Knowledge transfer in project-based environments: a study on innovation projects in the construction industry.

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1 Knowledge transfer in project-based environments

In this paper our main concern is on the transfer of knowledge in innovation projects performed in cooperation with several firms in a project-based industry (PBI) (in this case the construction industry). In a project-based industry, firms organize their structures, strategies and capabilities around the needs of projects, which often cut across conventional industrial and firm boundaries (Hobday, 2000). In this perspective, projects are embedded in an organizational network and institutional context (Gann & Salter, 2000). Most project literature however, discusses singular projects and their management and leave out permanent ties, organizations and institutions in and through which projects operate (Engwall, 2003; Gann & Salter, 2000; Themistocleous & Wearne, 2000). In a project-based firm (PBF) organizational partners cooperate on a temporary basis within a specific project (the organizational ties can be both temporary and permanent relationships).

We have chosen to investigate the construction industry, since this is a well-researched industry and a good example of a project-based environment (Keegan & Turner, 2002). The construction industry is a complex industry involving a number of discrete transactions usually undertaken on an ad hoc, one-off geographically specific basis. Innovation performance of the construction industry in terms of productivity, quality and product functionality has been low in comparison to other industries (Winch, 1998). The low level of innovation performance is based on the fragmented nature of the industry; the uniqueness of the construction as a product; the division between design and construction; the role of consultants and the procurement methods for receiving assignments (Naoum, 2003). The often-applied project control systems around which the PBF operates serve to stifle innovation (Keegan & Turner, 2002). However, several authors (Seaden & Manseau, 2001; Winch, 1998) discuss that it is difficult to measure innovation in this industry based on traditional measurements like R&D activities and patents, since the construction industry mainly focuses on organizational processes, contracting arrangements and assembly methods (Seaden & Manseau, 2001) and the way innovation is measured; e.g. architectural and engineering firms are usually not included (Winch, 2003), while they score relatively high on innovation (Waalkens, 2006). New ideas can be (a) adopted by firms and implemented on projects (top-down), or (b) result from problem solving on projects and be learned by firms (bottom-up) (Brady & Davis, 2005; Slaughter, 1993; Winch 1998). According to Winch

(1998) the processes of adoption and implementation in the top-down mode are iterative learning cycles as the features of the new idea and the existing organizational context are mutually adjusted. Brady and Davis (2005) discuss in the bottom-up mode three phases: exploratory vanguard project phase (creation of knowledge), the project-to-project phase (transfer of knowledge to other projects) and the project-to-firm phase (transfer of project knowledge to the firm). In the bottom-up mode, new ideas generated through problem-solving need to be learned by the organization so that they can be internalized and applied for future projects (Winch, 2003). Winch (2003) however, does not mention specific projects designed to create a new idea or product in cooperation with other firms and R&D institutes and universities, i.e., innovation projects. In the construction sector it is a relatively new phenomenon to join other organisations in order to develop new knowledge that can be applied by the involved firms or even applied in the whole industry. This type of cooperation can enhance innovative performance of the industry. Important in these cooperative innovation projects is how firms cooperate in such a different setting, how they transfer and create knowledge and how they internalise this knowledge into their own firm and in future construction projects.

In order to investigate cooperative innovation projects in the construction industry we apply a knowledge-based perspective, in which knowledge is considered as the most strategically important resource of the firm (Grant, 1996). Knowledge is gaining increasingly attention as an important source of competitive advantage (Amit & Schoemaker, 1993; Grant, 1996; Kogut & Zander, 1992; Krogh & Roos, 1996; Peteraf, 1993; Spender, 1996). The role of the firm and its source of unique advantage rest in its ability to collect, integrate, use and transfer the knowledge of individuals in the production of goods and services (Grant, 1996). Through the execution of projects, knowledge capabilities and resources are built up in the firm over time. In this paper we mainly deal with knowledge creation and transfer between firms who cooperate in innovation projects. From literature we know that the pursuit of cooperative strategies can be used as a means for creating knowledge or gaining access to knowledge and skills outside the boundaries of the firm (Hamel, 1991; Inkpen & Crossan, 1995; Kogut, 1988; Lane & Lubatkin, 1998; Larsson et al., 1998; Wathne et al., 1996). Several authors have however indicated that knowledge transfer in project-based environments is difficult due to a short-term perspective and a fluctuating workforce (DeFillippi and Arthur 1998; Prencipe and Tell 2001), moreover project-based organizing often lacks incentives and formal structures for

