DEVELOPING A CONCEPTUAL FRAMEWORK OF FRAGMENTATION IN CONSTRUCTION

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ABSTRACT

Fragmentation is a well-known problem in construction and its influence on project performance and efficiency has been addressed by numerous studies. Despite of this recognition, there is still no precise definition of fragmentation in the literature. In this paper, we describe the development of a conceptual framework of fragmentation by identifying its underline construct and indicators. We argue that fragmentation involves two levels: fragmentation of construction industry and fragmentation of project. Both are related to team fragmentation, which can be measured by five constructs, namely: Level of Integration, Level of Coordination, Level of Collaboration, Project Boundaries and Spanning Knowledge, and Decoupling of Diversity. Each of these constructs can be determined by several measurement items, which are highlighted in this paper. Future study will test the framework empirically to determine the measurement constructs in the context of construction projects.

Keywords: Fragmentation of projects; construction; industry's fragmentation; boundaries

1. INTRODUCTION

The term fragmentation implies breakup of parts from the same kind of type into smaller and separated parts. In construction, the term refers to a lack of integration of project processes or entities. Fragmentation has a negative influence on project performance. It is an inevitable status in construction and is rooted in the nature of construction project. Forgues et al. (2009) cited the problems resulting from fragmentation into the following: lack of iterations in the design process, lack of consideration of constraints within subsequent phases, and lack of leadership and accountability. Fragmentation may cause variability of performance and productivity of projects, design clashes, omissions, and errors (Anumba et al., 2002; Baiden et al., 2006). Other influences of fragmentation include

eliminating learning and innovation solutions, and hindering knowledge production (Egbu, 2006; Hertog & Brouwer, 2001).To reduce the negative influence of fragmentation, Alashwal et al. (2011) referred to three solutions: utilizing information communication technology (ICT), utilizing knowledge management (KM) solutions, and motivating partnership and team integration. These solutions could reduce the negative impact of fragmentation and attain better learning and performance in projects.

Studies that discuss fragmentation in construction are vast (Anumba et al., 2002; Fellows & Liu, 2012; González et al., 1998; Langford & Male, 2001; Love et al., 2004b). However, there is no consensus of what fragmentation really is. Fragmentation in these studies was referred to as two cases: fragmentation of projects and fragmentation of the industry. On the other hand, factors that determine this notion are still not clear in the literature. Therefore, the purpose of this paper is to determine the variables that measure fragmentation, in an attempt to develop more precise definition of this notion. We propose a conceptual framework embraces the underlying variables of fragmentation in construction projects.

2. LEVELS OF FRAGMENTATION

The structure of construction industry can be determined by a large number of dispersed contracting firms and the usual separation of design from construction (Hillebrandt, 2000). Vlies and Maas (2009) described the industry's structure from the perspective of social capital theory. They argued that the industry contains little network closures and many structural holes caused by fragmentation and project-based contract. The relatively sizeable number of small construction firms makes the industry more segregated, while various players within a construction project escort the segregation of design and construction process (Vlies & Maas, 2009). Essentially, the characteristics of construction product determine this structure (Hillebrandt, 2000; Oragne et al., 2005). Characteristics such as delivery requirement that depends on a client, location dependency, and weather-influenced activities escort fragmentation (Hartmann & Caerteling, 2005; Langford & Male, 2001). Other criteria of project could also escort fragmentation including: high degree of product specificity (detailed plans and specifications), each project is designed to order, heavy, and most of its components are manufactured elsewhere (Hillebrandt, 2000; Lange & Mills, 1979).

Construction project as a temporary multidiscipline organization involves numerous stakeholders who collaborate with each other during the project life cycle (Dave & Koskela, 2009). The ad hoc relationship between these stakeholders and the statistic-based production escort

fragmentation (Dainty et al., 2005). Other factors associated with the nature of projects that cause fragmentation include the following: separation of design and construction process, lack of coordination and integration between various functional disciplines, and poor communication (Love et al., 2004b; Xue et al., 2005). More discussions on the characteristics of construction can be found in (Carassus, 2000).

