Development of SCM competencies in construction: Lessons learned from New Zealand

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Abstract

The construction industry, which contributes around 5 percent to gross domestic product, is a vitally important industry in New Zealand. With over 50,000 businesses, the construction industry is the third largest industry by business count in New Zealand's economy (Statistics New Zealand 2009). Although it is widely accepted that productivity can be improved by adoption effective supply chain management (SCM), no studies have investigated this in the New Zealand context. The purpose of this paper is to understand the nature and extent of current practice of Construction Supply Chain Management (CSCM) in NZ construction. Consequently to examine whether current SCM practice exemplified in NZ could be considered to be international 'Best Practice'. A case study approach is used for probing SCM practice on a NZ$75m commercial project located in Auckland Central Business District (CBD. The supply chain network of the principal ground works and superstructure construction stages was studied. The key findings of the case study suggest that the flow of materials remains the main focus of CSCM practice. It was found that essential skills training for CSCM was extremely limited and largely ill-defined in terms of its nature and content. Finally it was identified that as the NZ construction industry moves towards a significantly more collaborative framework, the efficacy of CSCM operations is expected to substantially improve. However this last point did not negate the requirement to expand and improve skills training in CSCM. This indicates that there is room for improving CSCM to reduce construction project costs and increase productivity.

Keywords: construction supply chain management, logistics, skills, training, collaboration, New Zealand

1. Introduction

The construction industry is regularly described as suffering from poor performance (Cox and Ireland 2002), such as time and schedule overruns, quality defects and poor health and safety performance. Similarly, findings from numerous studies have categorised the problems facing construction into five broad areas: industry's fragmented nature, adversarial relationships between participants, project uniqueness, separation of design and production,

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and competitive tendering. Supply chain management (SCM) and related concepts (i.e. partnering, alliancing and PPP) have been proposed as solutions to these issues.

As a result these 'post modern' contracting frameworks have received increasing interest in construction research and practice (Bankvall et al. 2010; Briscoe and Dainty 2005; Bygballe et al. 2010; L??nngren et al. 2010). In NZ there have been numerous studies and discussions related to the implementation of such high level strategic approaches on the behaviour of the NZ construction sector (Liu and Wilkinson 2011; Masurier et al. 2006) which is very much in line with 'rest of the world' thinking. This is an interesting observation since the understandings of the principles of SCM in NZ are much less well documented from the literature.

As the scale of the discussion is brought down to focus on tactical issues around construction and site operations, SCM literature is quite substantial. However, as the scope of discussion area has reduced, the amount of work specifically related to the NZ experience of CSCM has reduced. This is a key finding since at present there seems to be an oversupply of NZ research targeted at the high level, strategic aspects of CSCM, but is unsupported by research dealing with the low level capabilities necessary for its effectiveness. The main conclusion to date is that the construction industry worldwide seems to be facing problems in managing supply chains and is lagging behind in terms of supply chain practices (Bankvall et al. 2010), and specifically in NZ there are many deficits in the knowledge of best CSCM practice. This paper illustrates the initial results of an ongoing research project which aims to map construction supply chain structure in the Auckland region. The aim of this paper is to investigate the adoption of SCM to date in the NZ construction industry. There has been little research on the understanding of the nature and extent of CSCM current practice in NZ. The research described in the paper begins to fill this current gap in New Zealand SCM knowledge. It also seeks to establish current best practice elsewhere, before proposing how the NZ industry can improve its performance to achieve higher efficiency and productivity.

The paper starts with a preliminary inquiry into how SCM is viewed in NZ construction. This is conducted through a review of construction literature with regard to various flows of construction supply chains occurring at a construction site. Thereafter, barriers in implementing SCM in constructions are examined. The case study methodology and key findings are described subsequently. In the concluding section, the principal insights and suggested directions for future research are discussed.