cross-project learning (Ekstedt et al. 1999: 60). We therefore mainly focus on how the developed and transferred knowledge from the innovation project is transferred towards the project partner firms. We apply the notion of absorptive capacity which is defined as a set of organizational routines and processes, by which firms acquire, assimilate, transform and exploit knowledge to produce a dynamic organizational capability (Zahra & George, 2002: 186).

For this reason we have investigated four cases in the Dutch construction industry. These cases are innovation projects in which several firms cooperate to develop a new product. The structure of the paper is as follows: first we introduce knowledge transfer in a project-based environment and we discuss absorptive capacity. In the third section we present the methodology of four comparative case studies and we describe these cases in section 4. Section 5 presents findings of the cases and we conclude the study in section 6 and discuss future work.

2 Knowledge transfer in a project-based environment

Cooperation with other firms is perceived in the literature as a possible way to increase a firm's competitive advantage. Through cooperation, firms assess and/or acquire each other's capabilities in the form of partnerships or alliances (Doz & Hamel, 1997; Hamel, 1991; Kogut, 1988). Cooperation between firms can on the one hand create knowledge or firms can gain access to knowledge outside the boundaries of the firm (Hamel, 1991; Inkpen & Crossan, 1995; Kogut, 1988; Lane & Lubatkin, 1998; Larsson et al., 1998; Wathne et al., 1996). On the other hand, authors mention that learning and development of knowledge in cooperation can be problematic because of, among others, a competition to learn and the fear of firms to disclose knowledge (Hamel, 1991). When we focus on project-based environments, working usually is to a large extent geared to optimization of the design and structuring of projects and subsequently proper management and execution of project plans and targets, instead of on knowledge creation and innovation. Research has shown that project based working can act as a major limiting factor for learning and innovative potential (Dubois & Gadde, 2002; Gann & Salter, 2000; Keegan & Turner, 2002; Winch, 1998). According to knowledge literature, knowledge is often generated in organizations through projects, (Nonaka & Takeuchi, 1995; Leonard-Barton, 1995). But in project-based industries, discontinuities that are created between project tasks, personnel, resource and information flows mean that knowledge and

learning gained from one project cannot easily be transferred to another (DeFillipi, 2001; Prencipe & Tell, 2001).

Some authors state that project-based firms (PBF) are always innovating – their work is always unique, always delivered to bespoke designs, always achieving something new (Keegan & Turner, 2002). However according to Keegan and Turner (2002), when it comes to planning and control systems, PBF are failing to provide a context supportive of innovation.

The flow of knowledge between cooperating partners in an innovation project in a project-based industry (PBI) can be studied in various forms of cooperation: i.e. subcontracting, consortia, strategic alliances, (innovation) networks (see Tidd et al., 2002) and partnerships. In this paper we focus on cooperation (both long and short term partnerships) between suppliers, R&D institutes and or universities, customers and contractors.

Knowledge transfer is defined as the process through which one unit is affected by the experience of another (Argote & Ingram, 2000). Knowledge transfer can be perceived in explicit (codified) knowledge and tacit (deeply rooted) knowledge. The success of knowledge transfer depends on the ease of communication and intimacy of the overall relationship between source unit and the recipient unit (Szulanski, 1996). Transferring knowledge is difficult because of inertness (Kogut & Zander, 1992), stickiness (Szulanski, 1996) and ambiguity (Simonin, 1999). According to Simonin, moderating effects on relationships between knowledge transfer, ambiguity and its antecedents in alliances are (1) Collaborative know-how: past experience leads to the emergence of a distinct form of collaborative know-how that helps achieve greater benefits in subsequent alliances. (2) Learning capacity: the extent of knowledge transfer is closely linked to the goals of each partner. (3) Alliance duration: as an alliance sustains itself over the years, cultural distances decrease and trust intensifies.

