

THEORETICAL SUPPLY CHAIN NETWORK MODELLING IN THE BUILDING INDUSTRY

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Various supply chain management models have emerged in the last two decades in the manufacturing industry. Current supply chain techniques in the construction industry have focussed on project-based models particularly the logistics of materials management. It has been established in manufacturing that the greatest successes have been in those supply chains where strategic alliances have been developed between key parties and longer-term relationships have been developed across the entire network of suppliers at each stage of production. The link between the customers' internal management systems and the external suppliers' management systems has been identified as important to creating successful alliances. Unravelling this complex web of successful buyer-supplier inter-enterprise relationships and dependencies in manufacturing has relied upon the two key causal factors of supplier *coordination* and supplier *development*. Theoretical SCN modelling in construction needs to consider that the underlying structure of the majority of parties involved within construction projects is largely a network of small to medium enterprises. A theoretical supply chain procurement model is developed that reassesses the fundamentals of organisational structure and explores the potential for future flexible inter-organisational arrangements. The modelling draws upon network sourcing concepts and aims to foster risk sharing and engender stability in contractual chains. The methodology for a future research project is described that will explore supply chains in a small remote construction market.

Keywords: Supply chain, network.

INTRODUCTION

There has been a great deal of research exploring the nature of the building industry. Emerging from this research, has been a picture of a fragmented range of small to medium specialist enterprises that gather into temporary organisations. There is increasing evidence that these temporary organisations do have significant component replication sometimes forming "quasifirms", moving from project to project. This seems to indicate that firms tend to form loose strategic alliances to assist in strategic objectives.

More structured strategic alliances have been examined in the manufacturing literature, and more recently in construction, and have generally fallen within the topic of supply chain management. There are two approaches to supply chain theory, depending on whether the researcher is interested in the flow of information and materials in a logistic sense, to reduce the cost of construction; or the achievement of strategic objectives via active participation down each entire supply chain without structured vertical integration. These two approaches are termed 'supply chain clusters' and 'supply chain networks'. The concepts of supply chain clusters and

supply chain networks in the construction industry are introduced and the difference is discussed briefly.

The latter view of supply chains forms the basis of this paper, which substantiates the need for exploring the development of a theoretical supply chain procurement model through a review of existing literature. Certain causal factors of organisational networks that affect stable relationships and reduce financial risk in supply chains are considered as a framework for supply chains in building procurement. Finally, a research project methodology is offered and outlined as the first stage in the development of this supply chain procurement model.

BACKGROUND

The building industry in Australia is predominantly structured of small firms with 98% employing less than 20 employees and with 88% of establishments with low annual turnovers, of less than \$500 000 (Gyles 1992). This is not a phenomenon only applicable to the Australian industry as similar trends indicating the important role of small firms in the construction industry were uncovered in research in Asia in the last 10 years and the UK in the early '70's (Hillebrandt 1971).

In Australia particularly, the contribution of small enterprises to the construction industry is very significant, yet the emphasis to date has mainly been on the role of major firms on large projects (Gyles 1992). In recent times policy makers have begun to consider the role of small to medium enterprises (SMEs) with broad national strategies aimed at improving the ability of SMEs to access government business with the view to assisting economic growth in the industry (APCC 1997). The premise behind such strategies is that SMEs are an integral part of economic reform in the industry and that they are to be encouraged to participate further in the contractual chain. There is little doubt then of the importance of SMEs and that it is worthy of investigation. Further to this claim is that one of the key issues in this area of research is to explore the nature of the interfaces between small and large firms.

The widely accepted view is that this industry is fragmented and fraught with short-term relationships that form to react to particular and unique projects. Although this creates a responsive and dynamic environment there is often little regard to the development of long-term relationships and stability, which will support economic growth within the industry. However, there are indications that under *certain conditions* long-term and stable relationships do form within some networks, which is contrary to the current fragmented view of the industry.

One of the most significant studies related to the nature of relationships in this area is on the US housing industry. This study considered organisational issues and in particular the relationships between subcontractors and contractors (Eccles 1981). From this, Eccles describes project organisations as being within the framework of a 'quasifirm'.

