

# A TWO DIMENSIONAL VIEW OF THE SUPPLY CHAIN ON CONSTRUCTION PROJECTS

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## ABSTRACT

Subcontracted trades undertake most of the physical construction work in construction projects. While many research projects have examined relationships between designers, developers and head contractors, there has been limited focus on detailed analysis of the relationships between subcontractors. Where relationships in the supply chain have been examined it has tended to be along the dimension of contractual relationships between subcontractors and their suppliers.

This paper looks at the relationships between subcontractors in a second dimension where they build on each other's work on the construction site, but are not contractually related, except through the head contractor. Initial investigations carried out during this research confirm that subcontractors focus on the head contractor as their primary customer, and hence attention on the following trade as a customer is minimal. This paper proposes a shift in focus, whereby a subcontractor (preceding trade) attempts to meet the product and service quality expectations of the trade that will be building upon that subcontractor's work (following trade) leading to an improved project culture and better overall project quality outcomes. Tools were developed to increase the interaction between preceding and following trades and communicate product and service quality expectations. These were implemented on three construction sites in Sydney, Australia while three other sites were monitored for changes in customer focus and culture without any interventions. Results to date show that the tools developed have in fact increased focus on following trades resulting in improvements in overall project characteristics.

## KEY WORDS

Construction, supply chain, process relationship, subcontractors, service quality, customer focus.

## INTRODUCTION

Quality and productivity issues plaguing the construction industry are well documented. The quality problem, particularly in relation to defects and rework, has

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been the focus of many research efforts including identifying cost and time implications (examples Thomas *et al.*, 2002; Love, 2002) and causes of defects (Karim *et al.*, 2006). Strategies put forward to ameliorate this quality problem are wide ranging and include technology improvements, such as quality function deployment, pre-manufacture, and information management, process transforms, such as performance measurement and benchmarking (Karim *et al.*, 2003), use of quality systems (Abdelhamid, 2003; Dissanayaka *et al.*, 2001) and improvements to design process and personnel aspects, such as leadership, motivation, communication, culture and a combination of the above as a system in moving products or services from a customer supplier perspective. The last of the aforementioned categories is generally termed Supply Chain Management (SCM) and has gained interest within the Construction Industry in recent years as a tool for achieving quality and productivity gains (Vrijhoef & Koskela, 2000, Cheng *et al.*, 2001). The following sections of this paper discuss the product and information flow characteristics of subcontractors as supply chain partners at a micro level and aligning supply demand expectations with a view to improving focus on following trades as internal customers and using this as a move towards better application of lean concepts through improved product flow reliability in construction supply chain management (Zimmer *et al.*, 2008), defect cost minimisation and reduction of non-value adding activities. The last section shows how this focus on following trades as internal customers can be achieved on a construction site.

## **SUBCONTRACTOR ROLE IN CONSTRUCTION**

Two issues strengthen the case for detailed assessment of supply chain issues at subcontractor level.

First, is the changed role of the head contractor as a supply chain partner. The biggest cost centre leading to occupation of constructed premises is the construction itself. In recent times, the way head contractors deliver the product has changed though their central role has not. As the construction industry has repositioned itself to be able to respond better to cyclical fluctuations typically faced by it, a key element in its reorganisation has been the structural change in the way head contractor firms construct a project, from primarily using in-house expertise and labour previously, to the use of a large number of subcontractors at present. Presently, up to 90% of the construction work may be done by subcontractors (Mathews *et a.*, 2000; Karim *et al.*, 2006), and head contractors mostly tend to undertake management and coordination activities (Humphreys *et al.*, 2003). This aspect is recognised in the context of supply chain management. Egan (2002) refers to it as supply side integration and went to the extent of recommending that “clients should *require* the use of integrated teams and long term supply chains and actively participate in their creation”.

Secondly, fragmentation, while being an inherent characteristic of the current construction industry, is at its highest at subcontractor level. There are many instances where multiple organizations have been hired from the same trade, sometimes to work in different areas and on other occasions to finish up another organization’s half done job.

## SUPPLY CHAIN STUDIES IN CONSTRUCTION

Supply chain studies typically have conformed to the notion of a linear product/service flow from one supply chain partner to the next. Hence, at a macro level, the typical supply chain of a construction project has included client (end user), designers, head contractor, subcontractors, and suppliers through a traditional path of delivery. Wong and Fung (1999) used the client, consultants, the general contractor and its subcontractors and suppliers as supply chain members as in Figure 1 through a traditional path of delivery.

