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Organisation, 'anchoring' of knowledge, and innovative activity in construction

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The construction industry is characterised by the widespread use of project organisation. It has been suggested that the relatively low level of innovative activity in the industry can be explained by the temporary nature of firm boundary-crossing projects. Survey data from the Danish construction industry is used to investigate the importance of learning and 'anchoring' of project-specific knowledge at the firm level for participation in innovative activities. The data cover both the overall Danish construction industry and a specific region, North Jutland, which has a relatively high specialisation of construction workers. Latent class and regression analyses reveal that firms that make extensive use of partnering, together with internal product and process evaluation and knowledge diffusion (labelled 'knowledge-anchoring mechanisms'), are more likely to participate in innovative activities than firms which make less use of these mechanisms. This indicates that construction firms are able to compensate for the problems that temporary interorganisational projects may cause in relation to continuous learning at the firm level.

Keywords: Project organisation, partnering, innovative activity

Introduction

While knowledge of innovative activity in construction is limited, analyses of this phenomenon have begun to emerge (see, for example, Miozzo and Dewick, 2004). The frequency of innovation in the industry is generally considered rather low.[1] One explanation for this may be that varying collaborations in project organisations are not particularly conducive for continuous learning and knowledge assimilation at the firm level. In order to investigate this further, the present paper focuses on firms' ability to share knowledge between project partners and 'anchor' knowledge[2] through integrating and assimilating the knowledge developed in a specific project by the participating organisations, i.e. making the project-specific knowledge organisation-specific and thus available for use in future projects. In the following, the closeness of relations to collaboration partners and the use of knowledge-anchoring mechanisms are related to construction firms' participation in innovative activities.

The paper is organised in the following way: Section 2 discusses characteristic features of the construction industry, with a particular emphasis on the industry's use of inter-firm project organisation and the implications this may have for learning and anchoring of knowledge. Section 3 presents an empirical analysis of the relation between the use of partnering and knowledge-anchoring mechanisms and participation in innovative activity at the firm level in the Danish construction industry. Section 4 presents the conclusions of the analysis.

Innovation and learning in project-based firms

Any analysis of innovation in construction must keep in mind the particularities of the construction industry and its various outputs. Constructed facilities tend to be large, complex and long-lasting 'items', which are created and built by a temporary alliance of disparate organisations within an explicit and political context. The long life span of the products compels customers to stick to proven methods rather than aiming for

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radical changes. The fact that constructed facilities are circumscribed by codes and regulations to a much higher degree than traditional manufactured products may have similar innovation-hampering effects (Slaughter, 1998), although change in regulations, e.g. in terms of environmental legislation, can also be a driving force behind innovation in some cases (Barlow, 1999). The tendering system, where bids are invited for a project described in minute detail, can also act as a barrier to innovation (construction firms are not supposed to come up with novel solutions), although it can also contribute to lower coordination costs in an industry subject to radical external shifts in aggregate demand (Thomassen, 2003).

With regard to the role of project organisation, the development of innovations within a temporary alliance of independent organisations cooperating on a single project implies that even small modifications to components, systems or activities require a high degree of interorganisational negotiation (Slaughter, 1998). This could explain why the construction industry is more often a user than a producer of innovations (see, for example, Pries and Janszen, 1995), making the industry strongly dependent on other industries (this is reflected in Pavitt's (1984) characterisation of construction as a supplier-dominated industry). Changes thus tend to occur though piecemeal improvements in building materials, rather than through radical transformations within the industry itself (Ball, 1999).

Because every project is unique and there are few possibilities for repetition, there is little reason for a building contractor to invest in innovation beyond the optimisation of his own processes, which means that economies of scale and learning effects are largely absent (Pries and Janszen, 1995; Thomassen, 2003; Bresnen *et al.*, 2004). In addition, conservative clients may have negative attitudes to innovation,[3] i.e. the aversion to innovation may come from both within and outside the firm. On the other hand, in some cases client demands may be the only driving force behind innovation in project-based firms (Briscoe *et al.*, 2004).

