Who should be leading in the process of successful SCM implementation in construction?

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Abstract

Despite the critical role of a client in enabling supply chain integration, parties on the supply side of the construction supply chain – the lower tiers of the construction supply chain – are believed to be able to develop into more integrated production systems, independently from the demand. Main contractors are acknowledged to have a central position in the management of supply chains, offering great potential in the effective integration of their supply chains. 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 – projects are characterised by a high supplier involvement. This study sets out to explore the differences between the organisations involved at the lower tiers of the construction supply chain, focusing specifically on the internal SCM organisation of main contractor and supplier organisations, and their direct inter-relationships. SC Maturity levels are formulated according to relevant SCM concepts and based on Holti et al.'s (2000) seven principles of SCM organisation, and used to examine the relative SC Maturity of eight large main contractor and supplier organisations within the context of the Dutch construction industry. A case study, representing a construction supply chain initiated by a main contractor as a result of ongoing poor financial performance during the economic crisis and the existence of high failure costs, is further investigated to examine the SC Maturity levels based on one of the principles in more detail. This way the paper starts a discussion towards the development of an improvement framework and brings up the need for a more mature supply chain integrator, an organisation leading in the process of SCM implementation.

Keywords: SCM, Supply Chain Maturity, main contractor-supplier collaboration, construction supply chain, leadership.

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 & 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 & 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' relationships (Latham, 1994; Cox & Ireland, 2002; Pryke, 2009) and there has been a move towards better supply chain integration, and the formation of strategic partnerships and collaborative agreements between supply chain actors since (Akintoye et al., 2000; Holti et al., 2000; Briscoe & Dainty, 2005; Rimmer, 2009).

As part of this movement, the search for new and more integrated approaches to the construction supply chain has taken on a renewed importance for many organisations operating within the wider construction industry (DTI, 2003; Holti et al., 2000), also 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). At the lower tiers of the construction supply chain, the supply side, however, there remains a paucity of properly documented examples of successfully implemented Supply Chain Management (SCM) initiatives (Cox & Ireland, 2002; Aloini et al., 2012). Construction projects are characterised by a high 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). The low levels of repetition increase the unpredictability of the flow of work (Vrijhoef, 2011). Major developments, such as the increased use of integrated contracts, have resulted in a shift of responsibilities from client to main contractor. A consequence of this increased responsibility is that main contractors require capabilities and knowledge which do not belong to their own core competences and need to be purchased from suppliers (Bemelmans et al., 2012) – main contractors increasingly depend on their suppliers, both for realising projects and for achieving the required performance in these projects (Bemelmans et al., 2012). The term suppliers covers subcontractors, material suppliers and service suppliers.

While several studies underlined the importance of main contractor-supplier collaboration (Kale & Arditi, 2001; Cao & Zhang, 2011; White & Marasini, 2014), 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). The increasing percentage of project turnover which is spent on buying goods and services does provide opportunities for collaboration and emphases the importance and significance of managing suppliers (Bemelmans et al., 2012). Contractors are willing to develop closer relationships (Ross & Goulding, 2007), but implementing SCM seems a long-term, complex process and requires a certain level of understanding and therefore learning throughout the supply chain. SCM 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).

This study sets out to explore the differences between the organisations involved at the lower tiers of the construction supply chain, focusing specifically on the internal SCM organisation of main contractor and supplier organisations, and their direct inter-relationships (Broft, 2012; Pryke et al., 2014; Broft et al., 2016). SC Maturity levels are formulated according to relevant SCM concepts and based on Holti et al.'s (2000) seven principles of SCM organisation, and used to examine the relative SC Maturity of eight large main contractor and supplier organisations within the context of the Dutch construction industry (Broft, 2012; Pryke et al., 2014; Broft et al., 2016). A case study, representing a construction supply chain initiated by a main contractor, is further investigated to examine the SC Maturity based on one of the principles in more detail. This way the paper starts a discussion towards the development of an improvement framework and brings up the need for a more mature supply chain integrator, an organisation leading in the process of SCM implementation.

