnroos, 1998).

The paper builds on a case study of the development and commercialization of a new scientific method to analyze the human genome. Belonging to the Swedish biotech sector, this innovation was originally developed at the Royal Institute of Technology in Stockholm. The innovation was "productified" and commercialized in the Uppsala based biotech firm, Pyrosequencing. In 2000 it was termed one of the world's most promising technologies by the Forbes magazine. Pyrosequencing went public the same year, and was valued to USD 620 million. However, the sales never took off, and Pyrosequencing did not deliver values that could justify that kind of market value. At a later stage, Pyrosequencing was merged with two other firms, before this new company was acquired by a Dutch bio tool company in 2008.

The paper is structured as follows. Sections 2, 3 and 4 present literature focusing on innovations, embeddedness and controls. The methods is presented in section 5, and the empirical material is presented in section 6. Section 7 provides an analysis and discussion of multilayered innovation process and the role of control in these processes. Finally, conclusions are presented in section 8.

MANAGING INNOVATION: THE DOMINANT PARADIGM

In many ways, the view of innovation as an isolated process can be said to represent the dominant perspective in literature (Tidd et al., 2004). One reason to this may be that organizations tend to look into the local space and close time when problems are to be solved (March, 1991; March and Lewinthal, 1993). The problems that are most local to the firm will be prioritized first, as will problems that are closest in time. For example, this means that customers or stakeholders that affect the short term survival of the firm will be given attention when the firm prioritizes resource allocation to different activities.

This has also consequences for how firms manage innovation and product development projects. Basically, this view implies that the product development process and the product as an outcome are to some extent separated from the context, at least the inter-organizational context or network (Anderson et al., 1994). Focus is instead set on the process and the product *per se*. The process becomes a means to obtain an end: the product (Meredith and Mantel, 2006). The models that firms use to manage product development are traditionally divided into planning and implementation steps (Lindell, 1991). This view underlies numerous models on managing product development, depicting product development as a process that starts with an idea or a discovery, and results in a product. Among the more widespread of these are the seminal model of Booz, Allen and Hamilton (1968) (see Biemans, 1992), and Cooper's Stage-Gate™ New Product Process (Cooper, 1993; 2005). Common for such models is that they provide advice on how to manage product development. This advice includes how to divide the product development process into a number of stages, or activities, and how to establish gates, or checkpoints, throughout the process.

The models point at various key success factors that ought to be followed as part of managing the process, such as "strong market orientation", "effective quality control procedures" and "speed, but not at the expense of quality" (Rothwell, 1992; Cooper, 1993; Cooper and Kleinschmidt, 1995). In a similar vein, different techniques for managing product development are launched, such as concurrent engineering (CE), quality function deployment – "house of quality", cross-functional integration, the design-build-test cycle, computer assisted design (CAD), test panels and design for manufacturability to mention some (Clark and Wheelwright, 1994; Crawford, 1997).

Product development can be regarded as a particular type of project, and projects can be divided into two types: R&D projects and construction projects (Meredith and Mantel, 2006). Product development projects, as characterized by a relatively high degree of newness and uncertainty about the outcome, can be regarded as a type of R&D project. By reviewing the literature on project management, similar observations from the literature on product development projects can be made: models that are clearly based on the project and its outcome are viewed in isolation; i.e., the focus is on a singular project as a lonely phenomenon (Engwall, 2003). Moreover, literature strongly influenced by the normative project management theory. Management of projects becomes a question of sticking to plans, avoiding changes in the latter phases of the project and managing resource availability.

Various techniques are introduced for management of projects, including Gannt charts, CPM (Critical Path Method), PERT (Program Evaluation and Review Technique) and WBS (Work Breakdown Structure) (Morris and Pinto, 2004). By applying this approach to projects, they are regarded as tools rather than organizations (Packendorff, 1995). These models, techniques, key success factors and advice on managing product development are accompanied with corresponding advice on measuring product development, through terms such as control, evaluation, audit, and determination of the degree of success.

Measurement concerns this process and the outcome. Time, cost and performance represent three basic types of measures that are frequently used to measure the process of product development, both throughout the process and subsequent to its completion. Measurement becomes a question of meeting the plan, i.e., goal-fulfillment. How is the product development project doing with respect to time consumption compared to the plan? Is the project behind or ahead of time? Similar questions can be asked with respect to costs.