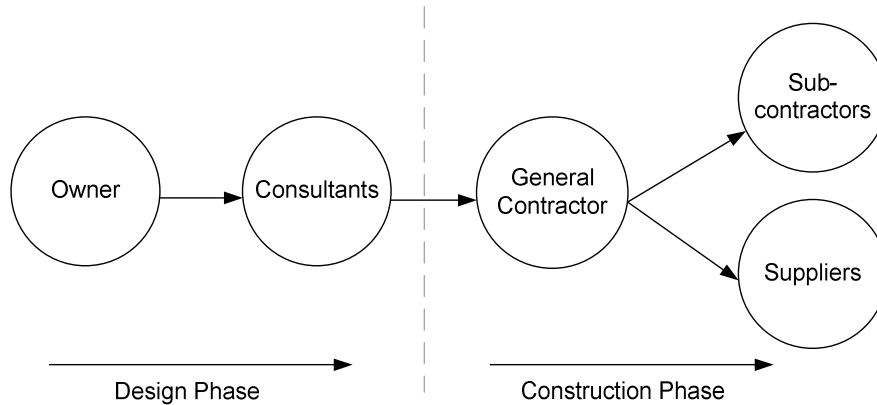


Figure 1: Supply Chain of a Construction Project (reproduced from Wong & Fung, 1999)

More recent studies have maintained a similar model with some minor changes, most notably, Vrijhoef and Koskela (2000) included the information and material flows while O'Brien *et al.* (2002) identifies the complexities of project site activity procedures and multiple layers of suppliers connected to subcontractors.

Many studies at this level have led to concepts such as aggregation and integration (example Dainty *et al.*, 2001) seeking a framework to create linkages within and between supply chain partners. Consequently the primary focus has been on partnering, alliances, joint ventures and consortia between clients and service providers including integrating design and construction. Humphreys *et al.* (2003) observe that partnering has mostly been seen in terms of clients and head contractors and very few studies have been devoted to the relationship between the head contractor and subcontractors.

However a key aspect missing from these studies is the focus on subcontractors. While detailed analysis of subcontractors' role as supply chain partners has gained some interest lately construction supply chain models proposed by Vaidyanathan and Howell (2007) and Vrijhoef and De Ridder (2007) are still limited to recognizing the multiple players and layers of subcontractors and suppliers in construction further expanding the horizontal contractual chain, with no linkages between subcontractors. Figure 2 summarizes the output of these studies during the construction phase. While the model recognizes the complexities in linkages between upstream and downstream supply chain partners at this level, there is no evidence of recognition of linkages across streams particularly between subcontractors who need to interact on the construction site.

Further, Dainty et al. (2001) refer to all the interfaces: client/contractor, consultant/contractor, contractor/subcontractor, and subcontractor/supplier: but do not include the interface between preceding and following subcontractors. Humphreys et al. (2003) focused on HC/SC partnering. In doing so they looked at a number of issues but did not investigate the work flow linkages between various subcontractors.

Essentially, the notion of a large number of subcontractors and sub-subcontractors forming a supply chain of preceding/following trades is not acknowledged as such by the existing project management strategies of the head contractors or subcontractors, nor is there any evidence of its recognition in the literature.

Karim et al, (2006) agrees and adds that studies on relationships between subcontractors are further complicated due to the subcontractors being contractually obliged only to the head contractor, whereas the construction process flows from one subcontractor to the other. Hence, the current issue of subcontractor linkages is attributed to the lack of integration of the output of one subcontractor (preceding trade) to the input requirements of the following trade.

