

A COMPARISON OF A TRADITIONAL AND AN UNCONVENTIONAL CONSTRUCTION PROJECT PROCUREMENT METHOD

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ABSTRACT

During the last couple of decades, transport agencies over the world have started to utilize innovative approaches to a higher degree for procuring construction projects. However, although this procurement strategy, at least partially, have been launched to increase the efficiency and effectiveness of the construction sector, few studies have investigated whether the aims has been reached. One explanation for the lack of such studies may be the shortage of tools to characterize procurement methods and their effects. This study investigates differences among procurement methods using a longitudinal case study based on two comparatively large infrastructure projects: a traditional so-called design-bid-build (DBB) project and an unconventional so-called design-build-maintain (DBM) project. The effect of procurement method was investigated using a network-based model and the three concepts of uncertainty, interaction and knowledge. The empirical part of the investigation, which was carried out based on literatures studies, interviews and field observations during a 10-year long period, concerns in addition to the two focal projects also 10 prior and subsequent projects. Although many characteristics were similar for the two cases, the traditional procurement approach resulted in lower degrees of uncertainty, interaction and knowledge than the unconventional project for the actors involved. Furthermore, the differences between procurement methods become even more apparent when the time-frame of the study is extended beyond the focal projects investigated. In particular, the comparison of the two cases presented indicates differences regarding the establishment of inter-project connections, a consequence of the greater uncertainty in unconventional projects as well as the greater need of accessing knowledge through interaction. The results of the study may provide a tool to investigate procurements more closely as well as some answers that positively affect the construction sector since visualization of the benefit of connections facilitate knowledge transfer which could serve to counteract the common opinion of the poor competition, high production costs and low product quality.

Key notes: Project management, procurement, uncertainty, interaction, knowledge

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INTRODUCTION

The construction sector is often characterized by complex large-scale undertakings, organized in project-form and procured on a one-off basis, characteristics often considered to show important consequences for business (e.g. Eccles, 1981; Winch, 2002). Accordingly, procurement methodology represents a widely discussed topic within the sector during the years, in particular in connection to the common opinion of the poor competition, high production costs and low product quality (cf. Egan, 1998; SOU, 2002). In accordance with a trend among European public bodies, the Swedish national transport administration (STA) launched a new procurement strategy in 2003, aiming at counteracting the negative opinion of the sector, by significantly increasing the number of unconventional package deals, or in construction vocabulary: design-build (DB) and design-build-maintain (DBM), projects on the behalf of the traditional, design-bid-build (DBB), approach. In this case, the bundling of activities, e.g. design, construction and maintenance within one and the same contract, was assumed to result in lower overall costs for the client by increased competition, lower costs and improved quality for the projects procured. Despite the wide range of literature devoted to procurement methodology (e.g. Pietroforte and Miller, 2002; Fahmy and Jergeas, 2004), no definitive answer exists regarding whether any particular approach is to prefer over others. Instead, the research presented suggests that the choice of procurement method for a given construction project is largely dependent on circumstances of the project, e.g. complexity and actor perspective taken. Consequently, it appears that a major task when analysing procurement methodology and decision-making thereof concerns contextual aspects. Accordingly, in order to investigate whether the new strategy of STA meets its aims, it is important to compare procurement methods based on the essential features of each approach compared.

The purpose of the current paper is to compare differences and similarities between traditional and unconventional procurement within a Swedish road construction context using the model described below.

THEORY

In a previous publication (Lundström, 2013), a model has been presented where procurement methods are characterized based on a network approach and the three concepts of *uncertainty*, *interaction* and *knowledge gained*. Figure 1 illustrates a conceptual project network comprising three inter-organizational projects, each representing up to three interacting actors (in this case a contractor, a client and a consultant) which at the same time are members of hierarchical organizations (dashed lines). The arrows between the actors within each project represent *intra-project interaction*, while the bold lines between the projects indicate explicit connections resulting from dependency in the form of resources transferred from a project to the next (*inter-project interaction*). For a more comprehensive description of the model, references and assumptions made, the reader is referred to Lundström (2013).

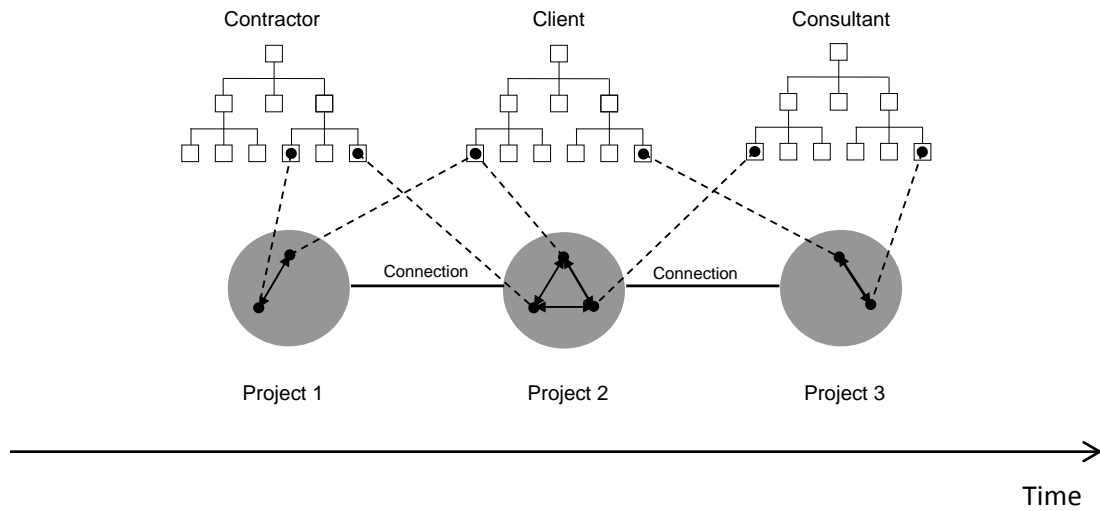


Figure 1. Illustration of market consisting of three inter-organizational projects comprising actors of hierarchical organizations (dashed lines). Arrows and bold lines among project participants and between projects indicate intra-project interaction and inter-project connections, respectively.

In principle, the model may provide a means of characterizing the degree to which a given project may be seen as a (1) discrete one-off project or (2) a network consisting of successively sleeping/reanimated relationships. The basic idea of the model will be further described below utilizing three concepts of uncertainty, interaction and knowledge (Figure 2).