2. Construction supply chains: barriers and contributors to 'Best Practice'

2.1 Construction: An Industry Unique?

Compared to other industries, such as manufacturing, the construction industry is a highly project-centric industry. As we have indicated previously it operates in an environment of extreme complexity and uncertainty. This is largely due to the fragmented structure of its supply chain, short term trading relationships, poor information flows and a high degree of

dependency between tasks and activities (Briscoe and Dainty 2005; Wegelius-Lehtonen 2001). This is particularly difficult to deal with since the supply chain is constantly evolving as the project develops through its constituent phases. As a result creating the conditions whereby construction operations achieve the same level of certainty and consistency as a manufacturing facility are next to impossible.

The two most important aspects of the construction industry are customer specificity of the final product, the essential mobility of the production process and the involvement of numerous value-adding organisations (Cherns and Bryant 1983). The construction industry is customarily viewed as having a high degree of fragmentation, low productivity, cost and time overruns, and conflicts and disputes. Certain characteristics of construction, such as one-of-a-kind products, temporary management team and site production (i.e. weather dependent), are major causes of performance-related problems facing the industry and prevent the attainment of flows as efficient as in manufacturing (Segerstedt and Olofsson 2010; Xue et al. 2007).

Expert estimates and historical data analysis indicate that materials costs amount to circa 50-60% of project cost and control 80% of its schedule (Ibn-Homaid 2002). This demonstrates the importance of the material logistics tasks and shows that they comprise a large segment of the construction industry. Material logistic management is "the system for planning and controlling all the necessary efforts to ensure that the right quality and quantity of materials and equipment are appropriately specified in a timely manner, are obtained at a reasonable cost, and are available at the point of used when needed" (Business Roundtable 1983). Furthermore, in a construction project, any delay of the materials deliver may have knock-on effects on delaying works. If the material supply is on the critical path, the project will likely be delayed as a consequence. Nevertheless, research suggests that the biggest risk factor impacting on projects was delays in material flow, followed by labour flow, information flow and 'plant, equipment and temporary work' flow (Hatmoko and Scott 2010).

2.2 NZ Construction: A unique case in a unique industry?

These fundamental problems that are observed and reported upon in the literature appear to be extant everywhere in the world to greater or lesser degrees – the main problems summarised neatly by Dainty et al (2001) in Table 1. In New Zealand, these problems are exacerbated as a result of significant local issues. The economy is small for a developed nation, however as a developed nation we collectively have very high expectations of all industrial performance. The combination of high expectations, low economic size and physical isolation from other key markets reduces the purchasing power of local industry. Consequently materials and commodities in NZ are noticeably more expensive than in the next 'nearby' economy (Australia – some 4500km distant). This is made more contentious yet in NZ as a result of up to the minute media and communications which allow local consumers to know exactly how expensive things are in NZ compared to elsewhere. This in turn has driven extensive efforts to drive up productivity in construction through the Productivity Partnership (more details see http://www.buildingvalue.co.nz/).

Key issues	Barrier to subcontractor integration into the supply chain	Change required to alleviate barrier
Financial	Late and incorrect payments Tendering process Retention	Fair payments from main contractors Main contractors need to focus on value rather than price Trust needs to exist between parties
Programming	Unrealistic programme times	Parties should be involved in construction projects earlier
Contractual	Traditional contracts do not engender good working relationships	New contractual documents or less reliance on contracts
Main contractor's staff	QSs do not encourage subcontract integration Estimators are too demanding on small organisations	QS training in communication skills Educate estimators into the demands of these businesses
Knowledge and information	Companies do not understand other businesses within the supply chain	Time needs to be taken to learn from partner organisations
Partnering	Some partnering relationships are executed for the wrong reasons Many partnering relationships were one sided Some subcontractors lack skills relating to design, legislation and costing that may be required for partnering	All employees should be educated in the benefits of partnering Main contractors need to offer subcontractors benefits if they are to enter into such relationships Subcontractor training for those lacking skills
Miscellaneous	Main contractors do not treat subcontractors fairly	Educate main contractors into the business needs of smaller organisations

Table 1: Barriers to supply chain integration (adapted for Dainty et al. 2001)