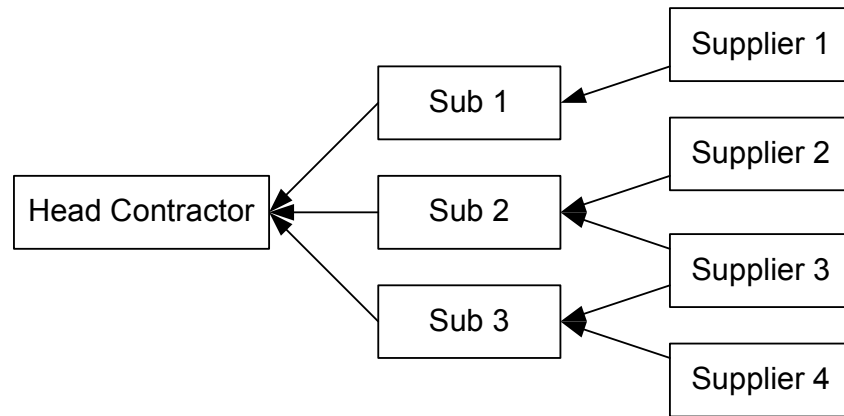


Figure 2: Construction Phase Supply Chain in Construction

The industry response towards integration and continuance of learning has concentrated on some head contractors initiating long term relationships mainly between the head contractor and subcontractors (vertical integration).

Efforts towards horizontal integration addressing the issue of having a high number of subcontractors on projects though are still in its infancy. Hence, it is still not uncommon to see over hundred subcontractors being procured for a typical multi storey building project. In the absence of a detailed study and an acceptable framework, the current industry practice attributes this to a coordination issue as part of the head contractor's role. Some initiatives being implemented with limited success as a result include regular subcontractor coordination meetings and head contractor administered defect checklists. This may in fact have compounded the quality problem in construction by taking away the responsibility for the work from the respective trades. Hence, it is proposed that by establishing a stronger customer-supplier relationship between the preceding trade and the following trade, recognizing the following trade as an internal customer within the project setup, the quality issue could be addressed more effectively and with reduced non-value adding activities.

It is not possible to overhaul the construction industry characteristics to fit within an existing theory. While, some have attempted the use of multiple theoretical approach (Isatto & Formoso, 2006) to provide a comprehensive description and understanding of construction supply chains, the focus in this ongoing research is to model the existing characteristics and to adapt the theory such that improvements can be implemented within the modeled framework.

**CUSTOMER FOCUS EXPERIMENT**

An investigation was performed on 6 construction sites, involving 30 subcontractors, to see if the sub-contractors’ perception of the following trade being their customer could be influenced. Half of the sites administered a Pre-Start checklist focusing on handover quality issues and half did not. All sites were surveyed before and after to determine the effect of the Pre-Start process.

Projects for this were provided by industry partners for the research project around Sydney, Australia. The projects were similar in characteristics in that they were all building projects in New South Wales (NSW), most of the work was carried out by subcontracted trades while the head contractor was focused on management and coordination. Most projects had repeating floors or units.

**BASELINE STUDY**

The aim of the baseline study was to examine the current customer orientation associated with trade subcontractors prior to any interventions. A questionnaire was developed to obtain empirical evidence of the existence of relationships with possible customers as well as the parameters affecting these relationships, particularly with internal customers.

As part of the initial survey, respondents were asked to identify their perceived primary customer from a choice of four: end user, architect (designers), builder (head contractor) or following trades. The next question asked for the main reason for their choice. More than 90% of the subcontractors identified the head contractor as their main customer with the most common reason for their choice being the contractual relationship. Results are presented in Table 1:

Table 1: Subcontractors’ Perceived Main Customers before Interventions

Customer Group	Percentage	Reasons	Percentage for each reason within each customer group
Builder	91%	Contract	47%
		More Projects	4%
		End of Chain	3%
		Didn’t Specify	46%
End User	6%	Warranty Card	100%
Architect	3%	Represent Client’s Needs	100%
Following Trade	0%	None	N/A

Interestingly, none of the subcontractors surveyed on the six sites identified the following trade as their primary customer. While one of the key ideas of Quality

Management is pleasing the customer, it is also well recognized in the literature that this applies even when the customer is another part of the same business or the project, a so called internal customer.

The next part of the survey was aimed at understanding how each subcontractor trade focused on different potential internal customers within a construction project. For this, each respondent was asked to divide 100% between three internal customer groups namely; head contractor, designer/architect and following trade according to what they thought their current focus is. On average while the head contractor received more than 60% of their attention as an internal customer, the following trade received only 15% of the focus. Figure 3 shows the variability of the responses across the six sites and focus spread between head contractor, end user and following trade as customers at the beginning.