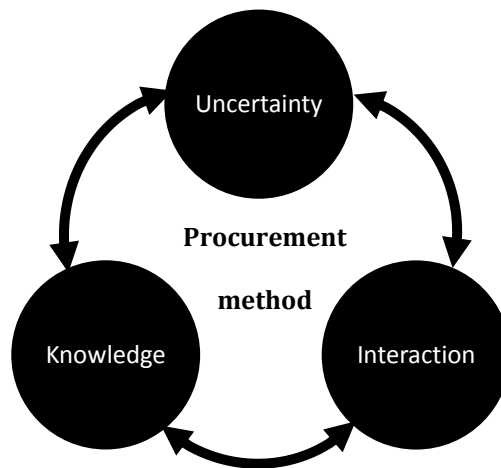


Figure 2. Illustration of theoretical concepts utilized to characterize project procurement method.

UNCERTAINTY

Projects are generally interpreted as temporary organizations exhibiting uniqueness and complexity, either originating from within the project itself or from the environment. An important negative consequence of these characteristics is uncertainty, the degree of which could vary considerably among procurement methods depending on type and amount of responsibility contracted (Winch, 2002). For the purpose of the current study, four types of administrative and technical uncertainties are emphasized: number of activities contracted, contract length, type of technical requirements and design methodology used.

Construction projects are often conceptualized as processes constituting a sequence of main activities, or phases, e.g. design, construction, maintenance and operations, the duration and order of which depend on the procurement method and contract type used. In the case of a client, the bundling of responsibilities into a new contract may result in significant unforeseen consequences, e.g. willingness of counterparts to submit bids or perform R&D activities. A contractor or consultant, on the other hand, may in a similar way resume responsibility for activities not previously performed, which may result in corresponding uncertainty requiring needs of contract clarifications, establishment of complementary agreements, and development of new administrative routines and even sub-organizations. Consequently, the greater the *number of the activities* involved in a given contract, the larger the uncertainty for the actors involved. Although often related to the number of activities contracted, the *contract length* constitutes a second major aspect of procurement methods since it may provide additional explanatory power as apparently similar project categories, e.g. unconventional DB projects, may be subjected to radically different contract lengths. In essence, the longer the contract time, the greater the uncertainty due to the need of optimizing a larger part of the total life-cycle costs of the project.

A third aspect concerns the *type of requirements* used in a given contract. Technical requirements can be defined at different levels of aggregation, of which the lowest level constitutes the so-called procedural specifications. These requirements are specific in the sense that they prescribe properties of components in great detail and how they are to be assembled, often without prescribing the physical performance of the final product made from the different components. On the other hand, so-called performance requirements require knowledge regarding the relationship between procedural requirements and performance over extended time-periods. Consequently, procedural requirements are considered to result in low uncertainty while performance requirements result in a higher degree of uncertainty for the actor responsible.

In order to present a technical design, engineers normally have to adhere to certain design principles, methods and models, normally integrated in legitimized design software. However, in cases where such institutions are not available, significant uncertainty may prevail for any actor responsible for costs of inadequate design due to future change, maintenance, operations or legal advice. Consequently, the cognitive activity related to *design methodology* used to determine structural build-up including materials and production methods to secure fulfilment

of requirements stated in a given project contract may constitute a major uncertainty. Hence, if design within a given project procured is supported by existing design tools or if knowledge regarding materials, structural build-up, production technique and technical requirements and their relations is great, the technical uncertainty is low and vice versa.

INTERACTION

The second concept of the model concerns interaction, i.e. the degree of mutual and reciprocal action occurring between human actors participating in business activities. In principle, interaction may range between the two extremes of pure arm's length relationships to deep partnerships. Interaction may also, as in the case of uncertainty, either be a direct cause or consequence of, or indirectly related to, procurement method applied (cf. Figure 2). Hence, a given procurement method may both provide prerequisites and consequences for interaction, e.g. prescribe with whom to interact and the number of formal meetings to be held. In the case of an indirect relationship, a given procurement method may provide a certain degree of uncertainty, which in turn results in interaction in the form of uncertainty identification, joint expert meetings and information search initiatives towards other project participants or projects. It is often argued in the literature that interaction is necessary to reduce uncertainty since it provides access to both problems and possible solutions in the form of interpretations of experiences and casual relationships between actions and outcomes (Cova et al, 2002; Engwall, 2003). Consequently, interaction is considered an important link between the characteristics of uncertainty and any knowledge gained (cf. Figure 2).

Interaction in project networks can be characterized in a number of different ways depending on the level of analysis and the phenomenon investigated. Due to the inherently complex character, neither all interaction nor all the interaction details can be given in a limited study. Therefore, the main aspects chosen to characterize the degree of intra-project interaction are restricted to *frequency*, *breadth* and *depth* of the relevant content exchanged. In this study, frequency denotes whether the number of formal meetings held are less or greater than normal. Interaction breadth concerns whether the information exchanged involves a limited (one) or relatively great diversity of information topics, e.g. contractual, financial or technical issues at once. In the case of depth, a distinction is based on whether the content is according to established administrative routines or technical standards (low degree) or if it goes beyond and into greater detail, e.g. by investigating non-standardized aspects (high degree). Since the interaction may change over time, it may for the purpose of a study be useful to subdivide a given project into phases where the interaction can be characterized in slightly more detail.

As indicated in the beginning of this section, the network lens is employed to observe the organizational phenomena by both characterizing individual projects as temporary networks comprising the main actors of interest (*intra-project interaction*), but also any resulting dependence among projects using the concept of inter-project connection. By interpreting individual projects as collections of relationships (Håkansson et al, 1999), the concept of connection is utilized to describe how project procurement characteristics affect project participants to establish connections to other projects. Interconnections may concern reuse of

technical, e.g. an old technical design, administrative, e.g. documentation systems, or organizational aspects, e.g. personnel from previous projects (Engwall, 2003). Furthermore, following the notation of sleeping relationships (cf. Hadjikhani, 1996), connections between actors involved in a certain focal project and other subsequent projects provide an interesting type of relationship, especially if knowledge developed in previous projects is reused and reactivated as a consequence of search activities, e.g. by exploring information stored regarding its performance. Consequently, *inter-project interaction* by the establishment of connections between a focal project and other, historical and future projects may be of interest as the number of explicit connections indicates that the focal project has potentially provided more knowledge to future projects.

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As in the case of the other two concepts, knowledge could, in principle, either be a direct consequence of a procurement method applied or indirectly related through the other two concepts. A procurement method already established in existing routines may both imply and require different knowledge compared to an approach not as established in any corresponding institutions (cf. Figure 2). As in the case of uncertainty, knowledge is categorized based on whether it is *administrative* or *technical*. The degree of knowledge gained is made with reference to exploitation and exploration (cf. March, 1994). Without making any further judgment whether any of the two modes is better than the other, exploitation is considered as a comparably low form of knowledge while exploration is considered as a higher form since it may require additional resources and commitments from the actors involved.