The New Zealand construction industry contains a relatively high proportion of micro enterprises as well as small to medium enterprises (SMEs) (Building and Construction Sector Productivity Partnership 2012). The labour force working for the sector has a relatively lower skill level/education level than those in other sectors. For example new concept introduction is generally late in NZ compared to the rest of the world. At present BIM is being used widely in the US, UK and Europe (Azhar 2011). BIM compliance is a prerequisite of governmental contract/tendering in US/UK (Tran et al. 2012). Historically, NZ initiatives mimic UK initiatives, delayed by around 8 years. The counterpart of Egan report (1998) is not published in NZ until 2006 by the New Zealand Construction Industry Council (2006). In NZ discussion and debate still rages as far as whether BIM, as well as many other initiatives, are worthwhile to undertake and who should bear the cost of introducing new ways of doing business.

What can be said without fear of contradiction is that CSCM has significant problems in all construction sectors around the world, including NZ. However there are some unique factors that make the NZ case even more challenging for developing excellence in CSCM. Therefore the situation in NZ is both by degrees unique and generic. Consequently is the first instance to establish correct NZ SCM practice in the context of the wider global "Best Practice". Once this has been achieved it should be possible to propose opportunities for further development and improvement in the capability of the construction industry.

3. Research methodology

The objective of the research reported in this paper was to investigate the nature of current "close to best" practice in CSCM in New Zealand. The full study was very wide ranging and recovered substantial amounts of operational data related to vehicle movements and the logistics of construction supply. The findings reported in this paper concentrate on the specific issues related to management of logistics and SCM processes as they occurred on site. From the literature review reported earlier, it was established that the main areas of

interest for this aspect of research revolved around understanding of SCM, training in SCM skills and the relationships between supply chain protagonists.

To this end, a case study research method was adopted, with 'Elite Interviewing' selected as the principal method of data collection (Davies 2001; Tansey 2007). The method of case study research was chosen for this initial probing into the local situation for two main reasons. The first reason was that there was a need to recognise the importance of the changing dynamics of CSCM as projects develop through time. This, it was felt, did not allow for a 'snapshot' type of interview in order to make meaningful observations. Consequently a strategy of speaking to the project 'Elites' on a regular basis was adopted to gain a longitudinal insight into the processes being undertaken.

Secondly, there was a need to be able to engage with these 'Elites' in their real-life context, as well as using multiple sources of evidence to support the research observations (Yin 2003). The research team took the position that the best way in which both practice and context could be reported upon was through an action oriented "Genba Genbutsu Genjitsu" (3G) approach. Genba Genbutsu and Genjitsu, means actual place, actual thing and actual situation, is a special technique developed Honda Motor Company (Hartley 1992). This "seeing in operation" approach allowed the principal researcher to gain a much deeper understanding of what was happening and what were the implications of the research problem.

It is important to select a critical case that can explicitly demonstrate the "how-problem" (Yin 2003). The first criterion was that the main contractor must have extensive experience and a high reputation in the New Zealand construction industry. The firm acting as main contractor in the case study is the leading contracting organisation by company capitalisation and volume of work in New Zealand. Maintaining a dominant position in the construction industry implies either cost advantage or technical advantage over the remainder of the market. As such it may be deduced that this contractor must therefore represent NZ "Best Practice". It was anticipated that this practice may approximate World Class, but may not actually achieve it. However, it is reasonable to assume that the company represents the best competitiveness that NZ has to offer in this area. The second criterion was that the construction project represented a commercial building being constructed in the strategically important Auckland region.

Auckland is the largest city by population and area in New Zealand – indeed it is the city that continues to grow more rapidly than any other in NZ. Regional planning wants to direct part of this growth towards more intensified land-use and higher building densities (SGS Economics and Planning Pty. Ltd 2007). Auckland's growth results in mounting pressure on existing transport networks which suffer under frequent congestion problems that also impact on construction processes (Sankaran et al. 2005). A commercial project normally has more complicated concerns in SCM than other types of construction projects, such as residential and infrastructure. Therefore, the construction project located in Auckland downtown reflects typical problematic issues for SCM in NZ.