From literature we know that several factors affect knowledge transfer in cooperative structures. These factors are the characteristics of the knowledge transferred; the characteristics of the source and recipient and of the context in which the transfer takes place (Leonard-Barton 1992; Rogers 1962, Szulanski, 1996, Teece 1977; Zander & Kogut, 1995). An important aspect in knowledge transfer is the absorptive capacity (ACAP) of firms (Cohen & Levinthal, 1990; Lane et al., 2002). In order to transfer knowledge between parties in the

network, the focus of the firm should not be internally oriented, e.g., on efficiency and costs, but on obtaining new skills and/or routines or combining these to create new knowledge and to have a competitive advantage in the market. Absorptive capacity is related to innovation in literature, in which it is stated that ACAP helps the speed, frequency and magnitude of innovation and that innovation produces knowledge which becomes part of the firm's absorptive capacity (Lane et al., 2002; Van den Bosch et al., 1999). Cohen & Levinthal (1990) have indicated the level of prior related knowledge and the sharing of a common stock of knowledge (both technical and organizational) as facilitating the transfer of knowledge in a group. Measurements of ACAP, as becomes clear from the literature, usually focus on R&D activity and patents of firms. Van den Bosch et al. (1999) assume that besides the level of prior related knowledge, also the organizational form and combinative capabilities determine absorptive capacity. Zahra and George (2002) mention other factors like external sources (like acquisitions, licensing and contractual agreements, joint ventures and inter-organizational relationships), activation triggers and social integration mechanisms. The above mentioned literature investigates ACAP at firm level; however, for our study we are interested in the learning capacity at project level (a similar perspective is mentioned in Scarbrough et al., 2004). It is important to make the distinction between the firm (back-office of the project members) and the project itself. Within the project new knowledge is created and transferred to project members, however, this knowledge does not necessarily have to be transferred to the back-office firms. Scarborough et al. (2004) indicate that in some instances learning by absorption may constrain the generation of learning at project level and not all learning has positive performance advantages for the firm (Leonard-Barton, 1995).

3 Methodology

We apply a comparative case study analysis (Eisenhardt, 1989) of four cases of cooperative innovation projects in the Dutch construction industry. We selected four case studies of technological innovation projects that were performed in cooperation with several different parties (mainly contractors in cooperation with suppliers and or researchers). We held in total 35 in-depth semi-structured interviews (from 1 hour till 3 hours) with involved parties of the four case studies, of which 11 interviews were held with construction firms, research institutions and suppliers about the context of the construction industry and the exploitation of the developed innovation of the investigated case studies. The amount of interviews held per case differed due to the number of partner firms involved in the investigated innovation

projects (Case A: 5 interviews; case B: 5 interviews; case C: 9 interviews; case D: 5 interviews: interviews were held with the contact persons of the cooperative firms). Items we took into account during the interviews were: the innovation process, the parties involved, the transfer and creation of knowledge between the different parties and questions related to absorptive capacity (e.g., internal knowledge base, openness to new knowledge, internalization of knowledge from cooperating firms). The data of the cases was validated through feedback and respondent validation. The qualitative data were coded and labelled according to qualitative analysis methods (Eisenhardt, 1989). For the codification several stages were applied iteratively throughout the research and the theoretical framework on PBF, i.e. innovation and the knowledge-based view drove this process. After a comparison of labels and data incidents, the labels were re-named and categorized into several groups: aspects of the characteristics of the innovation project, the innovation process, knowledge transfer and absorptive capacity. In the following section we discuss the four case studies separately (see also table 1).

4 Case descriptions

In this section we describe the four investigated case studies shortly.

4.1 Case A: Underwater Concrete

The initiating firm of the innovation project was a medium-sized contractor, which developed in-house a new method for pouring underwater concrete for constructions (process-innovation). This method improved the quality of the underwater concrete in terms of hardness and smoothness. In order to test this method, the firm needed external knowledge from diving (for checking the process and cleaning the underwater surface), concrete (for developing the right concrete formulae) and concrete pumping (for pouring the concrete in the right way with the suitable tools) firms. The method has been tested with help of prototypes in several real-life projects together with these firms. Furthermore, tests were performed by unbiased R&D institutes. The reason for innovation was to solve an amount of problems occurring with other methods (the innovation was project-led, implying that it is based on problem solving from construction projects). The relationships in this case were mainly short term and contract based (in the form of supplier-customer contracts). The contracts contained clear expectations, risks and responsibilities of all involved parties. The contractor chose to work with these partners based on prior experience and price. The partners had conflicting

objectives and a win/lose mentality. There was a short term focus and price-based competition.