Administrative knowledge represents both project-specific information associated with capacities and costs of activities and resources of carrying out a given project, and more general aspects, such as development of new contract types, sub-organizations or routines. For example, to have read and adhered to a contract, and developed a contract where financial and/or technical aspects needed explanation is considered to have resulted in a low and high degree of knowledge, respectively. Another important category of contractual aspects concerns how to establish and interpret technical requirements. In the case that new information of costs associated with an existing production technique is gained by an actor, this knowledge is considered as being of comparatively low degree since it is in accordance with existing knowledge, but not necessarily known to that individual. New framing, e.g. simultaneous evaluation of certain aspects not previously performed, e.g. investment and maintenance costs, or financial and technical content, may represent an example of high degree of administrative knowledge gained.

Technical knowledge is associated with physical materials, production technique and the more cognitive category of design methodology. If materials used essentially are according to existing standards, the degree of knowledge gained may be of lower degree. However, the degree of knowledge gained may be high if new types of materials or production methods are tested, evaluated or implemented. Structural design can be made according to a standardized design tool, e.g. an existing computer-based model, or by developing a new approach which

better agrees with the context it is utilized. The former design approach is considered to provide a lower degree of knowledge than the latter. In Table 1, the different concepts and aspects suggested are summarized.

Table 1 Summary of characteristics and aspects emphasized in the study.

| Characteristic | | Aspect |
|-----------------------|----------------|--|
| Uncertainty | Administrative | <i>No. of activities contracted</i> <i>Contract length</i> |
| | Technical | <i>Type of requirements</i> <i>Availability of design model</i> |
| Interaction | Intra-project | <i>Frequency</i> <i>Breadth</i> <i>Depth</i> |
| | Inter-project | <i>No. of connections to past projects</i> <i>No. of connections to future projects</i> |
| | | |
| Knowledge | Administrative | <i>Contractual</i> <i>Financial</i> |
| | Technical | <i>Material/Production technique</i> <i>Design methodology</i> |

METHODOLOGICAL CONSIDERATIONS

Both main projects studied constituted sub-projects at a large infrastructure project outside Stockholm. The two focal projects chosen were selected partly due to data accessibility but also superficial similarity, e.g. concerning the, so-far, successful construction of relatively large road-infrastructure projects procured by one and the same client. The main reason for focusing on road projects is the opinion that roads may be considered as so-called repetitive projects while some road-related activities, at the same time, are significantly affected by procurement used. The choice of road projects also means that a number of actor categories, resources used and activities performed are similar in the two focal projects.

THE CASES

The first focal project represents a traditionally procured project, chosen to provide a contemporary picture of a typical construction project as a basis of comparison. The focal project of the second case is intended to represent a polar project to be contrasted with the first, traditional, project. In order to investigate whether connections were established from

the focal project of each case to other projects constituting the organizational context, each case also includes a number of historical and subsequent projects. These projects were to a large extent chosen based on whether they were mentioned during the interviews.

DATA COLLECTION METHODS

In the current investigation, three basic sources of data were used: literature studies, observations and interviews. The main bulk of interviews performed in both cases were conducted between June 2008 and October 2012 with 22 employees from relevant actor categories (mainly clients, contractors and consultants) of the two cases. The interviews were based on an in advanced supplied semi-structured interview guide where a list of topics and questions guided each interview. One of the more important issues during the study concerned how the theoretical concepts would be obtained from the empirical part. The concepts used to study procurement methods: uncertainty, interaction, knowledge, was each analyzed using the data collection methods presented in this chapter and the aspects given in Table 1. Using the content indicated in the previous sections, the two cases were analyzed first individually and then by comparing them to each other.

EMPIRICAL STUDY

This section introduces the two cases of which the first is based on a conventional DBB project and the second an unconventional DBM project.

CASE I - THE TRADITIONAL APPROACH

This case concerns a 4.1 km long four-lane highway between years 2001-2007 from design, to construction and until final inspection after entering service. The decision of the client to utilize the DBB approach for this particular project was rationalized by achieving adequate competition among contractors, by attracting as many bidders as possible, minimizing the time to realize the project due to an already long-progressed design work. The design activities were procured from a private consultant company. The two actors indicated already knew each other well from previous projects. In the case of road design, i.e. analysis and normative suggestions of structural build-up for the road pavement, the consultant established a standard pavement design using a computer program distributed by the road authority. Using this software, materials and layer thicknesses were determined in order to achieve adequate structural integrity during the specified traffic volume and life expectancy. The decision to use the particular pavement type chosen was also based on the relevant technical standards, which stated that the particular pavement type should normally be used, as in this case, where surplus of adequate rock materials prevailed. No alternative candidate pavement type, also complying with formal requirements, was ever considered. As customary, the design phase comprised a number of standard meeting categories including *assignment meetings* held monthly between the project leaders and managers of each organization to discuss comprehensive issues such as the scope of undertakings, production times, work routines, additions and alterations, and financial issues. A second meeting category, *technical meetings*, varied in occurrence but was in general held on a monthly basis between individual consultants of a particular department,

or departments, and the corresponding client specialists. The purpose of the meetings, involving more than a single technical area, was to inform other technical areas, while meetings within a technical area was held in order to discuss specific technical issues.

The tendering documents were provided by the client in February 2004 to 12 potential contractors. As soon as the documentation had been received, the contractor studied established a formal bidding organization comprising two quantity surveyors, a staff member responsible for administration, and a few purchasing specialists (on part time). Besides this conventional bid organization, a technical specialist responsible for interpreting technical requirements and to propose alternative bids was also involved on part time. The interaction within the bid organization occurred at five semi-formal meetings during the three month long bid period. Besides these meetings, most communication took place at close quarters by e-mail and personal contacts. The principally most important parameters for the quantity surveyors to determine were the time to perform each activity specified and the associated costs. In this case, the capacity to perform a given activity was largely based on personal experience of previous projects but also information provided by external sources such as subcontractors, material suppliers and equipment manufacturers. The main work of the purchasers was to gather information regarding prices from potential subcontractors and suppliers. In general, the prices offered by the potential sub-contractors and suppliers were mainly decisive in each procurement decision, since it would affect the single most important parameter in the main contractor's own bid, the total bid price to the client. The current project was not considered by the contractor to show any significant risks regarding site conditions and the nature of undertakings according to previous general experience.

