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The logic of innovation in construction

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ABSTRACT

The paper investigates the logic of innovation in construction by addressing four questions: What is actually being renewed in construction? How is it being done? Who is involved? and Why do or do not the companies innovate? The paper draws on a combination of an industrial network perspective and the exploration–exploitation dichotomy to analyze data from a study of innovation in the Norwegian and Swedish construction industries. The findings show that construction companies are increasingly working more systematically to turn project-level ideas into company-wide knowledge. This indicates an innovation logic that is oriented towards exploitation of new combinations through the internal network. The companies are also increasingly concerned with establishing closer connections to customers and users, which have traditionally been weak. This has led to an orientation towards exploitation through the external network, at least on the customer side. In turn, this may lead to more innovative behavior and renewal in the industry as a whole. However, it requires that not only the customer relationships, but also the relationships on the supply side must change. Companies in the construction industry should be conscious about their innovation logic, in terms of whether they base their innovation behavior on a biased orientation towards exploitation or exploration or towards the internal or external network. A balance is needed.

1. Introduction

How innovation is achieved and what drives and impedes innovation processes are heavily related to industry-specific features and the evolution of industries (Abernathy & Utterback, 1978; Malerba, 2004; Pavitt, 1984). The construction industry is constantly accused of being non-innovative and conservative. However, it is also acknowledged that common indicators for measuring innovation, such as R&D expenditure, number of R&D personnel, and number of patents, are not necessarily appropriate measures of innovation in this specific setting (Seaden & Manseau, 2001). The discussion indicates the need for a deeper understanding of what innovation is within construction, how it happens and the impact of the industry's specific features on innovation processes. The overarching goal of the current paper is to add to this understanding by examining the innovation logic of construction in terms of *what types* of innovation are realized, *how* it is done, *who* is involved and *why* innovation happens or not.

The construction industry has several specific features which are likely to affect how innovation is or can be achieved. Earlier studies have shown that contextual features, such as the regulatory environment, have a strong effect on how innovation is fostered or hindered (Blayse & Manley, 2004). Organizational features also have an impact; the project organization is arguably both an innovation hindrance and driver (Slaughter, 2000; Winch, 1998), and the lack of long-term relationships (Dubois & Gadde, 2000, 2002) and integration in the supply chain (Akintoye, McIntosh, & Fitzgerald, 2000) are pointed to as inhibiting innovations. The complexity of the construction process itself is yet another complicating factor (Gidado, 1996; Miozzo & Dewick, 2004). The industry involves many actors and interactions at multiple levels, which means that the innovation process needs to engage a set of different actors with different economic logics (Bygballe & Jahre, 2009). We take this complicating factor as a standpoint for our paper in investigating innovation as a result of the industry's specific multilevel and inter-organizational characteristics.

One theoretical framework focusing particularly on inter-organizational issues in business-to-business situations is the industrial network approach. Drawing on the IMP research tradition (see Håkansson, Ford, Gadde, Snehota, & Waluszewski, 2009) the current paper sees the construction industry as an industrial network in which innovations are related to "the carrying out of new combinations" (Schumpeter, 1934, p. 65) among interconnected activities, resources, and actors (Håkansson & Waluszewski, 2007) that leads to "a non-trivial improvement in a product, process, or system that is actually used and which is novel to the company developing it" (Slaughter, 2000, pp. 1466). From an industrial network perspective there is a correspondence between the type of inter-organizational interface and the likelihood of innovation. As interaction promotes learning, useful new solutions can be created.

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What type of learning is employed, and how, has consequences for innovation. According to March (1991), balancing between explorative and exploitative learning is a key to corporate longevity. While exploitative learning refers to primarily known combinations being further developed, explorative learning is about identifying new combinations of which the effects are more indefinite. In construction, this balance has proved to be difficult, particularly in transferring new combinations created in projects to the wider organization (Brady & Davies, 2004) and the industry level (Seaden & Manseau, 2001). Understanding the connection between what is learned in separate projects and how this is implemented at the company and industry level (and vice versa) and seeing this in relation to the exploit-explore dichotomy seem relevant for understanding how and why innovation appears in particular ways within construction. While previous literature on learning and innovation in construction has clearly acknowledged the exploration–exploitation dichotomy (e.g., Brady & Davies, 2004; Prencipe & Tell, 2001), we still know little of the implications for innovation of this need for balancing in the network context in which construction occurs. What we do know is that the opportunities for exploitation and exploration are linked to types of relationships (Wilkinson & Young, 2002) and environmental settings (Wilkinson & Young, 2005).

In general, the twin concepts of exploitation and exploration have come to dominate organizational analyses of a multitude of different topics including technological innovation, organization design, organizational adaptation, competitive advantage and firm survival (Gupta, Smith, & Shalley, 2006). By combining insights from the industrial network perspective with research focusing on the concepts of exploration and exploitation, as well as drawing from earlier studies on innovation in construction, we discuss the innovation logic of construction. More specifically, we find the interactions within and between the project level, the firm level, and the industry level to be particularly interesting for understanding innovation as the process in which new combinations of activities, resources and actors are created (exploration) and further integrated and utilized (exploited).

In the next section, we present key propositions for how to understand the logic of innovation in construction, which draw from these three theoretical and empirically based sources. These will be used to analyze findings from an empirical study of innovation in the Swedish and Norwegian construction industries. The study includes surveys in both countries and 20 interviews with senior managers. The final section discusses the findings in relation to the theoretical propositions, drawing together the sources in a final argument for how we may understand the logic of innovation in construction.

2. Theoretical background

2.1. Innovation in the construction industry

When companies perform new or existing activities in a new way, this is often considered to be innovation. In other words, innovation involves a "change in routine" (Nelson & Winter, 1982, pp. 128) and the "carrying out of new combinations" (Schumpeter, 1934, pp. 65). Innovation has been seen in relation to new products, new processes, new raw materials, new forms of organization, and new markets. According to Lundvall (2007), it can be useful to distinguish between technical innovation and organizational innovation as the former is highly influenced by how the economy and the firm are organized, and because training and organizational change are important prerequisites to transform technical innovation into economic results. Lundvall (2007) argued that for analytical reasons, if not in practice, it is important to separate the different types.

Common indicators of innovation are R&D investments, number of R&D personnel and patents, and emphasize technological and product development. A general observation in several countries is that the construction industry scores low on R&D expenditure and that few construction firms take advantage of R&D or innovation programs offered by governments (Miozzo & Dewick, 2004; Seaden & Manseau, 2001). The literature recognizes, however, that the traditional measures of innovation are not necessarily applicable in this particular setting (Winch, 2003). For example, it is argued that traditional measurements do not consider innovation in organizational processes, which are important in construction where contracting arrangements, assembly methods and the integration and interaction among systems are core activities (Seaden & Manseau, 2001; Slaughter, 2000). Winch (2003) also showed how the standard industrial classifications classify the most innovative parts of construction, i.e. design and product development, as "Other Business Services" and not as construction.

Even if debate remains over the extent to which traditional measures of innovation fit the characteristics of construction or not, the potential for improving the rate of innovation in this industry is considered high (Winch, 1998). One such characteristic is the inter-organizational character of the industry, which we have taken as an explicit standpoint for our investigation of the conditions for innovation. The following section presents a selection of literature addressing the industry's inter-organizational features in connection to innovation, first what types of relationships are existing in general and then what this means specifically for innovation on the project, company and industry level.