4.2 Case B: Concrete Development

The initiating organization was the headquarters of a large consortium consisting of several contractor firms who specialized in different disciplines. The cooperating partner was a concrete company (supplier). The (process) innovation concerned the development of a new method based on existing technologies. The innovation was a project-led innovation. The project consisted of creating knowledge about self-compacting concrete (a new formulae was tested that could be shuttered more easily the next day) in tunnel constructions for residential houses in a real life project. The project reached to a testing phase in which the concrete was tested in a real-life project. One of the partners still continues exploring the possibilities in order to deliver a full concept of this application for concrete. Both partners shared a mutual interest in the development of the concrete method. The supplier of concrete tested the formulae of concrete in its laboratory and together with the consortium it tested the method and the new form of concrete in a construction site for residential houses. The test results were perceived as positive for both firms. However, due to workload and economic pressure the continuation of the innovation process was stopped. The supplier is intending to explore the product further in the near future (with consent of the consortium). The relationship was based on mutual trust, in which both parties defined (orally) their mutual responsibility and financial resources. The relationship was project-specific (only for this innovation project) and the partners had professional relationships with other organizations as well on these topics.

4.3 Case C: Flexible Floor

The initiating firm was a consultancy firm for the construction industry (e.g., advice on innovation), who wanted to solve some of the problems in the construction industry: (a) inflexibility of current houses and buildings; (b) dependency on a number of different companies with their specific knowledge and ways to work and (c) the amount of failures occurring in a construction project. The project was partly a project-led innovation, but since the whole construction industry discusses these problems, it could be an industry-led innovation. In case C, several parties (suppliers, contractors, R&D institutes and universities) were involved in the innovation process. The innovation involved the development of a concept of flexible building. This idea is perceived in separating installation parts (e.g.,

electricity, water) from architectural parts. In case C this was performed in the development of a floor in which all installation parts could be placed and removed easily. During the innovation process, different partners presented their capabilities to the project. In the initial phase (exploratory vanguard project phase, Brady & Davis, 2005), mainly informal relationships between the initiating firm and universities and R&D institutes were present, which were based on personal relationships (they knew each other from previous experiences) and were based on mutual benefit (for society or their own industry or future business) and trust. In the testing phase prototypes and projects were performed to test the ideas and develop them further. The relationships in the cooperation were more formal in this stage and were based on supplier-customer contracts. The partners involved were suppliers (an installation company and steel manufacturer), a customer (contractor firm) and R&D institutes (performing tests on safety). The final stage of the project in which the product was produced for construction projects contained different partners, i.e., suppliers (steel and concrete). These relationships were long-term commitments based on a standard contract and mutual trust. Most cooperating partners felt intrinsic mutual values of improving the construction industry. The project consisted of long-term relationships without guaranteed workload in both contract and trust based forms. Trust between the partners was high and members were very open in sharing their knowledge. All partners became involved in the innovation project because they shared a similar perspective of solving the abovementioned problems in the construction industry.

4.4 Case D: 3D modelling

The partners in the innovation project were; an architect firm and two largely independent organizations (a selling centre and a knowledge centre that initiated the development) working within a medium-sized holding company in the construction industry. The innovation was business led; implying that the management of the holding firm initiated the idea as strategic development. The developed process innovation of 3D modelling and calculation changes the way of working in the firm and in a building project. With help of this model, the whole construction process can be divided into small steps (CadCam) until the whole construction project (all separate parts) is negotiated and drawn (in a 3D picture on a computer). This new process requires a close cooperation between the construction parties. The positive aspects are that there are less construction failures and costs can be controlled. Furthermore, information is stored centrally in one intranet instead of with several different construction parties. The holding has a strategic alliance with the architect company, for

which a number of principles have been described in a contract. Between the knowledge centres of the holding, no contracts have been made, since both organizations have a common interest. Currently, the partnership is in the execution phase of implementing the innovation and processes at the subsidiaries of the holding company and exploiting parts of the technology on the market (the architect firm exploits 3D modelling commercially to other clients).

