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The need for the creation of knowledge chains in construction

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Abstract

Construction is a project-based industry and the construction supply chains generally work with a unique product in every project. Commonly, repeated project organizations are reconfigured for each project. This means that construction supply chains are characterised by adversarial practices and disjointed relationships, with the result that construction supply chain members generally have transient relationships rather than long term partnerships. A consequence of this is the lack of trust between construction clients, designers, main contractors and subcontractors. Because the construction supply chain works as a disparate collection of separate organisations rather than working together as a unified team, the supply chain suffers from lack of integration. Besides this, there is still an unwillingness to share knowledge between the supply chain partners, thus, there is poor knowledge flow. These characteristics of the construction supply chain are the main reasons of its low efficiency and productivity in project delivery. It is believed that construction supply chain management (SCM), when integrated with knowledge management (KM), can successfully address the major problems of the industry and its clients. There is a need for the development of appropriate systems to ensure the effective diffusion of knowledge such that each sector of the supply chain adds value to the project delivery process. This is expected to result in the creation of knowledge chains in construction.

This paper first reviews the current SCM issues of the construction industry and highlights the potential of KM research in construction SCM. It also argues for the transformation of construction 'supply chains' to 'knowledge chains' and identifies the key considerations for making this happen. The potential benefits of these are discussed at the end.

Keywords: Construction, supply chain management, knowledge chain, knowledge management

1. Introduction

Construction SCM can be defined generally as managing the process of knowledge flow, financial flows, materials, activities, tasks and processes involved within various networks and linkages (upstream and downstream) of organisations in order to develop high quality

construction products and services [1], [2]. SCM in construction includes principal contractors, subcontractors, suppliers, and distributors. The network of suppliers in the construction sector can be extremely complex, generally on a larger project the number of suppliers can be many hundreds [3]. As a consequence of this complexity, SCM becomes an emerging concept in the construction industry.

The main roles of SCM are managing operations to link successive operating stages through product flow; and transforming these operating stages into a single product by co-coordinating and controlling internal actions within these stages [2] The upstream of construction SCM involves a main contractor and consists of the activities leading to preparation of the production on site involving construction clients and design team, whereas the downstream consists of activities in the delivery of construction product and involves construction suppliers, subcontractors, and specialist contractors in relation to the main contractor. In the construction industry, there is a growing interest in the upstream supply chain integration however, the downstream needs a better investigation in terms of the supply chain issues [3].

A construction project includes various processes through the project lifecycle as procurement, planning, design, manufacture, construction, and facility management of buildings and other structures [4]. Therefore, cross-discipline coordination and knowledge exchange are crucial for these multidisciplinary collaborative processes [5]. However, in reality, the construction industry has many short-comings such as; being fragmented; lacking co-ordination and communication between organisations; creating adversarial contractual relationships; lacking client focus; perceived low productivity; and cost and time overruns.[6] [2] Moreover, there are serious SCM issues which affect the whole supply chain and decrease the productivity and efficiency of construction supply chains such as lack of partnering, integration, trust, innovation etc. To overcome these issues, in this research, the creation of knowledge chains in construction is proposed as a solution. The main aim of the research is to transform the supply chain to knowledge chains and by this way, enhancing the knowledge quality and quantity within construction supply chains and providing better integrated and innovative supply chains.

2. Current Management Issues of Construction Supply Chain Management

A construction supply chain is characterised by its generally unique product in every project, and repeated reconfiguration of project organisations for each project. This creates the instability and fragmentation, therefore, construction projects are treated as a series of fragmented operations without focus on long-term collaborative success [7] [8]. Besides this, industry is mainly based on price competition and organisational contractual arrangements depending on the complexity of projects [9]. Construction is characterised by project-based contracts and fails to develop long-term relationships between main contractors and key suppliers [10]. Consequently, customer-supplier relationships in construction are generally of the arms-length type rather than being strategic partnerships. Because of this, sub-contracting is generally provided by the lowest-price supplier with limited guarantee to future work [2].