What about the performance of the product? Is the prototype performing as planned within, for example, the specified temperature range? Product development processes that meet or are ahead of these three types of measures are often referred to as successful, whereas processes that fail to meet these measures are often regarded as unsuccessful. This ought not to be confused with measures that report success related to the process implying a successful product, or the other way round. A product development project that is regarded as successful due to meeting the plan on time, cost and performance measures as determined in the plan, can still result in little or no sales, thus leading to the product being regarded as unsuccessful from an economic point of view. After all, the product is subject to its own measurement, e.g., sales results, shares, margins, and profits (Cooper, 1993). On the basis of these measures, the economic success of the product is often estimated on the basis of its return on investment (Cooper, 1993), i.e., whether or not the earnings from the sales of the product exceed the costs related to the preceding development process.

INNOVATION: ORGANIZATIONAL AND TECHNICAL RESOURCES IN TIME AND SPACE

In the following, and contrasting the foregoing section, focus is set on the embeddedness of innovation. This embeddedness implies that the innovation process interacts with a context, i.e., influences it and is influenced by it, with all the constraints and opportunities that come along.

In this paper, the two basic dimensions of time and space are used in order to analyze the embeddedness of an innovation process (cf. Halinen and Törnroos, 1998; 2005). These two types of embeddedness are also referred to as the spatial and temporal forms of embeddedness (e.g., Fletcher and Barrett, 2001), or processual and structural embeddedness as presented in the seminal articles by Granovetter (1973; 1985). Embeddedness in time refers to the past and the future in which the innovation process is embedded. Any innovation draws upon preceding resources, and in a is in a similar vein succeeded by other resources. Embeddedness in space refers to the present, or contemporary context in which the innovation process is embedded. Innovations stretch out in space in the sense that connect resources from different actors, hereunder make use of, and influence other resources that are possessed by other companies.

The context in which the innovation process is embedded can be analyzed according to types of resources. In this paper, the resources that embed the innovation process are divided into organizational and technical as two basic types (Håkansson and Waluszewski, 2002; Baraldi and Strömsten, 2006). Organizational embeddedness refers to the business units and business relationships which embed the innovation process. Technical embeddedness refers to the products and facilities which embed the innovation process. Again, these two types of resources are connected. Business units is here used as a flexible concept that refers to parts of companies, companies, or even groups of companies, dependent on where it is appropriate to draw the boundaries. Business relationships refer to the bundle of intangible resources that exist in the interface between two business units, such as knowledge, experience, expectations, trust, adaptations, administrative agreements, contracts and social bonds. These two organizational resources control the two technical ones, e.g., they develop and make use of facilities and produce and exchange products. The two technical resources make the business units and the business relationships meaningful. Business units need to develop or produce products for exchange, often by making use of facilities. Product exchange lies at the core of business relationships, also depending on facilities.

By combining the two types of embeddedness and the two types of embedded resources, four types of embeddedness are introduced. See figure 1. This figure represents a way to elaborate on the context that embeds an innovation process, and forms the structure for this paper.

Type of embeddedness		Types of embedded resource: Organizational	Types of embedded resource: Technical
	Time	*Organizational Embeddedness in Time*	*Technical Embeddedness in Time*
	Space	*Organizational Embeddedness in Space*	*Technical Embeddedness in Space*

Figure 1 : Innovation embedded in multilayered contexts

Organizational Embeddedness in Space

This type of embeddedness draws attention to the contemporary business units and business relationships that interact with the innovation process. In this way, social relationships that form complex networks are introduced, contrasting the neo-classical market thinking (Granovetter, 1985: 481; Uzzi, 1996). Attention is directed towards suppliers, customers, and other cooperative parties as well as the network of relationships that connect them (e.g., Håkansson and Snehota, 1989; Hallén et al., 1991; Anderson et al., 1994; Kreiner, 1995). This type of embeddedness has received considerable attention in literature: Customer relationships are identified to be important sources of knowledge in relation to innovation processes, e.g., “lead-users” (von Hippel, 1988). Suppliers and other cooperative partners are in a similar vein identified to be important (e.g., Lei and Slocum, 1992; Teece, 1992). In relation to innovation processes, Håkansson (1989: 120) points out that *“relationships tend to open the way towards a variety of solutions”*. Moreover, Ford and Håkansson (2006) point out that business interaction involves resources from far wider in the network than the companies that are directly involved, thus often easily identified. Powell et al. (1996) point at the network of business relationships as a source for knowledge in relation to innovation processes, in particular when this product is complex and when the sources of expertise are widely dispersed among companies. A company’s ability to identify this type of embeddedness depends on the knowledge of how the connected business relationships and business units interact with the innovation process. In this regard, a company can be said to hold limited knowledge of its business network, i.e., “network horizon” (Holmen and Pedersen, 2003).