Thus, the way the construction industry is organised, with independent and complex tasks, a large number of participants, unique coalitions of project teams, the pressure of deadlines, conservative clients, and the tender system, may in some ways hamper long-term change—including learning and innovation—in the industry (Kadefors, 1995) and instead promote short-term goals. Dubois and Gadde (2002) specifically relate the loose couplings in the construction industry outside individual projects—as opposed to the tight couplings within projects—to a focus on short-term productivity in individual projects. In the long term, however, loose couplings can have a negative effect on innovation and learning, because although they may nurture novel solutions to problems, at the same time they may prevent their diffusion. Focusing too much on the project leaves no room for external factors, which means that the project team risks becoming a knowledge silo, where the knowledge developed is not available for other members outside the team (Sydow *et al.*, 2004).[4] Furthermore, managers in project-based firms do not necessarily regard innovation as particularly useful, since traditional project management places more importance on efficiency in order to complete projects within predetermined criteria of time, cost and quality. The short-term horizon leaves no room for reflection on and documenting experiences of lessons learned (Keegan and Turner, 2002). This in turn leaves little room for the time, space and creativity needed for pursuing new products, services and customer requirements.

It might therefore be considered paradoxical that networking and project organisation are regarded as being a successful mode of organisation for realising innovation in other types of industries than construction. The pharmaceutical industry is a good example of an industry that successfully uses project organisation—intra- as well as interorganisationally—for realising innovations (see, for example, Zeller, 2002). But experiences from firm alliances in other industries, e.g. office machinery and software, also show that well-managed relations to other firms can result in sustained competitive advantages (Dyer and Singh, 1998), and that networks can be regarded as resources in themselves (Håkansson, 1993). Powell (1998) stresses that, in rapidly developing technological fields, such as biotechnology and pharmaceuticals, with complex and expanding knowledge bases, the locus of innovation is likely to be found in networks of learning, rather than in individual firms.[5] But Powell also notes that, under such circumstances, learning is a complex, multi-level process which also involves learning how to distribute newly acquired knowledge across different projects and functions. And also for biotechnology and pharmaceutical firms learning across projects is a challenge—a challenge that is not handled equally successfully by all firms, depending on their routines for transferring knowledge. Here, we call these knowledge-transferring routines knowledge-anchoring mechanisms, i.e. mechanisms for not only collecting, but also diffusing and assimilating project-generated knowledge at the firm level. This leads to the first hypothesis to be explored in the following:

> *Hypothesis 1*: Firms that have formalised routines for transferring knowledge from project to firm level in the form of mechanisms for knowledge anchoring are better equipped for engaging in innovative activities than firms that do not use such mechanisms.

This is assumed to be true for firms in all industries, but here it is explored in relation to construction firms since innovation intensity is particularly low and project organisation widely used in this industry.

Interfirm partnering has been suggested as a trigger for the development of a more learning-oriented culture in the construction industry (Barlow and Jashapara, 1998). Partnering involves a variety of managerial practices and organisational designs that enhance and maintain collaboration in client–contractor or supplier relationships. The main idea behind partnering is that the involved parties in a construction project work closely together from the beginning of the project and share knowledge throughout it. Despite the fuzziness of the partnering concept, trust and mutual understandings, including agreements on common goals, are regarded as necessary components (Nyström, 2005). Barlow and Jashapara see partnering as providing an environment that allows firms to redefine and develop new skills and innovations in a relatively controlled way. However, they also underline that the mere existence of a partnering relationship is not in itself sufficient; knowledge also needs to be retained and distributed in the organisation. The quality of information distribution—i.e. the anchoring mechanisms—may therefore lead to a more broadly based organisational learning (*ibid.*). There is therefore assumed to be complementarity between the use of partnering and knowledge-anchoring mechanisms in relation to innovation:

> *Hypothesis 2*: Firms that engage in partnering and use knowledge-anchoring mechanisms inside the firm are more likely to engage in innovative activities than firms that do not combine these two factors.