Boundary issues, such as what is and what is not part of the case, are important to address in all case studies (Dubois and Gadde 2002). In this case study, since the construction project is still ongoing we focus on the ground works, frame and envelope stage of the project only - covering about 18 months of the total build. In designing the case study we have included the supply chain from the main contractor to subcontractors and their suppliers. The main reason for this is the construction industry is deeply dependent on subcontractors and suppliers of building materials (Agapiou et al. 1998). Indeed it is widely accepted in construction to subcontract extensive portions of any project (Eccles 1981). Main contractors largely purchase labour and materials from their subcontractors, rather than maintaining contract staff themselves. This process of outsourcing reduces staffing "cost risk" as well overheads. Consequently such main contractors have become increasingly reliant on other actors in the construction supply chain (Vrijhoef and Koskela 1999). In spite of significant research on CSCM, little attention has been paid to upstream relationships from the construction site, such as between contractors and sub-contractors or material suppliers (Bankvall et al. 2010).

The data from the study reported in this paper were gathered by interviews, supplemented with site observation and documentary information. A face-to-face interview technique was used because it allows an in-depth understanding of the research topic and the use of intensive probing questions to gain more insight into the research problem. A semi-structured questionnaire was adopted as the data collection instrument, since it allows for structure, spontaneous discussion and follow-up questions on the research topic (Harris and Brown 2010; Polonsky and Waller 2005). However, the 'main' questionnaire interview was followed up with a number of subsequent contacts and discussions with respondents on points of clarification, as well as to gain the 'through process' longitudinal insights.

The interviews captured similarities and dissimilarities of experience on a project compared with other projects in which the subcontractors were, or had been, involved. This approach made it possible to discuss and evaluate different views of SCM implementation in NZ more broadly. Each interview session was recorded electronically (with interviewee permission) to ensure all relevant issues were captured. Once complete, the entire interview session was transcribed and analysed using qualitative data analysis techniques. Multiple sources of evidence, such as site observation and access to project documentation and reports (i.e. truck delivery documents, progress reports, minutes of meetings and proposals) were utilised and collected in a project diary (Yin 2003).

The case study described in this paper has been developed from a commercial project hosted by AUT University. The construction site was located in central Auckland, implying special requirements in terms of logistics and physical distribution. The $75million project consists of a 13 level tower block with roof top plant room surrounded by a lecture theatre wing with roof level at level 6 of the tower. The new construction ties into existing buildings on campus. The construction has three stages: ground works, structure, and fit-out. The contract was fixed price, with the client being allowed certain flexibility in the scope without extra charge. The general contractor had a total of 21 subcontractors working in the construction project for the ground work and structure stages.

4. Case study findings

4.1 Understanding of SCM – Material flow focused

Respondents were asked to relate their understanding of some of the key concepts in SCM/CSCM. The first question asked about their current understanding of SCM in terms of operating requirements and objectives. All participants mentioned optimisation of material ordering and material delivery as principal operation objectives. Over and above, three participants indicated that subcontractor selection is also a significant part of SCM as well.

This is a highly significant observation. Whilst it is not surprising that material logistics is a predominant emphasis in understanding of SCM, it was a surprise to see it as the overarching or main consideration. The simple fact is that the order versus delivery dynamic expected in the relationships place the onus exclusively on the supplier. However few of respondents recognised the duality of that position. If a supplier fails to perform, this is regrettable. However there was limited recognition of the fact that the supplier whose performance was being lamented upon was placed on a list of approved suppliers. In that case what is at fault, the poor supplier or the poor supplier selection process? The fact that only three respondents identified supplier selection being a substantial part of the SCM process is indicative of a failure to grasp the basics of SCM.