There is a general trend towards specialization, outsourcing and core competencies within the field of business (e.g., Hamel and Prahalad, 1994). This trend points at increased cooperation and use of the business network in relation to innovation processes, i.e., organizational embeddedness in space in many cases becomes highly important when developing innovative new solutions.

Technical Embeddedness in Space

This type of embeddedness includes the contemporary products and facilities that interact with the innovation process. It includes related products, technical solutions, components, technological standards, technical tools, machinery and production equipment, i.e., various types of complementary assets (Teece, 1992). These technical resources, which are controlled by different business units, alone or jointly, in the business network, interact with and embed the innovation process in a space (Håkansson and Waluszewski, 2002). After all, *"Inventions hardly function in isolation."* (Rosenberg, 1982: 56), i.e., the innovation process in focus needs to be related to a larger technical structure in order to be useful. This type of embeddedness draws attention to the systemic side of innovations (Teece, 1988), i.e., that innovations need to be connected to other technical resources in order to become useful and succeed.

In a similar vein, studies on diffusion of innovation draw attention to the importance of these technical resources, referring to them as interdependencies (e.g., Rogers, 1995). Also, the foregoing argument on specialization, outsourcing and core competencies strengthens the need to relate innovation processes to other technical resources.

Organizational Embeddedness in Time

This type of embeddedness draws attention to the part of the context that covers the past as well as the future business units and business relationships with which the innovation process interacts (e.g., Ford et al 2009; Medlin, 2004). For business units and business relationships, the knowledge, skills, memories, experience, trust, expectations, and capabilities to cooperate that constitute important parts of them indicate that their creation and shaping is of a long-term nature. Furthermore, the business units and business relationships are characterized by an "organizational heaviness" in the sense that they often prove a resistance due to knowledge, time and administrative routines that are hard to change. Thus, they are frequently pointed out to be characterized by a remarkable stability (e.g., Håkansson, ed., 1982).

For innovation processes, this means that an organizational embeddedness is present in the sense that the historical and future relationships and network connections holds a grip over a single innovation process. Experience within particular fields has been developed, relationships and inter-organizational routines with certain suppliers and customers have been established, and so forth. But also hopes and expectations about the future affect how innovation processes unfolds. By incorporating the history and the future, the processes underlying the development of the network of business relationships can be more thoroughly understood and taken into consideration (Ford and Håkansson, 2006). For the innovation process, the organizational embeddedness in time bears with it distinct restrictions. The business units may feel "trapped" by past business relationships (Håkansson and Snehota, 1995), or by the paths along which they have developed their expertise, providing them with the feeling of being unable to break out of a pattern (Leonard-Barton, 1995). But this type of embeddedness may also inspire the actors and make opportunities visible.

Regarding the future, the organizational embeddedness points at the effects that an innovation process bears with it for future business units and business relationships. I.e., an innovation process entails development of several resources, such as new knowledge and experience within the business units (Nonaka and Takeuchi, 1995; Danneels, 2002) as well as the business relationships that connect them.