2.1.1. Relationship features in general

Construction companies must interact with other actors in order to develop and implement new solutions. According to Blayse and Manley (2004), clients are often the recipients of new solutions, but without knowledge about what fits into the user context, it is difficult to implement new solutions and be able to create economic benefits from doing so. Manufacturing firms are also key sources of innovation as they can be suppliers and developers of new solutions that the construction companies can use. Manufacturing firms often operate in a more stable market, which means that they can maintain R&D programs and learn from experiences and then build knowledge bases that facilitate innovation. Thus innovation is influenced by the relationships between individuals and firms within the industry and between the industry and external parties. Relationships with "innovation brokers," such as professional institutions, universities, and construction research bodies, are also considered important (Blayse & Manley, 2004). However, these external sources of innovation are generally considered by the industry to be of minimal value (Bygballe & Ingemansson, 2011). Furthermore, previous empirical studies have showed that the industry is characterized by mistrust and skepticism embedded in adversarial behavior and conflict among the actors (Dainty, Briscoe, & Millett, 2001). Fearne and Fowler (2006) argued that to improve the construction performance, a fundamental change in the management of relationships between clients, contractors and sub-contractors is required. Supply chain integration (for an overview, see Bankvall, Bygballe, Dubois, & Jahre, 2010) and partnering (for an overview, see Bygballe, Jahre, & Swärd, 2010) have been suggested, even if the deep rooted attitudes in the industry are considered to be difficult to change (Bresnen & Marshall, 2000). In general, innovation is seen to be dependent on long-term relationships between producers and users (e.g., Harrison & Waluszewski, 2008). The price focus and culture for competitive bidding result in a constant shift in actor constellations across different construction projects. This hinders continuity and long-term developments, resulting in "loose couplings" among the construction actors and an inability to create network effects for improving productivity and innovation (Dubois & Gadde, 2002).

2.1.2. Features at the project level

It is well accepted that projects provide unique arenas for inventing new solutions since they lack the stability of a mature organization and are per definition reliant on problem solving or creating new knowledge among a group of people. As Grabher (2002) noted: "Through their trans-disciplinarity and transience, projects thus indeed appear as a

most pertinent form for creating knowledge in the context of application" (pp. 1492).

New project objectives that cannot be met with known means trigger search activities that are needed for identifying new solutions (Slaughter, 2000). New solutions are risky, however, and introducing change in complex systems such as construction can create unanticipated effects. Thus, innovation must be managed properly. According to Winch (1998), managing attention is particularly important since innovation depends on the coincidence of means, motive and opportunity to innovate. Construction projects are inter-organizational, due to the tradition of sub-contracting, which means that new solutions must be negotiated with one or more actors within the project coalitions (Winch, 1998). As a result, the perception of degree of change and links to other systems can differ among involved parties (Slaughter, 2000). Given the different interests involved, it is likely that some solutions that are good for one party or a group of the involved firms may not be good for others which reflect the notion by March (1991) that learning effects are distributed across space. Proper incentive systems must therefore be in place, where the benefits from innovations are split between the clients and the actors in the project coalition (Winch, 1998).

2.1.3. Features at the company level

Much research has been devoted to the exchange of learning and new knowledge across the project and the organizational levels. Capturing knowledge gained in single projects, transferring it back to the organization and using it in new projects has proved to be challenging (Brady & Davies, 2004). Nevertheless, for innovation to happen, construction firms must be able to adopt and implement new ideas on projects or transfer results from problem-solving on projects to the firm level (Winch, 1998). For example Grabher (2002) noted that project participants are assigned to other projects as soon as a project is finished. Faced with a different objective and confronted with a new deadline, there is little time to reflect and recognize the usefulness of the experiences made in the former project. Furthermore, Bresnen, Goussevskaia, and Swan (2005) found that transferring knowledge generated in one project to the wider organization is difficult because of existing routines and knowledge and power structures. New knowledge may threaten existing practices, and as such be counteracted. Blayse and Manley (2004) noted that innovation depends on the nature and quality of organizational resources, the internal attitudes, and processes conducive to innovation. These resources include a culture of innovation, absorptive capacity, innovation champions, knowledge codification systems, and an innovation strategy. Individuals and champions are also important drivers of innovation, and these must be given slack resources for innovation (Nam & Tatum, 1997).

2.1.4. Features at the industry level

Winch (1998) argued that the structural features of the construction industry at large hamper innovation, particularly the fragmentation and separated responsibilities for system integration among designers and contractors. Furthermore, the character of regulations and the way these are influenced by different interest groups influence innovation. Blayse and Manley (2004) also emphasized the influence of regulations/standards on innovation. Detailed prescriptive specifications may impede the adoption of new solutions offered by contractors. While prescriptive regulations hamper innovation, many observers have recognized that performance-based regulations can actually facilitate innovation. However, this requires that the regulators and policy makers possess sector-specific knowledge. If policy does not acknowledge that innovation is spurred by interaction rather than price competition, then it will not greatly facilitate innovation (Bygballe & Ingemansson, 2011). The existing procurement systems in the construction industry is also pointed to as an impediment of innovation, with traditional lump-sum contracts that trigger price competition rather than interaction (Dubois & Gadde, 2000). In several countries, such as in the UK, governmental reports have been opposed to these practices arguing for partnering and closer collaboration between the parties in the construction process (Egan, 1998; Latham, 1994).

The above review of organizational features of the construction industry at different levels in relation to innovation clearly shows how innovation activities in the construction industry involve complex interactions within and across firm boundaries (Seaden & Manseau, 2001). Being project-based, construction companies comprise complex internal interaction patterns. Furthermore, construction can be regarded as an archetypal network (Miozzo & Dewick, 2004), involving a range of companies working together to build a new building or infrastructure. The complexity of construction suggests that there are a number of different interfaces and interdependencies between tasks, parts, and units (Gidado, 1996) that must be handled and where innovation can or cannot take place. Because of the inter-organizational nature of construction work, innovation is not implemented within the firm, but instead in multi-actor projects, which means that most innovations must be negotiated with one or more actors within the project coalition (Winch, 1998). The importance of relations across firm boundaries for innovation in this particular setting implies that a network perspective might be useful to understand innovation in construction. Such a perspective may aid elaborating how innovation takes place across multiple boundaries and also why or why not it takes place, which is essential for understanding the logic of innovation.

2.2. An industrial network perspective on innovation

The industrial network approach explains the effects of inter-organizational issues on technology development and innovation. According to this perspective, companies are embedded in a network constellation of different *actors*, *resources*, and *activities* (Håkansson & Snehota, 1995) in which they interact to gain access to resources or activities which they themselves do not possess. Companies are seen as incomplete in terms of not having all the needed resources to produce individual products or services, but must interact with other companies (such as suppliers and customers) in order to sustain themselves. Relationships, or interfaces, to other actors (and their resources and activities) are thus of central importance to the individual company. The connections that the interaction processes induce are analyzed as actor bonds, resource ties, and activity links, constituting the ARA-model (Håkansson & Johanson, 1992; Håkansson & Snehota, 1995). Actor bonds are mainly social and organizational phenomena, while resource ties or combinations can be both physical (products and facilities) and/or organizational entities (business units and business relationships). Activity links represent the interdependence between, for instance, different logistical or production activities taking place across organizational borders (Håkansson & Waluszewski, 2002).

In this view innovation is not seen as the work of an individual company but rather "the result of an interplay between two or more actors: in other words, as a product of a 'network' of actors" (Håkansson, 1987, pp. 3). Håkansson (1987) brings forward three main arguments for this which are connected to knowledge development, resource mobilization, and resource coordination. He argues that new ideas often emerge at the intersection between different bodies of knowledge as they are confronted or need to be combined in a certain way, for instance in an exchange situation between a producer and a user. The producer has a certain type of knowledge and particular types of technological solutions while the user has needs connected to a different type of knowledge and solutions. This poses opportunities for the creation of innovative solutions (but also difficulties which is discussed below). To carry out the innovation process however, which means to actually materialize the new idea and bring it into use, the new innovation needs to become related to existing products, systems and organizational solutions. This requires learning and adaptation which in turn require resource mobilization by the individual company. As companies have become all the more specialized in terms of which internal

resources they choose to invest in, this motivates interaction processes and cooperation with other companies as a way to mobilize external resources, which means coordinating resources from different organizational units, both internal and external (Håkansson, 1987).