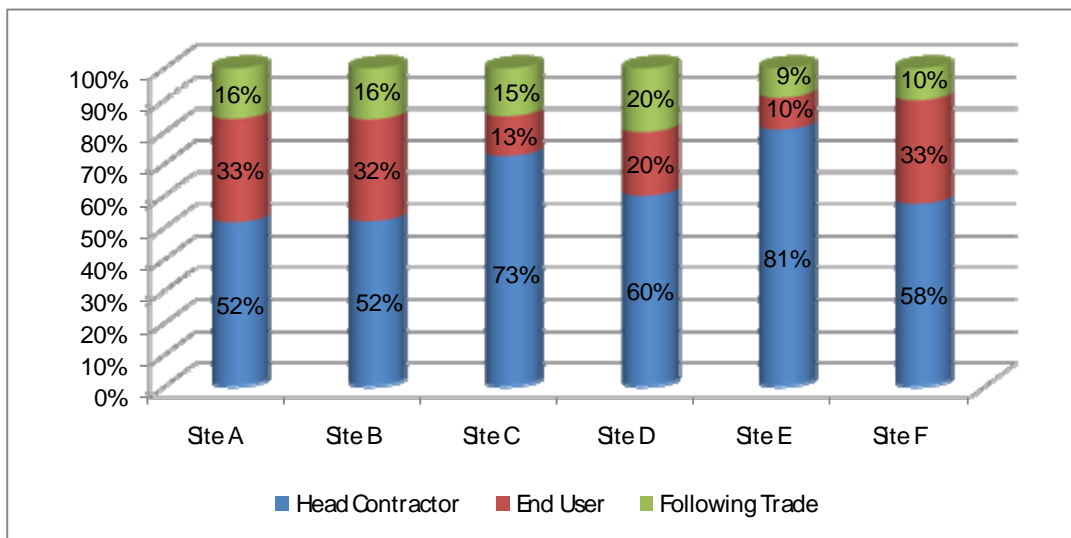


Figure 3: Baseline Survey Results of Six Construction Sites Showing Customer Focus Spread of Subcontractors

This confirms that the traditional supplier-customer relationship does not recognize the view of a trade subcontractor treating the following trade as an internal customer. Nevertheless, the process and information flow characteristics observable between these entities suggest the need to recognize the existence of such interdependence.

Given the above results it is not surprising that trades often leave defective work for the following trade, and that following trades are prepared to work on top of defective work.

#### **TRADE START-UP CHECKLISTS: PRE-START**

The handover of work from one trade to the next is a significant stage in the construction process for a number of reasons including:

- Occupation of the work area changes typically from one organisation to another;

- Last opportunity to assess the quality and safety outcomes of the preceding trade prior to the preceding trade moving to a different work area, level or project;
- Opportunity to identify defects as close as possible to the work phase to avoid building up on defective work;
- Opportunity to assess integration of needs between preceding and following trades including communication of information; and
- Opportunity for following trade to assess support services provided by the head contractor and service quality expectations from the preceding trade.

Based on initial investigations, the previous stage of this research and comments from industry partners, it was recommended that a checklist could be used to best capture the relevant product and service quality attributes during the trade handover process. Hence Trade Start-up Checklists were developed by the research team to utilise the above opportunities and thereby capturing key physical/ product and service quality expectations among key trades at trade handover points. Marosszeky *et al*, (2005) presented an example of such a trade start-up checklist developed for the plumbing trade for one of the three project sites it was implemented in.

#### **IMPLEMENTATION**

A key learning outcome of the implementation of the trade start-up checklists was the implementation process itself. On the first of the three sites, the head contractor initiated the development of checklists. This process faced a number of obstacles and eventually failed to be implemented due to issues in getting buy-in from the relevant subcontractors. It was seen by many subcontractors as a document seeking responsibility for the work received by them from the preceding trade. Further, it tended to include only those items that were of interest to the head contractor and missed key items that were required to ensure a desirable handover.

While the use of these checklists was not compulsory, there was no additional reward other than any perceived benefits from the implementation of the checklists itself for both the head contractor and the selected subcontractors. Hence, giving ownership of the checklist to the trades who were using it was important. Therefore, on the remaining two sites, the selected trades were given a blank slate during the meeting to identify the items that were important to them when they move into a new work area. Interestingly, there were many similarities with the failed checklists developed by the head contractor but they also included items that were seen as services and coordination responsibilities of the head contractor, that were missing in the failed ones. These included, having a clean site with preceding trades' waste removed from work area, preceding trade being out of the way when starting work, suitable site facilities and storage allocated, etc. Some key categories of checklist descriptions and examples are presented in table 2.