Besides these short term adversarial trading relationships, industry suffers from poor information flows and remarkable distrust between clients, main contractors and subcontractors [11]. The culture in construction impedes innovation and makes this industry a slow adopter of supply chain information strategies [12]. Despite the fact that there is a growing interest in the issues of construction supply chains, there is still an existing need for change in construction supply chains in order to be more efficient and effective [11].

Based on a detailed literature review, SCM integration, partnering, trust, skill deficiencies, innovative thinking and KM are considered as the main issues that needs detailed investigation.

2.1 SCM Integration

The level of integration in construction supply stays as one of the major problems of the construction industry [1]. The key barriers to integration originate from the historical fragmentation of project delivery systems, and the adversarial culture of construction project relationships [3]. A fragmented and largely subcontracted workforce has increased the complexity of the construction supply chain and disabled the process integration [8]. Moreover, the relationships between the contractors and subcontractors are heavily based on price and competitive bidding [3]. In this context, the downstream of construction does not have longstanding, efficient supplier-contractor relationships [1]. A case study in SMEs of construction industry, performed by Dainty et al. [3] revealed that although there is a growing interest in the integration of the upstream of construction supply chain, however there is lack of interest and development in the downstream of the construction supply chains. Barriers to subcontractor integration in the supply chain can be defined as; late and incorrect payments, unrealistic project planning; traditional contracts which do not endanger good working relationships; lack of encourage on subcontractor integration in the main contractor organisations lack of knowledge and information sharing, lack of long term partnerships, lack of skills relating to design, legislation and costing and, lack of fair treatment on subcontractors by the main contractors [3]. For a well integrated construction supply chain all these issues should be investigated in detail especially in the downstream of construction supply chain.

2.2 Partnering

A case study by Fernie & Thorpe [13] revealed that SCM is considered to be synonymous with partnering by many practitioners within construction organisations. However, it can be concluded that partnering is an important subset of supply chain management. Egan [14] defined partnering as; “the involvement of two or more organisations working together to improve performance through agreeing mutual objectives, deriving a way of resolving any disputes and committing themselves to continuous improvement, measuring progress and sharing the gains”. In other words, partnering can be viewed as a relationship between organisations committed on common objectives and benefits to increase the overall performance of each organisations.

One of the most important problems of construction supply chain is the lack of partnering within the downstream relationships. In current construction supply chains, partnering is mainly focused on only developing collaboration in upstream relationships between regular and frequent clients, consultants and contractors [15]. Moreover, the aspects of context as workload continuity, and legitimacy of short term thinking impedes the partnering opportunities [13]. The lack of trust in the industry is another barrier to create partnerships. Although it was stated that even in the absence of trust, partnerships can be initiated and integrated [16], this kind of partnership will be open to conflicts and may easily end when the project is completed. Because of this distrust culture, many subcontractors who had not previously had partnering agreements were very sceptical that such an arrangement could succeed [10].

Construction industry is based on high degree of competitive bidding amongst its many different suppliers instead of having relationships based on common goals and benefits [10]. However; as stated in Egan's report [14], partnering is more than selecting the lowest price. Instead, it implies the selection on the basis of attitude to team-working, ability to innovate, and to offer efficient solutions. The benefits of partnerships in supply chains can be explained as; full communication with partners; working together rather than trying to take advantage; knowledge sharing; straight talking with no hidden agendas; rapid responses to queries; enabling partners to perform teamwork and interdependence; seeking continuous improvement through co-operation; willingness to change to accommodate partners; profit sharing on a "win-win" basis; and common interest in providing client satisfaction [10] This approach to partnerships clarifies that relationships should extend beyond the exchange of materials or services for a price and proves that partnering has a remarkable potential for better SCM.

2.3 Trust

Trust, being one of the most complex issues of construction supply chains, is a major requirement for successful SCM. However, in the construction industry, it is negatively affected by many factors such as lack of honest communications and reliability, and the problems in the delivery of the project [17]. Especially the relationship of SMEs with their potential partners suffers from a basic lack of trust. The degree of distrust is significantly high on financial issues. Especially, in the situation that the main contractors systematically take advantage of the financially weaker SMEs in withholding monies that were due for payment, distrust is unavoidable [10]. It is believed that current SCM process just try to enhance main contractor's profitability at the expense of other supply chain companies [3]. As a result of these, the culture of distrust is apparently dominant in construction industry.