The importance of inter-organizational interfaces brings a certain understanding of innovation to light; it can be studied as changes in bonds, ties and links, or as new combinations of such (Håkansson & Ingemansson, 2013). The interconnectedness of the network also implies that any change, such as innovation, will affect not only the individual company but also other actors, resources and activities; the single company's resources and activities are interconnected through single relationships with other companies which in turn are directly or indirectly connected to other relationships in the greater network. Process innovation can thus be reflected in changes in activity links in terms of new types of production (or other) activities across firm boundaries, product innovation will mean changes in resource ties as it will affect interrelated suppliers and customers, while organizational types of innovation will imply changes in actor bonds in terms of how the different actors organizationally relate to each other.

While a distinction is often made in the literature between process, product and organizational innovation, in practice it is hard to differentiate between the different types (Laage-Hellman, 1987). Firstly, often they are intermixed in terms of a product innovation requiring changes in production ways (thus process innovation), and secondly, what is enforced as a product or process innovation by one actor can have consequences for how another actor need to relate organizationally.

From a network perspective introducing change or innovation is a non-trivial process. While the network is an important source of innovation, existing combinations may also act as an impediment to innovation due to path dependency and the heaviness of adaptations (Håkansson & Waluszewski, 2002). Combinations of resources, activities or counterparts have been adjusted to each other in a process of repeated investments. Over time, these repeated and interconnected investments result in a network of interdependent solutions, which makes it difficult to replace or combine them with any solution that has been developed outside this network (Gadde & Håkansson, 2001; Håkansson, 1987). A new solution, be it physical or organizational, will affect not only the solution it replaces, but also the entire constellation of surrounding solutions to which the old solution is interconnected (Dosi, 1982; Håkansson & Waluszewski, 2002; Rosenberg, 1994). As Stinchcombe (1990) noted, the adjustments needed to implement a new solution that differs significantly from existing supporting solutions involves great costs. Therefore, achieving innovation is a matter of creating benefits for different actors, in terms of creating a match with their respective resource combinations and ongoing activities, which might induce significant costs if it breaks considerably with the investments in place (Håkansson & Waluszewski, 2007). These investments involve learning processes within and between the involved organizations, which is dealt with more specifically in the next section focusing on the issue of balancing between explorative and exploitative learning behavior.

2.3. Balancing between exploration and exploitation

The balance between exploitation and exploration is important for company learning, renewal, prosperity, and survival (March, 1991; Crossan, Lane, & White, 1999; He & Wong, 2004; Siggelkow & Rivkin, 2006; Burgelman & Grove, 2007). Companies must experiment with new alternatives and explore new possibilities to avoid stagnation and inertia. However at the same time they need to stabilize and routinize the new solution in order to benefit from the exploration. Exploitation refers to the refinement and extension of existing competencies, technologies and paradigms (March, 1991). Explorative and exploitative behavior compete for scarce resources, and maintaining the balance is difficult and influenced by organizational forms, customs, procedures, search rules and practices, the ways targets are set and changed, aspiration levels and incentive systems, as well as the ecological system in which the organization operate (March, 1991). The distribution of consequences of learning across time and space affects the lessons learned; what is good in the long-term is not necessarily good in the short-term and what is good for one part of the organization is not necessarily good for other parts. The nested nature of the system in which learning occurs is a complicating factor. Learning and types of learning behavior take place at many levels, including individual, group, organizational and the social system level. New ideas and explorations often result from questions and problems that occur while performing routine tasks (Nelson & Winter, 1982) and dissatisfaction with exploitative behavior is a trigger to explorative process (Holmqvist, 2004). However, it is not given that explorations will happen at lower levels and further be diffused throughout the organization and lead to renewal and organizational innovation. As Siggelkow and Rivkin (2006) remarked, the idea that decentralized organizing will contribute to explorative behavior that is vital for the organization at large, must, at best, be nuanced. Often, lower-level managers are more concerned about incremental improvements and short-term operating result, and direct their search and choose alternatives that are beneficial for them. Exploitative learning provides more immediate and direct effects, compared to explorative behavior. Thus, there is a tendency to exploit and build on existing competence, which in the long-run is potentially destructive (March, 1991). Exploration may be sustained by introducing incentives for rewarding successes or for removing downside risks, organizational structures that facilitate learning from experience, adjustments of aspiration levels and beliefs about risks, and promotion of people that are not only successful (Levinthal & March, 1993).

According to Gupta et al. (2006) there a debate remains about whether ambidexterity or punctuated equilibrium is the best way to achieve the balance. Ambidexterity refers to the specialization of some persons or sub-units in either exploration or exploitation, implying that exploration and exploitation happen simultaneously. Punctuated equilibrium, on the other hand, refers to temporal rather than organizational differentiation. In other words, it suggests that organizations cycle through periods of exploration and exploitation rather than pursue both at the same time (Gupta et al., 2006). Andriopoulos and Lewis (2009), on the other hand, showed how companies manage tensions in balancing between exploration and exploitation through virtuous cycles of integration and differentiation tactics. Tensions were found in relation to the strategic intent of the firms, customer orientation and personal drivers. For example, one way companies were handling the strategic intent paradox, i.e. balancing between profit seeking and breakthroughs was through communicating both and/or a vision, which means integration, while at the same time diversifying their project portfolios. This means having both routine 'money making' projects and high-risk break-through projects that can result in building new capabilities (Andriopoulos & Lewis, 2009). Yet others argue that exploration and exploitation are highly intertwined processes and part of a continuum. Crossan et al. (1999) developed the 4I framework to explain how learning processes result in strategic renewal. They argued that strategic renewal happens through four sub-processes; intuiting, interpreting, integrating and institutionalizing, whereby feed-forward (exploration) and feedback (exploitation) processes enable the diffusion of ideas from individuals to the group and organizational levels. The ideas eventually become institutionalized at the organizational level and contribute to renewal.

Much of the literature on exploitation and exploration deals with intra-organizational issues, but these twin concepts have also proved appropriate to explain learning in an inter-organizational setting. Holmqvist (2004) showed how relationships with business partners provide opportunities for both types of learning. The experiences of one party in a business relationship are extended to the other party, thus exploiting each other's experiences. The partners also engage in collective explorative learning, producing new experiences, which each of them need to internalize and exploit in their internal organizations.

The industrial network perspective also provides evidence that close, cooperative long lasting relationships are valuable since they provide both the opportunity for governance and operating economies to emerge through exploitation (Håkansson & Snehota, 1995; Wilkinson & Young, 2002), and the creation of new combinations (Håkansson & Waluszewski, 2007). New relationships are important, however, since they comprise important sources of learning and development that can help prevent opportunism and inertia (Wilkinson & Young, 2002).

2.4. Understanding the innovation logic of construction

Construction is a complex product system that does not follow the traditional product life cycle; thus, innovation also follows a different pattern (Winch, 2003). To understand this pattern, which we call the logic of innovation, we argue that the following questions may act as guidelines: *what type* of innovation takes place in construction? *How* does innovation take place? *Who* is involved? and *Why* does or does not innovation happen, that is to say, what are the drivers and impediments of innovation? Based on the theoretical discussion above, these questions require that we delve into how the industry is organized and how the construction parties act and interact at multiple levels. Furthermore, we need to examine how these issues in turn impact upon the processes in which exploration is turned into exploitation, which we believe is the essence of innovation.