Finally, a secondary set of hypotheses concern the types of firms most likely to use knowledge-anchoring mechanisms:

> *Hypothesis 3a*: Larger firms are more likely to use formal organisational practices, in the form of knowledge-anchoring mechanisms, for integrating and assimilating knowledge in the firm than micro firms.
> *Hypothesis 3b*: Firms in the knowledge-intensive business service sector—for construction this means architects and engineers—are more geared towards integrating and assimilating knowledge through established organisational forms and hence more likely to be engaged in innovative activities than other types of firms.

The reasoning behind Hypothesis 3a is that micro firms do not need—and are not geared to using—formal organisational practices for transferring knowledge between the project and firm level. Rather, these firms rely on informal interactions between the limited number of employees. Hypothesis 3b is based on the assumption that there is generally more focus on how knowledge is generated and managed in so-called knowledge-intensive firms. In these firms the competitive advantage is to a large degree based on being able to generate new ideas, and therefore being engaged more frequently in innovative activities.

Knowledge-anchoring, partnering and innovation in construction firms

Data and method

Most studies of learning and innovative activities in project organisations have been based on qualitative data (e.g. Dorée and Holmen, 2004; Keegan and Turner, 2002; Gann and Salter, 2000, 2003; Prencipe and Tell, 2001). In this paper, the analysis of these activities is based on quantitative data from a Danish survey of collaboration in the construction industry carried out in 2003. The survey is part of a larger research project designed to create better and cheaper building activities in Denmark. In North Jutland, the construction industry has long had a reputation for collaboration, so this region was used as a benchmark in the survey. The dataset thus consists of two subsamples: approximately half of the firms in the sample are representative of the Danish construction sector as a whole (excluding North Jutland), while the other half represents North Jutland only. Although the influence of regional characteristics is not the central issue here, the over-sampling allows an exploration of whether construction firms located in a rather peripheral region, such as North Jutland, which has an overrepresentation of construction workers compared with the national average[6] and a reputation for collaboration, act differently from Danish construction firms in general in terms of knowledge anchoring, partnering and innovative activity.

Here, the construction industry is defined as all agents involved in construction-related activities, i.e. the analysis includes more firms than the narrow definition of the construction industry in NACE group 45. The aim was thus to include builders, as well as suppliers, architects and consulting engineers, alongside the contractors. Below, the different types of agents are characterised according to the industry (NACE) classifications:

- Builders are primarily identified in NACE group 70 (real estate activities).
- Suppliers are mainly found in NACE groups 20 (manufacturers of wood products, etc.), 26 (manufacturers of other non-metallic mineral

products), 28 (manufacturers of fabricated metal products other than machinery and equipment), and 51 (wholesale and commission trade).

- Architects and consulting engineers are primarily classified in NACE group 74 (other business activities).
- Contractors are the executing construction firms found in NACE group 45.

The number of firms in each segment varies in order to reflect the actual numbers in the sub-populations. Furthermore, firms with activities in more than one of the segments are categorised according to their primary activity. The aim was to carry out at least 200 interviews in each of the two subsets (i.e. North Jutland and the rest of Denmark respectively). A total of 996 firms were contacted, of which 361 turned out to be irrelevant for the survey. Of the remaining 634 relevant firms, 441 participated in the CATI (computer-assisted telephone interviewing) survey. The distribution of respondents between regions and types of agents is shown in Appendix Table A1, while the questions used in the analysis are shown in Appendix Table A2.

Since knowledge anchoring and partnering are complex processes that depend on several actions, latent class analysis (Lazarsfeld, 1954) has been used to identify different behavioural patterns in relation to such activities in the firms. In the latent class analysis knowledge-anchoring mechanisms are primarily expressed by two types of post-project reviews and diffusion of experiences:[7]

- the use of systematic post-project reviews and diffusion of experiences from these in relation to the construction *process*; and
- the use of systematic post-project reviews and diffusion of experiences from these in relation to the *project*.