To implement successful SCM in construction is only possible when a trust culture if flourished within the supply chain actors. Khalfan et al. [17] explains the ways to build trust as; sharing goals, having experience of working together, solving problems together, rewarding culture on trusted behaviours, fair working and reasonable behaviours in work environment. It can be concluded that a strategy to create collaborative working environment and appropriate training and education at all levels of the industry will be helpful to change this distrust culture [1].

2.4 Skills Deficiency and Attitude Change

As defined earlier, construction projects consist of huge number of different organisations from different disciplines. These organisations have to work together to complete a project over a long period. For effective communication between these organisations, the skills of interacting organisations should be compatible. There is a clear need to find out more about what skills already exist in the construction supply chain and how these might be improved to facilitate successful partnering in the 21st century [10].

The barriers of SCM in construction industry show that there is a demand to change for a better integrated construction industry. A cultural change within the industry may only be possible when the skills of the industry are assessed and a training strategy developed for the skill improvement. Especially the interpersonal skills, customer care, team building, business understanding and IT skills are the deficiencies that should be developed in the construction industry [3]. As long as these skills are developed and the culture is changed, partnering, long term relationships and better integration of construction SCM will be more achievable.

2.5 Innovative Thinking

In the construction industry, innovation has been recognized in three domains: product, process, and organisation, but, it is dominantly seen in terms of product, or material innovation. However, the strategic priority areas in construction as supply chain integration are not issues of design [18]. Innovative procurement initiatives in supply chains can promote the collaborative culture, long term relationships, team work, transparency, visibility of the future work with the existing clients and have potential to overcome the problems of construction supply chains [19]. Despite the fact that there is a growing interest in innovation in construction supply chain process, it is still at the developing stage. The adversarial culture firstly created by the clients and transferred through the main contractors to subcontractors is a strong barrier to innovation [20]. Knowledge can be regarded as a vital organisational resource and stays at the hearth of innovation. However the lack of knowledge sharing culture impedes innovation in construction [21].

Innovation has a great influence on supply chain performance, by improving quality, reducing costs, and speeding up the process, therefore it may become a 4th performance dimension for construction industry in the future in addition to the traditional dimensions, cost, quality and time [22]. Therefore, it will have a great potential to create effective and efficient SCM.

2.6 Knowledge Management

A critical issue in SCM is the effective management of knowledge through the project lifecycle. This involves the flow of knowledge within and between different sectors of construction supply chain as well as the accumulation, coding, and storage of knowledge in the

organizations. There is a heavy reliance on KM to manage the supply chain [2]. As a result, KM becomes the heart of construction SCM.

A typical construction project involves various tasks which are divided between professional and trade disciplines [6] [23]. There are numerous of distinct organisations working in a collaborative environment over long periods. The documents shared between these organizations vary from technical drawings and legal contracts to purchase orders, project reports, and schedules [12]. Within such a complex environment, knowledge flow and sharing is the backbone of effective communication of supply chain actors. However, the large number of organisations in construction and their complexity make it difficult to facilitate fluent knowledge flow and sharing [12]. Moreover, construction organisations have an unwillingness to rationalise their supplier and client bases and share knowledge and information within their supply chains [9]. Besides the tendency to keep knowledge, the nature of the construction projects is also a disadvantage for the knowledge sharing. Construction projects usually consist of temporarily designed teams from different organisations to produce a unique product. These team members are generally new to each other and have not necessarily worked together before. Thus, it is difficult to set up channels to exchange information and knowledge. In addition, lack of common goals make project participants focus only in their part and ignore the knowledge needs of their partners [12]. The commitment of participants to contribute to both individual and common benefits is the first step of knowledge sharing [24]. Moreover, because the organisations in construction industry come from different disciplines, the shared information and knowledge may not have the same meaning for the supply chain partners [6].

Because there are numerous documents in different formats that need to be shared between the organisations of different disciplines, the use of Information & Communication Technology (ICT) seems to be regarded as one of the main enablers of supply chain integration. ICT creates a platform to share information in order to improve supply chain performance among all of the players. However, in construction the effectiveness of ICT in a construction project is hindered by inability to share data in an electronic form between partners [25]. Moreover, there is skill deficiency in ICT within the construction organizations [10].