Technical Embeddedness in Time

This type of embeddedness includes past technical achievements, successful products and experiments, failures, technical standards, investments made in production facilities as well as the effects that the innovation process entails for future products and facilities. By directing attention towards this type of embeddedness, it becomes evident that an innovation process rests upon the past in the sense of earlier achievements, i.e., history matters (e.g., Rosenberg, 1982; Teece et al., 1997). Path dependence is a frequently used concept that refers to this phenomenon (e.g., David, 1985; Teece et al., 1997). Path dependence can be used to draw attention to the effects that follow from past products, knowledge, routines, investments in facilities, etc. (e.g., Coombs and Hull, 1998). The structure of the past represents a "heaviness" that bears with it distinct restrictions for an innovation process (Håkansson and Waluszewski, 2002). But this past also entails opportunities, i.e., past achievements can lay the foundation for future innovation processes. In relation to path dependence, lock-in effects are often referred to (e.g., David, 1985). These effects refer to how one path, e.g., a particular type of product technology, often hinders development of other solutions. An innovation process is furthermore identified to often take place "close in" to previous successes (Teece, 1988). After all, at least in a short-term perspective, the resource structure of companies is quite stable (Penrose, 1959). As a consequence, in particular within the resource-based view, some authors argue that companies can utilize their past innovations in order to maintain a sustained competitive advantage (e.g., Amit and Schoemaker, 1993; Barney, 1991; Hamel and Prahalad, 1994). Incremental innovations, also referred to as improvements or refinements, represent a type that obviously draws extensively upon past achievements (Rosenberg, 1982; Utterback, 1994). Similar observations are also made for projects on a more general basis (Engwall, 2003). Obviously, the notion of "cumulativeness" (Teece, 1988) becomes important in relation to this type of innovation processes.

By introducing this type of embeddedness, attention is directed towards a single innovation process as part of larger processes in time, both proceeding and succeeding it. This type of embeddedness is dealt with in literature in the sense that authors have introduced "aggregate project plans" (Wheelwright and Clark, 1994), or portfolio management tools, such as product/market-matrixes and the BCG-matrix (e.g., Ansoff, 1965; Kotler, 1997) as instrumental tools that take this type of embeddedness into consideration.

THE ROLE OF CONTROLS IN MULTILAYERED INNOVATION PROCESSES

Given that innovation is embedded in technical and organizational structures in time and space, what is the role of control in these processes? When it comes to accounting and control space and time has been discussed in relation to centralization and decentralization in organizations (Quatrone and Hopper 2001). Space and time are seen as constructed by the accounting information created and presented in firms and are not merely representations of the same. Within the management control literature three generic types of controls are often discussed, result or outcome based controls, action controls and personnel controls (Davila 2000; Merchant and Van der Stede 2007). Result based controls refers to desirable results a firm aims for. In this process the firm defines dimensions and follows up on these. Action controls refer to the desirable actions needed in an organization in order to meet objectives. Action controls can be related to manuals, instructions etc. But also to action accountability, by preventing some type of actions by rules and procedures. Personnel control is about hiring, training and socializing individuals within an organization to work towards the defined objectives.

In product development projects classic forms of outcome controls include time, cost, and performance as three basic dimensions in relation to the innovation project itself, i.e., controls as goal-fulfillment (Meredith and Mantel, 2006). Questions asked can be: How is the innovation project doing with respect to time consumption? What about costs and performance compared to the plan? Innovation processes that meet or are ahead of these three types of measures are often referred to as successful, whereas processes that fail to meet these measures are often regarded as unsuccessful. Following the innovation project, the innovation itself is subject to its own controls, e.g., sales results, shares, margins, and profits, and return on investment (e.g., Cooper, 1993).

However, by viewing product development as embedded in space, it becomes evident that the role of control must be different, as for example outcomes of the process exceed the product itself. As examples, a useful customer relationship may be developed, or investments in a critical test laboratory may be conducted by one of the suppliers. These outcomes are difficult to assess, as they need not be visible to the participating companies beforehand. Moreover, their value is dependent on their use, or the “useful customer relationship” and the “critical test laboratory” may first appear useful a long time period after the development of the product. In this way, the outcomes of product development become blurred and difficult to assess. This does not, however, make such outcomes less important. Several of these outcomes emerge and change throughout the development of the product, rather than exist as parameters that are well defined and immutable from the initiation of the development process. In relation to this, Kreiner (1995) looks at the challenge of “drifting environments” in the sense that the outcomes of projects tend to change throughout the development process. The role of control in these “drifting environments” is certainly different from environments that are more stable. This implies that managing product development becomes a challenge that goes beyond the isolated product development process and its product as the outcome. Managing product development may become a challenge of utilizing existing resources at a customer or making use of the skills that are developed over a long time period through cooperation with a supplier. Further, it may also be a matter of identifying critical resource interfaces that are changing, not only in the close environment but more importantly in “spaces” that are more distant to the organization being active in an innovation process. In this way, the network is used to influence product development. But the challenge of managing product development may also concern how to utilize the outcomes of the process, e.g., a promising software tool developed for a customer as part of the product development process, or immaterial resources, such as trust and willingness to share information (as an example of personnel control) in a relationship with a supplier. Controlling product development needs to be looked at in a way where the outcomes (or results), actions and personnel controls in the network are included.