In addition to the activities involved in establishing the commercial aspects of the bid, strictly according to the tendering documents, it was also stated in the tendering documents that bidders were allowed to submit alternative bids (propose different constructions or production method). However, in order to have an alternative bid evaluated by the client, it was up to the individual contractor to show that the alternative proposed was acceptable according to the transportation agency's standard technical descriptions. In short, the alternatives proposed by the contractor aimed at decreasing the amount of material in the pavement structure, and thereby the total production costs, a saving that was motivated by calculations using the publicly available design program.

The communication between the contractor and the client was formal as required by the Procurement Act and constituted public questions submitted by e-mail. After questions had been received and internally discussed by STA's specialists, the client published both questions and the corresponding answers in so-called supplementary tendering documents. Of the totally 22 questions asked by the contractor and its competitors, most concerned administrative issues.

Of the 12 contractors originally invited for tendering, only four bids were in the end submitted for evaluation in April 2004. Each bid was evaluated by STA based on a tendering sum according to the supplied bill of quantities. The lowest bid was submitted by the contractor studied, while higher bids (from 18 % up) were submitted by competitors. In addition to the main

bids all four bidders submitted a number of alternative bids. If the client had accepted the contractor's alternatives, the price would have been decreased by approximately 5 %. However, all alternative bids were rejected by the client based on the formal argument that they would result in a *too optimized design* (sic), which could result in increased maintenance costs compared to the original design.

As soon as the client and the contractor had signed the contract in June 2004, both actors continued their preparations for onsite construction activities. In order to manage the extensive on-site day-to-day operations, where individuals of the contractor organizations met face to face, the client project leader was assisted by a project organization comprising six specialists.

Although the main design work had been intended to be finalized when the contract between STA and the contractor was signed, certain design works still needed to be performed. More specifically, each time any other actor noticed that the existing design did not correspond to field conditions or requirements, the consultant had to revise their drawings and documentation taking the deviations into account. The deviations indicated often resulted in additional construction works, and consequently, additional costs for the client who was responsible in relation to the contractor for the design. Since the technical consultants did not have any office on site, the main design works were performed after meetings had been held directly with STA, normally without the participation of any contractors.

After an approximately four-week long planning period, the main construction activities were initiated by the contractors in mid-July 2004. The contractor's site organization comprised a site manager, staff devoted to quality, environment, work environment and economy. The production personnel were organizationally divided into five functions, corresponding to those of the client, with one to two supervisors for each category of ground/road works, rock works, water and sewage, bridges and asphalt paving works. Besides the organization indicated, a large part of the site organization constituted external suppliers and subcontractors.

Each subcontractor was only responsible for the undertakings agreed on according to the individual contract, and consequently, remained on site only as long as it took to perform the construction activities including verifications of the quality by tests or inspections. All materials used and production were monitored by means of laboratory and/or field tests. The results from the testing were later utilized during the final inspections to verify whether or not adequate technical quality had been delivered according to the requirements stated in the contract. Only a few minor exceptions beyond normal existed with regard to equipment, material and production technique used during the project.

As in the case of the previous project phases, several different types of intra- and inter-organizational meetings were held. Among others, significant efforts were made by the client to inform project participants and other stakeholders regarding the project and its progress. According to STA, a wide range of initiatives was taken and outcomes obtained from the current project of relevance for organizational learning. One example was the ambition of

providing opportunities for engineering students to participate on the construction site in practical or theoretical work.

Apart from a single joint meeting, the consultant only made sporadic appearances, primarily in relation to the client but also in some specific cases with the contractors when swift problem solving was considered necessary. The formal meetings strictly between client and contractor largely complied with the contract and comprised, besides work-safety, environmental and quality, mainly meetings which focused on production. So-called *Production meetings* were held regularly every other week where the progress of project activities was discussed. In so-called *project meetings*, held once a month, aggregated issues including information and economy were handled by the project leader of the client and the area manager of the contractor. All meetings followed a specified agenda and resulted in minutes that were signed by each party. Among the most important questions discussed during the meetings concerned the amount of alterations and additions. As previously indicated, no alternative design was ever accepted during procurement. However, although the client expressed interest in discussing alternative technical solutions during production, the pavement type originally established by the consultant was maintained.

When the construction activities had been finalized in May 2007, the principal site organization was disbanded and started to work on other projects. According to material presented by the client, the project was successful when it came to project delivery time, technical quality and total costs so far. Besides inspections on site, including the warranty inspection in 2012 few follow-ups and meetings have been held among the project participants despite an explicit intention. Most respondents state that only very few follow-ups have actually been performed to date, and in each case, the work has been solely internal and mainly concerning administrative, financial and environmental aspects. Furthermore, no particular effort has been devoted by any actor to the technical performance of the project. As a consequence, only limited information and experience from the current project has been utilized in subsequent projects. Among the reasons was the fact that it was neither explicitly required by the contract, nor motivated by it, to improve knowledge for the future. Later in 2010 and 2011, all actors were involved in a number of comparably far-reaching DB projects. According to several respondents, the current project did not have any particular impact on these new projects.

CASE II – THE UNCONVENTIONAL PROJECT

In the autumn of 2002, a formal decision was taken by client, STA, to realize the current project, a 7 km long road stretch, as a DBM approach. First, it was considered important to start and complete the construction works as soon as possible by early procurement of a contractor able to perform the design while at the same time constructing it, a consequence of an earlier time-delay. Additionally, there was also an interest from the client to test an unconventional procurement method, an argument aiming at improving existing procurement methods by applying incentives to competition based on technical quality and innovation. The arguments mentioned evolved around experiences made in some previous DBB and DB projects. However, substantial work was needed to developing the new procurement method

since the client wanted to achieve an approach that went beyond previous approaches. The extended contractor responsibility would not only concern design and construction activities but also to ensure the technical quality during a 15 year long maintenance and operations period. Such a long period had never been contracted for a road project previously in Sweden. The final procurement method would become an advanced form of DBM-contract, involving, among other things, performance requirements and an unconventional compensation model based on the fulfillment of the requirements.

The main part of producing the tendering documents was carried out in-house but with help of some external specialists. The work was supported by an internal reference group, comprising personnel with experience of large projects and unconventional procurement methods. For each technical area, both domestic and international specialists were engaged to develop appropriate requirements, i.e. the amount, type and scope for each construction elements concerned. In total, it took the client as much as one year to obtain a draft of the tendering documents. Afterwards, the client arranged meetings with potential contractors to discuss the approach. The technical performance was expressed by seven requirements for the road surface and was partly the result of experiences of previous DB projects. In addition to specified requirements, the tendering documents also stated that the pavement structure should be designed according to certain principles, including the use of an *established* technical description with the purpose of avoiding too radical and untested designs.