Briefly, lack of sufficient knowledge flow within construction supply chains, inefficient communication channels, inability to share information, lack of knowledge sharing culture and common goals can be regarded as the barriers of effective KM in construction supply chains. Therefore, a detailed study on these issues will help the implementation of successful SCM.

3. Transformation of Construction Supply Chains to Knowledge Chains

Construction supply chains are formed from various organisations which come together with their specialties and knowledge to complete a construction project. Each organisation contributes its knowledge in a form of people, processes and technologies, to the construction

process [26]. Therefore a successful supply chain is only possible when all organizations are linked to each other in terms of their processes, people and technology.

Knowledge Chain (KC) can be defined as a chain network based on the knowledge flows between various organizations with the aim of reaching a more innovative state for each organization [27]. A firm's knowledge chain shows the effectiveness of the management of its knowledge resources and the ability of the organization's to cope with its business environment. It also represents a firm's cognitive power for action: its capacity for recognizing, and acting on market changes and developments [28]. It is clear that the creation of strong knowledge chains not only enhances the final product but also can affect the whole business nature in a positive way. Because of this, transformation of the supply chains to knowledge chains is critical in terms of diminishing the issues of construction supply chain.

KC within a firm has four interrelated stages as given in the Figure 2. [28]

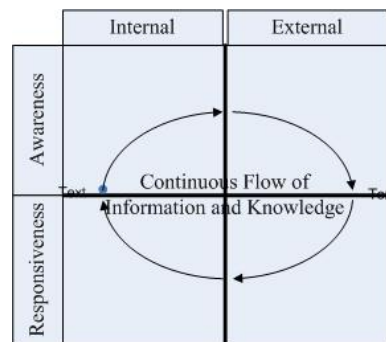


Figure 1 *Four stages of Knowledge Chain (KC) (Adapted from Spinello, [28])*

The brief definition of each quadrant of Figure 2 is explained as:

- External awareness is defined as the ability of a firm to absorb information and transform it into usable knowledge.
- Internal awareness is defined as a firm's understanding of its resources and a firm's ability to preserve and disseminate the knowledge.
- Internal responsiveness is defined as the ability to organize and marshal the resources to meet the needs of the market, take advantage of an economic opportunity, develop a new project/ product or cope with an apparent threat.
- External responsiveness is defined as taking the necessary steps to bring the product into the external marketplace and market it properly [28].

The most important part of this approach for organizations is the continuous flow of knowledge while dealing with business processes and competing in the evolving business environment. Since it never ends, the quantity of the information and knowledge becomes huge. When the complex construction supply chain composed of various organizations is considered, the only way for effective supply chain is; re-examining each organization's knowledge chains in terms of their awareness and responsiveness both internally and externally. There are some KC activities that should be done to increase the awareness and responsiveness levels. These are

three primary activities called Knowledge Conversion Process and four secondary activities called Function Management of Knowledge Activities as shown in Fig 3 [29].

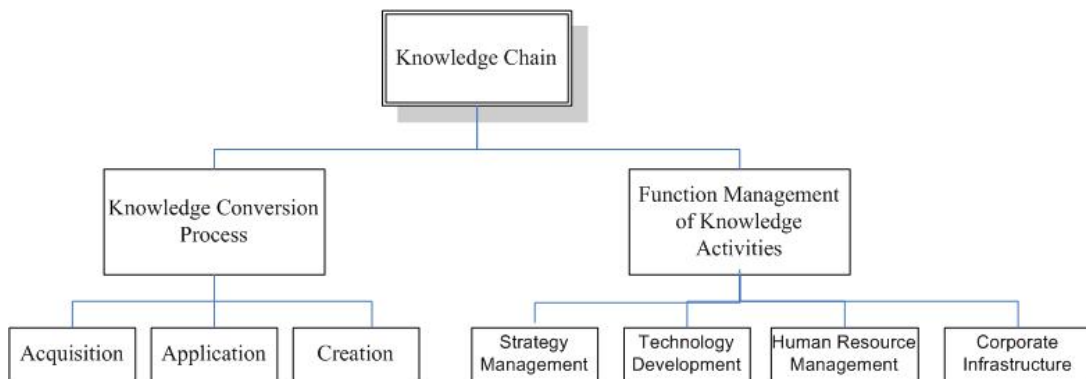


Figure 2 *Activities of Knowledge Chain Process*

These activities can be defined briefly as:

