

Towards Supply Chain Maturity in Construction

Broft, R., Badi, S. and Pryke, S.

*The Bartlett, School of Construction and Project Management, University College London (UCL), 1-19
Torrington Place, London, C1E 6BT*

1. INTRODUCTION

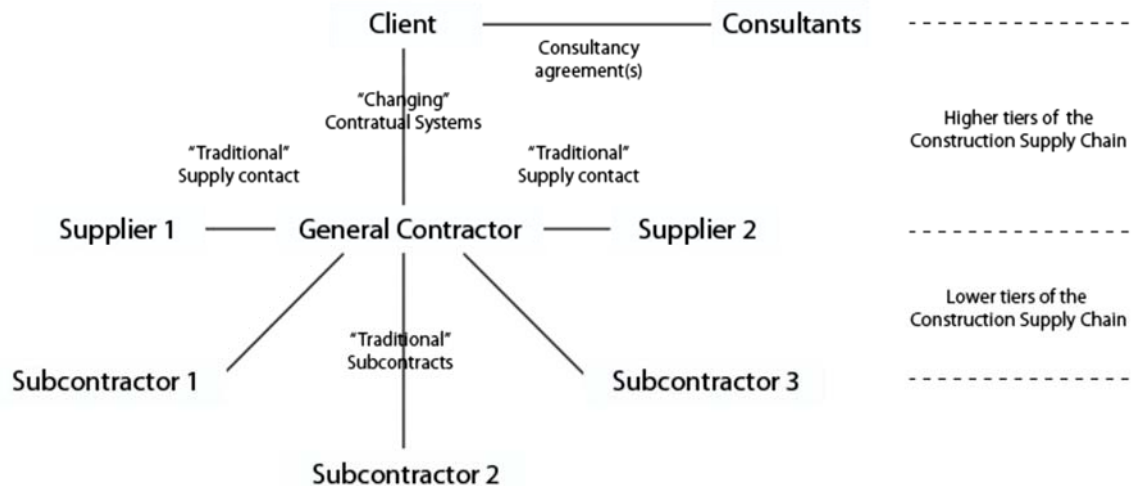
The construction industry is widely criticised for adopting highly adversarial and fragmented approaches to relationships, where design is separated from production and there is a lack of suppliers' involvement at the early stages of projects (Egan, 1998; Bresnen and Marshall, 2000; Chan et al., 2003). Although fragmentation originally occurred in response to highly variable workloads and subcontracting developed as a flexible way of dealing with these, it has resulted in complex contractual relationships and discontinuity of teams (Fulford and Standing, 2014). Several studies have underlined the need for radically different approaches to supply chain relationships that achieve 'customer delight' and minimise turbulence in stakeholders' relationship (Latham, 1994; Cox and Ireland, 2002; Pryke, 2009).

In response to UK government reports such as Latham (1994) and Egan (1998), criticising the industry, there has been a move towards better supply chain integration and the formation of strategic partnerships and collaborative agreements between supply chain actors (Akintoye et al., 2000; Holti et al., 2000; Briscoe and Dainty, 2005; Rimmer, 2009). In the Netherlands, following the large number of recommendations in PEC's final report (2003) and following the British vision on collaboration as described in 'Rethinking Construction' (Egan, 1998), suggestions were made for the agenda of the Construction Industry Advisory Council. This council was found to stimulate structural change, recover trust and normalise the relationships in the construction sector – one of the core themes involving customer-focus as a result of the integration of knowledge and systems in the supply chain, and teamwork (2007). All these approaches have been extensively adopted by parts of the industry as possible instruments for improving performance and inter-organisational relationships (Briscoe et al., 2004; Bemelmans et al., 2012; Meng, 2013). Arguably, these improvements are achieved through the adoption of a 'holistic' approach by focussing on the network of relationships between supply chain actors involved in construction projects (Pryke, 2009).