...a contracting mode intermediate between the relational contracting modes of bilateral governance (obligational contracting) and unified governance (internal organisation) is the preferred mode for construction work given certain conditions. I call this mode of form the 'quasifirm'. This organisation based on a set of stable relationships between a general contractor and special trade subcontractors, is analogous to the inside contracting system in manufacturing. (Eccles 1981 p335-336).

Empirical data supporting the existence of the 'quasifirm' was taken from 26 residential homebuilders in Eastern Massachusetts. Eccles (1981) notes that general contractors who retain the services of special trade subcontractors execute construction projects. This form of organisation is preferable to *vertically integrating*⁴ these trades because of the transaction cost implications of construction technology. From the results it was claimed that the general contractor and special trade contractors could when *conditions permit* form a stable organisational unit even though most projects are market based through competitive bidding. This organisational form, called here the 'quasifirm', is analogous to the 'inside contracting system' discussed by Williamson (1979). Eccles (1981) used Williamson's (1979) transaction cost approach to support the theoretical existence of the quasifirm in the construction industry. It is important to note at this point, that the 'quasifirm' study sample was restricted to one sector of the construction industry and excluded civil engineering and non-residential projects.

However, the Royal Commission into Productivity of the Building Industry in New South Wales seems to support the phenomenon of the 'quasifirm' by concluding that subcontractors consistently work for the same contractor (Gyles 1992). In one of the studies, it was indicated that of 396 subcontractors surveyed, 36% estimated that their total workload was committed to one client organisation - a contractor or client. A similar percentage (34%) had only worked for the three next largest customers. Thus 70% of subcontractors only work for three clients (Gyles 1992). This strongly suggests that informal alliancing already exists in the industry.

The evidence of a strong network cluster between contractors and subcontractors should be seen in the context of the money trails on construction projects. Preliminary studies on mapping money trails on construction projects (Gyles 1992) have indicated that subcontractors take approximately 80% of the cost of which a little over half of that is derived from materials. The following diagram summarises the money trail from client to consultant, contractor, sub-contractor and materials suppliers.

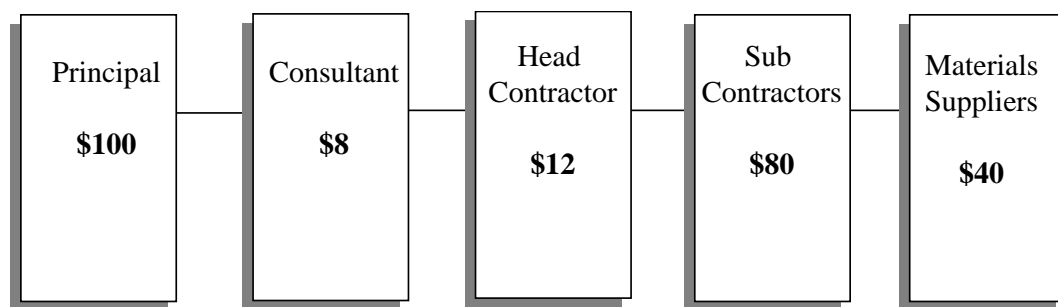


Figure 1: Construction Industry Money Trail (adapted from Gyles 1992)

The importance of this study is that it highlights where the majority of cost to the client is and the potential to impact on costs in the supply chain through client decisions. This suggests that the research to date with materials management and the associated logistics approach taken for supply chain management is important research, however a premise to this approach seems to have been to exclude other significant parties. For example with current procurement models there has been little interest or scope for clients to impact on the supply chain through direct decision making processes.

⁴ The extent to which a firm is responsible for producing all the inputs for its products (Eccles 1981)

SUPPLY CHAIN THEORY

There are two primary schools of thought within supply chain theory in the construction industry. The first is associated with logistics theory and is exemplified by reducing waste through efficient management of the flow of supply of materials to site. Evidence suggests that the primary focus for the logistics concept in construction should be on information flows (ie coordination and communication activity) between project participants during design and construction phases (Agapiou et al 1998). This view concentrates on the logistics of construction process, and views supplier interaction as clusters of subcontractors concentrated around the contractor. Although suggestions of 'new' (non-traditional) roles for materials suppliers have been clear it is not as clear what the implications of such new roles will be on the organisations involved.