METHOD

The discussion on how product development is spatial and temporal embedded, but also handled in isolation is illustrated with a single case study (Yin, 1994). The empirical setting is the biotech sector that had a great upswing in Sweden in the late 1990s. The focal firm of the case, Pyrosequencing, a biotech startup that for some time was seen as a success story and was also put on Forbes list of the 300 most interesting companies in 2000.

Typically, case study as a research method is regarded as appropriate when dealing with phenomena that are difficult to separate from their context (Yin, 1994). This is certainly true for this study, where the phenomenon studied is an innovation process that is highly complex, and where its embeddedness is paid particular attention. Moreover, this study focuses on business networks, which are in themselves complex and difficult to delimit (Easton, 1995). According to Halinen and Törnroos (2005), the complexity of these business networks makes case study an appropriate method when investigating them. Furthermore, Halinen and Törnroos point at case study as an appropriate method for conducting process research, i.e., dynamics and the time dimension, hereunder history, present, and the future. In a similar vein, the authors point at case study as an appropriate method for dealing with network boundaries, embeddedness, and structures, i.e., the space dimension. Taking the purpose of this paper into consideration, i.e., to explore on embeddedness in time and space for an innovation process, and with particular focus on business networks, case study projects as an appropriate research method.

Drawing on Easton (1995), Halinen and Törnroos (2005) discuss four critical challenges in relation to case study research that aim at theory development: the problem of network boundaries, network complexity, and the role of time and case comparisons. The first three issues are also implicitly related to how innovation as embedded in time and space is presented in this paper, while the last one (case comparisons) is not relevant for this paper.

First, the issue of network boundaries is related to how to delimit a study. In this study we have approached the empirical phenomenon by "following" the resources, the products, the facilities, the units and the relationships. Moreover, the study is retrospective, and we could therefore identify critical resource interfaces in hindsight, hidden for the firms at the time when decisions were made. The second issue, network complexity is also "embedded" in our study. The technology studied in this case is about DNA sequencing and its usage. It involves a large number of products and facilities, different knowledge areas and units where these reside. To understand this structure fully is not possible, however, the theoretical framework, the 4R model (Håkansson and Waluszewski (2002) guided us in this process. The framework has been used in a large number of studies on innovation (e.g., Ford et al., 2009). The third issue regards the role of time. Again, as the study is retrospective we have information that the actors did not have and we are able to see and judge decisions in hindsight. This is certainly not fair. However, this gives also the opportunity to trace effects of decisions on resource combinations in one point of time (which seemed to be quite reasonable) and then see the effects of the combinations in the further process. Without the retrospective study this would certainly not be possible.

The empirical material consists of 35 interviews with individuals working in seven different organizations. The interviews were conducted between 2002 and 2007. Further, secondary information such as annual reports, internal documents such as financial reports, product descriptions and organizational charts have been used in order to increase our understanding of the focal firm.

The interviews were conducted in a semi-structured way. They were tape recorded and then transcribed. The questions focused on the development of the firm and its product development activities. The product, which in fact is a system consisting of three parts, a hardware, software and biological reagent kits, developed over time and how customers used their system, in what activities the system was used, in combination with other products or systems etc. In addition, the competitive situation was also covered during the interviews, that is, what alternative technological solutions were considered by the customers.

PYROSEQUENCING: A BIOTECH NEW VENTURE

Pyrosequencing grew out of a research project conducted by a group of researchers at the Royal Institute of Technology (RIT) in Stockholm. More specifically, the company was founded in order to take advantage of the increasing interest in applied genomics. Pyrosequencing developed a specific method for sequencing and detection of single nucleotide polymorphisms (SNPs) – information that could be used in the development of new drugs. On the basis of this method, Pyrosequencing developed its main product: PSQ96.

Pyrosequencing and its Organizational Embeddedness in Space

The researchers behind PSQ96 at the Royal Institute of Technology held a well-developed network of relationships to the Swedish biotech tool industry as well as to the venture capital industry. These relationships steered them into first the type of research that focused on genetic variation, second the type of "productification" and type of commercialization that they chose. The network that emerged when Pyrosequencing was set up to a large extent influenced the design of PSQ96. The decision to set up the firm in Uppsala were based on the close connections to Amersham Biosciences, and made it easy to convert the innovation of Pyrosequencing into a biotech tool.