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". Attention is nowadays focussed on ensuring competitive advantage for the integrated supply chain (Green et al., 2005) – businesses no longer compete as a sole business entity, but rather in a 'supply chain versus supply chain' manner (Lambert & Cooper, 2000; King & Pitt, 2009). In construction, a supply chain is characterised as (Vrijhoef & Koskela, 2000):

§ Converging at the construction site – the object is assembled from incoming materials and through different services;
§ Temporary – one-off construction projects are produced through repeated reconfiguration of project organisations; and
§ A typical make-to-order supply chain – every project creates a new product or prototype.

These characteristics are often seen as peculiarities of the industry and prevent the attainment of flows as efficient as in manufacturing (Koskela, 1992). The relationships required for the delivery of the constructed product among main contractors and suppliers are often weak and difficult to manage (King & 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) – the management of the discontinuous exchanges in project-based industries is problematic due to the discontinuity of demand for projects, the uniqueness of each project in technical, financial and socio-political terms, and the complexity of each project in terms of the number of actors involved (Skaates et al., 2002; CrepsinMazet & Ghauri, 2007).

Rapid technological development in both products and services has driven main contractors to adopt outsourcing strategies involving external suppliers rather than develop in-house capabilities (Cox & Ireland, 2002; Green et al., 2005). The main contractor, the principal construction organisation that manages a construction project, executes only a small part of the product by its own personnel and its own production facilities (Dubois & Gadde, 2000). 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 & 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 main contractors competing to win work through competitive pricing whilst reducing the quality of the end product in order to improve profit margins (King & 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). Fragmentation however, must not be seen as strictly problematic. The involvement of many different specialised firms in projects does not necessarily cause low levels of efficiency. On the contrary, it has been claimed that this could just as well increase the efficiency of resource allocation and speed of information exchange between parties (Pryke, 2002).

The ability to build collaborative relationships is also hindered by the prevalent adversarial relationships brought in by opportunism, lack of trust and inequitable allocation of risk. While suppliers 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 & 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 An integrator of the construction supply chain

Intense and often global competition, high technological standards and rapidly changing market demands have pressed manufacturing industries to manage processes throughout the supply chain in an

effective and efficient way (Cagliano et al., 2006). The high levels of alignment and repetition within these supply chains have led to highly productive and fast operating strategic coalitions of firms (Kirche et al., 2005; Zailani & Rajagopal, 2005; Kim, 2006). The construction industry on the contrary, knows two typical problems resulting from high levels of fragmentation and low levels of repetition: lack of control and decreasing performance – the industry supposedly shows low levels of performance and backwardness in many respects (Woudhuysen & Abley, 2004) – which tend to reinforce each other throughout the supply chain because of causal relationships within the supply chain (Pryke, 2002). The main objective of SCM is to enhance mutual competitive advantage and this can be achieved through improved relationships, integrated processes and increased customer focus (Pryke, 2009).

For this reason, the interest in adopting SCM techniques has been growing in the construction industry since the 1980s (Segerstedt & Olofsson, 2010), but many applications of SCM in construction have been limited to the management of construction materials and long-term arrangements with suppliers (Vrijhoef, 2011). One of the supply chain principles from manufacturing that could be reconceptualised and applied to the specific context of construction (Vrijhoef, 2011) includes the introduction of the role of the supply chain integrator in the supply chain – one of the critical phenomena lacking in the construction industry is the recognition of a generally accepted focal company initiating the integration of the supply chain. This focal company coordinates and ties together all flows through the supply chain as if it were an extended enterprise (Figure 1).

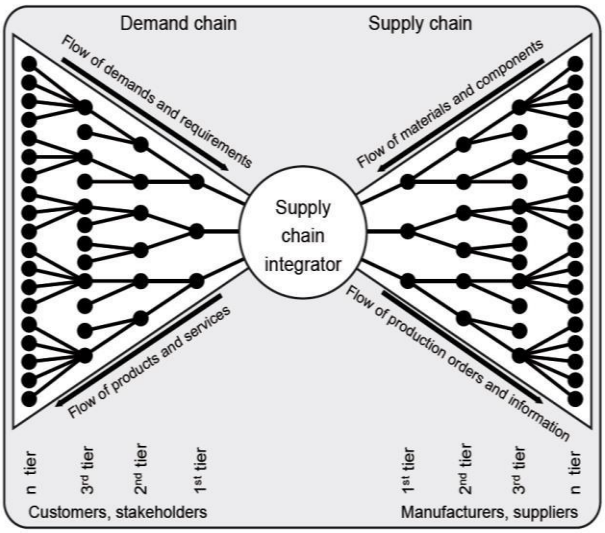

Figure 1: Supply Chain Integrator (Segerstedt & Olofsson, 2010, pp. 349; Vrijhoef & De Ridder, 2005).