- **Knowledge Acquisition** activity comprises sub-activities such as identification, collection and organization activities;
- **Knowledge Application** activity comprises sub-activities such as distribution, diffusion, share and conversion activities;
- **Knowledge Creation** activity comprises sub-activities such as sprout, incubation and projection activities;
- **Strategy Management** comprises leadership and culture management;
- **HRM** comprises the improvements in the people side of KCs
- **Technology Development** comprises technology and tools management;
- **Corporate Infrastructure** comprises measurement, control, corporation, protection and other support for entire KC [29]

The main idea of this research is mainly based on the positive outcomes of these KC activities. It is considered that the flow and the diffusion of knowledge within the construction organizations will be investigated in detail with the application of Knowledge Conversion Process and this will be helpful to increase the quantity and the quality of shared knowledge between and within organizations in the supply chains. The increase in the efficiency of knowledge flow and diffusion and improvements in the links between the organizations can totally infect the efficiency of the construction process. As it is stated, “the more fluently knowledge flows as the organizations in KC maintain close link with each other, the more effectively does the KC operate” [27]. An effectively operating KC will also be an important step to create innovative supply chains. Function Management of Knowledge activities which provide a collaborative environment for fluent flow of knowledge are considered to be very helpful in the creation of common goals and strategy between the supply chain actors. This is especially an important step in the creation of partnering opportunities. Improvements in skill deficiencies of organizations by the HRM strategy can also support these partnerships since, compatible skills between two organizations provides better communication. All these activities

will increase the trust within and between the organizations and thus, will create better integrated supply chains. .

In Figure 3-4, a close look over the supply chain actors adopting SCM and KM through the knowledge chains are presented. As it is seen, the actors are aware of the knowledge conversion processes and there is a continuous flow of knowledge through upstream and downstream of supply chain. The possible outcomes of the adaptation of Function Management of Knowledge Activities are considered as; to support common goals and strategy between organizations, provide partnering opportunities, create knowledge sharing culture, increase trust, improve the organization skills and create compatibility for better communication. To make this ideal situation happen, in this research; as shown in Fig. 3-5 starting form the investigation of primary knowledge chain activities, the supply chain actors will be assessed in terms of their ability to acquire, apply and create knowledge. The main focus will be on the flow and the diffusion of knowledge during the knowledge conversion process. This study will be conducted by semi-structured interviews with construction supply chain actors. Main output of this investigation will be the main input for the identification of knowledge requirements of each construction supply chain actor. While investigating the knowledge conversion process, the function management of knowledge activities of organizations will also be examined in terms of their support to create knowledge chains. For the identification of knowledge requirements a case study for a specific project will be carried out. At the end, a framework for the transformation of supply chain to knowledge chains will be developed.