Literature indicates two levels of fragmentation; the first is industry level or firm level, which occurs due to firms' segregation. The second is project level, which occurs due to disintegration of construction process and entities. Figure 1 illustrates the two levels of fragmentation. A third level appears at the organization level due to hierarchical boundaries between different functional units within the organization (Kofman & Senge, 1995).This level seems insignificant in construction as fragmentation of construction process is considerably deeper than the fragmentation of functional departments (Fischer & Tatum, 1997; Yates & Battersby, 2003). Thus, this paper is focusing on the industry and the project levels only.

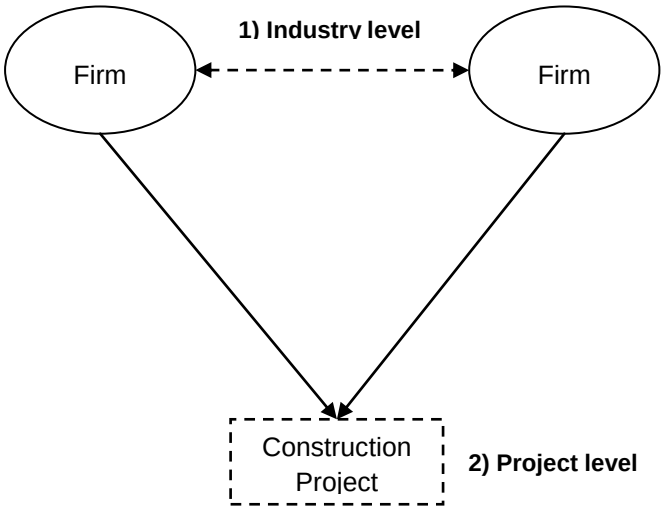

Figure 1: Levels of fragmentation

2.1 Industry level (firm fragmentation)

The construction industry is composed of a large number of small enterprises; it comprises multiple professions, occupations, and organizations to deliver the project (Garcia, 2005; Lange & Mills, 1979; Langford & Male, 2001). Ofori (1993, p. 12) stated that the construction

industry is characterized by a multiplicity of small firms and a few large ones, which is largely due to the nature of construction activities involving discrete projects that are dispersed, location-specific, varied in scale, and predominantly small in size. Thus, fragmentation of the industry level is related to increasing the number of small firms and decreasing their average size (González et al., 1998).

The construction industry can be described as fragmented if no company has a significant market share and is able to influence considerable outcomes within the industry (Langford & Male, 2001). Graham Winch indicated that fragmentation occurs when "the bespoke-integrated intra-firm networks are difficult to establish because of the relatively small size of firms […]" (Winch, 2010, p. 391).

In Malaysia, for example, more than 62,000 construction firms were registered with the CIDB (construction industry development board) (CIDB, 2011). Approximately 50,000 firms are considered small and medium enterprises - SMEs (under the categories G1, G2, and G3), representing about 80% of the total number of registered firms. Although fragmentation at this level can be viewed as an enabler of competition among firms (Langford & Male, 2001), but majority of these firms do not act together in such a way that can improve the performance of the construction industry as a whole.

According to Duffy et al. (2007, p. 462), SMEs own most of the skills and knowledge, but they are hindered by setbacks such as lack of funds to invest individually in research and development. This is accompanied by the dynamic and temporary relationship between construction partners and the various disciplines in these firms (Duffy et al., 2007). The temporary coalitions of stakeholders result in complex and detailed contracts, low trust, and adversarial relationships (Winch, 2000). Garcia (2005) emphasized on the importance of a network of SMEs to enable integration and innovation, and to foster the creation, dissemination, and valuation of knowledge in a frame of cooperation and confidence.

González et al. (1998) affirmed that firm or industry fragmentation may be interpreted as team fragmentation. They affirmed that fragmentation can be viewed as change in contractual patterns from employment relationship to market relationship, and "this qualitative change of contracts is a transfer of the entrepreneur's rights to other members of the team, who become entrepreneurs themselves. Thus, from this point of view, firm fragmentation is interpreted as team fragmentation" (González et al., 1998, p. 439).