Holti et al. (2000) do offer an approach to managing supply chains in which they 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). One of the other main concepts however, 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. The client and chosen procurement method are both critical in enabling supply chain integration and project-independent construction. However, independently from the demand, parties at the supply side may evolve towards more integrated production and business formats, through

projectindependent collaboration with other parties in the supply chain as well as internalisation of neighbouring activities or businesses (Vrijhoef & De Ridder, 2005).

Pryke (2009) acknowledged the central position that main contractors play in the management of supply chains, offering great potential in this leading role. It is believed that main contractors have more influence on the organisation of the project and on the performance and quality of the work of its suppliers (Latham, 1994). Despite the fact that they have such an important role in channelling client demand through their own supply chains, main contractors are overlooked when it comes to research and useful advice (King & 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). In addition, within a main contractor's organisation, the management function is typically disconnected from the production function on site as if it were two separate organisations: "one for the management function and one for getting the work done. The two organisations do not coordinate their work, and they are characterised by different goals and viewpoints" (Applebaum, 1982).

2.3 Towards SC Maturity in construction

SCM 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 & Ellram, 1993; Christopher, 2005; Pryke, 2009; Blanchard, 2010; Fulford & Standing, 2014). It can be categorised into four different levels (Harland, 1996):

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 management of the different levels 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 & Pitt, 2009; Van Weele, 2010).

Holti et al.'s approach (2000) involves essential ingredients for a construction company (level 1) to function in a SCM-driven environment (Figure 2), described as seven principles. The first principle 'Compete through superior underlying value' is concerned with enhancing the value of what 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 longterm 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.

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

The seven principles outlined above demonstrate that implementing SCM encompasses the recognition of essential SCM elements internally, within an organisation. The aim of this study is to outline the differences in SC Maturity of main contractor and supplier organisations, and to underline the need for greater degree of main contractor leadership, in order to improve the internal organisation of both types of firms, and subsequently achieve greater collaboration between them.

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 supplier organisations.

From an earlier pilot study (Broft, 2012; Pryke et al., 2014; Broft et al., 2016), it was evident that the companies involved in the study had 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 supply 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 (Broft, 2012; Pryke et al., 2014; Broft et al., 2016).

The first part of the main study thus focused on the analysis of the current SCM status of all individual companies involved (Broft, 2012; Pryke et al., 2014; Broft et al., 2016) – four large main contractors and four larger suppliers, operating in the Dutch construction industry, were included in this research. 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	Organisation 01 (BN)	Construction, development, infrastructure, services and specialist activities.
Interviewee 02	Director Purchasing	Organisation 02 (BM)	Construction, mechanical/electrical services, civil engineering, property, PPP.
Interviewee 03	Director	Organisation 03 (DV)	Construction, real estate and infrastructure.
Interviewee 04	Director	Organisation 04 (WB)	Housing, social/commercial properties, and renovation.

SUPPLIERS			
Name	**Position**	**Company**	**Company Profile**
Interviewee 05	General Director	Organisation 05 (GV)	Supplier/manufacturer of aluminium windows, facades, doors and blinds.
Interviewee 06	Business Leader	Organisation 06 (GB)	Precast concrete floor systems and other concrete construction elements.
Interviewee 07	Director	Organisation 07 (TV)	Plumbing and sanitary installation company.
Interviewee 08	General Director	Organisation 08 (BV)	Manufacturer of the interior door/frame package.

The themes and accompanying questions for this analysis were derived from the seven principles, described in Section 2.3. Maturity levels were developed after the interviews were held with the highest maturity level representing the ideal elements of an SCM organisation according to Holti et al. (2000). Jointly, the current score 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, and to compare the two different types of companies and relate this comparison to the different role perspectives. Section 4.1 and 4.2 include a description of the findings.