The second school is associated with 'lean' thinking (Womack and Jones 1996) and seeks to create value across the entire chain of supply, with the logistics of production as a necessary and integral subset of the broader perspective. It is contended that in the construction industry, similar to supply chain theory in manufacturing, the two approaches are appropriate and are examining related problems with a different perspective.

Much of the literature in the construction industry has focussed upon the construction phase and the management of the supplier, subcontractor and contractor relationships (Hinze and Tracey 1993, O'Brien 1995, Agapiou *et al.* 1998). The significant areas pursued have been materials management and off-site fabrication through such techniques as logistics (Agapiou et al 1998) and lean construction (Horman 1997, Howell 1997) in seeking to achieve waste minimisation in cost and time.

O'Brien (1995) adopted supply chain theory from manufacturing to construction and developed a model that relied upon the project as a 'nexus of many supply chains each with its distinct properties.' This model was quite focussed upon the construction site and management of production flows between off-site to site. It was observed that there are multiple supply chains and that interference on site causes off site supply chains to interact just as off site delays cause interaction on site. A systems approach to supply chains was advocated that sought to reduce global costs in the supply chain and that this may in fact be problematic given the profitability needs of individual firms. O'Brien (1995) suggested the need for careful analysis.

Research in the UK has considered materials and components supply and flow with an emphasis on the role of builder's merchant in the supply chain. This work has called for long-term relationships and alliances to be developed between construction companies and merchants (Agapiou et al 1998). It was also suggested that during the design phase merchants should become the party responsible for the flow of information relating to building materials, as this may contribute to significant cost savings and increased productivity. The involvement of the materials supplier/wholesaler at an early stage of the decision making process in for example, Scandinavia, did lead to cost savings and increased productivity (Agapiou et al 1988). These studies have focussed on project-based models and considered on-site management through observing material flows and improving 'doublet' relationships (Poirer and Reiter 1996). These types of doublet relationships are typically a supply chain cluster around a key buyer.

Similar supply chain clusters such as the construction site management are evident throughout the building procurement process. The potential for clusters has been identified by Tombesi' (1997) design cluster. It is suggested at this point that supply chain networks may be distinguished from clusters in that the network is the chain of directional interconnected clusters.

The following definition and Figure 2 exemplify the broader perspective of supply chain management. Its application to the construction industry is worthy of investigation.

A supply chain is a system through which organisations deliver their products and services to their customers (Poirer & Reiter 1996: 3)

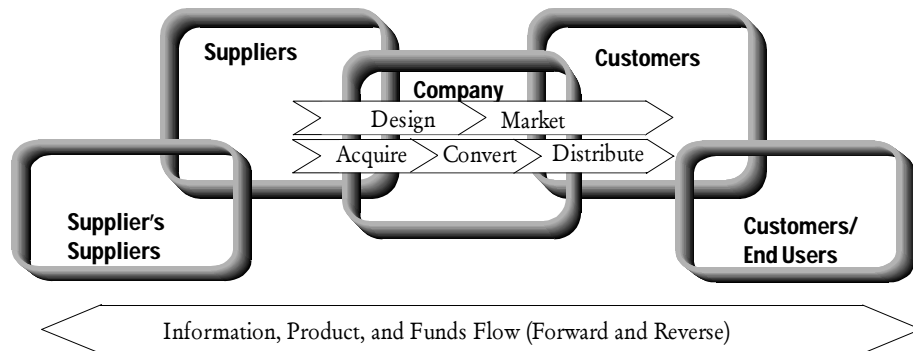


Figure 2: Supply Chains (Poirer & Reiter 1996 p6)

A more significant interpretation of supply chain management by Christopher (1993) involves understanding that the production phase, ie. construction phase, should not be seen in isolation as the upstream decisions affect projects significantly and are therefore an integral component of supply chain management. To do so, loses sight of the importance of the inception and design phase where the value of the product to the eventual customer is defined. The following definition underpins this broader approach:

Supply Chain Management is the 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. (Christopher 1993)

To date, this role has largely been transferred to the contractor and subcontractors and clients have tended to buffer themselves from the financial risk and management responsibility. It is suggested that the management of upstream and downstream linkages needs to be 'pulled' through from the 'customer' or in the case of the construction industry, the client. The potential role the client will play is in need of investigation to assist managing a number of such 'doublet' relationships, or single links, in the procurement of buildings.