However, there remains a paucity of properly documented examples of successfully implemented SCM initiatives, particularly at the lower tiers of the construction supply chain (Cox and Ireland, 2002; Aloini et al., 2012). Construction projects are characterised by a high subcontractor/supplier involvement and rely heavily on subcontracting (Mbachu, 2008). Subcontracting has been adopted as the dominant procurement strategy as a consequence of the uncertainty faced by main contractors in obtaining continuous work and the need to accommodate the different, increasingly specialised and complex, requirements of each project (Tam et al., 2011). However, while several studies underlined the importance of main contractor-subcontractor collaboration (Kale and Arditi, 2001; Cao and Zhang, 2011; White and Marasini, 2014) opportunistic, arms-length and adversarial relationships are still prevalent among main contractor and subcontractor organisations (Greenwood, 2001). There appears to be a belief that existing SCM initiatives are adopted by contractors in order to increase their profitability at the expense of other members of the supply chain (Dainty et al., 2001). Where challenges arise, subcontractors and suppliers are often the most affected (Hillebrandt et al., 1995; Oviedo-Haito et al., 2014). Cost reduction was so often a crude exercise in reducing profits of subcontractors, and open book costing was frequently

abused causing the exploitation of commercial confidentialities associated with building a tender price (Holti et al., 2000). Despite the successful examples of SCM initiatives at the higher tiers of the construction supply chain, e.g. Slough Estate (Rimmer, 2009), relationships at the lower tiers seem to remain traditional (see Figure 1), confirmed by the urge for thick juridical contracts capturing agreements as detailed as possible.

Figure 1: Current Procurement structure.



This study sets out to explore the enablers and barriers to the implementation of SCM at the lower tiers of the construction supply chain, particularly the problematic collaboration between main contractors and subcontractors. Several studies have emphasised the need for collaborative relationships between main contractor-subcontractor organisations (Kale and Arditi, 2001; Cao and Zhang, 2011; White and Marasini, 2014). The aim of this paper is to extend the existing debates on the issue by adopting an alternative approach focusing specifically on the internal SCM organisation of both main contractor and subcontractor organisations, and their direct inter-relationships (Broft, 2012). SC Maturity levels are formulated according to relevant SCM concepts and based on Holti et al.’s (2000) seven principles of SCM organisation, and transformed into a conceptual model. This model is applied within the context of the Dutch construction industry and used to examine the relative SCM maturity of eight large main contractor and subcontractor organisations (Broft, 2012). This way the paper starts a discussion towards the development of a SC Maturity Model and brings up the need for an improvement framework.

2. CONCEPTUAL DEVELOPMENT

2.1 Supply chain relationships in construction

Construction is a complex systems industry, managed through projects involving multiple, temporary, and transient organisations (Kumaraswamy et al., 2005; Pryke, 2012). The largely sequential approach typically supports a lack of integration between design, construction and maintenance methods, leading to inefficiencies, inferior value and poor margins (Holti et al., 2000). A supply chain is described by Christopher (2005, p.17) as “a network of organisations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products

and services in the hands of the ultimate consumer”. In construction supply chains, the relationships required for the delivery of the constructed product among main contractors and subcontractors are often weak and difficult to manage (King and Pitt, 2009). This is largely as a result of the fragmented nature of the industry and its notorious dependence on subcontracting and competitive pricing (Morledge et al., 2009). Rapid technological development in both products and services has driven main contractors to adopt outsourcing strategies involving external suppliers and subcontractors rather than develop in-house capabilities (Cox and Ireland, 2002; Green et al., 2005). The low barriers to entry, proven by the large amount of small and medium-sized construction-related enterprises, is a characteristic of the industry that encourages fragmentation (King and Pitt, 2009). Competitive pricing is also promoted through procurement strategies often pursued by clients, such as design-and-build, which favours the lowest bidder (RICS, 2006). As a result of the industry’s fragmentation and prevalent competitive tendering, relationships are often opportunistic with contractors competing to win work through competitive pricing whilst reducing the quality of the end product in order to improve profit margins (King and Pitt, 2009). The consequences are poor production processes, limited ability or willingness to innovate due to lack of investment, late project delivery and budget overrun (Morledge et al., 2009). The ability to build collaborative relationships is also massively hindered by the prevalent adversarial relationships brought in by opportunism, lack of trust and inequitable allocation of risk. While subcontractors are often regarded as individualistic and only motivated by profit, contractors are viewed as opportunistic when it comes to winning bids, usually transferring risk to the lower tiers of the supply chain (Cox and Ireland, 2002). More often than not, it is clients rather than main contractors that take the initiative towards building good relationships with their supply chain.