Partnering is expressed in both a static and a dynamic way. The variables reflecting partnering in a static way express the actual use of different functions and mechanisms related to the partnering concept. These include:

- the setting up of common goals among partner firms;
- the use of open calculations and accounting in the projects, which may be important for building trust among partners (see Lorenz, 1999, for an analysis of the role of trust for successful cooperation);[8]
- the use of self-governing teams on the construction site, which can improve individual job performance and with it organisational performance (Banker *et al.*, 1996; Arthur, 1994), and further increase the trust between partners;
- increased attention to the needs of the end-user. End-users are indirectly related to the partnering concept through the main objective of partnering, which is a better end result for customers/users.

Partnering is included in a more dynamic sense through a variable for whether firms have *increased* their use of partnering during the three years preceding the survey.

Latent class analysis

The model of latent classes allows the application of the basic logic of factor analysis on qualitative data. Latent class and factor analysis models are both data reduction techniques that attempt to account for the observed interrelationships of variables in terms of a few underlying factors, or latent dimensions (Green, 1952). The latent class model is estimated by maximum likelihood, where the number of classes is determined by goodness-of-fit tests (χ^2 and G^2) and two informal information criteria, the Akaike information criterion (AIC) and the Bayesian information criterion (BIC).

Table 1 shows the latent class estimation with different classes.[9] With respect to Pearson χ^2- and likelihood ratio G^2-tests, the latent class models for one and two classes are strongly rejected. BIC puts forward three classes, whereas AIC argues for four classes. Weighing the obvious need for significant results against the aim of reducing complexity, the three-class solution is applied in the following.

Table 2 shows the three classes, which can be described in terms of size and profile.[10] The size of the pattern indicates the probability of observing the pattern when a firm is selected randomly from the population. The profile for the included variables indicates the conditional probability of validating the statements, given the type of pattern. The three classes have a distinct profile, since low probabilities in one class are replaced with higher probabilities in the others classes and vice versa.

Table 1 Latent class estimation, goodness-of-fit (p-values in brackets)

Number of classes	χ^2	G^2	AIC	BIC
1	1048.14 (0.000)	545.31 (0.000)	4348.19	4384.99
2	398.49 (0.000)	369.64 (0.000)	4270.20	4192.51
3	286.20 (0.110)	277.87 (0.189)	4120.74	4239.32
4	232.97 (0.745)	218.02 (0.915)	4080.89	4240.37

Table 2 The estimated latent structure with three distinct structures

	Class 1 No anchoring	Class 2 Anchoring	Class 3 Anchoring and partnering
Conditional probabilities	*27%*	*46%*	*27%*
Partnering			
Discuss common goals—strongly agree, binary	0.271	0.310	0.774
Open calculations and accounts—strongly agree, binary	0.058	0.063	0.501
Self-governing teams on site—strongly agree, binary	0.100	0.099	0.457
Increased use of partnering—strongly agree, binary	0.108	0.000	0.704
Focus on end-user—strongly agree, binary	0.475	0.513	0.636
Knowledge anchoring			
Use of *process* evaluation and diffusion	0.000	0.802	0.637
Use of *process* evaluation only	0.552	0.102	0.310
No use of *process* evaluation	0.448	0.096	0.053
Use of *product* evaluation and diffusion	0.000	0.702	0.590
Use of *product* evaluation only	0.479	0.123	0.223
No use of *product* evaluation	0.521	0.177	0.187

Class 1 consists of 27% of the firms included in the survey. There is only a low probability of these firms using methods for partnering and knowledge anchoring. The probabilities for using some of the partnering methods—static as well as dynamic—range from 0.058 (open calculations and accounts) to 0.475 (focus on end-user). Probabilities for using methods for knowledge anchoring are zero, since only product and process evaluation is applied (with probabilities of 0.479 and 0.552 respectively), whereas the probabilities for using diffusion mechanisms are zero for both product and process knowledge. Hence, Class 1 firms are labelled as *no anchoring* firms.

Class 2 firms, which account for 46% of the firms in the survey, are characterised by the use of anchoring mechanisms in terms of both process and product evaluation and systematic diffusion of experiences from building projects. The probabilities range from 0.70 to 0.80. However the scores on the partnering variables—static as well as dynamic—are low. Class 2 firms are labelled users of *anchoring* of knowledge.