2.2 Project level (production process fragmentation)

Fragmentation at this level implies lack of coordination, collaboration, integration, and poor communication between various functional disciplines and contractual partners (Bresnen & Marshall, 2001; Xue et al., 2005). Another aspect of fragmentation at this level is the inability of specialists and professionals to work together efficiently. Specialization can cause certain concomitant problem to knowledge sharing. Moreover, knowledge created in construction is, to a certain extent, "situated" and a sizeable body of experiential knowledge created in practice remains tacit and thus difficult to transfer (Demaid & Quintas, 2006). "Of course, as there are obvious benefits to be gained from specialization, fragmentation itself is not necessarily a problem […] However, it is precisely the problems associated with lack of integration that have long been the focus of industry, government and academic attention (from Emmerson to Egan)" (Bresnen & Marshall, 2001, p. 343). Hence, collaboration and integration of professionals can attain the benefits of specialization and enable better communication and sharing of knowledge. Another aspect of fragmentation at this level is the separation of design and construction stages. The function of the master builder was fragmented into designer and constructor specialties during the late part of the 19th and early part of the 20th century (Yates & Battersby, 2003).

2.3 Definition of fragmentation

The previous discussion implies that fragmentation essentially involves two dimensions: entities and process. Entities dimension of fragmentation involves disintegration of expertise, situated knowledge, and specialists' inability to work together efficiently (Demaid & Quintas, 2006; Hertog & Brouwer, 2001; Murdoch & Hughes, 2008). Process dimension of fragmentation involves the separation of construction process into several stages: initiation, design and planning, construction, and operation and demolishing. A vast divide exists between the design stage and construction stage (Baiden et al., 2006; Forgues et al., 2009; Oragne et al., 2005). Fragmentation of process influences fragmentation of entities. A good description of this case is 'over-the-wall' approach, where several participants work independently or in silos due to construction processes separation (Anumba et al., 1997; Anumba et al., 2002).

The current study follows the view of Bresnen and Marshall (2001); Xue et al. (2005); Love et al. (2004a); and Demaid and Quintas (2006) on fragmentation; it is defined as the lack of coordination, collaboration integration, poor communication, and diversity of specializations of contractual partners and various functional disciplines. Fragmentation here is a matter of degree rather than existence. Thus, the dimensions highlighted can indicate the level of fragmentation.

3. FRAMEWORK OF FRAGMENTATION

The purpose of this section is to identify the factors that determine/measure fragmentation. The current study is concerned about identifying latent variables that influence the level of fragmentation. Thus, factors such as project delivery process or project team features, including composition or size, will not be considered. The previous discussion about fragmentation implies a multi-faceted construct consisting of the following latent variables: level of integration, coordination, collaboration, boundaries, decoupling of diversity, and spanning knowledge across boundaries.

Integration of the construction project team is defined as the point "where different disciplines or organizations with different goals, needs and cultures merge into a single cohesive and mutually supporting unit with collaborative alignment of processes and cultures" (Baiden & Price, 2010, p. 129). Characteristics of integrated construction project team include single focus and objectives, diminished boundaries between individuals, and teamwork based on beneficial outcomes (Baiden & Price, 2010). Indicators of construction team integration were explored in the study of (Baiden et al., 2006). Approaches used to facilitate team integration include toolkit for integration, project delivery process, computer-integrated construction (CIC), construction collaboration technologies (CCT), computer-integrated framework for concurrent life-cycle design and construction (CLDC) (Anumba et al., 1997; Dulaimi et al., 2002; Koskela, 1992; Nitithamyong & Skibniewski, 2004; Vock', 2001).

Low levels of coordination and collaboration imply a high level of fragmentation. Ali et al. (2009) identified the factors that determine coordination during refurbishment of the design process, including lateral relationship, IT, interpersonal relationships, and the architect's role. The role of architect can be replaced by the role of coordinator to suit the current study's setting. On the other hand, collaboration of the project team can be determined by the following factors: common goal among firms, trust, self-governing teams, focus on end-user needs, and free exchange of information (Baiden et al., 2006).