2.2 SCM Concepts

Supply Chain Management (SCM) first appeared as a term in the early 1980s with its core concepts primarily originating from the Japanese automotive sector (Peck, 2006; Womack et al., 2007). It is a new way of thinking about management and processes, in order to coordinate supply chains more efficiently, by managing the associated relationships to deliver customer value, through innovation and continuous improvement (Cooper and Ellram, 1993; Christopher, 2005; Pryke, 2009; Blanchard, 2010; Fulford and Standing, 2014). Stadler (2000) defines SCM as “the task of integrating organisational units along a supply chain and coordinating materials, information and financial flows in order to fulfil customer demand with the aim of improving competitiveness of a supply chain as a whole”. Harland (1996) categorises SCM into four different levels:

1. The management of an internal supply chain integrating the activities of a firm;
2. The management of a dyadic relationship between two immediately connected suppliers;
3. The management of a chain of businesses with which a firm has no contractual relationship; and
4. The management of a network of interconnected businesses involved in the ultimate provision of a product to customers.

The interest in adopting SCM techniques has been growing in the construction industry since the 1980s (Segerstedt, 2010). The management of the different levels proposed by Harland (1996) is necessary as they form an integral part within a greater context: the supply network. Dainty et al. (2001) and Pryke (2009) describe SCM in construction as the management of the network of relationships within which firms are embedded. A holistic view is required for each of these levels to ultimately contribute to performance improvement and customer delight within the industry (Pryke, 2009). This contribution is fundamental in the creation of competitive advantage, which reflects the influence of efficient and

constructive network relationships on a firm's short-term financial position and long-term competitive power (King and Pitt, 2009; Van Weele, 2010).

Porter (1985) developed the concept of the 'Value Chain' which reflects the importance of a focus on value and relates to all activities, both inside and outside the firm that contribute to its delivery (Van Weele, 2010). Value creation has become a function of the network of iterative and transient relationships between actors that are connected – material and information moves back and forth, and value is created non-sequentially (Easley and Kleinberg, 2010). Management objectives have therefore moved away from the attention focussed on the finite domain of a single organisation to deliver competitive advantage. Attention is now focussed on ensuring competitive advantage for the integrated supply chain (Green et al., 2005). Lambert and Cooper (2000), and King and Pitt (2009) affirm the paradigm shift, stating that businesses no longer compete as a sole business entity, but rather in a 'supply chain versus supply chain' manner. Pryke (2009) states that the main objective of SCM is to enhance mutual competitive advantage and that this can be achieved through improved relationships, integrated processes and increased customer focus.

In essence, SCM is based on integrating supply chain actors to enable the sharing of knowledge and information (Holti et al., 2000; Christopher, 2005; Martinsuo and Ahola, 2010). Under traditional procurement, firms have the tendency to withhold vital information, such as those relating to risk (Gann, 2000). Edkins (2009) points out that such practice can hinder collaboration and prevent the establishment of trust and long-term relationships. SCM is based on a 'holistic' management approach by bridging the gap between actors, thus, providing the supply chain with the flexibility in adapting to changing client's needs, as uncertainties are reduced through the sharing of knowledge and information (Cox et al., 2006; Segerstedt, 2010; Marra et al., 2012).

From the preceding discussion, the potential benefits of adopting SCM approaches and developing long-term relationships are evident. However, implementing SCM is a long-term, complex process and requires a certain level of understanding and therefore learning throughout the supply chain. It also questions the functional structure of many organisations as these can impede effective collaboration internally and subsequently collaboration with its direct suppliers (Van Weele, 2008). In the next section, essential SCM elements needed internally within an organisation are outlined.

2.3 Towards SC Maturity in construction

Holti et al. (2000) offered an approach to managing supply chains that provides support to supply chain actors and encourages collaboration. One of the main concepts is that all supply chain partners have the potential to contribute to the aggregation of value (Holti et al., 2000) – all supply chain actors need to be able to make a full contribution to ensure that the client's needs are fulfilled and that value creation is maximised.

Holti et al. (2000) do recommend single point responsibility to the client and describe a collaborative model of overall leadership in achieving value for money, to effectively integrate supply chains. This integration knows two complementary senses: At project level – an integrated supply chain requires a productive balance of leadership of both the design and the construction or delivery processes – and over time across projects (Holti et al., 2000). This is deemed to be necessary as construction supply chains are fragmented, complex, highly uncertain and with many stakeholders, requiring a leading actor to coordinate the process and relationships (Holti et al., 2000). Pryke (2009) acknowledged the central

position that contractors play in the management of supply chains, offering great potential in this leading role. It is namely believed that contractors have more influence on the organisation of the project and on the performance and quality of the work of its subcontractors/suppliers (Latham, 1994). Despite the fact that they have such an important role in channelling client demand through their own supply chains, contractors are overlooked when it comes to research and useful advice (King and Pitt, 2009). Moreover, implementation of SCM by main contractors is relatively slow (Green et al., 2005) as SCM is often seen as a project-specific approach in construction rather than a central strategy such as in industries like aerospace and car manufacturing (Green et al., 2005; Womack et al., 2007).

