Decision Making Model by Specialty Subcontractors in Construction Project

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ABSTRACT

Specialty sub-contractors enter construction projects due to their expertise, possession of special machineries and skilled workers or both. Like other project based organizations, specialty sub-contractors gain their organizational knowledge during projects. However, experiencing specific limited tasks several times, in different circumstances, raises their level of knowledge over that of other parties and impedes knowledge deterioration over time. This organizational knowledge distinguishes them from other parties involved in construction projects. Despite their critical role in construction industry, specialty subcontractors have not received enough attention from academia. This study looks at the procedures of different knowledge that specialty sub-contractors acquire through their experience and the way they use it in their future jobs. This study proposes a decision making model exercised by the specialty contractors which differentiates events from routines. The model was validated through interviews with constructional professionals. This model clarifies the potential contribution of subcontractors in managing knowledge in different stages of construction projects.

INTRODUCTION

Project delivery in the Construction industry is a multidisciplinary and multiphase process, with different parties playing a variety of roles at different times. Such dynamic and complex procedures must be designed with adequate precision to avoid rework, cost overrun, hazard, delay, inferiority and defections with the product. Project design includes designing the project deliverables and their components, the temporary facilities and the construction process itself. Although design does not solely include decision making, decisions play a critical role in efficient design, as mentioned by Lewis (Lewis et al., 2007). Design consists of many interdependent decisions with knowledge about the technical process and object systems being an essential part of decision making (Eder and Hosnedl, 2010). Specialist contractors are of vital importance to the construction industry, decision making processes and their contribution to the total construction process can account for as much as 90% of the total project (Nobbs, 1993).
The terms “subcontractor” and “specialty contractor” have been used interchangeably based on the assumption that subcontractors provide specialist construction services (Arditi and Chotibhongs, 2005; Chiang, 2009; Hsieh, 1997) although some believed that specialty subcontractor is a subclass of subcontractors (Hsieh, 1998). Following the aforementioned judgment, this research does not discriminate between specialty contractor and subcontractor. Various compelling reasons such as financial benefits, workload pressures, human or plant resource constraints, and better efficiency (Thomas Ng et al., 2009; Elazouni and Metwally 2000; Hsieh 1998) can persuade the general contractor to sublet part of their work to subcontractors. But as Arditi and Chotibhongs (2005) mentioned “the general contractor will perform the basic operations and subcontract the remainder to various specialty contractors.” Specialty contractors (SCs) have a wealth of process and product design knowledge that they have primarily gained through past experience (Gil, 2001). This knowledge can help general contractor (GC), consultant, and other parties in making better decisions in different phases of the project.

These complex decisions have different options with constraints, and performance characteristics that may be subjected to uncertainty. They are also numerous and could be interdependent or dependent. Possible choices can be interacting with each other. Simon (1977) stated that because assessing all decisions jointly is too complex and unmanageable, project managers apportion the problem into manageable fractions. AEC projects can be broken down so that design decisions occur in a sequence of stages. The sequence starts with fundamental questions (e.g., building location) and are followed by detailed decisions (e.g., facilities) (Chachere and Haymaker, 2011).

Although these researches have significantly improved the understanding of subcontractors’ role in the construction industry, none attempted to integrate level on knowledge as a classification parameter. Consequently, the purpose of the current research task is to define a classification methodology for subcontractor involvement and decision making processes based on knowledge level. To that end, the proposed decision making model is validated through two interviews with experienced construction practitioners.

However, the section before this goes through some backgrounds on subcontractor classification and their contribution to the design process. “When do specialty contractors design?” is the question in particular that precedes the answers in the section afterwards. After looking at decision-making models, the common practice and classifications have been discussed in more depth and the need for further investigations has been suggested. The last section is a brief conclusion of this study accompanied with further works.