5 Case findings

The findings and description of the case studies are summarized in table 1.

Insert Table 1 here

5.1 Innovation modes

When we dive deeper into the case studies for analysis of the data, we find that the innovation projects have different structures, time schedules and partners who are involved. These differences might be related to the kind of innovation project that was performed. From literature we know that there are two kinds of innovation in the construction industry (Winch 1998): (1) bottom up, problem solving (Slaughter, 1993) or project-led innovation projects (Brady & Davis, 2005), which are based on problems perceived from the perspective of projects. (2) Top-down (Winch, 1998) or business led projects (Brady & Davis, 2005), which occur when top down strategic initiatives are taken to develop something beneficial for the firm from the perspective of the top (management). In the cases described above, case A and B are clearly project-led innovation projects, based on problems occurring in construction projects which need to be solved. An engineer from case A states:

> "The reason for developing this method was based on my frustrations with the previous methods, they were disastrous" (interviewee shows several examples of how previous methods failed in construction projects).

The innovation projects of A and B had a short development time and clear ideas of what the final product should be capable of. Furthermore, partners in both cases were aware what kind of knowledge was needed for such a development and were able to define the internal and external knowledge needed. The initiating firm in case A developed the method and product with help of its internal capabilities, but needed external knowledge in order to test the product in real-life projects. In case B, the initiating firm had already performed an earlier

study about what kind of concrete it would need for solving its construction problems, but it did not have the capability to test the formulae in a laboratory. The initiating firm in case B found a concrete supplier who was interested in the same problem but who was not able to solve it by itself, since the supplier did not have the means to test its laboratory tests in real-life projects. A member of case B mentions:

> "Our firm stands for new solutions. To be able to solve the problems which come forward from the construction market, from our customers. The important question is: how can we make this easier for the customer".

We can relate project A and B to the phases of learning in a project-led innovation mode (Brady & Davis, 2005, see section 1). Project A went through all phases of moving into a new technology or market base. Participants in project A learned in the exploratory vanguard project phase to solve one of its major problems in construction. In the second phase, they learned through performing projects to develop the method further. The partner firms also learned to apply the methods and took this knowledge back to their own firms (last phase, project-to-firm phase). The partner firms internalised the project knowledge and improved the method that they could sell without being dependent on the contractor firm. For the contractor firm the innovation was lucrative, but too small to be part of their core competence, they decided to stop improving the method once their patent was expired. A member of the contractor firm of case A stated:

> "Most innovation in the construction industry comes forth from coincidence. Furthermore, there should be a market or niche in which one can specialise oneself. For example, we were for a long time market leader (niche) for underwater concrete, until other parties with better papers started to adopt the techniques. We as a contractor firm at that point decided that underwater concrete was something extra, it was no core business".

Case B was a smaller project and partners did not intent to move the knowledge related to this project into a new technology or market base. Furthermore, the knowledge that was developed through testing the method and the concrete formulae was not transferred back to the firms. The project members decided that they needed further testing before a new technology was developed. Which in fact marked the end of this project.

Case D, however, was a business-led project. The (top) management of the holding company set out a strategy to increase information sharing through the holding and among the construction projects. The management set aside resources in order to develop and implement

this strategy (financial resources and capabilities). The innovation project was performed with the main strategic alliance partner of the holding firm, with whom the firm had a good professional contact and previous experience. In a group interview with project D the following remarks are made:

> "Most partnerships primarily have a profit motive and profit sharing is a central point in the cooperation. However, in this case, the project is completely financed by the Holding".
>
> "When you have a partnership based on making a profit instead of a sponsoring project as we have now, than you have a completely different 'need', which goes much deeper than we have now. I believe that in that case the intended innovation of this project would not have got off the ground. This is performed with more brute force in a positive sense".

Case D was a rather successful innovation project, in which the innovated product and methodology were implemented in the organizations of all the partner firms. Furthermore, the firms developed new routines and knowledge which were internalised in the back-offices of all partners. The project had a rather long development and implementation time, but the consequences of the innovation for the organizations were rather big and time consuming, when implementing the new routines in the firms. According to the partners of the project, this innovation would not have succeeded without the sponsoring of the management of the holding. The sponsoring was not only financially, but also the management supported and stimulated the changes in the organization.