Interestingly, there is currently considerable interest in the market place in the potential benefits from supply chain management. Anticipated benefits listed by the Australian Commonwealth include:

- faster response times;
- less waste;
- reduced inventory holdings;

- increased return on investment;
- more effective information flow;
- less cost;
- more profit; (DIST 1998).

It has been established in manufacturing that the greatest successes in managing the upstream and downstream linkages have been in those supply chains where strategic alliances have been developed between key parties and longer term relationships have been developed across the entire network (Poirer and Reiter 1996). In the construction industry, selected readings support an approach to SCM in this holistic manner (Weston and Gibson 1993; APCC 1997; DIST 1998) although it seems little research has yet embraced these concepts.

Strategic Alliances

Increasingly there has been a blurring of boundaries between *competition* and *cooperation* in certain industry groups. In the recent past, strategic alliances could be found among competing firms in the automobile, computer, aerospace, oil, gas, mining and telecommunication industries (Ramu 1997). The formation of alliances is not a new phenomenon although relatively new to the building industry. It is often seen merely as an extension of the concept of partnering.

Strategic alliances are collaborations between firms and can take varying forms. They may be used to;

- enter new markets,
- access new technologies and
- achieve economies of scale.

Alliances have legal, economic and organisational elements.

Some of the larger client organisations involved with the construction industry are well placed to manage strategic relationships between key players in the supply chain by virtue of their purchasing power (Weston and Gibson 1993; NSW Govt 1996; APCC 1997). Weston and Gibson (1993) claim that successive contractual obligations can not be maintained by the US Army Corp of Engineers due to US legal regulations for equity and probity issues. They also maintain that these relationships have to be developed on a project by project basis through 'partnering' arrangements. However, the Australian literature indicates an acceptance that longer-term relationships are inevitable to manage the supply chain.

Within the Australian context the development of strategic alliances by government organisations is seen as integral to their role in the development of the industry's culture. Strategic alliances in this context are being considered in relation to the support for small to medium enterprises that make up much of the industry. The rationale for this is discussed in further detail later in this paper and is based upon the structure of the industry.

The structured strategic alliance in heavy engineering construction projects, tends to rely upon a concept of strategic alliance contracting for individual projects and appears to be a natural progression from the partnering concept (*The Weekend Australian* 18-19 May. 1998). It is possible that these alliances still maintain distinct organisational boundaries. The extension to the partnering concept is that the alliance

is with firms who will play a major role in the operation and maintenance of the facility, thus developing an upstream linkage with key players involved in downstream events 'post' project procurement. Partnering in the construction industry has tended to concentrate upon developing those relationships particularly for the construction phase. Strategic alliance contracting in heavy engineering projects does not appear to involve suppliers at this stage and to date little is known regarding their legal, economic and organisational characteristics.

Examples of formal strategic partnering in the construction industry that are repetitive partnerships from project to project are not common. Such relationships where the boundaries of the partnership are outside projects are not well documented yet. There are limited examples of this and it is difficult to draw any firm conclusions. This suggests that there is scope to explore factors that might affect the linkages of networks and improve value across the entire supply chain through the development of strategic alliances between firms, particularly the small to medium enterprises. It also suggests that it may be worthwhile observing alliances in other industries.

True strategic alliances tend to be characterised by hybrid organisational arrangements that use resources and/or governance structures from more than one existing organisation (Borys and Jemison 1989). The formation of strategic alliances relies upon the development of networks (Ramu 1997) and to understand further, the factors that have been identified in other industries that affect the supplier-buyer relationship, a concept known as network sourcing is now investigated.

Network sourcing

It has been widely recognised that we are in the midst of an organisational revolution. Throughout the 1980s, organisations around the world responded to an increasingly competitive global business environment moving away from centrally coordinated, multi-level hierarchies and toward a variety of more flexible structures that closely resembled networks rather than traditional pyramids. These networks - clusters of firms or specialist units coordinated by market mechanisms instead of chains of commands - are viewed by both their members and management scholars as better suited than other forms to many of today's demanding environments (Miles and Snow 1992).