Figure 2 illustrates Holti et al.'s approach (2000) which is based on seven principles, described as essential ingredients for a construction company to function in a SCM-driven environment. The first principle 'Compete through superior underlying value' is concerned with enhancing the value of what

Figure 2: The seven underlying principles (Holti et al., 2000)



is actually delivered by improving quality and reducing underlying costs. Members of the construction supply chain use their capabilities to collaboratively take the 'right' costs out in order to achieve competitive prices and mutual benefit. This requires a good understanding of the client's perception of value, in principle defined as a combination of a lower price and higher quality, and insight into cost components, the protection of margins, and the elimination of waste and inefficiency. This main principle depends on embracing the other six as a mutually reinforcing set. 'Define client values', the second principle, involves a more rigorous way of value assessment – client value being defined as a built-up and clarification of the functional requirements, the design character and the target through-life cost (TLC) profile for the desired building. The third

principle 'Establish supplier relationships' encompasses commitment to forming long-term relationships with a small number of suppliers in each key supply category around major and core-business, still allowing variety and flexibility for varying types of projects in varying regions. Essential are the project-independent characteristics and the need of commonly identified and clear business goals for the overall supply chain at the outset. 'Integrate project activities' is the fourth principle and describes a mechanism for the choice of strategic long-term partners through which effective management of the partners that collaborate on a project can be achieved. The goal is to resolve all design-related issues at key interfaces at an early stage by creating clusters and use concurrent engineering, with specialist suppliers involved early in the process to create commitment to subsequent phases. The fifth principle 'Manage costs collaboratively' employs a unique approach to dealing with and optimising costs, referred to as 'target costing', where suppliers work backwards from the client's functional requirements and the maximum market price for the item. Margins are then disengaged from risk allowances and costs through ring-fencing, providing the security to look at underlying costs. 'Develop continuous improvement' is the sixth principle aiming to achieve decreasing prices and/or improving functionality and value for future projects. It is a vehicle for achieving long-term performance improvement that cannot be achieved over

the life of one project and therefore, involves agreed long-term relationships where component and process costs are continuously reduced through systematic planning and process improvement. Lean principles and kaizen events are made a regular, reliable and long-lasting occurrence by taking control of the supply chain (Blanchard, 2010). ‘Mobilise and develop people’, the final principle, responds to the substantial cultural change needed in the construction industry in order to successfully implement SCM. This includes the mobilisation and development of employees through four key mechanisms: a visible, systematic commitment from the top, the facilitation for project teams, training in new skills and economic incentives.

The seven principles outlined above demonstrate that implementing SCM encompasses the recognition of essential SCM elements internally, within an organisation. The aim of this research study is to underline the challenges on the path towards becoming a well-functioning or ‘mature’ SCM organisation within an interdependent supply chain in main contractor and subcontractor organisations (Broft, 2012). For this reason Holti et al.’s (2000) principles are used as a framework and transformed into usable maturity levels, as will be explained in the next section.

3. RESEARCH METHOD

Given the exploratory nature of the study, a qualitative approach was considered the best-suited for this research (Blumberg et al., 2011). Data collection was largely based on primary data, which, building on Yin (2014), was gathered from semi-structured interviews with representatives from main contractor and subcontractor organisations. Four large main contractors and four larger subcontractors, operating in the Dutch construction industry, were included in the research (Broft, 2012). The participating companies, like most other European firms, had been confronted with a difficult economic climate, during the period of this research, characterised by increasing competitive pressures and profit demands. The research was limited to the managerial level of the companies and involved respondents with the responsibility of implementing SCM. Table 1 provides an overview of the participating companies and representatives.