Case C was a different innovation project compared to the other case studies. Case C could be perceived as project-led, since it aimed at both a new technology and a new market base. However, the problems that were solved were on such a large scale and the numbers of partners involved were rather many, that one could perceive the innovation more on industry level.

> "The flexible floor has been developed, not because we wanted to develop a new floor, but because we had a vision about the construction industry".

The problems that initiated the innovation came forth from an international line of research at universities, which was stimulated (financially) by the Dutch government. Furthermore, the time span of the project was rather long (> 10 years). The partners in the innovation project were formal (suppliers, customers, contractors) and informal partners (universities, R&D institutes, governmental institutes). Furthermore, the product was vaguely defined in the beginning and a large amount of time went to brainstorm sessions between researchers,

consultants and suppliers about how such a product could look like. Another interesting item was that the project was financed by governmental funding and several companies. Besides the difficulties in creating the product, the project's financial support was not always constant. However, the partners that were involved in the project (especially in the exploratory vanguard project phase) were sharing their capabilities without self-interest (many even without funding or contract, but based on mutual trust and future benefit). When we focus on learning and knowledge transfer, partners only transferred knowledge in the phases of the project they were participating. Since the partnerships changed over time, depending on the capabilities needed to develop the product, the knowledge of the partners in previous project phases was not part of the project anymore. The knowledge developed in the whole project, was transferred mainly to the firms that were present in the last phases of the project (suppliers and initiating firm). These firms internalised the knowledge that was developed to some extent.

From this discussion it becomes clear that differences in innovation mode (project-led, business led and industry led) have different consequences for the process of the innovation projects. We summarize the findings of this discussion in table 2.

Insert table 2 around here

5.2 Absorptive capacity

Literature discussing absorptive capacity states that the level of prior knowledge is one of the ways to measure ACAP of firms. Cohen & Levinthal (1990) measure ACAP by focusing on R&D activities and outcome measurements like patents. One of the critiques of Lane et al. (2002) is that few attempts are made in the literature to measure ACAP outside of the R&D context. In the construction industry, however, R&D activities are difficult to measure, since many construction firms have no formal resources allocated to R&D (R&D is performed, but is less visible since it is done by individuals at several levels of the organization). As discussed above a large amount of innovation in the construction industry comes from project-led problem solving. Furthermore, the theory of ACAP is mainly held at firm level, and is not taken down to project level. Investigating ACAP in a project-based industry on project level might be rather different than presented in the current literature. In our data we have looked at several aspects that, according to literature, indicate ACAP. These aspects are: the level of prior knowledge and the sharing of a common stock of knowledge, both

organizational and technical (we focused on internal or in-house knowledge and external knowledge of the project partners) (Cohen & Leventhal, 1990; Lane et al. 2002; Lane & Lubatkin 1998; Scarbrough et al., 2004; Van Den Bosch et al., 1999; Zahra & George, 2002).

When we examine the prior knowledge and common knowledge in the four case studies, it is important to mention the aforementioned learning phases of the innovation projects (exploratory, project testing and knowledge to the firm phase Brady & Davis, 2005). In the exploratory phase of case A and B the initiating firms developed a large part of the innovation in-house based on their firm's internal technical capabilities. In the second phase, the initiating firms were in need of external knowledge to develop the product to a final stage. The firms that were attracted as partners could offer specific capabilities. The external knowledge was rather diverse in both cases, since all partner firms came from different disciplines, although they were used to work together in construction projects. The last phase indicates whether learning from the innovation project went back to the firm. In case B, the knowledge developed in the project was rather specific. This implied that the firms could not use this knowledge directly; it had to be processed by the project members first in order to generate lessons learned. In case A, the project-related knowledge was learned through acquiring the new techniques and applying them in real-life projects. The partner firms applied the knowledge and combined many areas of specialised knowledge to produce their own product (an improved technology). Grant (1996) refers in this respect to the ability of both acquiring knowledge through specialisation and applying knowledge by combining specialist areas.