A network approach to understanding the innovation logic of construction means acknowledging the types and strengths of resource ties, activity links, and actor bonds that exist among the parties, and how they are created and used (Holmen, Pedersen, & Torvatn, 2005). These connections exist both in the temporary (the project) network and the more permanent network across projects (Dubois & Gadde, 2000, 2002). Process innovation can be seen as new activity links in which activities are coordinated in new ways across firm boundaries. Product and technical innovation can be seen as changes in resource ties and the way resources are combined and used across firms, which will affect interrelated suppliers and customers. Finally, organizational types of innovation can be seen as changes in actor bonds in terms of how different actors organizationally relate to each other. These three types of innovation are highly interwoven and changes in resource ties are likely to affect and be affected by activity links and actor bonds (Håkansson & Snehota, 1995). Thus, the following proposition is made:

- *To understand what type of innovation that takes place in construction, a starting point will be to identify new activity links, resource ties and actor bonds among construction actors.*

Projects represent decentralized environments, and are seen to provide unique opportunities for innovation, because they allow for exploration: "Construction projects involve considerable problem-solving as the general repertoire of technologies and techniques is adapted and applied to meet the specific client's needs in interaction with the constraints of the site" (Winch, 1998, pp. 273). Thus, in relation to how innovation takes place in construction and who is involved, we may make two key propositions. The first proposition may be formulated as follows:

- *The inter-organizational construction projects might be important sources of innovation for construction companies, since each construction project provide opportunities for exploration in terms of facing new counterparts, resources, and activities.*

Seaden and Manseau (2001) noted that even if construction projects require the involved companies to do something new every time, this does not necessarily mean that the industry is good at adopting new processes and products on a company or industry level. There is an intimate relationship between innovation and how new ideas are generated, shared (or not shared), and institutionalized (The 4Is of Crossan et al., 1999). This is important at an organizational level, but also across organizations. As Dubois and Gadde (2002) reported, new solutions created in projects usually only become temporary couplings and the resources or activities do not really change in a more long-term and encompassing way. Construction may be considered as an extreme variant of the nested learning system (March, 1991) that complicates the balancing effort between exploration and exploitation; being project-based with loose couplings between the project and the company level (Gann & Salter, 2000), strong couplings in the inter-organizational project network and weak couplings in the permanent inter-organizational network (Dubois & Gadde, 2002). Thus, the second proposition in relation to how innovation takes place (the process) and who is involved goes as follows:

- *The nature of the couplings within and across construction firms indicates that even if explorations may happen at the project level, it is difficult to exploit these new solutions to the wider organization and/or the industry levels.*

Winch (1998) noted that construction companies might risk becoming subject to either an exploitation trap where the system is institutionally locked into particular technologies or in an exploration trap in which technologies are continuously re-invented; while there are plenty of new ideas, they are seldom turned into good currency. For the latter to happen, it is vital that the problem-solving is turned into solutions that are learned, codified, and applied in future projects (Seaden & Manseau, 2001). Realizing innovation in terms of exploiting a new solution and ensuring that it is actually used means that it has become an "implemented reality" and "incorporated into the taken-for-granted assumptions and thought structure of organizational practice" (Van de Ven, 1986, pp. 604). For this to happen, the acceptance of and fit with the surrounding network is essential. Thus, the following proposition is made in relation to *why* does or does not innovation take place in construction:

- *The adoption of new ideas and thus innovation in construction will depend on how well physical and organizational solutions fit with each other, as well as on the acceptance by various actors in the construction network.*

Considering these four propositions, one major challenge of achieving innovation within construction is to establish new solutions across different organizational levels of the industry (project, company, and industry level). As these levels seem to be characterized by different types of relationships and ways of working, they also represent different logics in terms of developing and implementing new solutions. This means that there is a need to understand the characteristics of these different levels in terms of implementing change, and also how these processes are (or are not) interconnected. The model presented in Fig. 1 illustrates the identified problem of creating 'feedback' from industry to project level and 'feed-forward' from project to company and industry levels. For innovation to be achieved, project level explorations, in which new activity links and resources ties are created across construction actors, need to be fed forward to other projects both informally (personal interaction, experiences, personnel turnover, etc.) and formally via the central level of the organizations (resource allocation, procedures, standards). These explorations need to be exploited at a company level whereby the new combinations can be fed back to new projects. As has been discussed in connection to the innovation process, the complicating factor is that this requires acceptance both internally and by external actors. This suggests that interaction over time (i.e. long-term relationships) is an important mechanism for the concurrent feed-forward and feedback processes to happen. Interaction enables renewal in terms of creating systematic ways of exploiting new solutions and making them organizational practices across levels.

The model is used as analytical instrument for investigating and discussing the interactions within and between the project, company and industry levels.

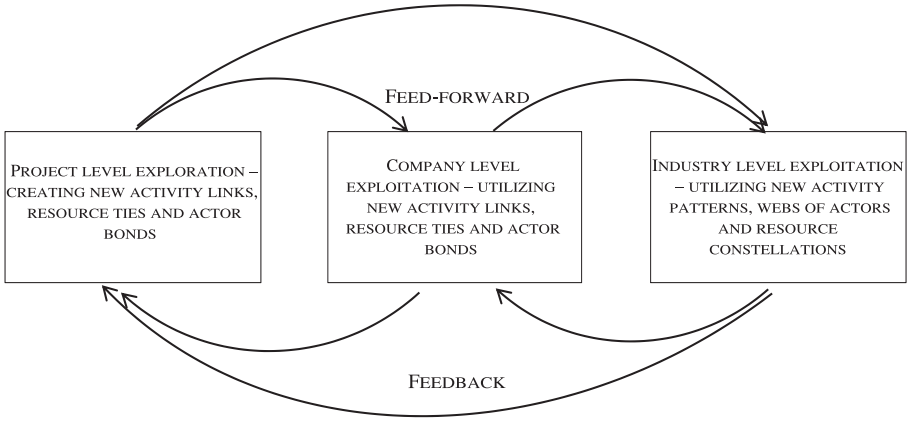

Fig. 1. An analytical model for the understanding of how new solutions need to be transferred between three different organizational levels for the achievement of innovation.

3. Research design and methods

The paper draws on two studies of innovation in the Swedish and Norwegian construction industries, conducted between June 2010 and February 2011. Both studies included surveys and structured interviews of managers in the respective industries. Although the studies in the two countries were separate, they included similar questions, both in the surveys and the interviews. The aim was not to compare the results from the two studies, but to use them as complementary sources in order to understand innovation in construction in general and the innovation logic of construction companies in particular. The Norwegian and Swedish construction industries are both highly decentralized, with many small companies and only a few big ones, and they have similar challenges related to an apparent need for more innovation and improved productivity, poor relationships between the construction parties and increasing competition from foreign companies on the domestic market. One key difference between the two industries is that while the largest construction companies in Sweden have a large share of the total market (about half of the total turnover), this is not the case to the same extent in the Norwegian construction industry.

The surveys in the respective studies included questions regarding the type of firm (independent or part of a national or international corporation), the size of the firm (turnover, workforce), progress during recent years, employees' education level, investment in competence development and R&D (primarily the Norwegian study), and methods of knowledge generation and transfer. Furthermore, questions were asked about the characteristics of each company's customer and supplier bases, as well as key relationships within the construction network, and identified sources and barriers to renewal and innovation, as well as areas for recent (Swedish survey) and future (Norwegian survey) development. In Norway, the questionnaire was sent to 4500 e-mail addresses covering the whole construction industry, including not only construction companies, but also clients, consultants and suppliers. The addresses were collected from the various industry organizations. The 840 responses represented a response rate of approximately 18%. The Swedish questionnaire was sent to all registered member companies of the national trade association with five employees or more, which covered 2160 companies (almost all of which were contractors). This number also included around 200 group units for three of the largest corporations (PEAB, NCC and Skanska), spread across the entire country. The 440 answers represented a response rate of 20%.