It could be said that firms within the construction industry are largely familiar with the need for flexible structures as each firm simply responds to project needs. Projects require a large degree of flexibility and firms consistently attach themselves to the 'larger organisation' known as the temporary construction project organisation (Jennings and Kenley 1996). There is potential for further investigation into the types of organisational arrangements that arise between firms in the construction industry.

Ramu (1994) categorised networks in general into four groups, based on both intra and inter business unit networks, including vertical (franchising, subcontracting), diagonal (interdisciplinary), horizontal (alliances) and internal (profit centres, strategic business units). The linkages between the units are explained by two key variables involving capital and operation. That is, they are economically based with distinctive organisational structures.

Miles and Snow (1992) who suggested that networks of firms were either stable, internal or dynamic dependent upon the type of linkages proposed an alternative typology. This model favoured that the type of linkages were not the causes for network failures but rather the management of the network. It was claimed that

management failures were caused by a lack of understanding and violation of the logic behind the structure of the linkages.

Further to these two approaches, Hines' (1996) research on buyer-supplier relationships can assist in understanding interfirm relationships between networks. He suggested that the literature regarding the buyer-supplier relationships could be categorised into three groups. The three schools are the

1. Trust school
2. Partnership school
3. Japanese school

Within the Trust School the general view emerges that the causal features of the type of beneficial relationships suggested are primarily due to a complex mix of social and moral norms, with technological, economic and government policies also of some importance. There is therefore some suggestion that such approaches may be more difficult, or even impossible, given the set of external and internal factors in the Western world.

The Partnership School suggests that relationships should be developed on the basis of partnership on the creation of one-to-one basis with individual strategic suppliers, with the emphasis on the formal creation of the partnership. This primarily UK model, plays down the potential problems of cultural specificity by following an approach designed to form relationships of the type exhibited in Japan (Hines 1996).

The third approach, which appears to take the middle ground of the above schools, the Japanese school suggests that although conditions are different in the West, a somewhat modified or developed Japanese-style approach can be translated to other cultures. A number of authors describe the route to developing the desired supplier-buyer relationship in this (Hines 1996) and it involves supplier grading, supplier coordination and development.

The network-sourcing model was developed within the Japanese school context (Hines 1996). A study using data collected on 40 Japanese companies within the automotive, electronics and capital equipment industries, through semi-structured interviews and questionnaires, identified and then illustrated the relationship between ten causal factors. The results of the study demonstrate that within network sourcing supplier coordination and supplier development have emerged as the critical causation factors. The following are definitions of supplier coordination and supplier development:

Supplier coordination refers to the activities made by a customer to mould their suppliers into a common way of working, so that competitive advantage can be gained, particularly by removing inter-company waste. This type of coordination would involve areas such as; working to common quality standards, using the same paperwork system, shared transport and employing inter-company communication methods such as EDI.

Supplier development refers to the activities made by a customer to help improve the strategies, so that suppliers could plan their processes more effectively, as well as the customer offering specific assistance to the suppliers in areas such as factory layout, setup time reduction and the operation of internal systems. (Hines 1996 p12)

It was suggested that to achieve a lean supplier network both of these activities must be undertaken simultaneously. It is interesting that Hines (1996) commented that in the West, the best organisations generally endeavour only to address one or other of these areas, with the majority of firms failing to address either.

In summary, it bears out that supply chain procurement modelling needs to be customer driven as they are in the most strategic position to coordinate upstream and downstream linkages at all levels in networks oriented to the primary task. The relevance of this to the procurement process in construction is that for clients to make decisions that impact on the supply chain linkages a fine grained understanding of the supply chain is required.

As noted earlier a number of authors have attempted this and studied supply chain clusters within projects for various phases (Eccles 1981; Peitroforte 1997; Tombesi 1997). Such studies included observing the information flows for the design and construction of a curtain wall, relationships and contractual agreements in construction and specialisation activities in design. This research builds upon these observations.