BACKGROUND

In this section, pervious classifications of subcontractors have been reviewed. It is believed that not all subcontractors make similar decisions. In differentiating among subcontractors, it will become clear which will be the best pragmatic way for their contribution in engineering and construction design as well as construction planning and management. As a whole, their responsibilities can be conceived and compared systematically.
Classification

Specialty subcontractors are responsible for variety of tasks during construction projects. Despite their important role, they have not received adequate attention from academia. Three main streams- namely subcontractor selection, buyer-supplier relationship, and their contribution in design process- can be seen in the body of literature about subcontractors. Different categorizations have been proposed based on different needs. Trying to make his previous classification (Hsieh, 1997) more comprehensive, Hsieh (1998) divided subcontractors into five groups: the system specialist, the specialty contractor, the trade subcontractor, the labor-only subcontractor, and the material vendor. Elaborate description of these classes is not available, although in his subsequent publications subcontractors that related to rebar work, concrete placement, welding, equipment operation, masonry, tile placement, and plastering were classified into the first group. It is clear that some of the aforementioned groups such as welding require skilled labor and this contradicts with the Specialty Contractors (SCs) definition by Tommelein and Ballard (1997). In their definition, SCs perform construction work that requires skilled labor from one or at most a few specific trades (e.g., electrical, plumbing, HVAC, roofing, iron work, and concrete) and for which they have acquired special equipment as well as specialized knowledge (Tommelein and Ballard, 1997).

More recently, Ng et al. (2009) divided subcontractors into two categories: (i) equipment-intensive subcontractors, and (ii) labor-intensive subcontractors. Subcontractors also can be classified due their disciplines, such as drywall-plaster, painting, mechanical, electrical, masonry, utility, flooring, elevator workers (Hinze and Tracey, 1994), excavator workers, masons, steel erectors, roofers, finish contractors (flooring, drywall), elevator contractors, mechanical contractors (HVAC) and electrical contractors (McCord, 2010).

All subcontractors are service-supplying to general contractors while some have good-supplying roles as well. Hsieh (1998) proposed that subcontractors’ roles are excluded to providing one or more of the following four types of services:

1. Design input
2. Bulk material supply
3. Components prefabrication/preassembly
4. Site erection service

According to adopted definition of subcontractors under the current research task, it is believed that subcontractors should perform service on-site while any combination of other activities can also be a part of their duty. As Tommelein and Ballard (1997) stated that off-site tasks such as detail drawings, vendor selection and so on are increasingly being done by SCs. One of these contributions involves helping the general contractors, designers, and clients with decision-making. Gil (2001) stated that the availability of specialty-contractor knowledge can aid designers in:

- Ability to Develop Creative Solutions
- Knowledge of Space Considerations for Construction Processes (Site design)
- Knowledge of Fabrication and Construction Capabilities (productivity estimation)
Knowledge of Supplier Lead Times and Reliability (equipment and material selection)

Although these decisions have different natures, they all can be critical for success of projects. Overall, the SCs’ contribution in decision-making depends on many factors like contract type, type of subcontractor, phase, and so on.

Approaches to SC Contribution in Projects

This literature proposed three approaches in coordinating with SCs. The first approach involves dictating the task and its details, such as competitive bidding for an excavation job or a rebar fabrication task. Typically, all the components of these tasks are known and the uncertainty level is low. The second approach is very similar to turnkey delivery method, in that the final product or service output is important. As with turnkey, the GC does not want to get involved in the process and is only interested in the final result, although there may be some restrictions. Pile driving or trenchless pipe laying are two examples for such approaches. In none of these two examples GCs get involved much, they stand back and watch the task to be done.

The third approach, which has been discussed frequently in last decade, involves the SCs in decision-making. This approach is based on prevailing ones in other industries which involve having the suppliers’ role emphasized in the production process (Womack et al., 1990) both in the form of Supply Chain Management (SCM) or the Industrial Network Approach (INA) (Bygballe et al., 2010). According to this class of thought, the collaborators work towards a joint goal, with involvement ranging in scope from an informal business relationship to a joint venture agreement (Dainty et al. 2001), which make the definitions unclear and in many cases the terms have been used interchangeably (Bresnen and Marshall, 2000; Bygballe et al., 2010). The Construction Industry Institute’s (CII) definition of partnering emphasizes the length of the relationship and the prerequisites for such a relationship:

‘’Partnering involves a long-term commitment by two or more organizations for the purpose of achieving specific business objectives by maximizing the effectiveness of each participant’s resources. This requires changing traditional relationships to a shared culture without regard to organization boundaries. The relationship is based upon trust, dedication to common goals, and an understanding of each other’s individual expectations and values.’’ (CII, 1991)

This integration could not replace the traditional practices as much as other industries, although there was great interest in this method (Winch, 2000) and likewise, in this paper, this approach is not recommended for every subcontractor. Depending on the type of service that a specific SC provides, they can participate in end product design, construction design, or construction management and based on their contribution, SC can be invited to join in different phases of the project.