The leading role of main contractors is further investigated in a case study, the second part of the research, in which a main contractor decides to form long-term agreements with thirteen suppliers in its key supply categories. This main contractor believes in collaboration and initiates the integration of its supply chain. The study then examines the maturity of all supply chain actors involved at the start of their collaboration based on the most important principle (Section 2.4). The themes around Principle 1 include insight into cost components, margins and the level of waste (Holti et al., 2000). Again, the two different types of companies are compared – research is extended to project/site level. Table 2 provides an overview, including some basic facts, of the fourteen supply chain actors.

Table 2: Overview of organisations involved in case study (facts based on 2015).

	Discipline	**Location (region)**	**Turn-over**	**Amount of employees**				
			Total	**Total**	**Fixed**	**Flex.**	**Office**	**Site**
Contractor T	Main contracting	Utrecht/Overrijsel	188 mln.	258; 65	60	5	35	30
Supplier T1	Finishing	Overrijsel	15 mln.	125	95	30	25	100
Supplier T2	Plastering & Finishing	Zuid-Holland	15 mln.	150	40	110	20	130
Supplier T3	Timber structures	Groningen	-	89	58	31	23	68
Supplier T4	Concrete contractor	Friesland	53 mln.	209	186	41	57	152
Supplier T5	Finishing	Overrijsel	26 mln.	300	100	200	25	275
Supplier T6	Production of precast concrete	Friesland	21.1 mln.	80.8	65.4	15.4	19.2	61.6
Supplier T7	Production of doors	Gelderland	38.3 mln.	157	-	-	45	112
Supplier T8	Tiling	Overrijsel	35 mln.	58	28	30	4	54
Supplier T9	Production of wooden frames	Friesland	5.5 mln.	38	25	13	8	30
Supplier T10	Contractor of storages	Overrijsel	137 mln.	243	243	-	-	110
Supplier T11	Tiling	Noord-Holland	7.5 mln.	45	-	-	4	41
Supplier T12	Installation technology	Overrijsel	59 mln.	513	347	166	-	409
Supplier T13	Production of carpentry	Gelderland	17 mln.	119	95	24	34	85

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 a limited amount of main contractor and supplier organisations and need to be tested using quantitative research in order to be representative of the industry.

4.1 The relative SC Maturity of eight construction companies

The analysis of the research findings is based on the developed SC Maturity levels. Emphasis is placed on the current characteristics of the organisation and its level in implementing important SCM elements. The scores achieved in relation to the themes are summarised in Table 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 main contractors and suppliers. 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 – "*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*" (Interviewee 02, BM). Findings in relation to Principle 5 'Manage costs collaboratively' reflect practices that favour short-term financial gains, such as non-legitimate risk transfer, contradicting SCM. Principle 6 'Develop continuous improvement' was found to be well-understood, however doubts exist on how to correctly implement it in a project-environment. 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 often resides with people (Interviewee 07, TV).

Table 3: 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	3 / 4
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	1 / 2	1 / 2	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	1 / 2	1 / 2	2	2 / 3
Strategic partners	0	3	1	2	1	2	3	3
Principle 4: Integrate project activities								
Partner involvement	1	1	1 / 2	2	1 / 2	2 / 3	2 / 3	2
Integration of processes	0	0	2 / 3	2 / 3	1 / 2	2	2	2
Principle 5: Manage costs collaboratively								
Initial price	2	1 / 2	2	2	1	1 / 2	1 / 2	1 / 2
Risk management	1	1	3	1 / 2	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	1 / 2	1 / 2	3	3	3

4.2 A relative comparison of main contractors and suppliers

Comparing the two types of companies, it is easily noticed that Principle 4 and 7 are better exercised by suppliers. Principle 4 'Integrate project activities' encompasses the involvement of partners and the integration of processes and activities, which due to a supplier's greater specialisation is found to be more straightforward to manage. 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.