#### **DISCUSSION**

The trade start-up checklists were seen as a useful tool by both the subcontractors and the head contractor in the two construction projects particularly as a means of identifying defects early and coordinating the preceding and following trade

requirements at the beginning of a project to enable trouble-free coordination in subsequent work areas/ floors.

Table 2: Trade Start-up Checklist Sample Extracts: Plumbing & Rendering

Trade	Description	Description category
Plumbing	Penetrations as per latest drawings	Physical quality of preceding trade's work
	Tiler and renderer has protected FW from sand and cement	Service Quality of preceding trade
	Completion of preceding trades' work coordinated	Head contractor support services
	Clear access provided	Head contractor support services
Rendering	Brickwork square and plumb	Physical quality of preceding trade's work
	Membrane cured and suitable	Physical quality of preceding trade's work
	Work area left tidy and accessible	Service Quality of preceding trade
	Defects rectification of preceding trades' work coordinated	Head contractor support services

It was also observed that on the sites that implemented Pre-Start, the perception of the following trade as a customer has increased. The customer focus questionnaire was repeated on the two sites that implemented pre-start and three other control sites that did the baseline survey. The results are shown in Figure 4.

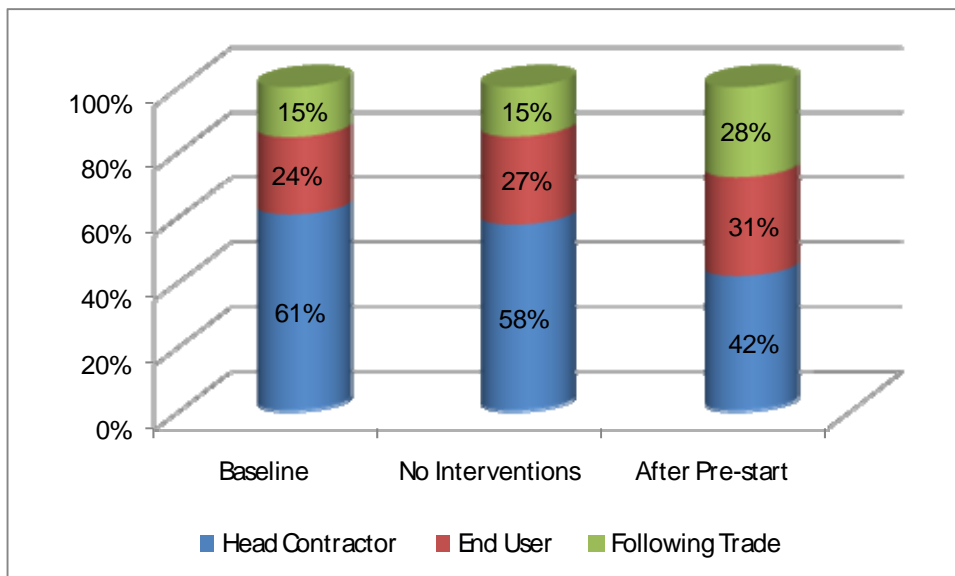


Figure 4: Change in Customer Focus with and Without Pre-Start

While it is not the scope of this paper to analyse in detail the changes in response by individual subcontractors, it is worth noting that a significant shift towards



increased focus on the following trade was observed with the trades that were involved in the Pre-Start process. This research acknowledges the many variables between construction sites, subcontractor organizations and various work phases (structural, finishes, etc.). Hence, the qualitative interpretation of the effects of the interventions becomes significant in verifying the quantitative results. Marosszeky *et al* (2005) reported the qualitative interpretation of a director of one of the head contractor teams where Pre-Start focused attention of workers on the site to the supplier-customer nature of the relationship between trades leading to significant improvements in quality.

### **FURTHER RESEARCH**

The need for detailed research at subcontractor level in construction is already detailed in this paper. This can be directed towards long term systemic shifts in practices and perceptions as well as developing a robust tool available for immediate implementation to alleviate a tangible, current issue. This research is continuing to refine the Pre-Start process to address the latter while progressing in modeling process flow characteristics and associated customer-supplier expectations between subcontractors to develop a typical framework to identify key stages of using the Pre-Start.

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