Together with the board of directors, the management team set up mile stones, worked out what the product would look like, consists of etc. The use of the milestones definitely colored the way management looked upon the development of the firm and the technology. Meeting the milestones was also important indicators that were communicated to the two different markets that the firm was so dependent upon, the customer market of course, but perhaps even more the capital market.

The product's features were based on assumptions from a rather tight and small social network. These assumptions were made by people with long experience from the international biotech sector. One can perhaps argue that the development work was done to some extent with a generalized environment in mind, and not specific customers or users. However, the product development process, which to a large extent mirrored the development of the firm, was in a rather early stage "frozen" (Strömsten and Waluszewski, 2005). That means, features of the product were early on decided upon and the time to reach these goals was considered as the main thing. The reason was partly driven by "market" reasons; Pyrosequencing saw a window of opportunity and saw that this opportunity required speediness. PSQ96 was at the time of the IPO evaluated as highly successful, whereas the same product was evaluated as dramatically less valuable only two years later.

Pyrosequencing and its Technical Embeddedness in Space

PSQ96 consisted of a technological system that covered hardware, a reagent kit and a software program that would facilitate the analysis of the output from the research of genetic variation of SNPs. Another technological component was the "clean room" where the sensitive chemicals were produced. The production facility that would produce the reagent kit was dimensioned given forecasts from potential users of the product.

The first generation of PSQ96 worked very well in relation to customers and users technological system. It was easy to use, intuitively users could quickly could get it up and running and do tests on it. Further on, PSQ96 solved an important problem for some users as it made the analyses more reliable and quicker. The step in the "production process" that Pyrosequencing focused on early on was "filled" with PSQ96 and the future certainly looked bright for some time.

It is also apparent how the "drifting environment" to some extent much played a bad trick on Pyrosequencing. Once the second generation of Pyrosequencing's instrument was ready for the market, there was another time, with new demands new knowledge, and as a consequence there was a totally new "space" out there as the firm's position in relation to customers and competitors had changed dramatically. We can partly explain that "failure" by the fact that time was running out for the focal firm in this case, Pyrosequencing.

Within some spaces certain logics are very dominating. One such space is the stock exchange. The financial time logic continued once the firm entered the stock exchange, where the quarterly reports in some cases seem to have affected how the firm interacted with customers. How this affected the firms is of course hard to say, we can only speculate about its possible effects. However, to press in sales and training sessions in order to get a sale within a certain quarter, cannot possible be the idea with a stock exchange. However, it is an interesting illustration of the old saying that "you get what you measure". It is interesting to note how these two different spaces, the financial space the industrial space or network, exists side-by-side, but to large extent live under opposite logics.

Pyrosequencing and its Organizational Embeddedness in Time

A firm's position in a network changes continuously. A product that is developed for one type of network, or space, is therefore sometimes left with new conditions, with new firms entering, changing relationships with customers and thus, there is a new space to deal with. Environments are drifting. For Pyrosequencing it was clear that several important changes had taken place over time; competitors had entered the market, or rather, the network and taken up the race for quick and reliable SNP analysis. For example, the first generation seemed to have worked very well in relation to customers and users. It was easy to use, intuitively users could quickly could get it up and running and do tests on it. However, as speed and cost per sample was something that guided product development, a second generation, a high throughput instrument was considered as necessary. The resources that were needed were more complex, as was the whole instrument. As the firm only had one product out, it was very sensitive to set-backs. This compared with the focus on time, now from the stock exchange, made the whole situation very stressful for the involved people.

Time plays an important role also on the organizational level for PSQ96. Health Cap, the venture capital firm, played an important role with respect to encouraging, or even imposing, the management of PSQ96. First, this company was a major investor in Pyrosequencing. Second, a partner from Health Cap was brought in as a "serial CEO" in Pyrosequencing. Health Cap put forward goals for Pyrosequencing that put a high pressure on speeding up the development of PSQ96, and later on also on reporting the sales on a quarterly basis. The motivation for Health Cap to manage PSQ96 in this way can be found in its inherent venture capital structure. Time is of great interest for any venture capital firm, and their interest of displaying the value of Pyrosequencing was substantial; first in order to conduct the IPO, later on as part of its strategy to conduct an exit. As a rather new venture capital firm, Health Cap was in need of an exit that could serve as a reference project for its present investors, but perhaps more importantly, its future investors. Thus, Pyrosequencing was to large extent, even if only implicitly or indirectly, managed for an IPO in a rather short time. In order to go public, growth and promises for the future are considered important. The investment in the production facility and how much of it that actually was used is an interesting example of this. The investment was in one way necessary as it promised future growth and thus an increased value of the firm. The technology therefore had to be "mature" and tested and ready for a market. The financial logic therefore had a clear direction on strategy and the operations of the firm.