Given the complex nature of project characterised by a vast network of inter-related dependant tasks, and delays in material flow have the biggest impact on a construction project schedule (Hatmoko and Scott 2010), there is evidence to support the notion that material logistics management is worth practitioner attention. A further observation from the research was that at no point was logistics management capability mentioned either explicitly, or as a price / non-price attribute associated with the selection of subcontractors. This is again highly significant as a finding in the context of the broader project currently undertaken in conjunction with Building Research Association New Zealand (BRANZ). Logistics embodies the management of ordering, transportation and delivery for any production process. Consequently in construction it has a substantial input on costs, material management, waste and productivity. However it is not addressed as a performance criteria explicitly. Logistics is an “implied competency” – both here in NZ and apparently worldwide.

Construction is fundamentally a manufacturing operation consuming materials that are generally low value with high volume, transporting to geographically mobile points of distribution on demand. Therefore logistics costs of the material accounts for a significant proportion of the material costs. In general, transportation costs represent approximately 39 to 58% of total logistics costs and up to 4 to 10% of the product selling price for many firms (Coyle et al. 2003). Due to Auckland’s geographical location, all the construction materials have to be transported from a considerable distance. Thus, the logistics costs are assumed to be at the high end of approximate average.

Compared to other industries, such as fast moving consumer goods and retail industries, construction lags behind in terms of both logistics and SCM. During the study, the

researcher was able to observe many truck deliveries for construction materials for the project moving around the road network either empty or half full. It is (and was) not uncommon for delivery trucks to wait on city roads to gain access to the site or be unloaded. Skilled tradesmen were often involved in unloading and moving materials around site, which significantly reduced their productivity. Thus, the consequences of poor construction logistics are apparent not only with unnecessary costs incurred, but also with negative impacts on environment and society, congestion and pollution.

4.2 Limited training

Only one of the interviewed firms indicated that formal training in SCM skills is given to key staff. This particular company provided perishable materials (i.e. ready mix concrete) that has strict delivery time windows, therefore logistics competency is 'mission critical' for the firm to carry out daily business. This is an interesting observation for the body of construction logistics knowledge. Prior to relatively recently the only construction logistics research undertaken has been dealing with the issue of concrete deliveries to site (Proverbs et al. 1999). This understanding and recognition of the relevancy of logistics planning seems to have appeared indigenously in NZ. Although the respondent reported that his company was looking more widely overseas for 'best practice'. He reported that logistics management techniques were the 'the way things were going around the [the ready mix concrete industry]'.

For this concrete firm, as well for SCM training around the world (ref), training in SCM has a principal emphasis on logistics. The main topics include 'Just in Time' (JIT) delivery, inventory management, stock control techniques, demand forecasting and monitoring as well as lean operations. Four other firms on the studied project mentioned that there was "some sort of training" in SCM techniques for their staff involved. This more broad training ranged from project programming to communications with clients, and normally are part of a package of staff development. However, there is no training regarding the body of knowledge for SCM for either the management level or operational level personnel. It can be seen that the reported 'some sort of training' in SCM was actually very much more general management methods with little specific relevance to SCM *per se*.

Workshops in construction logistics or SCM are not available in New Zealand through professional engineer organisations, such as Institution of Professionals Engineers New Zealand (IPENZ), at the time of writing. Although IPENZ deliver many professional development courses in professional and technical skills national wide, there is no SCM course available for professionals in construction. Indeed, there are few universities providing SCM course at tertiary and postgraduate level in construction disciplines. The personnel involved at middle and senior management level among NZ construction firms are therefore generally strong in technical expertise in specific engineering areas, however they generally do not have strong background management generally. In SCM discipline knowledge specifically, these engineers are largely very weak. It has been reported in the past that in order to implement SCM successfully, senior management commitment is one of the critical factors (Burgess 1998). Without even a basic understanding of SCM competencies, this commitment seems unattainable.