The primary aim of the surveys was to collect quantifiable data that was relevant to the focus on innovation, including levels of investments in competence development and R&D, as well as to the degree of interaction and the dynamics between actors in the industry as a whole. This information was considered difficult to access through secondary sources and single interviews. Furthermore, the results from the surveys made it possible to investigate the correlations between characteristics of the firms, including size, type of firm, and localization, as well as providing a basis for comparisons with previous research on innovation in construction (for example, Seaden & Manseau, 2001; Miozzo & Dewick, 2004). Here we report on the survey results connected to 1) what types of innovation are prioritized (Tables 2 and 3 showing areas for recent and future development), 2) most important learning sources, and 3) the most important counterparts in terms of acting as important sources for development of new ideas, processes and products (Tables 4 and 5).

In addition to the surveys, structured interviews were conducted with senior managers in the Norwegian and Swedish construction industries to gather up-to-date and in-depth data about current business challenges in construction, views on and behavior in the field of innovation, and interaction in the industry. To complement the view of the construction company, which is the focal actor, and to understand how its counterparts also engage in renewal, the study included interviews with subcontractors, material suppliers, and clients (see Table 1).

Qualitative methods are useful for gaining rich descriptions of interesting issues (Bryman & Bell, 2007). The interviews focused on questions about barriers and drivers of innovation, inter-firm interactions, competition, and the role of different actors such as customers, suppliers, and competitors. Ten interviews lasting approximately 2 h each were conducted in each country, with questions concerning the interviewees' experiences, opinions, feelings, and knowledge (Patton, 2002) about the following subjects: (1) technical and organizational renewal and innovation within their companies and the industry as a whole, (2) specific counterparts and their importance for renewal efforts and innovation, and (3) specific examples of renewal, how innovation is perceived and what is actually being done. These topics made it possible to investigate what senior managers considered innovation in construction and what types of innovation take place, who is involved, and how and why it takes place. Even if these were only opinions and did not necessarily reflect the actual ways in which innovation takes place, they provided a good basis for understanding the logic according to which these companies innovate. The interview notes were transcribed and sent back to the interviewees for quality check.

Table 1
Overview of interviews.

Type of company	No of interviews
Client	3
Consultants	2
Building contractor	11
Technical contractor	2
Building supply company	1
Production company	1
Total	20

Table 2
Areas for recent and further renewal and development reported in the Swedish survey.

Swedish survey	Share of respondents (%)
Planning level of production	69
Partnering relationships with clients	61
Share of subcontractors and specialists	56
Share of prefabricated materials and construction elements	53
Standardization through technical platforms	42

This paper uses the results from the quantitative data as a basis and complementary source, while the qualitative data provides the primary source of insight. The use of mixed-methods research was suitable for the problem at hand because it allows for the study of different aspects of a phenomenon (Bryman & Bell, 2007) and to identify similarities and differences between the different sources (Creswell, 2009). Both the quantitative and qualitative data were analyzed in a qualitative manner. Hence, even if the response rates of the surveys were low in both countries, the purpose was not to generalize statistically from them. Instead, several sources were combined in order to gain insight and increase understanding of the views on innovation within the construction industry (Bryman & Bell, 2007). Using manager interviews and survey data means that we have got *viewpoints* on the topics addressed and they do not necessarily reflect how things actually are. Nevertheless the triangulation approach and the assumption that the interviewees and respondents are qualified and professional representatives from the industry, provide confidence in the findings. The data from the interviews was analyzed according to the theoretical considerations made in the previous section, which combines insight from a network perspective on innovation with the explore–exploit dichotomy. The activities, resources, and actors involved in the companies' innovation efforts were identified and examined in relation to whether they were exploitative (that is, based on existing combinations of activities, resources and actors) or explorative (that is, based on new combinations), and the implication of three network levels on these two types of learning behavior, that is to say, the project, the company and the industry levels. The interviews provided good insights into why different types of learning behavior were pursued. Both authors scrutinized all the raw data from the interviews and interpreted and coded the data separately based on the above framework before conducting a joint analysis. This co-analysis was an important way of ensuring the quality of the analysis (Jarzabkowski, 2008).

4. Findings

4.1. Types of innovation and the creation of new activity links, resource ties and actor bonds

The findings from the study show that much of the innovation in construction during the last years is related to processes and organizational arrangements, particularly in relation to how planning is carried out and the type of administrative routines that are used for this type of activity, as well as how relationships with other actors are handled. As illustrated in Table 1, in the Swedish survey, nearly 70% of the respondents reported that the most common type of development during the past five years was related to planning of production.

Table 3
Areas for recent and further renewal and development reported in the Norwegian survey.

Norwegian survey	Share of respondents (%)
Specialist development	89
Management development	77
Sales and customer relationships	74
Partnering with other actors	66
Standardization	46

Table 4
The most important driving forces of innovation in the Swedish survey.

Driving forces of innovation	Share of respondents (%)
Co-workers	78
Customers	77
Competitors	32
Subcontractors	31
Technical consultants and architects	28
Other units in the company	26[a]
Material suppliers	21
Equipment suppliers	13
Research institutions	9

[a] This alternative was only available to units within larger corporations.

Table 2 illustrates that in the Norwegian survey, nearly 80% of the respondents said that management was a prioritized area for further development. Furthermore, sales and relationships with customers were prioritized by over 70% in the Norwegian survey, while collaboration with other actors was perceived as an important area for further development by two thirds. In Sweden over 60% stated that there had been an increase in partnering with clients during the last five years. [2]

Even if there is a strong focus on organizational and activity-related innovations, the study reveals that there is also innovation in technical resources. Construction companies are increasingly developing technical platforms and using prefabrication. Both surveys show that approximately half of the respondents have already seen renewal in standardization or it is a prioritized area of development. Many of the senior managers in the interviews referred to standardization of parts and components as an area for renewal and innovation. Standardization, as opposed to adaptation, can imply weak ties between resources, which in turn enables flexibility and the use of standardized components across projects and different construction objects. This is particularly common in the house-building sector to produce greater volumes of similar houses and apartments. Technical platforms are accompanied by industrialization and prefabricated building components, which are considered important means for reducing costs and ensuring stabile quality over time. Prefabrication is common in many other industries, such as the car industry, but has just recently been (re)acknowledged in construction, which means that it represents innovation in this particular setting. Even if it relates to the product and changes in how the different technical resources relate to each other (for instance, the modules and the other physical resources on-site), it has important implications for the activities and the organizational arrangements involved in production, assembly, and use. Prefabrication involves a production facility outside the construction site. Some of the companies in the study have invested in own factories, while others buy modules from sub-contractors and suppliers, which then influences the arrangements and bonds between the involved actors. This industrialization may lead to more long-term type of relationships and stronger type of ties. Regardless of which business model is chosen, industrialization will change the on-site logistics and production activities, since large modules need to be transported and assembled immediately after arrival. As one of the interviewees noted:

> *The planning level and the use of prefabricated materials are closely connected; the more prefab you use, the higher the demands on the logistical aspect of the project and the fact that it really works.*
> [CEO, Theta]

[2] On an industrial level it is also interesting to notice that both surveys indicate a development towards more specialized companies. Specialist development is reported as the most prioritized development area in the Norwegian survey, and more than half of the companies in the Swedish survey reported hiring an increased share of subcontractors and specialists. These results point to an increased number of inter-organizational relationships within the construction network.