Pyrosequencing and Technical Embeddedness in Time

PSQ96 was truly embedded in time in the sense that it was both rooted in the past and came to influence the future. Regarding the past, parts of the technology underlying PSQ96 was developed at the Royal Institute of Technology. One of the inventors, a professor at this academic institution, was also a board member to a company that would turn out to be a highly important cooperative partner for Pyrosequencing, namely Amersham Biosciences. In other words, past achievements played a crucial role as the development of PSQ96 was initiated.

Regarding the future, PSQ96 clearly formed a foundation for the development of a second generation of the product. For this second generation product, Pyrosequencing faced difficulties, both with the development and the launching. By viewing the development of this second generation of the product as embedded in time, as part of an “interrelated clustering”, e.g., highly dependent upon PSQ96, it becomes evident that some of these difficulties can be traced back to the path chosen at earlier moments of time. First, PSQ96 was developed under a lot of time pressure, hereunder alpha and beta versions of prototypes where the development work had to be “stop half ways”. Even though this rapid development seemed important for launching PSQ96 successfully, such a development strategy resembles “short terminism”, and may entail negative effects for future product development. Second, and closely related to this time pressure, PSQ96 could be regarded as a quite “narrow” product in the sense that it only included one step in the analysis chain. In particular throughout the sales process, Pyrosequencing experienced that its customers requiring a product that could handle several steps in the analysis chain, also gradually offered by the competitors. Pyrosequencing now found itself in a situation where the development of a second generation of the product became particularly cumbersome due to the past achievements and decisions on how to develop PSQ96. Third, Pyrosequencing recruited the majority of its employees from Amersham Biosciences, and also learned about the majority of the possible applications from this company. Furthermore, Pyrosequencing aimed at customers within the booming research and drug discovery market. This approach may at one time have looked promising, and likely had its advantages when it comes to speediness. However, the majority of these relationships had to be abandoned for the development and launching of the second generation of Pyrosequencing’s product. Whereas PSQ96 was at a certain moment of time regarded as a commercial success, it is evident that the new generation of product has so far not at all shown to be as successful. So, when evaluating these two products combined, as embedded in time, the question of PSQ96’s degree of success becomes a much more open one. Furthermore, the story is not over yet; Pyrosequencing has been merged with another company, and yet other products that draw upon PSQ96 are on their way.

ANALYSIS AND DISCUSSION

In this paper we have presented a framework that can be used to understand in what different contexts innovation takes place. We identified four different contexts where an innovation travels, and must survive and interact with different resources in the different contexts.

To a large extent, PSQ96 had clear imprints from being time-driven. There is no doubt that time affected its features, the way the firm had coordinated the supplier relationships and the overall product development process. A large part of the development work was early on decided to be conducted outside the focal firm, even if the core of the technology was left in-house. This decision, which indeed must be considered to be strategic, was based on the logic of saving time to market.

We could see that, explicitly and implicitly, different types of controls played important role in the development of the technology and in the commercialization process. Further, these controls were related to the four different contexts identified and discussed in the theoretical section. Hence, it was possible to see four different pairs of controls related to the four contexts.

First, controls related to time and organizational resources involved in the Pyrosequencing case to a large extent to as fast as possible to develop a product or rather a system. Hence, milestones were used extensively in order to track the development of the activities undertaken by Pyrosequencing and its suppliers in the product development process. The product development project was to large extent managed and controlled with time objectives that also was related to other objectives, not necessarily by the firm itself, but by its owners and their need to create an exit for Pyrosequencing on the stock exchange. Well at the stock exchange, the firm was affected by other time frames, the quarterly reporting system and financial analysts and the valuation models (where the time value of money is always present). Hence, a feeling of becoming more short term was perceived.