Commenting more broadly on the current situation in NZ, the survey respondents were somewhat disappointed with educational levels in the industry. This was a uniform observation from all respondents in the sample. At the operational level, a wide range of generic skills, including writing and reading skills, numerical and financial skills, client and contractor relationships, design communication, supplier communication, teamwork, planning and problem solving and manual skills, are required for effective SCM (Briscoe et al. 2001). However, employees in NZ construction have low levels of basic qualification attainment compared to the NZ norms of literacy and numeracy. Although Specialised Managers within the sector have the highest portion of employees holding bachelor degrees or higher, other trades at the operational level have much lower qualifications. The respondents reported that much of the skill acquisition of the construction sector is through "learning-by-doing", but it may not remain sufficient to equip operatives in construction firms with the range of skills necessary for enhancing supply chain performance. In short there is a pressing need to significantly enhance the general (i.e. transferable skills of literacy, numeracy etc) skills of workers in advance of developing the specific skill sets necessary for 'best practice' SCM. This in line with the findings of Saad et al. (2002) that formal training is a necessity to initiate the shared learning required for effective SCM implementation.

4.3 Partnering in the Supply Chain

All respondents were questioned as to their current working relationships within the supply chain and particularly in relation to the main contractor. All participants considered that they have a "close and trusting relationship" with the main contractor. One of the participants even made a remarkable comment: "We will do anything for the main contractor. This is how good our relationship is." Arguably this could imply that the subcontractor was outstandingly loyal. However in the context of the interview the implication was that of total dependency, and therefore weakness.

Most of the subcontractors interviewed had an extensive experience working with the main contractor. All of the respondents had a minimum of five year's relationship with the main contractor and were considered to be 'trusted' contractors. Simply put the view was taken that, 'If [the main contractor] did not have faith in our ability to get the job done we would not [be on the job]'. All of the firms had been working in the past on a variety of projects with this main contractor. Whilst there was no way of suggesting that these firms were working in a consortium or alliance form of contract on this project, the behaviours of the protagonists was very close to that which may be expected on such a contract. Practically, in the relatively small market that New Zealand represents, along with the smaller subset represented by the Auckland construction market, the firms represented by the respondents will always have to work together at some point in the future. The anticipated requirement for follow on work emanating from this project tended to therefore moderate behaviours on the contract. Anecdotally it can be reported that there is a very high rate of 'staff exchange' between the various construction companies in Auckland. The corporate entity that the main contractor represented on this project is widely considered as being the talent 'incubator' for New Zealand. The company has a strong recruitment strategy of engaging with civil engineering departments in universities, recruiting many fresh graduates annually. These graduate trainees then get subsequently re-recruited by other companies as they gain

experience. Several NZ construction companies were actually set up by alumni of the graduate recruitment scheme of the main contractor. This is also true for the main consultants on this and other contracts. In the context of New Zealand this creates a generally non-confrontational contracting framework between companies. Therefore the ideas of partnering and alliancing are ones that naturally fit to the NZ context.

Although the personnel of the management team from the main contractor may vary, the subcontractors reported that the firm has consistency in management style. Two of these subcontractors considered that they have a strategic partnering relationship with the main contractor. The main contractor is their major customer, producing more than 80% of their turnover. Furthermore, some of the subcontractors have stable and trusting relationships with firms working in a sub-subcontracting capacity. At least one of the sub contracting companies represented by the respondents considered that they formed a strategic partnership with their suppliers and contractors. The relationship among these firms has been developed over several years – often in excess of five. Participants admitted that problems are inherent throughout the project lifecycle. That is the nature of construction on this type of project – bespoke design with high rates of client revision. However, the respondents reported that it is usually not difficult to resolve these issues, since effective communication has been formed during the years of cooperation.

The finding suggests that the general contractor's relationships with subcontractors are healthy in the studied project. All participants value highly of the relationships with the main contractor and their own subcontractors. It implies that the construction firms understand that the quality of a firm's relationships with other firms (i.e. subcontractors and material suppliers) is a strategic asset that can have critical implications on its operations and activities, which includes its economic performance.

5. Conclusions and implications

This paper is a preliminary attempt in understanding and conceptualise the current nature of SCM practice in the NZ construction sector. Although the case study is only focused on the ground works and structure stages of a commercial project, the findings provide a useful insight into current behaviours from a leading construction contractor and its assembled team.