Table 5
The importance of relations to different actor groups as sources of innovation in the Norwegian survey.

Sources of innovation	Share of respondents (%)	
	Local	National
Customers	64	34
Personal networks	53	40
Suppliers	45	45
Industry organizations	36	45
Consultants	35	29
Competitors	35	25
Alliance partners	30	29
Other units in the company	12	10
R&D institutions	8	14

Innovation in some technical aspects of a product, such as prefabrication, often requires changes in how the project is planned and in the production process itself. Another example relates to the introduction of Building Information Models (BIM), which have changed how projects are planned, designed and produced. By enhancing the planning ability of the project management in terms of revealing possible logistical or assembly-related clashes, BIM has changed the way in which planning activities can be linked efficiently, which actors become involved in the different activities, and how:

BIM is a tool that can change how the construction industry does things. It presupposes that you look at the whole process in a new way.
[CEO, Kappa]

Thus the use of BIM as a new technical resource represents a new way of organizing and producing projects. The surveys show that around one third of the respondents in Norway and Sweden report that development has taken place directly connected to the use of BIM models. This suggests that it is not an area which engages the major part of the industry, which is also confirmed by a closer analysis of the Swedish survey. It is mainly implemented by the larger companies and units within lager corporations, with sufficient resources.

4.2. How innovation happens as construction actors explore and exploit across multiple levels

The findings clearly illustrate that projects are considered an invaluable arena for innovation. In the interviews with the Norwegian CEOs, they were asked to reflect upon the concept of innovation. As one of the managers explained:

I don't have any clear definition of innovation, but innovation occurs in projects. I have a good example of a skillful project manager of a tunnel project. Earlier they managed three rock bolts per hour, but now they make 36 per hour. They use a different working method and a new technology that they have invented themselves. Innovation is more coincidental progress; the project workers face a challenge, which they solve and then the question is how to manage this idea.
[CEO, Beta AS]

Exploration, in which new ideas and solutions are discovered during the projects, is more or less formally diffused to the rest of the organization. Some seem to diffuse as the project participants are talking about their experiences to colleagues, visiting other projects, and bring the ideas with them into new projects whereby they are utilized. Thus, for some of the inventions at the project level, the process of feed-forward and feedback throughout the organization takes place without the headquarters paying much attention. Other ideas, on the other hand, are soon identified and managed by central level management. For example, one of the construction companies in the study, Alpha Group, participated in a project in which the company together with the client and several suppliers invented new working methods and technologies to fulfill very ambitious energy consumption objectives. Central level managers deliberately facilitated project visits, personnel transfer, presentations in various forms, formal training, etc., to help diffuse these explorations, which were adopted and applied in new projects, involving both the companies' own workers and new clients and sub-contractors. The management of these new solutions led to "feedback" processes and thereby exploitation in new projects.

The results from the surveys confirm that learning by doing and the sharing of experiences are considered important sources to learning and innovation in the construction industry. The internal organization is very important in terms of bringing forward new solutions from the projects. The interviewees emphasized that the opportunities to share knowledge within the companies are a top priority. It was clearly recognized, however, that they struggle with exploiting the new solutions.

When it comes to the competence developed in the projects, we have not cracked the code for how to share it in the wider organization.
[CEO, Kappa]

Earlier we thought more in terms of databases and tools, but this was the wrong track. It is all about relationships between people and to bring people together.
[CEO, Public client]

However, exploitation at the company level is considered difficult. Firstly, the nature of project work means that the project team is dissolved and each member is transferred to a new project before the existing one is finished. Secondly, there is a lack of a positive attitude towards learning from others and sharing successes and failures. One of the CEOs said:

It is important to create a climate in which people learn from each other and in which these lessons can eventually become standardized working methods.
[CEO, Beta AB]

Efforts are made to create standardized activities across the project organization related to planning and production processes by identifying and implementing the 'best practice' across the organization. For example, a housing contractor that participated in the study, Theta, discovered that there were fourteen different ways for assembling a wall throughout the organization. Based on an evaluation, they decided which method was best and then this method was implemented in all projects on all locations. The company chose to use a single supplier which had specialized in the solution, instead of using a wide selection of suppliers. The idea was that instead of starting from scratch in each project the same type of procedure from supplier to realized product was implemented. In a similar way, the company chose to work with just one type of balcony door and consequently also one supplier of this product. By doing this the two parties managed to co-develop a particular type of balcony door which suits the standards of all the projects. In the interview, the CEO of the company acknowledged that it would take time before all the employees and subcontractors fully accepted and implemented the new way of working, but that it was highly important to gain efficiencies in the production.

The example shows how exploration at project level (resulting in a large variation of working methods for a particular operation) is exploited on company level in terms of evaluating and deciding upon the best method and applying it across all projects. From this process explorative type of learning is again activated in terms of involving one particular supplier and developing new solutions that should be implemented in all projects. This demonstrates how the concurrent process of exploration (feed-forward) and exploitation (feedback) involves both the internal and external network of the firm. Lastly, it also illustrates the interdependence and involvement of both technical and organizational aspects in the bringing in of new solutions in construction; it

involves the materials used, how suppliers are handled and which working methods are applied.

The importance of both the internal and the external network for innovation is also illustrated by another example. In the late 1990s, Beta AB started a new type of production program for residential building. The program is a standardized type of construction, both in terms of the production process and the components, and produces two-story houses across the Nordic countries. While the materials are basically the same as in other projects the major development relates to the process of assembling modules in a factory and transporting them to the various project locations, as well as using the same project organization across the projects. In this way the project organization, which consists of the same actors as well as people, learns across the projects and can continuously improve the production process. Beta is combining the internal and the external network of the company across projects over time in order to exploit previous learning and making the production process more efficient. More than a decade later they have started to see the effects in terms of the production process becoming more efficient and it is considered a very successful investment.

The examples illustrate the role of suppliers for innovation and how new combinations are exploited across projects. Multiple actors are involved in this, thereby facilitating innovation at the industry level. The results from the surveys and when asking the managers to elaborate on this issue, on the other hand show a more nuanced picture.

4.3. How the interactions between the construction actors affect innovation

In the Swedish survey, co-workers were considered the most important driving force for innovation and customers are considered as number two. Suppliers were not given as much emphasis. In the Norwegian survey, nearly all of the respondents reported that relations to customers had been important for innovation. Personal networks (which are likely to include co-workers) were also considered very important by the Norwegian respondents.

The Norwegian managers were asked to elaborate on the role of external actors in the interviews, and they confirmed the importance of customers. It was argued that customers need to be willing to transfer some of the responsibilities to the supply chain in the projects, involving the contractors and suppliers in such a way that enables their knowledge to be utilized and new solutions discovered. The previous example of how Alpha Group together with the client and suppliers invented new ways of reducing the energy consumption of the building being constructed illustrates the importance of such involvement. According to several of the managers, clients are in general focusing too much on price and control rather than trust to drive the projects:

> *Public clients are too price-focused. When price means everything, it is impossible to innovate in a low-margin industry.*
>
> [CEO, Alpha Group]

These views were supported by the consultants in the study. They referred to other industries, such as oil and gas, where resources would be allocated in the project to facilitate exploration and developing new solutions. They had never experienced similar initiatives from clients in the construction industry. Others noted, however that professional and larger public clients are changing their approach:

> *There has been a change on the customer side. Large public clients are now increasingly choosing suppliers based on competence and service.*
>
> [CEO, Kappa]

The public clients in the study were themselves also conscious about their role:

> *We take a long-term perspective and focus on the fact that the buildings must work optimally for a long, long time. We must demand the most appropriate solutions and be a driver when it comes to ensuring that the industry takes environmental considerations seriously.*
>
> [CEO, public client of educational buildings]

One example offered to illustrate this change was a public client of a large hospital project in the middle of Norway, which through new contractual arrangements focusing on collaboration and the early involvement of contractors, lean construction, BIM and careful considerations paid to environmental issues has contributed to supplier development in the region. The experiences from this hospital project have also been communicated at the industry level, and the new ideas, particularly related to collaboration and lean construction have been adopted by other construction actors in new projects across Norway.