A second pair of controls regarded the spatial organizational dimension. These involved foremost the business unit, Pyrosequencing and to some extent also business relationships that were directly involved in the innovation project, and could affect the performance of the product, PSQ96. Further, the firm evaluated implicitly by its ability to develop its close organizational space regarding customer relationships. For example, the short-term organizational controls included to what extent a pilot customer bought the product, or number of customers committing to use the product the first year after its launch. However, as Pyrosequencing was too a large extent managed and controlled with a time frame of a year or two, long term controls were less prioritized (even if the firm formally had a long range planning process). The firm therefore did not see or identify the threats by existing knowledge and routines in the network around itself. In a similar vein, distant organizational controls could concern the measurement of changes in business units and business relationships due to innovations, e.g., to what extent learning has taken place (cf. Leonard-Barton, 1995). An innovation that is regarded as a success for one company may represent economic losses, or the entering into a technological sidetrack for other companies that have been involved. Long-term organizational controls concern measuring the effects from the innovation on the business units and business relationships in the long run, e.g., to which new areas of knowledge have been developed, or to what extent business relationships have been established, or furthered, as a consequence of the innovation.

A third pair of control identified was related to time and technical resources and included technical solutions that form a basis for the innovation in hand, e.g. that the PSQ96 would consist of a system of hardware, software and a reagent kit. Close technical controls referred also to space, e.g., that Pyrosequencing agreed upon technical solutions and components offered by suppliers to the innovation process. From the case is became obvious that the successfulness of PSQ96 varied over time, e.g. it was considered a success early on but was later seen as less so. *Long-term technical controls* concerned issues such as what other, new products are developed as effects from the innovation at hand.

The fourth pairs of control had to do with spatial controls related to technical resources. The controls were "close" in the way that the object that were managed and controlled was the product, PSQ96 and its different features. Due to the time pressure several features of the product was taken away or less prioritized and this affected how the product related to more indirect resources and interfaces. Hence, one could argue that there was a lack of control mechanisms that went beyond the close product and also incorporated the indirect interfaces or more distant spaces where the product had to survive long term. Distant technical controls could then refer to outcomes, actions or even personnel controls that are related to effects that the innovation has on products and facilities that are located in the more 'indirectly' connected business units and business relationships.

Comparing the different types of controls, the ones related to short-term and close technical and organizational resources are obviously easier to deal with than the ones dealing with long-term and distant resources. It is easier to measure, and easier to plan for what is close in time and space. To many companies, these short-term/close effects also project as the most relevant ones as was also seen in the case presented. After all, most companies take on a single-firm approach when dealing with controls, as shown also in the Pyrosequencing case, i.e., effects for counterparts, or companies that were only indirectly connected, became less relevant. This phenomenon can be said to be rooted in the way companies operate, and are operated: single-firm focus, use of quarterly reports, performance-based promotion of people, bonuses and options based on meeting certain financial results, etc. However, by simply paying attention to the short-term/close controls, companies may face what can be referred to as ‘short-terminism’ (Dunk and Kilgore, 2001). On the other hand, companies can reduce this problem by establishing controls that are long-term/distant, looking beyond a single innovation project (Kreiner, 1995). Obviously, in some situations short-term/close versus long-term/distant may represent a dilemma for a company. Should it practice strict short-term controls and possibly complete the innovation project speedily, even though this may lead to negative long-term effects? Should certain distant controls be established, in order to see to it that supplier performance is raised as a consequence of an innovation project, even though this can be costly, thus influencing the close controls negatively. For companies, it seems important to seek a fruitful balance between the different types of controls in the process of managing innovation.

CONCLUSION

This paper developed a tentative framework in order to map and understand the different contexts an innovation must survive in. These contexts were related to the organizational and technical resources innovations are comprised of and how they are related to time and space. Hence, this paper examined the role of embeddedness in relation to product development and innovation and reported an in-depth case study from the Swedish biotech sector. In the study we saw how different actors (e.g. venture capitalists, companies that develops new products etc) apply different views on how to manage product development, but also how to measure product development. This is evident when one examines in what type of time and space logic these firm acts and how they have to adapt to these logics in their relationships with resource providers. Thus, measuring and managing product development is a matter of identifying the boundaries that might affect what is affecting what makes a product or a project successful. Sometimes, these boundaries can be manipulated in order to reach short term goals. However, these types of actions can be costly in the long run, if these boundary braking actions violate the logic of an interrelated space.

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