In the other cases C and D, the initiating firm was not able to develop a concept without the (technological) knowledge of external partners. Case D went through all learning phases of Davis and Brady (2005), while case C only went through the two first ones, but had little project-to-firm knowledge transfer. Initiating firms in both case studies selected partner firms based on their diverse and specialist capabilities in a certain field. Although the organizational context of all partners was within the construction industry (usually these firms cooperated in construction projects), however, their organizational firm structure was often different from the initiating firm structure. The initiating contractor (case D) and consultant (case C) firm are project-based firms that only work through projects. The partner firms of especially case C were suppliers and universities who have a different organizational structure (usually not project based) and compensation structure (universities are rewarded for research articles and

teaching). According to Lane and Lubatkin (1998), the similarity in compensation practices and organizational structures enhances the ability to value, assimilate and apply new external knowledge. In case C the absorptive capacity of the participating firms was relatively low due to the fact that prior knowledge was rather general, whereas the external knowledge base was very specific and diverse and organisational structures differed rather much. Furthermore, due to the fact that partner firms were not present through the whole innovation process, made it more difficult to develop learning from external knowledge. Important was to mention in case C that its partners were very open in sharing information and had a mutual interest and intent in creating something new together. Case D included partners who had previous experience in cooperating and both partners were used to working in the construction context. This implied that they had common knowledge about the construction sector and its problems. Furthermore, over time during the innovation process, the partner firm changed its internal organization, in order to be able to internalise the created knowledge and innovation in its firm. A partner of case D mentioned:

> "When we started with this project, we had a different culture in our firm. One and a half year ago we have changed our strategy and thinking in terms of products. This increased visibility and clarity for all employees but also it implied that we were thrown back upon our own resources. At that time the cooperation was pushed by the initiating partner. However, now the top-down push has become a bottom-up approach and this is based on knowledge transfer and integration".

Investigating ACAP on the level of projects is different compared to the firm-level. Projects lack the functional and permanent structure of firms and knowledge is more difficult to transfer over project boundaries or even back to the rest of the firm (see Ekstedt et al. 1999; Prencipe & Tell 2001). Sydow, Lindkvist and DeFillipi (2005) state that projects comprise of members from different specialties, different knowledge bases and ways of interpreting experience, there is thus limited overlap in knowledge bases and little time to build communal knowledge during the lifetime of a project. The levels of prior and common knowledge might not be sufficient to measure ACAP in projects. From the cases we also found that openness, responsibility and trust were important issues in order to create and learn new and external knowledge in project partnerships. A partner of case D stated:

> "In this partnership we have been struggling and are still struggling with the whole process about openness and trust. Openness and trust are necessary with cooperation, but are still rather difficult for human beings. You have to trust your partner, and that also

> counts within our project team. You have to trust the other partner so that s/he does what s/he is supposed to do and you should be able to confront them about this. The other side of the responsibility is that you have to comment on each other when things go wrong. Team creation, openness and trust are still aspects that need daily attention".

These aspects have been discussed in alliance literature as important for learning from alliance partners (Hamel, 1991).

From the cases it was also found that understanding the industrial context, implying the Dutch construction sector, its rules, regulations and network, were important to create a common understanding of the problems the construction industry is currently fazing. Especially case C and D (to some extent case B) shared a common perspective about what kind of problems were important and how these problems could be tackled. Case A also shared a common context; however, the strategy to approach the problems in the industry was rather different. Eventual, in case A, the partner firms became competitors and the initiating firm stopped improving and producing the innovation because it lost its market share.

6 Discussion

In this study we have investigated knowledge transfer in project-based environments. From the literature we know that transferring knowledge from one project to another is difficult (DeFillipo & Arthur, 1998) and that innovation is hindered by project basing (Dubois & Gadde, 2002; Gann & Salter, 2000; Keegan & Turner, 2002; Winch, 1998). However, few authors discuss the capability of projects and project-based firms to absorb knowledge (Scarbrough et al. 2004 is an exception). The theory of absorptive capacity is usually applied on firm level and measurements to define ACAP are based on R&D activity of firms. In project-based environments, the focus is however often on short term projects and not on long term R&D activities. Furthermore, the projects performed in this industry are usually based on cooperation between several firms who deliver specific knowledge for a certain amount of time. From ACAP literature several aspects are important: level of prior related knowledge, a common knowledge base and organizational structure (Van den Bosch et al., 1999; Cohen & Levinthal, 1990; Lane et al., 2002; Lane & Lubatkin, 1998; Zahra & George, 2002). These aspects are also important in project-based environments as discussed in the findings of four Dutch innovation projects in the construction industry. However, other aspects played an important role as well. Especially the mode of innovation was important for internalisation within the firm. In the project-led innovations (cases A and B), knowledge was more difficult to transfer and absorb by the back-office (the project-based firms) due to several reasons.

