Guest editorial

Supply chains in the construction industry

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Abstract
Purpose – The purpose of this paper is to introduce a special issue about the construction industry and the management of its supply chains. It aims to discuss and point to some differences and possible similarities with traditional manufacturing and its supply chains.

Design/methodology/approach – The paper is mostly a literature review and contains official statistics.

Findings – The market of the construction company is mostly local and highly volatile. The long durability of the construction “product” contributes to the volatility. The product specification process before the customer order arrives shows different degrees of specifications: engineer to order, modify to order, configure to order, select a variant. (The common make-to-stock in traditional manufacturing does not exist.) A construction company only executes a small part of the project by its own personnel and capacity. This is a way of risk spreading and risk mitigation and to compensate for an unstable market. If a construction company wants to establish a new concept, from “engineer to order” to e.g. “configure to order”, it must be engaged earlier in the business process and with other than usual customers, which might complicate the process.

Research limitations/implications – Experiences from Sweden and Swedish developments are the main source of information.

Originality/value – The paper introduces the articles that are a source of scientifically generated knowledge regarding various problems and opportunities associated with supply chain management in the project-based construction industry.

Keywords Supply chain management, Construction industry, Sustainable development, Sweden, Project planning

Paper type Literature review

Introduction
This is the introductory article in a special edition about the construction industry and the management of its supply chains. Eccles (1981) defined construction as “the erection, maintenance, and repair of immobile structures, the demolition of existing structures, and land development”. The term architectural, engineering and construction (AEC) industry also includes the design in the supply chain of the construction, repair and retrofit of our built environment. Also, the boundary between construction and the manufacturing industry is indefinite and fuzzy. Are plants producing building insulations part of construction or part of the manufacturing industry? The difference in output produced, firm size and use of technology in the residential, commercial/public, industrial and infrastructure sector also makes it hard to characterize and measure the performance of construction on industry level (Huang et al., 2009). Therefore, several investigations showing a slow increase or even decline in productivity developments may be debatable.

Even so, much research work and several public funded unraveling reports have assessed and suggested ways to improve productivity in the construction industry.

Since the 1990s there has been an increased interest of supply chain management theories to understand and characterize the deficiencies and to propose solution to improve the coordination of the often many subcontractors and suppliers in the construction supply chain. The UK-sponsored Latham (1994) and Egan (Construction Taskforce, 1998) reports investigated the current practice of loosely coupled supply chain; Dubois and Gadde (2002) suggested a more integrated supply chain using collaborative agreements between contractors, suppliers and clients. Cox and Townsend (1998) discussed the relationship between supply chain management and market structure, i.e. the constraints.

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and structural forces of the market and Agapiou et al. (1998) introduced the “building merchants” providing supply for the building industry as an important player in the supply chain. Other perspectives and explanations of root causes for low productivity development have been proposed by Vrijhoef and Koskela (2000), who recommended an integrated management of the interface between site activities and supply chain.

Several authors have also recognized the important role of the client. Briscoe et al. (2004) identified the client as the most significant actor in achieving integration in the supply chain. London and Kenley (2000) adapted Lambert et al. (1998) model of the supply chain structure from an industrial organization perspective and put the client organization in the focal point. Vrijhoef and de Ridder (2005) developed this concept further and discussed two strategies for integration; supplier driven integration and client driven integration.

What kind of supply chain is the construction supply chain?

It is not uncommon to hear that the construction industry is totally different to other industries and must find other solutions and concepts for improving performance and efficiency. Is it true or a myth? It is customary to view that there are certain peculiarities of construction, like one-of-a-kind products, temporary organization, and site production, preventing the attainment of flows as efficient as in manufacturing (Koskela, 1992). As an example the principal construction company that manages a construction project mostly executes only a small part of the “product” by its own personnel and its own production facilities. The great part, approximately 75 percent and more, of the product’s value is built with help from suppliers and subcontractors (Dubois and Gadde, 2000). It is often believed that advances in construction are related to the elimination of these peculiarities, like site production by means of industrialization or one-of-a-kind products by means of pre-engineering. These peculiarities are also at the core of the argument that construction is so different, especially from manufacturing that technology transfer from other fields is not possible. Ballard and Howell (1998a, b), advocates of Lean construction, who posed the question “What kind of production is construction?” argued that parts and components more suitable for manufacturing should take advantages of lean techniques developed in manufacturing while lean techniques suitable for the dynamics of construction should be developed to “minimize the peculiarities in construction”. One such technique to shield the production on-site from the jumbled flow and loosely linked process segments is the Last planner approach (Ballard and Howell, 1998b). Vrijhoef and Koskela (2000) characterized the supply chain in construction as:

• converging at the construction site where the object is assembled from incoming materials;
• temporary producing one-off construction projects through repeated reconfiguration of project organizations separated from the design; and
• typical make-to-order supply chain, with every project creating a new product or prototype.