In total, 15 potential companies requested the tendering documents but in the end only three contractors assigned for pre-qualification by June 2004. In order to produce a bid, the main contractor studied gathered its most experienced personnel to develop competitive technical solutions. In addition to internal participants, the bidding organization also contracted an external consultant to perform road-related design activities. The comparatively large formal bidding organization comprised, besides conventional construction-related activities, also technical specialists as well as personnel experienced in maintenance and operations activities. Although many activities resembled those performed at traditional projects, it was apparent to the contractor that more aspects were necessary to take into account when the bid also involved design, maintenance and operations responsibility. For example, it was not obvious how to choose optimal designs, when performance specifications were applicable since the normal procedure was to developed bids based on existing documentation obtained from the client. Consequently, the bidding organization needed to establish a way to cooperate internally and to take advantage of the different competences when technical-financial optimizations were to be made to optimize a potential road design and financially compare it to alternatives. Therefore, the quantity surveyors met technical specialists to discuss type, amount and costs of maintenance and operations activities during the comparatively long contract period, which required a number of additional activities, meetings and analyses.

In the case of *structural* road design, the contractor decided not to use any external consultants but to keep the work in-house. This was largely due to the opinion that the external consultants were of limited use when it came to aspects not covered in any public

available standards: consultants only prescribe standard solutions that do not say anything about the future performance. Although significant freedom existed in the project, the tendering documents clearly stated that the design should be based on an established technical standard. Initially several different pavement designs were considered including unconventional structures consisting of so-called hydraulic stabilization (cement-concrete) materials. However, as the bidding activity proceeded such comparatively radical designs were gradually withdrawn, either due to too high uncertainties or difficulties to motivate them based on stated requirements and available models, which in turn might jeopardize not only the quality of the current project but also the future of the entire procurement approach. After a number of candidate pavement designs had been proposed, each was cost calculated by quantity surveyors, who in turn provided feedback to the technical specialists regarding the financial effect and further potential modifications. Although the choice resulted in a comparatively conventional structural design, it was not obvious whether or not the design actually would comply with the performance requirements specified, whether maintenance activities were needed and what the consequences would be for the different subsidiaries if the requirements were not met during the contract period. Since the performance of the road would be determined by the contribution of more than one internal unit, it was agreed by the contractor that the main responsibility for the design would be borne by the largest business unit. The reason was that existing design models are not accurate enough to predict the performance and that it in practice is difficult to sort out which actor is responsible for the inability to reach the requirements. However, the choice of using a conventional design made it easier to appreciate the joint risk. One measure taken by the contractor regarding the appreciation of performance was to evaluate the historical road projects; in particular the few DB approaches procured by STA during the 1990s. During their work, it became obvious that only very few roads had been thoroughly analyzed and publicly presented regarding their technical performance. In general, it was not possible to access corresponding results of previous DBB projects, not even those once produced by the contractor studied, due to difficulties of locating reliable documentation. Although a comparatively conventional design was chosen in the end, it was conceived appropriate to use state-of-the art technology when producing the pavement, including best available materials and production technique. This decision was based partly by evaluating results from a past unique comprehensive field test carried out in cooperation with the client. In total, the work of compiling the experience necessary of previous projects took approximately 8 weeks and required several meetings with internal and external specialists.

Besides the tendering documents supplied early in the procurement phase, in total 10 complementary tendering documents, based on questions and answers exchanged, were sent to the three contractors participating in the bidding. Of the total questions submitted, a large part concerned technical aspects which led to changes in the tender documents (as suggested by the numerous complementary documents). According to the contractor, the work of compiling the bid was significantly more extensive compared to traditional bids of the same monetary size. All three bids were considered to be well executed by the client despite no ground breaking radical solution. The commercial part revealed that there were only small

differences between the three bids concerning design and construction works. However, significant differences existed regarding the more unfamiliar maintenance and operations activities, which resulted in that the total bid price differed significantly (715, 792 and 825 SEK million). In March 2005, an allowance permit was released by the client.

In June 2005, the client and contractor had established their project organizations, which constituted 9 and 28 individuals, respectively, in all. As in the case of the other projects, the formal organization was divided into a number of blocks for concrete works, ground and road works, rock works and installations works. The subcontractors and suppliers referred to contributed strictly according to drawings and descriptions established by the contractor and its consultant. An important consequence of the procurement method was the need for two additional departments: *verifications* and *design*. The first function indicates the extensive work of convincing the client that adequate quality had been delivered. The second department, constituting two individuals, was primarily established to administer the work of internal departments and the external consultant. Several respondents confirm that the common workplace for the client and contractor facilitated communication. The consultant participating contributed a project leader and a number of consultants depending on the amount and stage of the work. A large part of the design work was devoted to conventional activities, i.e. producing drawings and descriptions for construction elements and work on site. However, although the design work in several ways resembled conventional projects, there were a number of significant differences as well. The consultant experienced that it was different to work directly for a contractor compared to working directly for the client as customary in DBB projects. Although possibilities existed to evaluate several potential, or use unconventional, technical solutions, a large part of the materials and production methods established were simply obtained from the client's standard descriptions. Also, it was difficult to exploit so-called active design (changing the design as more information was discovered on site). A reason was the limited time available to evaluate new solutions during the project, insufficiently physical presence on site and uncertainty regarding what deviations that were allowed in the contract.

The verification process of the technical solutions was intended to ensure that appropriate solutions were chosen to *likely* meet the performance requirements. In the case of the pavement structure, technical specialists of the client reproduced in detail the calculations of the contractor's corresponding specialists to verify the assumptions and calculations made.

The type and number of meetings between consultant and contractor were essentially the same as in the conventional projects. One of the first meetings involving the consultant was a joint risk seminar comprising representatives from all three actors. As for conventional projects, both smaller formal meetings, comprising personnel from one technical area, and common formal design meetings were held to discuss design and technical solutions. When it came to meetings for the technical area concerning the road, two individuals of the consultant met the corresponding technical client specialist on a couple of occasions to discuss road-related issues under the supervision of the contractor's technical coordinator. The number of

production and *project* meetings (between contractor and client) were formal, with a fixed agenda, and held in accordance with the contract, and showed several similarities to the corresponding meetings of conventional projects. However, besides the two conventional meeting categories mentioned, a number of less formal meetings were also held to communicate and discuss opinions regarding how the interaction between the two parties should progress as well as certain technical aspects. According to most respondents, the construction activities on site were in many respects conventional and complied with the design successively established. However, when it came to the construction of the road, which was a construction element subjected to the most extensive performance requirements, several measures beyond normal, including additional quality control efforts, were taken by the contractor in the field to ensure the high quality of the road.