Although many disciplines contribute in shaping the end product, the question is what they can offer during the design process or decision-making in general? For instance, if the design firm wants to design a framework for a project, engineers should spend significant time calculating the framework and its support while concrete SC may do not go through that much calculations. Given this, do the SCs perform the same amount of calculations or do they simply offer a solution based on
knowledge of similar cases and the available facilities? Additionally, do SCs intend to design and share their knowledge with other parties? The next section will seek answers to these questions.

**WHEN DO SPECIALTY CONTRACTORS DESIGN?**

In the aforementioned discussion, it was argued that different disciplines may contribute in different decision-making and design processes. This section provides a classification for SCs through knowledge by finding answers to several questions about SCs, such as: Are SCs asked for contribution in design or decision making in general? If so, what is the reason behind this invitation? Also, when they are invited what is their participation procedure? This paper looks at knowledge, experience, and uncertainty as three factors which can answer the aforementioned questions.

**Knowledge**

Knowledge ranges from explicit knowledge that can be codified (Vaast and Levina, 2006; Zander and Kogut, 1995) to tacit knowledge that is difficult to articulate (Berry and Broadbent, 1984, 1987; Nonaka and Von Krogh, 2009; Polanyi, 1962). As Gertler (2003) illustrated: "Tacit knowledge is difficult to exchange over long distance because it is heavily imbued with meaning arising from the social and institutional context in which it is produced, and this context specific nature makes it spatially sticky." They also defined information as "a message containing structured data" while a code is described as "structured data and the necessary instruction for its processing' and as "knowledge reduced to symbolic representations". According these definitions, SCs have two types of knowledge:

1. Codified knowledge (which is broken into knowledge about the end product and the construction process)
2. Tacit knowledge about the organization

There is a third class of knowledge, which is tacit knowledge about the end product and construction process. This tacit knowledge has not been transferred into explicit knowledge potentially due to political or economic reasons or a lack of interest (Janik, 1986). For example, an SC may have a patent which does not want to be revealed in detail. Additionally, some tasks are not very common and spending time to put them in words is not worth it due to said lack of interest.

On the other hand, some of the SCs’ codified knowledge is readily available for architects and engineer designers to access. For example an experienced designer typically knows about steel erectors, roofers, painting, and masonry while an electrical or mechanical engineer at a consulting firm will know about the same information as an electrical or mechanical SC about a typical construction project.

It seems obvious that SCs who have tacit knowledge, or explicit knowledge about end product, superior to consultants and GC, should be asked for contribution. To avoid confusion, it worth mentioning again that knowledge addresses within this context relates to supplying service not good or product. If a SC installs his product, the installation is important and the product is out of the scope of this paper. For instance, installation of several industrial boilers has given the SC the chance to know much about different brands their pros and cons. This SC can share his knowledge during designing the project, even before GCs get involved, with consultant, and owner.
Construction design has even more opening for SCs’ contribution. They are called SCs because they are specialist in doing their tasks. Therefore they can be helpful in designing the process and choosing the most appropriate techniques. On the other hand, construction management is what every SC can contribute in by sharing their organizational knowledge. Nobody can estimate productivity of a group of dry wall installer better than their superintendent. It is the same story for an earth moving team than themselves. It is simply because they know their machinery productivity and their team performance records. By being aware of such information GC and consultant will be able to estimate more precisely and plan more accurately. Following section discusses how SCs acquire this knowledge through direct experience.

Experience

Tacit knowledge is based on accumulated learning form passed experiences (Debowski, 2006). However, it is believed that this learning should be from direct experience and action (Chen and Mohammad, 2009). What each actively involved party experiences can be different from others based on his role. For instance, if a consulting firm had ten projects which needed intensive plastering, their knowledge about plastering process and planning has been increased. If in all assumed jobs the same SC performed the plastering, consultant firm would have some organizational knowledge about that SC which can help them managing the SC more effectively in the future jobs.

While some tasks like plastering, drywall, facilities are ubiquitous; there are some others that not prevalent such as trenchless pipe lying. GC or consultants occasionally need such a specialty. Since such tasks do not repeat the knowledge usefulness decreases because of its nature (Ingram and Baum, 1997). On the other hand executing similar tasks over and over again routinize these procedures in SCs’ organizations. If activities routinized as March and Simon (1958) stated “choice has been simplified by the development of a fixed response to a defined stimuli.” In another word when tasks are routinized, these tasks can often be executed economizing on limited cognitive resources (Becker, 2004).