Class 3 firms have slightly lower conditional probabilities for the knowledge-anchoring mechanisms than Class 2, but most of the conditional probabilities for static and dynamic partnering variables are high, indicating that firms in Class 3 make a conscious effort both to diffuse knowledge throughout the organisation and interact closely with project partners. Firms in Class 3 evaluate and diffuse information in terms of experiences from both processes and products, they have increased the use of partnering, they often discuss common goals with their partners, they use open calculations and accounts as well as self-governing teams on construction sites involving different trade groups, and they pay more attention to the needs of end-users. Twenty-seven per cent of the firms in the sample fall into this 'knowledge-anchoring and partnering' category.

Although the profiles of the three classes are quite distinct, the probabilities reflecting a focus on end-users are similar across them. Since the variation in the probability is low, ranging from 0.475 in Class 1 to 0.636 in Class 3, it could be argued that firms in the construction industry in general are aware of the importance of information from users.

An analysis of the estimated latent structure according to type of agent, region and firm size reveals that firms with more than 20 employees are more often found in Class 3—i.e. firms with anchoring and partnering—than the very small firms, see Table 3. Almost 30% of the firms with more than 20 employees will fall into Class 3, which favours anchoring and partnering methods. For firms with fewer than 20 employees, approximately 20% will belong to Class 3. The pattern is less clear as regards type of agent and region, however, although 79% of architects and consulting engineering firms will use either anchoring or both anchoring and partnering methods. Although the differences between the various size categories and agents are not overwhelming, these results are in accordance with Hypotheses 3a and 3b: micro firms do not have the same need to use methods favouring anchoring and/or partnering as larger firms, whereas this is typical of architects and consulting engineering firms due to their intensive use of knowledge.

Model estimation

As mentioned in the introduction, innovation intensity in the construction industry is low compared with other

Table 3 Descriptive statistics on the estimated latent structure on size and type of agent/region

	Class 1 No anchoring	Class 2 Anchoring	Class 3 Anchoring and partnering	N
Type of agent				
Builders	34%	42%	24%	59
Suppliers of materials and components	39%	43%	18%	118
Architects and consulting engineers	21%	50%	29%	103
Contractors	27%	45%	28%	161
Region				
North Jutland	32%	43%	25%	212
Rest of Denmark	28%	47%	25%	229
Size				
50 or more employees	28%	43%	28%	67
20–49 employees	24%	46%	30%	105
10–19 employees	32%	47%	21%	139
1–9 employees	33%	44%	22%	129

sectors. However, the three classes identified in the latent class estimation may contribute to an understanding of why many construction firms appear to have difficulty with innovating: three-quarters of the firms in the construction industry only use mechanisms for anchoring knowledge to a small extent or use anchoring without partnering. The two main hypotheses in the present analysis is that knowledge-anchoring activities (Hypothesis 1), especially when combined with partnering (Hypothesis 2), improve construction firms' capabilities for engaging in innovative activity. The empirical validity of this argument will be explored below.

The analysis looks at the use of knowledge-anchoring mechanisms and partnering in relation to the propensity for participating in innovative activities. While data on actual successful innovations in construction would have been more appropriate, the survey only contains information about the firms' engagement in what they themselves perceive as 'innovative activities',[11] with no consideration of whether these activities lead to successful innovations in terms of new products, processes, organisational forms, etc.[12] It is assumed that the mechanisms which trigger engagement in innovative activities are similar to those related to successful innovations.

The basic structure of the model applied in the further analysis may be specified as follows:

$$a = f\left(\beta_{1z} + \beta_{2q}\right) \tag{1}$$

where a represents the firms' propensity to engage in innovative activities within a two-year period, z is a vector concerning the three latent classes, and q is a vector concerning control variables such as geographical location,[13] type of agent and firm size, which in the literature is argued to have an influence on innovative activity (Acs and Audretsch, 1988; Brouwer and Kleinknecht, 1996; Cohen, 1995).