Table 1: Overview of organisations involved

MAIN CONTRACTORS			
Name	Position	Company	Company Profile
Interviewee 01	(Ex-)Director Purchasing	Ballast Nedam (BN)	Building and development, infrastructure, services and specialist activities.
Interviewee 02	Director Purchasing	Royal BAM (BM)	Construction, mechanical/electrical services, civil engineering, property and PPP.
Interviewee 03	Director	Dura Vermeer (DV)	Construction, real estate and infrastructure.
Interviewee 04	Director	Waal (WB)	Housing, social/commercial properties, and renovation.
SUBCONTRACTORS			
Name	Position	Company	Company Profile/Comment
Interviewee 05	General Director	De Groot and Visser (GV)	Supplier/manufacturer of aluminium windows, facades, doors and blinds.
Interviewee 06	Business Leader	Geelen Beton (GB)	Precast concrete floor systems and other concrete construction elements.
Interviewee 07	Director	Trijsselaar Vermeer (TV)	Plumbing and sanitary installation company.
Interviewee 08	General Director	Berkvens (BV)	Manufacturer of the interior door/frame package.

A general group session was organised to introduce the process of primary research. This session clarified the exact research topic, refined the research aims and values, and shaped the following methodology together with the interested companies. It was decided to adopt a two-stage approach (Broft, 2012). First, a pilot study was performed prior to the main study in order to provide sufficient insight into the relevant context. This insight related to the concern arising from the literature review that effective and efficient relationships could be constrained by a number of intangible, rather abstract barriers; secondly, to understand the barriers to the implementation of SCM in the lower tiers of the construction supply chain. A series of eight individual open discussions was held to explore the perspectives of the companies involved with regards to their role and their partners' role within the SCM relationships and the existing barriers inhibiting integration and collaboration. Section 4.1 includes an analysis of the main challenges found during these discussions.

It was evident that the companies have several uncertainties regarding their own and their partner's position and role in an effective SCM collaboration. It seems that most barriers in the relationship flow from these uncertainties and that chain integration cannot be established when the parties involved are not integrated themselves. Therefore the conclusion was drawn that it would be beneficial to give the companies a system of self-evaluation as an indicator of SC Maturity and feedback to enable them to integrate internally and thus facilitate gradual and meaningful implementation of SCM within the entire chain.

The second stage of the research thus focused on the analysis of the current SCM status of all individual companies involved (Broft, 2012). The themes and accompanying questions for this analysis were derived from the seven principles that Holti et al. (2000) describe in their 'Handbook for SCM' as essential ingredients for an SCM organisation. Appendix 1 (Table 3) outlines the developed SC Maturity levels for each of these themes. These maturity levels were developed after the interviews were held, which means that the range of answers given by the participants influenced the five different levels established per theme. The highest maturity level represents the ideal elements of an SCM organisation according to Holti et al. (2000). Jointly, the current model provides a relative comparison of SC Maturity among participating companies rather than an absolute measure.

This relative comparison is used to differentiate between SCM elements, to compare the two different types of companies and relate this comparison to the different role perspectives, and to appoint the influence of the SCM ingredients to one of the barriers to collaboration (as described in Section 2).

4. RESEARCH FINDINGS

This section presents the research findings. It should be noted that the research findings have limitations presented by the chosen research methodology. The findings concern only eight main contractor and subcontractor organisations. Therefore, as Yin (2014) argues, the findings stemming from this type of methodology are merely hypotheses that need to be confirmed or rejected. In order to be representative of the industry, the research findings need to be tested using quantitative research.

4.1 Pilot study: Challenges in contractor-subcontractor relationships

The high interest of the companies for the research topic should be highlighted. They were equally familiar and enthusiastic about SCM and at the same time acknowledging problems in its application in their partnerships. All four contractors outlined rather differing examples of partnering initiatives,

attempts of implementing SCM elements and/or development of adjusted SCM techniques, during a varying period of time. Interviewee 02, BM, felt that some lack of success in implementing SCM was associated with the specific character of the construction industry – other industries, for example motor manufacturing, would allow more successful examples (Interviewee 08, BV). Interviewee 07, TV, related to the immeasurable character of SCM implementation. All parties expressed the will to cooperate but at the same time they all seemed rather reluctant to take the first step in accepting any compromises. They emphasised the distrust existing within the supply chain caused by fear of uncertainty and demonstrated by an opportunist way of thinking, and a hesitation to act openly and transparently. This was confirmed by the fact that current contracts reflecting this collaboration are mainly focused on juridical aspects (Interviewee 04, GV).