This paper has shown that there is awareness of the importance of SCM in broad terms. However, the critical part of operational tools and techniques for effective SCM in construction is not well recognised or understood. The lack of theoretical understanding of the content of supply chain management is notable in this research and says much about are current training and education of the construction professions. The absence of formal education or training courses at a high level – i.e. engineers and project managers – is considered to be a key aspect of this lack of knowledge. This in turn implies that there is a pressing need in the New Zealand context to provide improved educational opportunities for teaching SCM principles and concepts to construction professionals. Arguably there is already so much technical content in embodied in the education of engineering graduates that to add additional management components in general would be challenging to achieve.

However in SCM discipline skills in particular it would be virtually impossible to deliver at present since the skills are largely not present in faculty staff. It could therefore be argued that in the NZ context there needs to be increased promotion of construction management related postgraduate offerings with special attention to SCM to address this skills gap.

At a lower level there is an apparent serious lack of skills coming out of school leavers who come in to the NZ construction industry. This is an issue much wider than the problems of NZ alone. This will take concerted efforts into the future to 'raise the game' of school leavers before they leave school. More broadly there are substantial issues related to the requirement of the construction industry to attract more capable school leavers. The 'sexiness' of the construction industry as a destination is a complex issue which goes beyond the purview of this paper (see Murray et al. 2001 for a wider discussion on this subject matter), but needs to be addressed if we are to achieve the potential benefits of SCM implementation in construction.

A very positive aspect of the findings from this study is that the industry in NZ has started moving towards the collaborative relationships and trust among the larger firms is an obvious evidence of this collaboration. As has been noted earlier in this paper, the reasons for this appeal are closely related to the small market size and the closely interrelated business that are extant in New Zealand. Some less charitable (Aussie!) commentators may conclude this is evidence of NZ inbreeding. However this is not the case. The behaviour observed is a normal and to be expected under small market conditions. Arguably the same type of behaviour will be seen in any large market (e.g. USA, France, Japan etc) that sees regional specialist firms coming into existence. In a large market, 'bad' contractors and suppliers can rely on the poor market knowledge of clients to gain more work and therefore survive for longer. A classic situation of poor industry practice capitalising on 'a sucker born every minute'. In small market situations, poor contractor and supplier behaviours will rapidly come to the attention of the majority of important clients in the industry. In a small market it is easy to get on to a blacklist and very hard to get off of it. Consequently poor behaviours will generally not be sustainable for the long term. Conversely, the housing market supports the "cowboys surviving for longer periods", because of the limited market knowledge of clients.

Probably the key finding coming from this study is related to logistics management. The evidence points towards the fact that the construction industry does not effectively address, or have the skills to solve, logistics problems. At present the lack of knowledge is masked by lack of immediacy in recognising that there is a problem at all. It is hard to solve a problem that the industry does not recognise that it has. At present, from the analysis of the deliveries arriving at the case study site, there is a lack of transparency in costs throughout the construction process. Decisions on choosing suppliers and quantities of materials are often made by evaluating the quoted "cost as delivered" per unit. Since the cost of transportation is embodied in the delivery cost, there is no way of identifying how much cost is attributed by suboptimal transport planning. Unless there is a differentiation between the elemental costs, it is difficult to identify who benefits from an effective logistics system. Those who may be required to do things differently do not necessary gain benefits from changing to an optimal transportation planning model. None of the respondents to the

survey were even slightly aware of the quantum of money that was embodied in the transportation of materials to site (>39% as noted previously).

The next step for the research team working on this project will be to broaden out the logistical study from the commercial construction site described into housing and infrastructure projects in order to map the patterns and logistical flows developing. The data generated is also anticipated to develop and refine the model outlined in Figure 1. Moving forward the research is intended to inform a much larger study supported and funded by BRANZ into the mapping of Auckland's construction lifelines, which superimposes the materials flows in Auckland over a wider GIS model of the development of the Auckland Super City.

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