In traditional manufacturing, modularization and standardization of semi-manufactured items have been ways to increase efficiency and lower costs in production, decreasing delivery times, and even increasing the flexibility and variety of products to satisfy customers’ demands. Christopher (2001) discusses the introduction of a strategic inventory to hold common sub-assemblies and only complete the final assembly or configuration when the precise customer requirement is known. This type of postponement strategy moving the customer order point up-streams is utilized in the mass-customization industry separating “base” and “surge” demands. However, unlike the construction industry, the product design is often developed in a separate product development process in the manufacturing industry by the lead firm or system integrator.

The peculiar relation between design and production in the construction industry has also been recognized by Winch (1998), who classified from an institutional view the principal contractor and principal designer as sharing the role of the system integrator, see Figure 1. The customer of a construction company is often “separated”; this means the first tier customer to the construction company is often an agent for the second tier customer; and the real consumer of the product (e.g. the tenant of the flat) is still not known. However, this is not totally unique for the construction industry, other companies are also often in a supply/demand chain where the first tier customer delivers to second and third tiers customers, etc. But a construction company is often more movable and impermanent in its supply chain compared to other industries; the construction company can be the focal company in a development project and be positioned as first or even second tier supplier in other projects (see Figure 1) (Figure 1 is adapted after Lambert et al. (1998), London and Kenley (2000) and Vrijhoef and de Ridder (2005)).

Market volatility: the Swedish case

The construction industry is local. Governmental subsidies, national and local regulations and culture have essentially protected the construction industry from global competition. The building products also have a long life-span creating a situation where the demands vary dramatically over time. Since 1950 the number of initiated flats in Sweden has varied with a factor of 10 over time, Figure 2.

In the 1960s when the large governmental multi-dwelling program was launched many concrete prefabrication factories started changing the construction from an essential craft based industry to more of an assembly on-site operation. During this era both construction companies as well as client organizations started element factories. As the demand decreased in the 1970s many of these prefabrication facilities were closed and more work were again performed on-site (Kadefors, 1995).

In the 1970s the energy crisis introduced thicker insulation and more advanced systems for heating and ventilation introducing new specialists in the project organization. However, the market for single housing was still booming due to beneficial interest rate subsidies, which resulted in the build-up of the one-family detached timber house manufacturing industry in Sweden. The financial crisis in the real estate sector together with the de-regulation and decrease of governmental subsidies in the 1990s caused the production of single and multi-dwelling flats in Sweden to drop to historically low numbers.
The business cycles in the construction industry seem to have higher amplitudes than in other manufacturing industries. The unemployment of construction workers is greater in low business cycle than in other industries. In high business cycles more unskilled people are hired than in other industries; people go out and in from the construction industry at a greater rate than other industries (Eccles, 1981). The durability and the long life span of building products also contribute to the amplitude of the business cycle. The more durable a product is the more the demand will oscillate, since the yearly production only adds a small volume of an already existing product. It is also common, as described above, that governments try to stimulate the economy in low business cycles by subsidiaries and other

**Figure 1** The system integrator (SI) is located in the focal point of the supply and demand chain

**Figure 2** Started number of flats in apartment blocks (Flerbostadshus) and detached single houses (Småhus) in Sweden from 1950 to 2008


*Source:* Statistics Sweden and the Swedish Construction Federation
stimulation activities in order to start new construction projects (Kalbro et al., 2009).

**Factory (prefabrication) versus on-site production: current trends**

As in other Western countries, (Latham, 1994; Construction Taskforce, 1998; Huang et al., 2009), the construction industry in Sweden has been accused for low productivity and the Government has set up public investigations scrutinizing said industry, (SOU 2002:115, 2002; SOU 2009:6, 2009). The Swedish construction industry has replied by launching new systems for building multi-family houses, hereafter referred to as building system, in an attempt to make the construction process more efficient. However, some of these attempts have been closed down after unsuccessful introduction on the market.