Table 4 shows the results of the logistic regression. The aim of the model is to clarify the probability of engaging in innovative activities within a two-year period (2001–03). The results indicate that, even when controlled for size, type of agent and regional location, Hypothesis 1 is confirmed. Firms that use anchoring mechanisms, in terms of evaluating and diffusing experiences from building projects with respect to both the process and the product, but do not place importance on close relations with partners, are more likely (by a factor of 1.7) to engage in innovative activities than those that are reluctant to apply knowledge-anchoring mechanisms. However, firms that combine knowledge anchoring with partnering are even more likely (by a factor of 3) to engage in innovative activities compared with the benchmark, which supports Hypothesis 2. The difference between the class using anchoring alone and the class using anchoring and partnering together is significant, which indicates that knowledge anchoring, combined with specific ways of building up closer relationships with partners, has potential benefits with regard to engagement in innovative activities. Interaction is important for the individual firm due to the characteristics of the complex processes in the construction industry. Hence, building up and/or maintaining external relationships, combined with internal evaluation and diffusion of product and process knowledge, increases the likelihood of engaging in innovative activities. The importance of managing external relationships can be related to the fact that innovations in construction are not implemented within the individual firms, but in the projects they are engaged in. This implies that management of innovation is complicated by interfirm coordination, which

Table 4 Logistic regression results of probability of engaging in innovative activity within a two-year period

	Dependent variable: innovative activity		
Variables	Coef.	Std.Err.	Odds ratio
Intercept	−0.367	0.355	
LCA classes on anchoring knowledge			
Anchoring and partnering	***1.204	0.302	3.334
Anchoring	**0.545	0.244	1.724
No anchoring		Benchmark	
Type of agent			
Builders	0.192	0.340	1.212
Suppliers of materials and components	0.438	0.277	1.550
Architects and consulting engineers	***1.689	0.345	5.413
Contractors		Benchmark	
Region			
North Jutland	−0.280	0.212	0.755
Rest of Denmark		Benchmark	
Size			
50 or more employees	**0.765	0.370	2.148
20–49 employees	−0.098	0.306	0.907
10–19 employees	−0.306	0.302	0.736
1–9 employees		Benchmark	
N	440		
Log likelihood	66.059		

Notes: *** significance at 1% level; ** significance at 5% level. There is no serious sign of multicollinearity between the independent variables. The multicollinearity is estimated by using the predicted probabilities of the dependent variable. These predicted values are then used to construct a weight variable which is applied in a weighted least squares regression. A tolerance is computed by regressing each variable on all the other explanatory variables.

demands negotiation along the building chain (Miozzo and Dewick, 2004).

The results suggest that increasing the firms' ability to anchor knowledge and enter into partnering agreements can lead to an increase in innovative activity in construction. This supports case-based findings by Dorée and Holmen (2004) that intrafirm interproject learning, together with interfirm and interproject coupling, is important for technological innovation in the construction industry. Increased innovative activity can result in competitive advantages at the firm level, as well as benefit society in terms of improved construction facilities, e.g. more environment-friendly construction.[14]

The analysis also includes firm size and region as control variables. The results regarding firm size are in accordance with previous innovation analyses, showing that the probability of engaging in innovative activity increases with size. Regarding region, there are no significant differences between North Jutland and the rest of Denmark, i.e. there are no indications of a particular regional collaboration culture.

The dispersion in the value chain is also reflected in the results. Architects and consulting engineers are more than five times as likely to be engaged in innovative activities as contractors. It may be possible to increase the overall innovative activity of the construction industry through an increased focus by architects and consulting engineers on diffusing their knowledge and innovative capabilities, through knowledge sharing in collaborations, to other parties in the construction industry. However, as mentioned above, the survey only takes the firms' engagement in innovative activities into consideration. There is no consideration of the success of these innovative activities. Architects and consulting engineers are often involved in developing new concepts and solutions that are never implemented by contractors since they are not selected in the tendering process. This may help to explain the very high level of innovative activity among architects and consulting engineers.