It is likely that the traditional price focus in the industry prevents the companies to experiment with new alternatives. When competing on price, exploiting existing solutions will, in the short term, be most cost efficient and providing predictability. It is highly recognized that experimenting is risky:

> *Perhaps just because we are a low-margin industry, we cannot afford making any mistakes in the process. The down-side is too substantial, and even in a large company, one single project among hundreds may ruin the company's margins.*
>
> [CEO, Alpha Group]

This further influences the supplier side:

> *If we offer a completely new, revolutionary product, the chance of customers wanting it is very low and it will take 20 years to get customers using it and to pass the governmental regulations. Concrete is not appropriate to experiment with and predictability is more important than new development.*
>
> [CEO, production company]

Customers confirmed this approach:

> *We don't want to experiment too much with the materials, but instead stick to the traditional and sustainable building materials. We prefer traditionally robust construction elements such as concrete and wooden floors.*
>
> [CEO, Theta]

This view was reiterated during the interviews: the type of products that are being produced (buildings, roads, bridges, etc.) requires dependable, durable, and robust materials, and before anything new can be introduced in the construction object, a long period of testing and learning is necessary. Thus, there are few incentives for the material suppliers to experiment with new materials, and exploiting existing materials seems more appropriate.

The results from the Swedish survey support this argument. Here the supplier category was split into material and equipment suppliers and subcontractors, of which the two first categories were perceived of little importance. The results from the Norwegian showed another view, in which suppliers were considered very important, but here the category was not split up. The interviews with both the Swedish and Norwegian managers showed that they consider sub-contractors to be important for renewal and innovation:

> *Sub-contractors are more important than the material suppliers since they are more involved in the process. They supply a service and therefore they must share the same values as our own employees. Long-term relationships are thus important.*
>
> [CEO, Pi]

There are tight links between the activities performed by the construction company and those of the sub-contractors, as well as between the sub-contractors at the construction site, and there is often need for closer and longer-term relationships between the companies. However,

the Norwegian survey showed that while relations to suppliers were perceived important for innovation, the respondents considered connections to both sub-contractors and material suppliers to be weak. One of the CEOs explained, it is not necessarily the will to cooperate that is missing, but the ability to do so. Examples that the managers provided successful cooperation were primarily on single projects.

Overall, customers and sub-contractors are considered important for innovation. However, because of the traditional price focus with few incentives for experimenting and the inability of establishing long-term relationships, the findings indicate that the overall industry level is characterized by exploitative learning behavior. The price focus may also explain why both surveys showed that competitors are considered to play a relatively marginal role as drivers of innovation. As one of the interviewees said:

> *We don't think competitors can teach us much. Therefore we have turned to other industries, such as Scandia and IKEA.*
>
> [CEO, Theta]

The others emphasized the need for joint efforts to drive the industry forward. There were also differing views on the role of R&D bodies. Some reported substantial collaboration on issues such as BIM and materials, while others expressed caution about collaborating due to the risk of knowledge spillovers to competitors and the inability to communicate and access the results. In both surveys R&D institutions scored very low in terms of sources of innovation. Industry organizations, on the other hand, got a high score in the Norwegian survey. These organizations may play an important role as knowledge brokers in an industry, thus contributing to drive the industry forward.

5. Discussion

This paper set out to investigate the logic of innovation in construction, and the findings from the research have added to the ongoing debate about the innovativeness of the construction industry in relation to the industry's specific characteristics. In previous research, it is well accepted that the nature of the relations between construction parties acts as impediments to innovation and further improvement of construction performance (e.g., Dainty et al., 2001; Dubois & Gadde, 2002; Fearne & Fowler, 2006). In this paper we have looked into the interaction characteristics of construction, and the type of learning behavior that characterizes the industry at different levels. The findings enable us to discuss the initial four questions that we argued were important for understanding the logic of innovation in construction: 1) *what types* of innovation is realized in construction? 2) *how* is it done? 3) *who* is involved and 4) *why* does innovation happen or not?

The study shows that construction companies primarily innovate in relation to how to plan and manage projects, how to organize the construction process, and how to handle clients and other counterparts. By looking into the creation and use of new activity links, resource ties, and actor bonds, a nuanced view of what type of innovation that takes place in construction is offered. The findings confirm previous studies that have questioned the adequacy of using R&D investments and number of patents to measure innovation in this particular setting (Seaden & Manseau, 2001). The examples show how construction companies try to industrialize the construction process by creating more standardized types of buildings, and also standardize the working methods across the projects. Material or technical developments appear harder to enforce and less central. Besides the use of technical platforms (which are typically new combinations of existing physical resources) and the use of BIM, which requires combinations of organizational and physical resources, there seems to have been little technical development in the basic materials used and the product as such. The general opinion in the industry seems to be that it is risky and that predictability is the main objective. It takes a long time for customers to accept new materials and mistakes which do not show until much later can turn into expensive legal processes. This indicates that, with regard to basic materials, there is little incentive in the industry to try to achieve change in the existing combinations of resources. The organizational aspects appear to be more vital, as the companies need more efficient ways to manage the complexity of the projects and the decentralized organization of the industry. The construction literature has repeatedly addressed the project-oriented focus of the construction industry and its decentralized character as affecting innovation and productivity negatively (e.g., Blayse & Manley, 2004; Miozzo & Dewick, 2004; Winch,1998). *Thus, the core renewal for construction companies is connected to how resources, activities, and actors are organized, coordinated and adjusted in the construction process at the project level.*

Looking into the *how* question, the findings reveal that it is not straightforward whether the construction industry should be categorized as an exploiting or exploring industry. When change is implemented these two types of learning behaviors are tightly interconnected at different organizational levels. Construction projects are important sources of innovation and companies acknowledge vanguard projects and innovative units, as well as creative individuals as key to innovation. However, as Seaden and Manseau (2001) argued, even if building practitioners and their clients interpret the tendency to do new things at the site as innovative behavior, such activities are not necessarily truly innovative in the sense that the parties are good at long-term adoption of new processes and products. Several examples in our study indicate that changes are often a result of formal 'top-down' initiatives, whereby company management decides upon new ways of operating. Other initiatives are driven by 'bottom-up' implementation, whereby explorative solutions representing variations across projects are exploited through more informal feed-forward and feedback processes. It should however be acknowledged that these are successful examples rather than indications of the way the industry operates. At a more general level the surveys show that companies find it difficult to fully exploit new and temporary solutions (which are constantly being explored within the individual projects) at a company or industry level. Overall the industry sees a great need for further development in this direction. This finding is in line with previous research acknowledging the problem of inter-project learning, and that companies use different means to facilitate such exchange (Prencipe & Tell, 2001). At the company and industry level, some solutions are being exploited (such as basic materials and technical platforms), while minimal exploration activities (in terms of explorative activities outside the daily operations and R&D work) are being undertaken to drive the technological development forward within the industry. *Therefore, there appears to be a gap between the types of learning behavior and how innovation takes place at the project, company, and industry level — the former is mainly concerned with exploration, while the latter deals with exploitation. However, the solutions that are being explored at project level are not fully exploited at company/industry level and* vice versa.