Factory (prefabrication) processes and lean production concepts have successfully been adopted in Japan (Gann, 1996). Also, approximately 74 percent (between 1990 and 2002) of the detached single houses are still manufactured in permanent factories in Sweden. From a market point of view, this indicates that a traditional manufacturing approach could have potential for the whole housing industry (Bergstrom and Stenh, 2005). One distinct difference between the detached single-house market and the production of multi-storey houses is the way business is organized. Build-operate/own-transfer forms of contract including responsibilities to fulfill performance requirements to end users predominate in the detached single house market while design-bid-build or design-build contracts between actors in the project and the professional client representing the end user are common in multi-dwelling housing projects. This greatly affects the possibility of introducing building system on the multi-dwelling housing market. In the case of the detached single-house market the manufacturer is at the focal point of the supply/demand chain whereas in the case of a design-bid-build project the professional client acts as system integrator in the supply chain (London and Kenley, 2000).

New industrialized building systems have been introduced by construction companies on the Swedish market in the last decade (Andersson et al., 2009; Gerth, 2008). A serious obstacle for the successful introduction is the possibility to configure the building according to project requirements considering the constraints imposed by the building systems (Andersson et al., 2009). The traditional design-bid-build project often leads to requirements on technical solutions that can be hard to fulfill for the industrialized builder. This often leads to ad hoc customization of the building system that in the worst case are more costly to perform compared to the traditional on-site construction (Andersson et al., 2009).

Make-to-stock, assemble-to-order, make-to-order, engineer-to-order are distinctions in traditional manufacturing to differentiate how “deep in” or up-streams, in the manufacturing process the customer order determines the actual production. In traditional manufacturing the decoupling point is the boundary between make-to-order and make-to-stock. The system integrator does not complete a “product” that will be delivered to a stock; even if the “product” is built on speculation with end-users not known. Construction concepts and projects also show different preparations before the customer order arrives and before realization of the project. Figure 3 shows four different kinds of product specification processes before the customer order arrives, where the customer order decoupling point are represented with a line dividing the product development of the building system from the specification process of the specific project (Hvam et al., 2008). The dividing line represents how up-streams the customers enter in the product development process.

The first and lowest degree of a defined building system is the well-known engineer-to-order where the AEC industry design products in ordinary construction projects such as dwellings, offices, arenas and plants/factories. The design specification process is mainly based on client requirements, norms and standards. Winch (2003) divided the engineer-to-order further in concept-to-order and design-to-order reflecting the two main contractual forms between the client and the construction company; design-build and design-bid-build respectively.

The modify-to-order decoupling point is here defined as design using so called technical platforms. Typically, construction technical platforms have a generic product structure and constraints in measures and type of technical solutions to be used, such as standardized floor heights, a selection of approved technical solution of outer and inner walls and window types etc. The major Swedish construction companies have recently introduced these types of technical platforms on the market, e.g. “Skanska Xchange”, “NCC Bostadplattform”, “PEAB PGS” (Andersson et al., 2009). The introduction of these kinds of building system requires cooperation between the principal designer and the principal constructor owning the building system and acting as system integrator on behalf of the professional client.

There are also a number of companies working with standard products in the construction industry, especially in the detached single house market where the customer select-a-variant from a certain product portfolio often with only minor possibilities of customization. The recently developed building system, the Skanska ModernaHus, consist of three- to eight-storey dwellings with eight possible floor layouts and
options including energy performance and exterior design. This kind of building product is sold directly to the client or developer. The role of the principal designer is replaced by sales staff. It further requires that the product can be introduced early in the conceptual phase of the construction project.

The configure to order type of product offers are based on modules and standard parts that can be configured to satisfy customer needs. These type of building systems are relative uncommon. The “NCC Komplett” is an example of a more flexible and configurable building system that recently was closed down due high development cost and poor return on investment (Andersson et al., 2009). The system was quit flexible and consisted of configurable modules with all equipment, fittings, wallpaper and flooring attached to the elements before assembly on-site. As in the select-a-variant the configure-to-order system requires direct access to clients in the conceptual phase of the construction project.

Of the described building systems above, the select-a-variant and configure-to-order type of building systems affect the traditional business process with the professional clients the most. One possible solution for the industrialized builder is to offer generous framework agreements with big clients from which the client can call-off apartments when needed. This type of arrangements is coming into practice by some of the major property owners in Sweden (Andersson et al., 2009).