After the construction activities had been finalized and inspected in October 2008, most actors involved in the project left the construction site and resumed working on new projects. Thereafter, the operations department of the contractor resumed responsibility for the project with the aid of a number of subcontractors. According to material presented by the client, the project was successful when it came to project delivery time, technical quality and total costs so far.

Although much knowledge developed in the current project was similar to conventional projects a significant amount of unique knowledge has been gained and used in subsequent projects. When it came to the consultant, several respondents suggest that significant experiences have been obtained from the project, in particular regarding the work relationship that has been useful in new assignments. However, although much individual tacit knowledge was obtained during the current project, only limited experiences were related to technical aspects, which is partly a result of lack of involvement in investigations and follow-ups regarding performance of historical projects. This lack has provided some problems regarding the ability to serve clients in future projects, in particular when providing normative suggestions for unconventional projects. For instance, when a contractor is formally responsible for design in a given DB project not necessarily requested that a particular standard should be followed, but that the total costs should be minimized, it has shown to be difficult to convince consultants that alternative design methodology and materials actually can be used but also that the consultants should commit themselves to consider such methods solutions. Several respondents verify this view and motivate the standpoint by that both competence and clear responsibility towards the remaining actors contribute to this behavior.

Many of the experiences obtained during the project were publicly communicated by client at meetings, a number of reports as well as books. Although not performing any thorough evaluation of the project after the construction activities ended, the project has still resulted in significant learning regarding procurement, knowledge that was brought into new projects, in particular a series of new road projects were launched in Sweden between 2008 and 2014. In these projects, knowledge from the current project regarding administrative, juridical and

technical aspects was utilized. Consequently, the client used knowledge to develop a concept to procure DB and DBM projects comparable to a type of standard.

Although many measures taken by the contractor during the present project may be considered as small, several respondents argue that the project has resulted in commitments and experiences that have been possible to utilize in new projects. For example, results have been presented in monthly written production reports and seminars during public seminars and internal project kick-offs. Another consequence was a decision to devote additional resources to large infrastructure projects procured during the years 2008-2014. Among these commitments were direct investments in certain special equipment useful for improving paving operations and measuring road performance. It was among other things decided by the contractor to perform continuous follow-ups of relevant projects to investigate their performance. One example of a project investigated in this effort concerned a certain project located close to the present project, namely the project presented in Case I, which constituted one of many DBB projects also evaluated. Using these measures, not only uncertainties and risks were intended to be quantified and managed, improved production control could also be achieved by measurements during production as well as illustrating the results to production personnel, and thereby improve individual dedication in daily work. Furthermore, the contractor utilized and further refined simple theoretical models developed during the current project as well as results obtained from the performance measurements carried out the years after traffic opening. These models were used during bidding for the new projects to predict technical performance and thereby compensating for the limitations of traditional design methodology. A fourth example of development concerns the cooperation between the different organizational parts. It successively became obvious that contractor's organization was not suited for handling very long contracts during which significant maintenance and operations activities are planned. In 2009, the need of a more structured way of working together with new road projects was manifested in a formal joint quasi-organization for storing knowledge gained during successive projects. Among other initiatives made was to integrate more R&D projects in future DB projects by dedicating resources to evaluate different technical solutions within the actual construction project. In 2010, it was decided that relatively radical new techniques were to be utilized in a large DBM project based on the confidence built up by experiences from previous projects, such as the current one.

ANALYSIS

This section provides the comparative analysis in order to explain similarities and differences between the two cases just described using the model previously presented.

UNCERTAINTY

The two focal projects investigated in this study were in many respects not particularly different but concerned the establishment of similar road infrastructure and involved essentially the same number and type of well-known main actors, resources and activities. Furthermore, neither project was considered by any actor involved to show any significant deviance from normal regarding tendered price, number of bidders, time to realization or

quality at final inspection (when the road was finished for traffic service). Hence, many of the characteristics often used to indicate project success and uniqueness suggest that both projects studied showed many examples of similarity. However, besides such general characteristics, the aspects chosen to characterize uncertainty in this study suggest that significant differences between the projects still existed.

The traditional project is considered not to show any particular uncertainty regarding activities contracted for either the contractor or the consultant. In particular, the design was procured separately from the consultant and the actual production on site was procured from a main contractor based on existing standard agreements of which the actors were well experienced. The DBM project, on the other hand, was in many respects unique in the sense that the client had to develop significant parts of the procurement method instead of relying on existing institutions. Although some unconventional road projects historically had been procured by the client, no project of this size involving construction, maintenance and operations activities and over such extended time in the same contract had ever been procured. In this case, both the client and the contractor became subjected to higher uncertainty compared to the traditional project. The consultant was still subjected to approximately the same low uncertainty as in the traditional project due to the firm reliance on established institutions and short contract time (with the contractor). The firm reliance on technical standards and the client's responsibility for the technical functionality of the product in the traditional DBB project resulted in low uncertainty for the contractor and consultant. The unconventional DBM project, on the other hand, relied to a great extent on performance specifications, which means that the contractor assumed higher uncertainty compared to in the traditional project. Although the client delegated much of the responsibility to the contractor in the DBM project, the client is still considered to exhibit comparably high uncertainty. However, since this uncertainty to a large extent is of contractual character, the remaining and actual technical uncertainty is considered as being relatively low. In the case of distribution of responsibilities between the contractor and assigned consultant, the two actors mentioned used different tactics regarding the uncertainty of the unconventional project. The use of company-specific materials and production technique, and theoretical models to predict technical performance against stated performance requirements suggest that the contractor assumed comparatively high uncertainty in the DBM project. Since the consultant worked in a similar situation in both projects, this actor is regarded to experience similar low amount of uncertainty. The main responsibility for the design methodology in the traditional project was the client, while the contractor represents the main actor responsible in the unconventional project. The uncertainty is considered as being at a different level as the traditional project only showed moderate uncertainty while the unconventional one exhibited a high degree of uncertainty since the former project was designed in relation to a general standard, also applicable to a wide range of projects, while the latter project should exhibit a particular performance of this unique project.