Communication problems cause a number of conflicts of interest, especially when partners are often changed (Interviewee 04, WB). Sound communication is also constrained due to internal (disciplines) and external (subcontractors) compartmentalisation (Interviewee 01, BN). Interviewee 04, WB, confirmed that this compartmentalisation, especially during execution, and hierarchy approaches often block cooperation between people. One of the subcontractors (Interviewee 05, GV) believed communication to be a risk that becomes greater with the existence of intermediate parties, such as contractors.

The contractors mentioned some problems in understanding the client's demand and translating this downstream (Interviewee 01, BN; Interviewee 04, WB). Moreover, they highlighted problems regarding cost calculations and risk coverage.

Potential for improvement in the role system seemingly lies within the contractor's role as contractors are the most significant risk carriers. Almost all subcontractors acknowledged this coordinating role of contractors (Interviewee 05, GV; Interviewee 06, GB; Interviewee 08, BV) and emphasised that the ideal role for a contractor would be to provide clarity regarding the client's demand and to perform a timely selection of subcontractors. They articulated that contractors currently seem to lack all specialist knowledge (including knowledge regarding logistics) needed to fulfil a 'linking' role (Interviewee 05, GV) and that price calculations were mainly performed without transparency and aiming to achieve the lowest costs possible – *"the contractor seems to pursue an inappropriate role that ignores openness, but rather involves a 'divide and rule' tactic"* (Interviewee 05, GV). In general, the choice for suppliers is made too late (Interviewee 01, BN) and can be 'random' (Interviewee 03, DV), a simple result of the type of construction (Interviewee 02, BM) or a result of a search for common business drivers (Interviewee 04, WB). The relationship that follows seems a trial and error process with problems with discipline and holding onto agreements (Interviewee 03, DV) – by subcontractors perceived as missing professionalism (Interviewee 05, GV). Subcontractors are expected to take certain responsibilities and to show more commitment.

4.2 The relative SC Maturity of eight construction companies

The analysis of the research findings is based on the developed SC Maturity Model which attempts to measure the SC Maturity level of the companies involved in the research. Emphasis is placed on the current characteristics of the organisation and its level in implementing SCM elements. The scores achieved in relation to the seven themes are summarised in Table 2 below.

Table 2: Overview of the themes and SC Maturity ratings

	BN	BM	DV	WB	GV	GB	TV	BV
General								
Insight into the construction supply chain	0	2	2	2	0/1	1/2	3/4	¾
Principle 1: Compete through superior value								
Insight into profit/turnover level	0	1	2	0	0/1	0/1	2	2/3
Value adding activities and wastage	-	0	2	2	1	1	2	2/3
Principle 2: Define client values								
Client's wishes and specifications	0/1	2/3	3	½	½	1	3/4	1
Customer delight	1	2	3	3	1	3/4	3	3
Principle 3: Establish supplier relationships								
Black box of subcontracting	0	1	1	3	½	1/2	2	2/3
Strategic partners	0	3	1	2	1	2	3	3
Principle 4: Integrate project activities								
Partner involvement	1	1	½	2	½	2/3	2/3	2
Integration of processes	0	0	2/3	2/3	½	2	2	2
Principle 5: Manage costs collaboratively								
Initial price	2	½	2	2	1	1/2	1/2	½
Risk management	1	1	3	½	0/1	2	2	2/3
Principle 6: Develop continuous improvement								
Continuous improvement	0	1	3	1	0/1	1	1/2	3
Principle 7: Mobilise and develop people								
Development of people	0	2	2/3	½	1/2	3	3	3

The individual ratings as shown in this table mirror the status of each participating organisation against Holti et al.'s (2000) ideal SCM organisation. The table shows scores that range between 0 and 3 and just occasionally reach higher than 3, for both contractors and subcontractors. As set out in Section 2, the construction industry is known to be a challenging industry for SCM implementation (Aloini et al., 2012). The ratings achieved for Principle 1, 5 and 6 are the lowest across the seven principles.

Principle 1 ‘Compete through superior value’ requires insight into the build-up of costs and clarity about ‘right’ and ‘false’ costs, however, this clarity seems to be missing. As Interviewee 02, BM, commented: “*The construction world is familiar with the concept of failure costs, but nobody knows how high these costs are or even what the real definition involves*”. Findings in relation to Principle 5 ‘Manage costs collaboratively’ reflect practices that favour short-term financial gains in the difficult economic climate currently facing the firms, such as non-legitimate risk transfer, contradicting SCM. Principle 6 ‘Develop continuous improvement’ was found to be a well-understood principle, however doubts exist on how to correctly implement it in an industry characterised by one-off projects. Some of the issues raised by interviewees were the difficulty of applying project-specific knowledge to other types of projects (Interviewee 01, BN) and the fact that knowledge, particularly tacit knowledge, often resides with people (Interviewee 07, TV).