Previous studies show that collaboration and trust are important in relation to innovative activities (von Hippel, 1998; Lorenz, 1999). However, there seems to be a need to diffuse knowledge about the importance of combining partnering with knowledge anchoring within project-based organisations. The analysis suggests that close and more intense interactions with external partners, including building up trust and engaging in formal partnering, need to be combined with evaluation and diffusion processes within the firm. The present results show that firms' ability to deal with external partners, but also to integrate knowledge developed in a specific project within the organisation, hence making the project-specific knowledge organisation-specific and available for future projects, is important for innovative activity in the construction industry. In this respect, the concept of absorptive capacity (Cohen and Levinthal, 1990) is crucial, in the sense that a firm's ability to recognise the value of knowledge, assimilate it and apply it is important both in terms of external partners but also within the organisation.

Conclusions

The starting point of this study was the low frequency of innovative activity in the construction industry. In the increasingly global economy, innovation is fast becoming more and more important for the performance of the firm. Reichstein (2004) finds a positive relation between product innovation and employment growth at the firm level. The fact that the construction industry is characterised by project-based enterprises with varying degrees of collaboration with external partners, producing large and complex constructed facilities with long-lasting 'items', may to a large extent explain the low innovation frequency. Qualitative analyses carried out in the construction industry, as well as in other industries making extensive use of interfirm project organisation, have shown that the temporary nature of relations can also present serious problems as regards continuous learning at the firm level, because there are no automatic mechanisms guaranteeing the transfer of learning experiences between the project and firm level. However, as illustrated in this paper, survey data show that innovative activity in the Danish construction industry is supported by the use of specific ways of handling external partners, such as building up closer relationships through the use of partnering, combined with the use of internal evaluation and diffusion of process and product knowledge—knowledge anchoring. These procedures may thus help overcome problems of transferring knowledge and learning experiences between the project and firm level.

As the present analysis shows, the lesson for managers is that knowledge-anchoring mechanisms and partnering may help reduce the shortcomings of project-based organisations as regards capturing, sharing and diffusing knowledge and learning across projects and instead encourage them to become more knowledge-driven. The use of post-project reviews and systematic evaluation and diffusion of experiences means that managers may have less difficulty in combining strategies of short-term task performance with long-term learning and knowledge accumulation.

The analysis finds that architects and consulting engineers are more likely to be engaged in innovative activities than other agents in the construction industry, which may be partly explained by the high level of knowledge intensity among this group, but also by the fact that the process of developing a tender may often be perceived as an innovative activity, although many new concepts are never actually implemented because they do not get past the tendering process. Innovation at the beginning of the product value chain may increase the benefits further down the chain. Among other things, this can be achieved by the right handling of procedures and mechanisms between the firm and its partners, i.e. by the use of partnering. Thus, it is not necessarily a problem that the contracting part of the construction industry is more often a user than a producer of innovation. However, it is important that the users increase their ability to assimilate and utilise knowledge from other types of partners—an ability that may be strengthened through the application of partnering and knowledge-anchoring mechanisms.

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Notes

1. This is supported by a Danish survey covering the period 1998–2000. The survey found that, while 58% of firms in the manufacturing industry and 44% of firms in trade and services had introduced new products or services during the period covered by the survey, the corresponding figure in the construction industry was only 22%. Source: Aalborg University, 2001, Survey on Organisation, Employee Qualifications and New Product Development. Reichstein *et al.* (2005) find similar results for the UK.
2. Knowledge anchoring is related to the concept of 'project synthesis' used by Gann and Salter to describe 'the ability to draw together lessons from different projects to develop and exploit individual episodes of learning into an integrated whole' (Gann and Salter, 2003, p. 12).
3. As pointed out by Ball (1999), consumers (at least in the UK) are conservative in their tastes in house styles, claim builders and estate agents; conformity is self-reinforcing, since one unsuccessful design innovation tends to discourage further attempts by firms to innovate. According to Ball, this has led builders to

complain that they face a conservative market, which limits innovation.