Routines embrace the forms, rules, procedures, conventions, strategies, and technologies around which organizations are constructed and operated (Levitt and March, 1988). Although routines may looks like simple sequences, they in fact support complex patterns of interactions between individuals in the absence of rules, directives, or even significant communication. Moreover, routines apply important aspect of knowledge right at its application. For this reason, they are also considered as the building blocks of organizational capabilities (Dosi et al., 2000; Winter, 2003). These established organizational routines can help SCs in making decisions without spending much time communicating and coordinating. Conversely, there are occasions where decisions cannot be made just through routines and this is the topic of the next section.

Uncertainty and complexity

While organizational routines help SCs in making decisions, there is a higher demand for knowledge when decisions are made in presence of uncertainty and complexity. Anderson et al. (1981) defined uncertainty as “a situation in which there
are a number of alternative states of nature and one does not know which of them has occurred or will occur.” In complex space there are so many interacting causes and effects that predictions of system behaviors are subject to considerable uncertainty. DM will need to draw on her judgment, experience and creativity to make what sense she can of the situation, thus drawing on much tacit as well as explicit knowledge. As Grant (1996) stated Reliance upon high-interaction, non-standardized coordination mechanisms increases with task complexity (Perrow, 1967) and task uncertainty (Galbraith, 1973; Van de Ven et al., 1976). When dealing with difficult, complex or ill-structured situations, problems and decision-making tasks that are not easily addressed by a single professional alone, team application is necessary (Kululanga, 2009). However, Increasing usage of rules, routines and other integration mechanisms, reduce need for communication and reserve problem solving and decision making by teams to unusual, complex, and important tasks that increase the organizations efficiency (Grant, 1996).

This section was dedicated to how organizational routines develop when they are effective and when they should be replaced by team decision making. The next section is the decision making model which this research has proposed.

THE MODEL FOR DECISION MAKING

In the previous section, it has been illustrated that Subcontractors as well as other parties gain knowledge through experience. However, similar previous experiences help them to build organizational routines.

Therefore when SCs encounter new tasks that they have well established tacit knowledge about, the decisions are made without need for rigorous communication and coordination. It is as if all details and process designs have been done beforehand for the task. If they are not exposed to significant uncertainty or complexity they do not need new designs to be made as has been shown in Figure 1.

On the other hand, when the task has vital unclear aspects, and when its complexity is high (Grant, 1996) a switch from routine-mode to group problem-solving mode is made. Task-force teams are brought together specifically to do projects in a limited time period (Gersick, 1988). The assumption here is that for designing projects with high level of uncertainty or complexity, teams are formed. These teams can consist of managers or high experienced employees and are responsible for making decisions in execution processes. As a matter of fact, the design options are few. Comparing these options is highly impacted by previous experiences, positive and negative, and similar cases. For example, if a hydraulic pile
hammer had high performance in soft clay it is very likely to be chosen in the new project which has the same type of soil.

However, such problematic tasks will add to the organizational experiences (Argyris and Schon, 1978) and if repeated over time may become an organizational routine. As Grant (1996) stated “efficiency in organizations tends to be associated with maximizing the use of rules, routines and other integration mechanisms that economize on communication and knowledge transfer, and reserve problem solving and decision making by teams to unusual, complex, and important tasks.”

Model Validation
To verify the assumption during the model development, three interviews were done at two stages. Two of interviewees were SC and one was GC. The SC both agreed that the company does not intend to design. They also believed that for regular jobs can make decision himself while for more complex project a team in necessary. GC also approved that they don’t expect much design and in many cases he observed that decisions were made by project managers promptly.

CONCLUSION
This research brought knowledge from different fields, such as organizational behavior, decision making, knowledge management, and construction, to clarify the procedure of transforming experiences all the way into internalized knowledge and its implementation in decision making. It shows why different parties acquire different knowledge. The GC, consultants and SC should recognize what tacit and explicit knowledge they have and what they need for complementing their duties. The procedure and categorization help parties to collaborate more effectively and manage knowledge both inside their organizations as well as project team more productively. However, the model particularly helps the SC to clarify the decision making process within the organization as well as how to possibly improve it.

REFERENCES