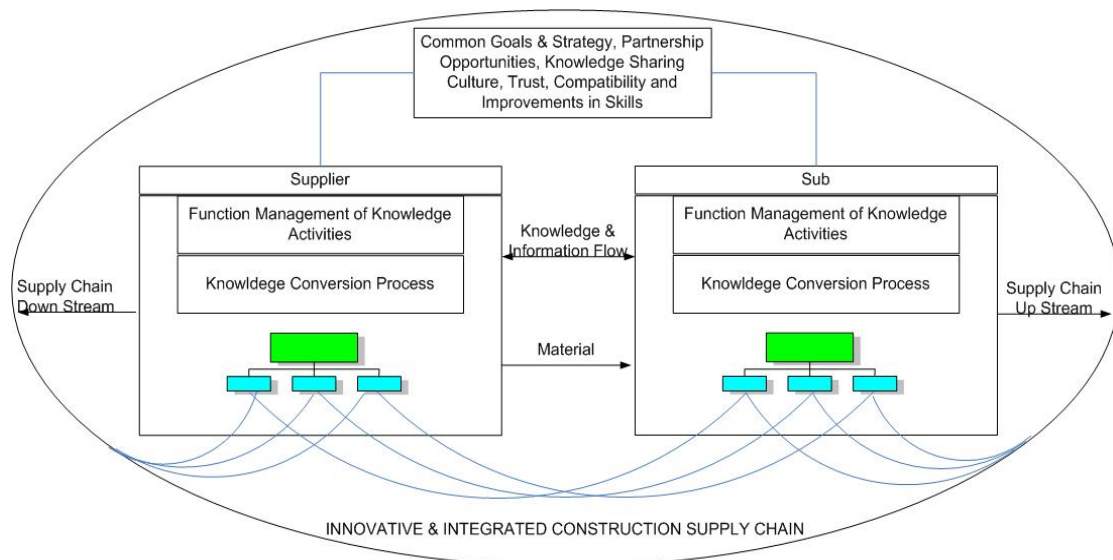


Figure 3 Supply Chain Actors Adopting SCM and KM, through KC Adapted from [30]

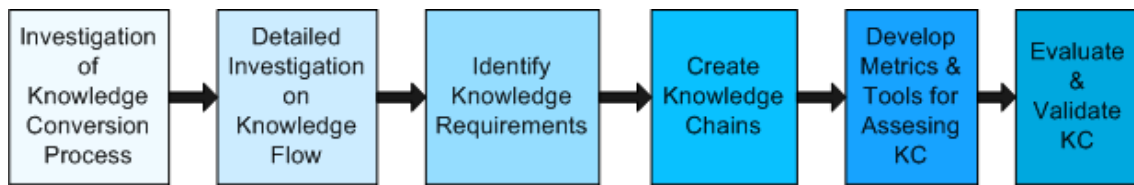


Figure 4 Research Outline on Transformation of SC to KC

4. Conclusions

In this paper, the current management issues of construction supply chain are clarified. The main problems of construction supply chain mainly come from the characteristics of the industry. Lack of strategic partnerships, distrust culture between partners, and fragmented supply chains create huge problems for the construction industry actors and make it less integrated. Because a typical construction project is one-of-a-kind, temporary, and involves different kinds of tasks divided between different organisations, knowledge flow between and within these organisations is very critical in terms of project success. However, there is insufficient knowledge transfer within and between organisations. The main reasons of these are, unwillingness to share knowledge, lack of commitment in common goals and objectives between actors of supply chain, and the adversarial culture of the construction industry. Inefficient knowledge sharing culture and lack of communication impedes the innovation required for value adding and competitive advantage. The skill deficiencies in organizations are a barrier for the innovative and collaborative construction industry. There should be compatibility between organizations in terms of what skills they have for a better communication.

All the problems defined for the construction supply chains are dependent on each other. As a consequence of the review of the literature, it can be concluded that creation of knowledge chains will directly affect the issues of construction supply chains. Therefore, KM based construction SCM is discussed as a solid solution to transform the supply chains to knowledge chains and changes the problematic nature of current construction. Creation of the KCs will support organizations in terms of their awareness about their resources and their business environment and improve their internal and external responsiveness. To make this happen, first the knowledge chain activities are investigated. Based on the literature review on knowledge chain, the outline of the research is presented. According to this, the supply chain actors will be investigated in terms of their knowledge acquisition, application, and creation. Especially, the two main factors, the knowledge flow and the diffusion will be investigated to identify the knowledge requirements of construction supply chains by conducting semi-structured interviews and a case study within construction supply chain for a specific project. Finally, a framework for transforming the supply chains to knowledge chains will be presented.

To sum up, the transformation of supply chains to knowledge chains are believed to:

- Providing sufficient and valuable knowledge transfer throughout the supply chain;

- Increasing trust levels between SCM actors by providing collaborative knowledge sharing environment;
- Supporting partnerships by providing collaborative knowledge sharing and trust culture;
- Supporting the innovative construction by increasing the quality of knowledge shared;
- Diminishing the skill deficiencies of different disciplines of supply chains;
- Thus, providing better integrated construction supply chains.

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