4. Andersen *et al.* (2004) thus stress the importance of information sharing, collaboration and mediation between different sets of complementary knowledge for successful innovation in construction.
5. As pointed out by Dubois and Gadde (2002), a notable difference between the construction industry and, for example, the pharmaceutical industry, is that in construction the resources of different suppliers are often quite homogeneous, which implies that a contractor cannot expect to learn more from one of them than from another.
6. North Jutland accounts for 8% of the total Danish employed labour force and 10% of employees in the narrowly defined construction industry (NACE group 45). The representation of real estate activities (NACE 70), which can be seen as an approximation for the presence of builders in North Jutland, corresponds to the representation at the national level, measured in terms of employees (based on employment data from Statistics Denmark from 2000).
7. Hobday (2000) pointed to the relation between post-project reviews and organisational learning in project-based organisations.
8. Ring and Van de Ven (1994) also suggest that trust reduces the need for formal contracts between collaboration partners, thus giving room for more flexibility in interorganisational relationships.
9. The variables reflecting answers on a 4-point Likert scale are recoded as binary variables, where 'strongly agree' is selected as one category while the other answer categories (see Table A2 in the Appendix) are collapsed into the second category.
10. There are no statistically significant differences between the sub-surveys of North Jutland and Denmark as a whole respectively as regards firm probabilities in relation to the latent classes, which is why the latent class analysis is carried out on the combined dataset rather than in two separate analyses.
11. The reference period for this question is two years before the survey. While 61% of the participating firms have been engaged in innovative activities, it should be stressed that this does not imply that all these firms have completed successful innovations. If this were the case, the Danish construction sector would have to be considered very innovative.
12. Firms were asked the following question: 'Has your firm—alone or together with others—been engaged in innovative activities within the last two years?' In the survey, innovative activities are defined as development activities related to products, processes, or types of collaboration new to the firm.

    The lack of knowledge about the success of innovative activities is just one problem with the dependent variable. Another problem is that the measure might to some extent be subjective, in the sense that firms might differ in their perception of what can be considered an innovative activity. Firms are also likely to differ with regard to their perception of actual innovations, but this problem may be exacerbated given the fact that there is no requirement to link the innovative activity to an actual outcome. These are factors which should be considered when interpreting the results of the model estimation.
13. North Jutland versus rest of Denmark.
14. Examples of environment-related innovations in construction include the use of natural thermal insulation materials for cavity wall insulation (this example is taken from Miozzo and Dewick, 2004) and the use of solar energy in the Sydney Olympic Village (Andersen *et al.*, 2004).

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Appendix

Table A1 Sample description

Type of agent/region	North Jutland	Denmark	Total
Builders	25 (6%)	34 (8%)	59 (14%)
Suppliers of materials and components	60 (14%)	58 (13%)	118 (27%)
Architects and consulting engineers	50 (11%)	53 (12%)	103 (23%)
Contractors	77 (17%)	84 (19%)	161 (36%)
Total	212 (48%)	229 (52%)	441 (100%)

Table A2 Descriptive statistics for variables included in the latent class analysis

All statements refer to the development within a three-year period prior to the survey	Strongly agree	Partly agree	Neither	Disagree	Don't know	N
Statement: We increasingly discuss common goals with our partners	42%	22%	5%	28%	2%	441
Statement: We participate more often in construction projects with open calculations and accounts between partners	18%	19%	7%	54%	2%	441
Statement: Self-governing teams made up of different professional groups are increasingly used on the construction site	20%	23%	7%	35%	16%	441
Statement: We use partnering as a way of collaboration to a greater extent	22%	20%	6%	49%	3%	441
Statement: We are more focused on the needs of the end-users	54%	18%	7%	21%	1%	441
	Yes, both evaluation and diffusion	Only evaluation	No			
Question asked: Do you evaluate the process in connection with or after a construction project? **If Yes**: Is there a systematic internal procurement of experiences regarding the process?	82%	15%	3%			441
Question asked: Do you evaluate the product in connection with or after a building project? **If Yes**: Is there a systematic internal procurement of experiences regarding the product?	66%	33%	1%			**441**