INTERACTION

In contrast to the established procurement approach of the DBB project, the unique situation of the DBM project provided incentives for the client to reduce both administrative and technical uncertainties. In general, the two cases often showed approximately similar interaction frequency despite that the meetings held could occur at different phases and times during the process. However, the unconventional project provided additional numbers of meetings which means that the overall frequency may be considered as slightly higher than in the traditional project. However, this conclusion may also be moderated by the fact that the project in question also is considered as the first of its kind to the actors involved. The traditional project showed a comparatively limited breadth of subjects discussed by the client and consultants at each time, while the unconventional project involved more multidisciplinary interaction. The traditional project also showed strictly arm's length exchange between the client and bidding contractors during procurement, while the comparably relational procurement process of the DBM project showed more evidence of involvement of a larger number of administrative and technical specialists as well as external consultants. The resulting difference in interaction breadth between the projects investigated is probably that the problems of the traditional project were distributed according to discipline and solved separately by different actor categories, while the problems of the unconventional project required that different competences and disciplines cooperated and solved them jointly (e.g. Håkansson and Snehota, 1995). Several differences also occurred after the procurement phase. In the traditional project, the main interaction occurred in accordance with formal institutions. The unconventional project, on the other hand, exhibited more interaction, by an additional number of meetings as well as meeting categories, where all three actors studied participated to a higher degree compared to the other project regarding joint aspects such as administrative and technical, and contractual and financial aspects within the same forum. Again, the difference in interaction breadth was partly due to the relatively higher uncertainty regarding roles and tasks and the need to incorporate a broader range of questions to solve the problem at hand. The actors involved in the traditional DBB project adhered to a higher degree to existing institutions than the actors of the unconventional project, which also affected the depth of interaction. In the first phase studied, the primary goal of the traditional project was to produce tendering documentation according to prevailing institutions. Consequently, no obvious benefit from providing the financial consequences of any technical alternatives were ever seen since the project was considered a discrete, one-off, project where short-term financial content prevailed. In the unconventional DBM project, the corresponding phase showed a completely different scope as it aimed at developing a procurement approach rather than simply exploiting an existing one, which required significantly deeper interaction among the actors involved.

The negotiated procurement of the DBM project, involving a large amount of specific questions and physical meetings, suggests that both administrative and technical aspects covered exhibited great depth compared to the traditional project. Since neither any established form of working nor technical standards, such as the ones normally used in

traditional projects, had to be complied with, an institutional vacuum appeared where new knowledge was needed. This is exemplified by the consultant's possibly deliberate strategy, or ambition with the relationship, of adhering to technical standards and not taking any responsibility for technical performance in relation to the other actors. However, the contractor acted in another way: the uncertainties regarding how to choose technical design and how it affected investment and maintenance costs resulted in interaction, which articulated uncertainties and potential solutions. The measures by the contractor to gain knowledge in order to reduce the uncertainties were not only based on existing routines but also by referring to theoretical models and empirical results of historical projects. The latter circumstance indicates the importance of connections between projects in unconventional procurement. In order to motivate technical solutions, it was even considered necessary by the contractor to re-evaluate the ontological assumptions regarding existing design models. It became obvious for the technical experts of the main contractor that a new design regime was needed since no available model existed that could reliably predict behavior in terms of expressed performance. The search for information regarding project performance resulted in inter-project connections, the equivalent of which could not be observed in traditional projects. In essence, while designers of traditional projects work according to professional responsibility when choosing a certain design, the corresponding responsibility in unconventional approaches has been considered to occur according to a sense of risk management (e.g. Fahmy and Jergeas, 2004). An interesting aspect related to the attempts related to reduce technical uncertainties is the empirical character of the search. Instead of primarily attempting to investigate theoretically advanced design models promoted, e.g. as found in scientific journals, the work was largely basic and devoted to understanding the fit between the client's new requirements and technical performance of historical projects. In principle, the conclusion follows the analysis of e.g. Cyert and March (1963), Kahneman and Tversky (1979) and Flyvbjerg (2006), where organizations deliberately attempt to reduce uncertainties by actions in form of adaptations to specific goals using simple search rules.

KNOWLEDGE GAINED

As is evident from the cases studied, both traditional and unconventional procurement methods may provide many opportunities to gain knowledge for any actor involved. A large part of the knowledge gained by the actors can certainly be considered as individual, tacit and concerning standardized, already codified, aspects of relevance in daily work. This concerned particularly individuals new to the task gained knowledge by experience accumulation (cf. Zollo and Winter, 2002). However, several differences existed between the two cases regarding knowledge gained by the actors investigated.

In the traditional project, the administrative knowledge of the client and consultant during the design phase concerned almost entirely aspects already existing in the form of informal and formal institutions. Not only were the actors involved aware of the institutions, they were also acting and learning within them (cf. Levitt and March, 1988). This result means that the knowledge gained to a large extent can be considered as being of low degree. This observation has been made in other studies, both from the international (Fahmy and Jergeas,

2004) and the Swedish construction sector (e.g. Styhre et al, 2004). The corresponding situation of the unconventional project is considered as radically different compared to the traditional project since the DBM approach resulted in extensive intra- and interproject interaction being needed. This was particularly evident in the case of the preparation phase regarding contractual aspects. The comparably high degree of knowledge gained by the actors is also considered to have been positively affected by the extensive articulation and codification (cf. Zollo and Winter, 2002), which also provided possibilities to utilize the knowledge in subsequent unconventional projects.

Knowledge gained was not only affected by uncertainty and interaction but also, in turn, affected uncertainty in subsequent projects, arguably even the type of procurement method subsequently utilized. The main reason for the higher degree of knowledge gained in the unconventional project is primarily related to the high degree of interaction, which provided access to more diversified, deep and explicit information. This finding can be compared to results presented elsewhere (e.g. Håkansson et al, 1999; Leiringer et al, 2009; Lind and Borg, 2011). Although significant financial knowledge is considered to have been gained in the unconventional DBM project, the results indicate that the consultant is the actor category that gained less. This result may partly be explained both by a lack of sufficient involvement due to that the contractor did not want to reveal certain aspects of importance for the bid, but also the limited uncertainty faced on this issue. Since technical issues in the traditional project to a large extent were predetermined based on existing requirements, no significant new knowledge of high degree is considered to have been gained by any actor. On the other hand, a high degree of knowledge was gained in the case of the unconventional project, in particular for the contractor who not only utilized and gained knowledge regarding the new materials and production technique used but also regarding how such knowledge can be utilized in design. The possibility to utilize such knowledge across project borders is to a large extent an effect of the inter-project connections that are manifested among unconventional projects due to the need of reducing uncertainties. The results of the current project suggest that the contractor realized both the needs and problems to organize and systematically obtain knowledge in order to be able to effectively compete in unconventional projects.