Concluding remarks and introduction of special issue

This volatility of market demand and increased complexity is one cause for fragmentation of the construction industry where subcontracting and rental of expensive equipment been a way of risk mitigation for construction companies. The major distinction between construction and manufacturing is that the construction industry is project-based and of discontinuous nature, while manufacturing industries involve continuous processes and relationships. While the majority of contributions involving supply chain relationships in management and marketing literature deal with continuous exchanges in long-term buyer-supplier relationships (Claycomb and Frankwick, 2010), there is a lack of research on discontinuous exchanges in project-based industries, such as the construction industry (Crespin-Mazet and Ghauri, 2007). Management of supply chain relationships is, however, especially problematic in project-based industries 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 (Skætæs et al., 2002). Also, the recent development of modular building system opens new research opportunities in the application of supply chain modularity in construction (Voordijk et al., 2006). This special issue therefore serves as a source of scientifically generated knowledge regarding various problems and opportunities associated with supply chain management in the project-based construction industry. The special issue includes the following contributions:

Andreas Hartmann and Jasper Caerteling, “Subcontractor procurement in construction: the interplay of price and trust”

A key characteristic of the construction industry is a huge amount of subcontracting. Subcontractors supply drawings, labor and material and transform order-related specifications into physical components that will be included in the construction projects. Selecting appropriate subcontractors and managing subcontractor relationships is very important for an efficient project performance. From about 200 questionnaires from the Dutch residential building industry the authors conclude that neither price nor trust can be downplayed as sole procurement mechanisms. The study shows what is more, and what is less important. We have no doubts about that most of this study in The Netherlands would also be found applicable to Sweden and other nearby cultures, and a lot of it also to more different cultures. This study may trigger, and be extended to, similar studies in other countries.

Charlene Xie, Dash Wu, Jianwen Luo and Xiaoling Hu, “A case study of multi-team communications in construction design under supply chain partnering”

Based on a previous survey result a study is performed to investigate communication issues and problems in the design and construction of a new shopping centre. Multiple research methods including questionnaire survey and interview are employed to explore how supply chain partnering procurement influences the team communications. A total of 26 participants, who were identified as “communication stars”, were asked to take part in two rounds of questionnaire survey and interviews. One important finding is that co-location is still important despite new techniques of communications. Another is that partnership provides a friendly and free environment for communication, but communication overload can occur if there is not a proper communication protocol established.

Pierre Hadaya and Robert Pellerin, “Determinants of construction companies’ use of web-based interorganizational information systems”

Information technologies (IT) may be beneficial to the construction industry by linking main contractors with their subcontractors, by reducing the response time and by enabling companies to expand their activities into new local and international markets. But, studies have concluded that IT is less used in the construction industry than in other types of industry. A survey is performed with 67 senior managers of Canadian construction companies. Characteristics of the organization and characteristics of its supply chain are the main determinates investigated. One interesting finding is that technology experts do not seem to play the role of opinion leaders and change agents in the adoption of IT in the construction sector. Another is that construction companies will more likely use web-based transactional processes with those strong supply chain relationships that can provide them with a competitive advantage.

Lars Bankvall, Lena E. Bygballe, Anna Dubois and Marianne Jahre, “Interdependence in supply chains and projects in construction”

Researchers have claimed that the construction industry suffers from poor performance. Supply chain management
Supplementary information: suitable basis for developing lean construction from the literature review and an action research case study in Sweden, the authors theorize and illustrate of how lean construction can be managed and can be used as a guide when implementing lean thinking in the construction industry. Based on a literature review and an action research case study in Sweden, the author theorize and extend an existing three stage lean construction model that can be used as a guide when implementing lean thinking in construction projects. The empirical data provide practical illustrations of how lean construction can be managed and how it affects supply chain actors and their performance. Based on the case study it is concluded that partnering is a suitable basis for developing lean construction from the collaborative second stage to the more sophisticated third stage, that is, full-fledged lean construction.

Hans-Martin Lönngren, Christoph Rosenkrantz, Harald Kolbe, “Aggregated construction supply chains: success factors in implementation of strategic partnerships” The article presents a network of German construction companies whose goal is to cover the entire life cycle of a building, from its design, planning to its final facility management. The authors focus on the establishment and implementation of this strategic alliance and its success factors. The key factors of success in such a strategic alliance within the construction industry are: a central coordination among partners but using decentralized task managements; an appropriate IT-solution; and mutual trust among cooperating partners.

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(1998) and related concepts such as partnering and lean construction have been proposed as solutions to these problems. The authors define, or point to, three different types of supply chain dependencies; pooled interdependencies (e.g. two specialists share a crane), sequential interdependencies (the traditional production process of material and components), reciprocal interdependencies (the output of each become inputs for the others). A plasterboard supply chain in a specific construction project is studied. An interesting finding, and hypothesis for further confirmation, is that better planning, synchronization and flexibility is more important than supply chain integration for a better performance. This is due to the comprehensive reciprocal interdependencies in construction industry.


Further reading


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