RESEARCH STRATEGY

This paper provides the background to a small research project that will be undertaken in Australia this year. The general research problem is concerned with investigating the networks in supply chains in a small construction market in a remote area. The study will consider loosely structured research questions:

What networks are operating as you move progressively down a supply chain?

What is the nature of these supply chains and what issues concern producer-stakeholders (London 1997) involved in the supply chain networks?

To explore these questions two supply chains will be selected and suppliers to each party involved in the construction contract along the supply chain will be interviewed. The initial point of reference for the supply chain will be three small to medium sized contracting firms who will provide details regarding projects that they are currently managing. The contractors' suppliers will then be interviewed and then their suppliers and so on until a 'rich picture' of the relationships is developed. At this stage this research is exploratory in nature and seeks to illuminate the general research problem. One of the premises of this study is that interesting patterns may arise through observation of the various interleaving supply chains across a number of projects. The few construction supply chain studies that have been carried out in the past have concentrated on single case studies whereas this exploratory study will consider the range of projects that are operating simultaneously within a firm's sphere of influence.

The data collection will involve recording semi-structured interviews and at this stage it is expected that approximately nine to twelve interviews will be carried out. The data will form the basis for interview transcriptions that will be coded and categorised. Industry participants for the study will be selected from those associated with the industry partners supporting this research program. The analysis and results of the study will be available next year.

CONCLUSION

The literature of supply chain theory and modelling was reviewed and analysed in this paper. One of the main claims in this paper is that there are two approaches to supply

chain management in the construction industry. The strategic management approach was taken for this research since the understanding of informal and formal alliances and the associated network relationships will provide the broad framework for supply chain management that the logistics approach has not achieved. To further this research, a strategy was proposed that would involve an exploratory study of the general research problem of investigating supply chain networks identified in a small market. The results of this first stage of research will begin to inform decision-makers of the impact on small to medium enterprises of the supply chain management concept. The results of this research project involving case studies will be available next year. It is expected that the study will highlight further research areas.

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@inproceedings{Fernie1999SUPPLYCM, title={SUPPLY CHAIN MANAGEMENT-THEORETICAL CONSTRUCTS FOR CONSTRUCTION}, author={Scott Fernie and D. Root and T. Thorpe}, year={1999} }. Scott Fernie, D. Root, T. Thorpe. Published 1999. This paper describes an ongoing research project addressing the issue of Supply Chain Management within a construction context. SCM is described as having various generic characteristics that have been rationalised from an initial literature review and open dialogue with practitioners in the field. Theoretical supply chain network modelling in the building industry. K. London, R. Kenley, A. Agapiou. Business. Every industry has a supply chain. Supply chains historically were straight line models that looked something like this: Raw materials>>>supplier>>>manufacturer>>>warehouse>>>shipping>>>end user. Today thanks to the global economy the supply chain looks more like a web with the manufacturer in the middle of the web. Without a strong supply chain management model in place a business will not thrive. Supply chains exist in both service and manufacturing organizations. Unlike the efficiency models that are built on sameness and schedules these models require quite a bit of human interaction which of course leaves the system prone to human error. Same Goals Different Measures. The SCOR (Supply-Chain Operations Reference) model, developed by a consortium of industry and the non-profit Supply Chain Council (now part of APICS) became the cross-industry de facto standard defining the scope of supply-chain management. SCOR measures total supply-chain performance. In the developing country public health setting, John Snow, Inc. has developed the JSI Framework for Integrated Supply Chain Management in Public Health, which draws from commercial sector best practices to solve problems in public health supply chains.[11]. Management[edit]. Main article: Supply-chain management. Supply chain network design is a powerful modeling approach proven to deliver significant reduction in supply chain costs and improvements in service levels by better aligning supply chain strategies. It incorporates end-to-end supply chain cost, including purchase, production, warehousing, inventory and transportation. In the eventuality of external triggers, the team needs to carry out preparatory exercises well in advance to accommodate long-term decisions and their lead time to implement. Supply chain network design with a powerful modeling approach can deliver significant reduction in supply chain cost and improvements in service levels. It incorporates end-to-end supply chain cost: purchasing, production, warehousing, inventory and transportation.