Table 2 provides a comparison between the two cases investigated. As indicated, there are some differences between the cases that appear as systematic. The generally low degree of knowledge gained is primarily considered an effect of the low degree of interaction breadth and depth, which in turn is associated with degree of uncertainty. Even though the client is considered to have faced a slightly higher degree of uncertainty than the two other actors in the traditional case, the degree is not regarded as sufficient to provide interaction and knowledge due to the firm reliance on existing institutions and large project portfolio. On the contrary, the high degrees of interaction and uncertainty of the unconventional project provided incentives for both the client and contractor to go beyond formal institutions, which resulted in a higher degree of knowledge.

Table 2. Summary of findings from comparison of the cases.

| Characteristic | Indicator | Procurement method | |
|-------------------------|----------------|---|--|
| | | Traditional | Unconventional |
| Uncertainty | Administrative | <i>Low degree for the consultant and contractor, while moderate for the client.</i> | <i>The client and contractor were subjected to a high degree, while the consultant experience low.</i> |
| | Technical | <i>Low degree for the consultant and contractor, while moderate for the client.</i> | <i>The contractor was exposed to high uncertainty while the client and consultant experienced low.</i> |
| Interaction | Intra-project | <i>Essentially dyadic, relatively high frequency, low breadth and depth.</i> | <i>High frequency, breadth and depth. Dyadic with some triadic tendencies.</i> |
| | Inter-project | <i>Few</i> | <i>Several</i> |
| Knowledge gained | Administrative | <i>Relatively low degree of knowledge by all actors.</i> | <i>High degree for client and contractor. Consultant gained high degree regarding contractual aspects.</i> |
| | Technical | <i>Low degree of knowledge gained for all actors.</i> | <i>High degree of knowledge for contractor while client and consultant gained low.</i> |

DISCUSSION AND CONCLUSIONS

The construction sector is often argued to show problems regarding efficiency and effectiveness, conclusions often drawn irrespective of the project procurement method used. The findings from the current study suggest that significant differences can exist between project procurement methods despite that many general characteristics, such as project delivery time, costs and quality, may not suggest so. It is also interesting to note that the procurement method chosen for each focal project studied was in both cases, at least, partly motivated by rapid construction start, an argument often only being utilized in favor of unconventional approaches. In the case of traditional project goals, both focal projects studied met expectations on delivery time, costs and technical quality. Consequently, the question of

procurement method requires that contextual aspects are understood in greater detail than the traditional characteristics emphasized in general project management literature (cf. Cova et al, 2002; Engwall, 2003) when analyzing advantages and disadvantages.

RELATIONS BETWEEN THE CONCEPTS OF UNCERTAINTY, INTERACTION AND KNOWLEDGE

A number of conclusions can be drawn regarding the three concepts studied. Although exceptions existed, the traditional case generally showed lower degrees of uncertainty, interaction and knowledge gained compared to the unconventional case. The unconventional project, on the other hand, resulted in significant uncertainty, which is considered to have positively affected the degree of interaction, in particular regarding detailed inquiries of administrative or/and technical character. One plausible reason for the higher interaction is that the actors needed information to reduce uncertainty within projects. Knowledge gained from traditional projects is primarily obtained and transferred through experience and to some extent by publicly revised institutions (e.g. STA technical documentation), which subsequently is learned by the actors, not necessarily during project works.

INTERACTION: TRANSACTION COSTS OR INVESTMENTS?

The extensive interaction in unconventional projects probably results in additional cost that ultimately is borne by the project in question. However, the rise of alternative procedures, materials and production methods within the unconventional projects studied show that the actors both utilized alternative solutions, which may both have reduced the price for the client but also resulted in a comparatively high degree of knowledge that could potentially be explored in the future. Although any quantification of such costs and benefits are difficult to establish with certainty, the results suggest, in contrast to other studies of unconventional projects (e.g. Leiringer et al, 2009; Borg, 2011), a relatively high degree of knowledge exploration (cf. March, 1994).

The study indicates that it is not only important for actors to manage uncertainty, interaction and knowledge during each phase of a given projects. In order to achieve sufficient competitive advantage on a market constituting a significant amount of unconventional procurement methods, it seems important to mobilize additional technical expertise, project- and risk management skills at a strategic level, as suggested by the higher amount of inter-project connections developed within the unconventional case. This is emphasized by the need of transferring knowledge from a project to the next, i.e. interpret a given project as an element in a sequence of successive projects (cf. Nobeoka, 1995; Hadjikhani, 1996; DeFillippi, 2001; Cova et al, 2002; Engwall, 2003). Consequently, while traditional projects adhere to logics of classical markets, low transaction costs and exploitation of knowledge, unconventional projects show several similarities to evolutionary theory where knowledge is successively accumulated as uncertainties are reduced by investments in the form of intense interaction.

NORMATIVE SUGGESTIONS FOR PROCUREMENT STRATEGY AND EVALUATION

The consultant appears as the actor that exhibited the lowest degree of knowledge gained, which is believed to be a consequence of limited uncertainty confronted and subsequent

interaction. The other two actors exhibited higher degrees of uncertainty, especially in the DBM case, which resulted in a higher degree of interaction and knowledge gained. It is therefore proposed that procurement strategy should reflect whether the actors are committed to invest in relationships and knowledge management since such commitments are important for achieving objectives long-term objectives such as lower costs, e.g. as measured by common project performance metrics. Consequently, the current study contributes to previous research by providing a way of characterizing procurement methods and how the concepts; knowledge gained, interaction and uncertainty, can be used to measure the effect of procurement strategy on the behavior of market participants. In the longer run, when long-term and more project data become available, it may also be possible to analyze trends in the three concepts discussed and even their effect on project performance, e.g. cost and quality, over time. Finally, if a client desires to increase the degree of knowledge gained while at the same time invest in more relational exchange by accepting higher degrees of uncertainty, a strategy of increasing the amount of unconventional procurement is recommended. However, while unconventional procurement shows some pros, traditional procurement also exhibit pros and a balanced mix of procurement methods appears a convenient intermediate way that reduces some of the problems of the construction sector.

CONCLUSIONS

- Traditional project characteristics (delivery time, cost and quality) are not sufficient to characterize project procurement methods,
- uncertainty, interaction and knowledge gained are proposed as important aspects of procurement methods when analyzing efficiency and effectiveness,
- degree of uncertainty affects and depends on interaction and knowledge gained.
- any choice of procurement methods depends on context, the desire to promote knowledge and the willingness to introduce uncertainty,
- significant differences between traditional and unconventional exist regarding uncertainty, interaction and knowledge gained,
- using different procurement methods may achieve a balance between knowledge exploitation and exploration to counteract general problems of the construction sector.

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