Fragmentation can be affected by boundaries within construction project. Fong (2003) regarded three types of boundaries in construction projects: expertise boundary, hierarchical boundary, and cultural-related boundary. These boundaries influence teams' ability to exchange and integrate knowledge. Ratcheva (2009) identified three boundaries that hinder knowledge integration of multi-disciplinary teams, namely: project social boundary (boundary within the team); project knowledge boundary (boundary around the team); and project action boundary (boundary

across the project Ratcheva (2009) proposed knowledge integration process to cross these boundaries. This process termed 'boundary spanning' and can integrate knowledge across the three boundaries. Each type of boundary entails a different type of knowledge, including occupational knowledge, contextual knowledge, and project relevant knowledge (Ratcheva, 2009). The process of boundary spanning of the second type entails integrating two types of knowledge: occupational and contextual. During this process, the project team faces certain difficulties such as different meanings of members' knowledge and the manner by which they acquire such knowledge (Ratcheva, 2009). Enabling this process will affect the level of understanding among team members with different disciplines.

Construction project encompasses multi-disciplinary or multi-professional teams. Disciplines of the project team differ in terms of number of specialized individuals, territories, and epistemology (i.e., world of thoughts and functional departments) (Ratcheva, 2009). Diversity of project team members in terms of varying professions and specializations is not a problem per se (Bresnen & Marshall, 2001). However, diversity of knowledge may influence effective sharing process (Ratcheva, 2009). This can be referred as decoupling of team members' specializations or diversity. Decoupling of diversity can be determined by the following: participation of different disciplines in projects, adversarial relationship among team members, misconception and misunderstanding, design clashes, and omissions and errors, typically due to data fragmentation (Anumba et al., 2002). Table 1 summarizes the five components of fragmentation and their indicators.

Table 1: A conceptual framework of fragmentation in construction project

Components	**Variables / Indicators**	**Reference**
1) Level of Integration	Single team focus and objectives, seamless operation, mutually beneficial outcomes, increased time and cost predictability, unrestricted cross-sharing of information, team flexibility and responsiveness to change, creation of single and co-located team, equal opportunity for project inputs, equitable team relationships and respect for all, and "No blame" culture.	(Baiden et al., 2006)
2) Level of Coordination	Lateral relationship, information technology (IT), interpersonal relationships, and coordinator role.	(Ali et al., 2009)
3) Level of Collaboration	Common goal among firms, trust, self-governing teams, focus on the end-user needs, and free exchange of information.	(Baiden et al., 2006)

Components	Variables / Indicators	Reference
4) Project Boundaries and Spanning Knowledge	- Expertise boundaries, hierarchical boundaries, and cultural-related boundaries between professions - Project action boundary, project knowledge boundary, and project social boundary - Level of integrating two types of knowledge: occupational and contextual knowledge during the construction stage (sufficiency of information from previous stage). - Understanding information from other occupational or disciplinary team members	(Fong, 2003); (Ratcheva, 2009)
5) Decoupling of Diversity	Participating of different professionals in projects, adversarial relationship, misconception and misunderstanding, and design clashes, omissions and errors (due to data fragmentation).	(Anumba et al., 2002)

4. CONCLUSION AND FUTURE RESEARCH

This paper discussed the underlying factors and variables of fragmentation in construction. A framework of the notion was proposed including five factors: level of integration, level of coordination, level of collaboration, project boundaries and spanning knowledge across boundaries, and decoupling of diversity. These factors form the first attempt to conceptualize and measure fragmentation. In addition, the proposed factors facilitate measuring fragmentation in various construction projects. Measuring the level of fragmentation would determine its influence on other factors such as performance or learning. Furthermore, the measurement of fragmentation in different construction projects can help to identify the appropriate factors that mitigate its negative influence. For instance, projects with high level of 'Project Boundaries' would be advisable to focus on knowledge integration process and find ways to facilitate the understanding of information within the project team.

A future study will test the proposed framework empirically. The study will investigate whether fragmentation can be measured using the five proposed components. Factor analysis would determine the components of fragmentation by defining inter-correlated indicators. In addition, the analysis would identify the contribution of each indicator to the level of fragmentation. The study would conceptualize the notion of fragmentation through developing a measurement instrument of fragmentation in the context of construction projects.

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