These reasons were (a) the knowledge and innovation was specifically developed for this project and that this was difficult at this stage to be transferred to and absorbed by the firm; (b) the knowledge and innovation were not part of the core competence and therefore not important to absorb and develop further within the firm and (c) there were time and financial restrains to process the knowledge so that the firm could exploit this knowledge. Knowledge transfer and absorption in the industry-led innovation (case C) was mostly restricted to the phase in which a partner participated. The business led (firm-level initiated) innovation (case D), had ample financial means, time for implementation and support of the higher management resulting in extensive knowledge transfer and absorption by the partners. Furthermore, case D had a long-term relationship between the cooperating firms (the relationship was based on mutual trust and previous experience in working together) which is presented as a moderating factor for the ambiguity of knowledge transferred between firms (Simonin, 1999).

Another important aspect in the cooperation and transfer of knowledge between firms was the sharing of a common perspective about the construction context (especially in case B, C and D). This is related to the common knowledge defined in ACAP literature (Cohen & Levinthal, 1990). The common perspective on the construction industry was especially in case C and D the main reason to develop this innovation and was an important motive for cooperation.

This case study is rather limited since it only investigates four case studies in the Dutch construction industry. However, the exemplary cases underline that ACAP is difficult to measure with help of traditional measurements as R&D activities in project-based environments (cf. Waalkens, 2006). This paper tried to shed some light on the intricacies of knowledge transfer of external knowledge on the project level. ACAP on the project level offers a fruitful area for future research.

7 Bibliography

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Table 1: Case study details

Cases	Case A, underwater concrete	Case B: concrete substance	Case C: new floor concept	Case D: 3-D calculation/modeling
Initiating firm characteristic	Contractor firm (middle large).	Contractor firm (very large)	Consultancy firm for construction industry (small)	Contractor firm (middle large)
Partners involved	Suppliers (3 types) Independent R&D institutes	Supplier (1)	Suppliers (several, > 6) R&D institutes and universities (2) Contractor (1)	Architect company (1) Subsidiaries of the contractor firm (2) University (1)
Innovation mode	Project-led	Project-led	Industry-led	Business-led
Absorptive capacity	High with partner firms, since they absorbed and exploited the learned knowledge	Low, little knowledge was absorbed and exploited by the partner firms	Low, little knowledge absorbed and exploited by partner firms (only initiating firm and suppliers in the final development phases of the product).	High, knowledge exploited and absorbed by both partners
Reasons for level of ACAP	Initiating firm stopped developing product further (no core competence). Patent ended. Partner firms could take over the product because of their experience in working with it.	Knowledge was too specific to be useful for the firms.	Time restrains and financial restrains to process the specific knowledge so that firms could absorb and exploit this.	Ample financial aid available. Support from top-management. Push by management to absorb the new method and knowledge. Large amount of time for development and implementation. Long term relationship between the alliance partners based on mutual trust.

Table 2: Mode of innovation

Mode of innovation	Description	Development time	Context
Project-led (bottom up)	Problem solving based on problems found in projects	Short (within certain amount of time)	Financial support sometimes difficult. Acceptance with firms not stimulated by management. Time constrain for development and improvement
Business-led (top down)	Strategic issues from management are put forward	Medium-long	Financial support available. Management stimulates adoption of innovation in the firms. Time is not a restriction.
Industry-led	Problems and issues coming forth from several groups in an industry (suppliers, customers, R&D institutes). Parties have a common perspective about a specific problem area	Long	Financial support sometimes difficult. Adoption of new ideas difficult in industry. Complex projects to manage because of large heterogeneity of skills and number of partners.