In regard to who is involved, the study concurs with earlier studies in finding that the client is an extremely important driver of innovation (Blayse & Manley, 2004). However, there are differences between clients in this respect; it matters what type and size of organization the client represents, and the nature of the relationship that exists between the client and the construction company. Collaboration between the construction company and the clients is important in terms of if and how new solutions are attempted (Håkansson & Waluszewski, 2007; Ingemansson, 2010). Examples provided by the interviewees of new solutions being initiated and created in projects, involved a dedicated client and close collaboration among the parties. The construction companies' focus on project partnering is an indirect indication of the project-orientation of the industry. By moving from one project to the next and therefore also from one customer to the next, the state of the relationship may need to be set more inorganically than in other business-to-business industries, where the customers can be more reoccurring. *Therefore, due to the project focus, the customer is often a new counterpart and sets the requirements of the product, which means*

that the supplying company must start from "scratch" every time in terms of learning about the customer needs. The price focus leaves few incentives for offering innovative solutions initially and even if there are opportunities for innovation in the individual project, it is hard to capitalize in new projects with new clients and their specific requirements.

Sub-contractors and suppliers often comprise 60–80% of the total costs in a construction project for a construction company. Since most contractors have a low margin, we would expect that they are highly concerned about the supply side. Earlier studies have shown, however, that while the relationship with the clients is highly valued, upstream linkages are rarer (e.g., Dubois & Gadde, 2002). The present study shows that the construction companies find little incentive to collaborate with material suppliers, while subcontractors are given more attention. One explanation could be the focus on the need to constantly explore new and temporary solutions in the separate projects. While material suppliers primarily provide standardized and traditional solutions, subcontractors work together with the companies' own staff in the projects and also provide knowledge that the construction companies do not possess. This creates a collective type of learning situation where explorative learning in the individual projects directly can become exploited across the projects through the re-occurring actor õconstellation. As illustrated in some of the examples, suppliers can play a crucial part if a longer time perspective than just for the present project is applied. However, this seems to be an exception rather than a rule. *Therefore, even if construction companies to some extent recognize the importance of suppliers for innovation, at least sub-contractors, the project focus means that long-term relationships generally are not pursued.*

While many other industries focus on collaboration with external actors as the key to innovation, the present study has shown that construction companies are more concerned about the internal network and how to encourage their own employees to come up with new solutions, which are then turned into new company-wide ways of working. While construction companies are now working more systematically to transfer experiences from projects to the organization, there is widespread recognition of the need for improvement in this respect. *Thus, even if examples show that the external network is essential for achieving innovation the internal network seems even more important to construction companies, which is only natural for a more isolated type of organization.*

Finally, there may be many reasons why construction companies innovate in one way or another. The most obvious explanation seems to be the characteristics of the interaction both in the internal network and the external network. The relatively weak internal couplings between the project and the company level imply that exploratory behavior at either level is rarely transferred to and exploited on the other level. Thus the feed-forward and feedback processes (Crossan et al., 1999) are challenging. This is a well-known problem in project-based organizations (Brady & Davies, 2004), and the companies in the study report that they put lots of efforts and work more systematically on this issue. The study illustrates a greater recognition of the role of external actors, particularly clients in developing and implementing new solutions. However, what the construction companies must acknowledge is their own role as customers, driving supplier development. Standardization and industrialization can imply either more interaction or less interaction within the supply chain. On the one hand it can be about co-developing solutions with producers and users, and on the other it can be standardized solutions developed mainly internally which then need to be accepted by the rest of the network. Such solutions, if they are accepted, do not require any deeper interaction. While the latter way of working seems to have been a characterizing feature of the industry in the past we do see some examples of a more integrated and interactive way of developing new standardized solutions, even though it cannot yet be stated to be a representative feature of the industry. Another factor influencing how the supply chain interacts is the strong focus on price in all parts of the chain. The way that suppliers are usually selected does not encourage long-term relationships but rather fortifies the uniqueness of the constellation of actors and resources in each project. The character of the construction network, with intense interaction during separate projects but little long-term interaction over several projects, enables explorative learning during the projects but impedes exploration at other organizational levels, as well as exploitation of explorative solutions at project level. *In sum, one explanation for why construction companies innovate in the way they do — the core of their innovation logic, may be found in the characteristics of the interaction and connections in the internal and external network.*

Referring back to the model presented in Fig. 1, it is clear that this is an idealized image of how the feed-forward and feedback processes should appear. We have shown that for these processes to take place interaction between different actors, resources and activities, including both the internal and external network of the single company, is needed. Thus, for innovation to be achieved through such processes, interactions stretching across different network levels and involving explorative and exploitative learning need to take place.

6. Conclusion

Our study has shown that the network context in which construction companies act impacts on the logic of innovation in this industry. We have identified two main network related concerns in relation to how innovation happens; one which is related to the internal network of the single company and one which concerns how this network is interrelated with the external network consisting of suppliers and customers.

The major challenge appears to be how to interconnect the project and company levels of the single organization, and in so doing also interconnecting explorative and exploitative type of learning, which is a prerequisite of the innovation process. The innovation process is a continuum of explorative and exploitative behavior, which means that for new solutions to become innovations they need to take part in both types of learning situations, regardless if they are new combinations of existing solutions or new solutions all together. While we have identified several successful examples of such feed-forward and feedback processes taking place our findings indicate that these are not yet characteristic ways of working across the entire industry. There appears to be great room for improvement in terms of learning across projects and truly adopting new solutions which appear at the project level and exploiting them at company and industry level. We identify this as a central managerial implication for construction managers as the study also show that the most important development issue for construction companies is how to manage the construction process and handle the counterparts in that process. Understanding how to spread more efficient solutions across the organization and the projects appears central in this type of process development. Moving on to how this internal network interconnects to the external network several, reasons have been brought up as to why there is a lack of inter-organizational interaction within the industry, related to procurement methods, price focus, project orientation, etc. We argue that the temporality of projects and the lack of long-term relationships induce an explorative type of learning behavior within the projects which rarely is implemented, or exploited, at company and industry levels. Thus, the lack of interconnection between the internal and the external network of the single company affects the concurrent feed-forward and feedback processes in which new solutions can (or rather cannot) spread across the organization. This lack emphasizes the importance of the *internal* network of the construction companies which results in an exploitative type of learning in terms of learning mainly from people and already implemented solutions within the company. Generally, although we see single examples of more integration in the supply chain across projects, this in turn seems to induce innovation in terms of standardized types of solutions which the rest of the network then will (or will not) accept.

The extent to which construction companies can actually be categorized according to different logics, reflecting an orientation towards exploration or exploitation, has here been shown to not be an issue of whether it is the one or the other but rather how it is a combination of both on different network levels, and how for the successful achievement of long-term change (i.e. innovation) these logics need to be interconnected. Construction companies should thus be conscious of their innovation logic in terms of whether they base their learning behavior on a biased orientation towards exploitation or exploration. This is strongly connected to how the internal respectively external network is valued in terms of learning opportunities. Our results indicate that the internal network is presently valued higher than the external, which according to a network perspective have negative consequences for learning and innovation. Paying attention to both networks and establishing appropriate relations in both seem to be an important prerequisite for achieving a balance between exploitation and exploration (March, 1991), and to enable explorations being exploited across levels (Crossan et al., 1999).

While our study has provided some first insights on the issues addressed, more research is needed on how the networks on project and company level co-exist and what can be said about the relationship between them. This will bring further knowledge of what characterizes the learning behaviors between the two levels and how this influences how and why innovation takes place within this industry at large. For this purpose performing case studies directed towards projects would be a suitable approach in investigating the inter-organizational interaction patterns in more depth.

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