4.3 A relative comparison of main contractors and subcontractors

In comparison between the two types of companies, it is easily noticed that Principle 4 and 7 are better exercised by subcontractors. Principle 4 ‘Integrate project activities’ encompasses the involvement of partners and the integration of processes and activities, which due to a subcontractor’s greater specialisation is found to be more straightforward to manage. For example, one subcontractor company depends on long-term strategic partners for 70% of their contracts (Interviewee 07, TV), another always works with the same supplier of sand, grind and cement (Interviewee 06, GB) or many of its partnerships involve commodities (Interviewee 05, GV). Principle 7 ‘Mobilise and develop people’ could be explained with similar reasoning as individuals are of greater importance in the delivery of actual value

in relation to their particular speciality. In addition, although the variation in scores is not high, it should be noted that main contractors, largely considered by Holti et al. (2000) as the leaders of SCM implementation, do not score particularly high in order to take up that role.

4.4 Effect on contractor-subcontractor relationships

Although the focus of this SC Maturity model essentially lies on the internal organisation of the companies, the data collected shows that a company's processes and activities are interrelated with the processes and activities of its surrounding companies. This validates a network approach, where each firm affects and is affected by the business environment of other firms (Pryke, 2012) and shows the impact of partners, or even the entire supply chain, on the individual implementation of effective and efficient SCM. In other words, the way in which an individual company implements SCM might influence the implementation of SCM in the relationship, chain and network. This refers to the first two related SCM uses as described by Harland (1996).

The individual SCM ingredients seem to be related to SCM enablers and/or barriers as discussed in Section 2. The findings indicate that Principle 3 'Establish supplier relationships' influences the basis for partnerships and the degree of trust, certainty and respect. Interviewee 02, BM, for example, spoke about the importance of reciprocity for a valuable partnership and Interviewee 04, WB, about the necessary equal perceptions on collaboration. In order for Principle 1 'Compete through superior value' and 5 'Manage costs collaboratively' to work, insight in relation to value, costs, risk and profit is needed which demands an increase in transparency and openness. This necessary increase is confirmed through examples such as improved discussions that take place when using self-developed sheets or checklists (Interviewee 07, TV), initiatives that develop during in-depth discussions of material use and processes (Interviewee 06, GB) and joint risk calculations (Interviewee 08, BV). Principle 2 and 4 relate to communication, demonstrated for example by how Interviewee 03, DV, values both client and partner sessions. Principle 6 and 7 relate to communication, commitment and a change of thinking. As Interviewee 01, BN commented:

"There is no truth in the construction industry. All projects are unique and therefore, an exception and each project comprises a new belief system and set of rules. This inhibits the recognition people are able to find in solutions that are offered to the industry."

(Interviewee 01, BN)

5. CONCLUSION

SCM can support the move away from traditional adversarial relationships prevalent in construction supply chains and provides an opportunity for the delivery of more value to clients. This value is derived through collaborative working, easier knowledge transfer and the creation of long-term effective working relationships. This study focuses on collaboration at the lower tiers of the construction supply chain, particularly the problematic collaboration between main contractors and subcontractors, and sets out to examine the enablers and barriers to the implementation of SCM at these tiers. All participating companies were found to be aiming at a similar outcome: performance improvement in order to create competitive advantage in the difficult economic climate they were facing. Despite their familiarity with SCM, and their enthusiasm and willingness to create the best environment in order to implement SCM appropriately, the construction industry was described as challenging with characteristics that obstruct successful implementation of SCM.

The developed SC Maturity levels proved to be valuable in reflecting the environment in which the participating companies attempted to deal with SCM, and to discover the particular elements that either enabled or inhibited SCM implementation. The seven principles by Holti et al. (2000) remained central throughout the entire research, described as essential ingredients for a construction company to function in a SCM-driven environment. Their approach involves single point responsibility to the client with a collaborative model of overall leadership in achieving value for money, to effectively integrate supply chains.