4.3 A case study: Another comparison

The fourteen companies involved in the case study are linked through long-term agreements for the construction of dwellings in three different regions of the Netherlands. For most of the key supply categories the main contractor has selected one supplier, except for categories related to the finishing stage, where the main contractor prefers to work with one supplier per region. All selected partners (see Table 2) are evaluated to indicate their SC Maturity at the beginning of their collaboration, following the method used in the first study. This Section focuses on the findings in relation to three themes – insight in cost components, margins and waste levels – and a total of eighteen sub-themes, characterising Principle 1 (insight in cost components is added to the original themes in this second part of the research). Table 4 gives an overview of the scores achieved, in which the sub-themes are averaged and reduced to six.

With regards to insight in cost components directors (showed as bold) on average show a higher score, sometimes even reaching 3.4 or 3.8, compared to other functions within the companies. In all cases, knowledge of general costs is limited to the own organisation and therefore, in most cases does not exceed a score of 2, and risks are known differentiating from score 0.7 to 3. Production companies (Supplier T3, T4, T6, T7, T9 and T13) seem to show unusually high scores on some elements, most probably due to their early involvement and a strong dependency on a limited amount of other partners.

Table 4: Overview of the three themes (Principle 1) and SC Maturity ratings.

	Insight in cost components			**Insight in margins**	**Insight in waste levels**	
	Material/Labour	**General costs**	**Risk**	**Margins**	**Hours**	**Duration**
Contractor T	2.8	2.6	2	2	1.6	3
Supplier T1 *	**3.4**; 1.6	**2**; 0.6	1	**2**; 2	**1.6**; 2.3	2
Supplier T2	2.2	2	0.7	**1**; -		1
Supplier T3	**2.2**; 1.4	2	2	**2**; 0	1	**1.6**
Supplier T4	2.4	1.6	1.5	2	1	1.5
Supplier T5	**2.6**	**2**	**2.5**; 1	**2**; 2	1.3	2
Supplier T6 *	2.8	**2**	1	**2**; 2	0.3	2.6
Supplier T7 *	**3.8**	**1.6**	**1**	**2**		
Supplier T8	2	**2**; 2.6	4	**2**; 2	**3**	**2**
Supplier T9	1.4	**1.3**	2	**2**; 0	**2**	3; 2.6
Supplier T10	1.8		**2.5**		**1.3**	2
Supplier T11	**2**; 0.6	**2**	1.5	**2**; 0	**1**	2
Supplier T12 *	1.5	1.6	3	1	2	3.8
Supplier T13	**3.2**		2.5	**2**; 0	**2**; 1	**2**; 2

It could be concluded that all companies have an equal insight into margins, limited to their own level (score 1 or 2) and therefore, no insight into their direct partners' nor suppliers' margins. Insight in waste levels differs from score 0.3 to 3.8. The companies that score higher turn out to be familiar with the Lean philosophy (marked with *) and its implementation within their processes. Even so, insight is limited to just parts of the process – their own process – rather than the total process. The main contractor, again, does not score particularly high regarding all three themes.

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 collaboration between main contractors and suppliers – this collaboration was described as challenging with characteristics that obstruct successful implementation of SCM – and it describes the potential of main contractors as focal companies or supply chain integrators.

With their central position in the management of supply chains, it is believed that main contractors have more influence on the organisation of the project, and on the performance and quality of the work of its suppliers. This research uses Holti et al.'s approach (2000), which involves single point responsibility to the client with a collaborative model of overall leadership in achieving value for money, to effectively integrate supply chains, and its seven principles to investigate the maturity of different supply chain actors. 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 compare the internal organisation of the two different types of companies with regards to essential SCM elements. It has shown that firms are faced with many barriers in the process of SCM implementation. 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. Further investigation, based on a case study involving an initiated supply chain, reveals the limited insight in margin levels, many unknown components in costs and differing knowledge of waste – most organisations, including main contractor organisations, only seem to focus on information within their own boundaries.

The findings of this study have a number of important implications for future practice. First, the study highlights the need for a greater degree of main contractor leadership – especially when main contractors would need to take the important role as supply chain integrators – 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 levels and the first steps towards changing it into a usable improvement framework that could be applied to main contractors' (and suppliers') SCM activities.

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