The investigation of SCM in eight main contractor and subcontractor organisations in the Dutch construction industry has shown that firms are faced with more barriers than enablers to supply chain management. Organisations were found to be particularly struggling to compete through superior value, manage costs collaboratively, and develop continuous improvement within their supply chains. The findings also underline the low SC Maturity of main contractors and their inability to play the essential role of supply chain managers.

The findings of this study have a number of important implications for future practice. First, the study may highlight the need for a greater degree of contractor leadership and improved internal organisation of both types of firms in order to achieve greater collaboration at the lower tiers of the construction supply chain. In addition, this paper lays the basis for further development of the SC Maturity model and the first steps towards changing it into a usable improvement framework that could be applied to main contractors' and subcontractors' SCM activities – a framework that guides companies towards successful implementation of SCM elements, extended integration and through this, a more collaborative relationship.

Finally, our findings provide several insights for future research. Research is currently being undertaken in order to quantify the different levels of SC Maturity, including metrics for 'best-practice' to establish some measure of absolute values for SC Maturity and to guide construction companies better in their growth towards this SC Maturity.

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APPENDIX 1: An SC Maturity Model

PRINCIPLE 1: 'COMPETE THROUGH SUPERIOR VALUE'

Insight into profit/turnover level	
0	No insight
1	Information related available
2	Engagement in discussions
3	Involvement and contribution to this level
4	Reciprocal contribution to this level

PRINCIPLE 2: 'DEFINE CLIENT VALUES'

Client's wishes and specifications	
0	Client's wishes and specifications received
1	Direct contact and discussion with direct client
2	Direct contact and discussion with final client
3	Wishes and specifications openly communicated through to partners
4	Wishes and specifications openly discussed with client and partners
Customer delight	
0	Customer delight is not considered
1	More is done to discover the real wish of the client
2	Value is reviewed
3	Customer delight is considered
4	Investment in customer delight without direct benefit

PRINCIPLE 3: 'ESTABLISH SUPPLIER RELATIONSHIPS'

Black box of subcontracting	
0	Criteria for subcontracting do not really exist and are not shared
1	Criteria for subcontracting are established
2	Criteria for subcontracting are project exceeding and based on best project outcome
3	Criteria are shared with all partners
4	Criteria are sustainably applied and in line with commonly identified goal of supply chain
Strategic partners	
0	No distinction is made between strategic/key and normal partners
1	Awareness of distinction exists
2	Long-term partnerships are established
3	Strategic long-term partnerships exist
4	More than one strategic long-term partnerships exist within each key supply category
Power leverage	
0	Power and responsibilities shift all the time

PRINCIPLE 4: 'INTEGRATE PROJECT ACTIVITIES'

Partner involvement	
0	Partners are not involved in the process
1	Partners are involved in the process
2	Partners are involved as soon as own involvement starts
3	Partners are involved before own involvement starts
4	Partners get involved as cooperating construction supply chain
Integration of processes	
0	Processes are not integrated and many problems occur at interfaces
1	Internal processes are aligned with company's strategy/goals
2	Internal processes are integrated; problems related to external non-integration
3	External processes are integrated; simultaneous/concurrent engineering
4	All processes are aligned with strategy/goals of construction supply chain

PRINCIPLE 5: 'MANAGE COSTS COLLABORATIVELY'

Initial price	
0	No commitment to initial price; initial price unrealistic
1	Initial price realistic, based on information received; occasional claiming
2	Competent people and/or partners are involved in improved price calculation
3	Construction supply chain tries to stick to initial price; transparent price calculation
4	Target-costing approach in construction supply chain
Risk management	
0	No awareness of risks; risks are transferred as much as possible
1	Awareness of risks; risks are transferred as much as possible
2	Awareness of risks; (some) risks are absorbed
3	Risks are discussed with partners; (some) risks are absorbed
4	Risks are actively managed and avoided

PRINCIPLE 6: 'DEVELOP CONTINUOUS IMPROVEMENT'

Continuous improvement	
0	No continuous improvement
1	Activities on continuous improvement exist within company
2	Awareness of activities of partners on continuous improvement
3	Involvement in partner's activities on continuous improvement
4	A jointly appraisal scheme of targets related to continuous improvement exists
Standardisation/Specialisation	
0	Standardisation in certain formulated product niches

PRINCIPLE 7: 'MOBILISE AND DEVELOP PEOPLE'

Development of people	
0	No commitment
1	Awareness of people's experiences and commitment within company
2	People are informed and involved in the company's development
3	People are actively developed
4	Construction supply chain is used in the development of people