Building Materials Supply Chains: An Evaluative Study of the New Zealand Residential Construction

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LIST OF ABBREVIATIONS

AGCA - Associated General Contractors of America

AIA - American Institute of Architects

ANOVA - Analysis of Variance

ASA - American Subcontractors Association

ASC - Associated Specialty Contractors

ASCE – American Society of Civil Engineers

ASTD - American Society for Training & Development

AUT - Auckland University of Technology

AUTEC - Auckland University of Technology Ethical Committee

AWCINZ - Association of Wall and Ceiling Industries of New Zealand

BCITO - Building and Construction Industry Training Organisation

BCPP - Building and Construction Productivity Partnership

BCSPP - Building and Construction Sector Productivity Partnership

BIFNZ - Building Industry Federation New Zealand

BM – Builders' Merchant

BMJ - British Medical Journal

BMSC - Building Materials Supply Chain

BRANZ - Building Research Association of New Zealand

CAQDAS - Computer-Aided Qualitative Data Analysis Software

CCA - Construction Contracts Act 2002

CCANZ - Cement & Concrete Association of New Zealand

CENZ - Constructing Excellence New Zealand

CHRANZ - Centre for Housing Research, Aotearoa New Zealand

CIC - Construction Industry Council

CII - Construction Industry Institute

CINZ - Claddings Institute of New Zealand

CIRC - Construction Industry Review Committee

CLM - Council of Logistics Management

CPS - Construction Procurement Systems

CSCM - Construction Supply Chain Management

CSG - Construction Strategy Group

CURT - Construction Users Round Table

DBH - Department of Building and Housing

DOL - Department of Labour

DSS - Decision Supporting Systems

EDI - Electronic Data Interchange

EFA - Exploratory Factor Analysis

EOQ - Economic Order Quantity

EPA - Exploratory Factor Analysis

GDP - Gross Domestic Product

HOBANZ - Home Owners and Buyers Association of New Zealand

ICE - Institution of Civil Engineers

ICT - Information and Communication Technology

IGLC - International Group for Lean Construction

IPD - Integrated Project Delivery

IRD - Inland Revenue Department

IT - Information Technology

JIT - Just In Time

KMO - Kaiser-Meyer-Olkin

LAMP - Labour and material payment bond

LBP - Licensed Building Practitioners

LTA - Land Transfer Act

M - Mean

MBIE - Ministry of Business, Innovation and Employment

MSC - Materials Supply Chain

NBSC - National Bureau of Statistics of China

NEC - New Engineering Contract

NSW - New South Wales

NT - Northern Territory

NZBC - New Zealand Building Code

NZBE - New Zealand Building Economist

NZBERS - New Zealand Built Environment Research Symposium

NZCF - New Zealand Contractors’ Federation

NZCIC - New Zealand Construction Industry Council

NZD - New Zealand Dollar

NZIA - New Zealand Institute of Architects

NZICE - New Zealand Institution of Civil Engineers

NZIOB - New Zealand Institute of Building

NZIQS - New Zealand Institute of Quantity Surveyors

NZPA - New Zealand Press Association

NZS - New Zealand Standard

NZSTCF - New Zealand Specialist Trade Contractors' Federation

NZTA - New Zealand Transport Agency

OECD - Organisation for Economic Co-operation and Development

PAF - Principal Axial Factoring

PCA - Principal Components Analysis

PD - Property Development

PFA - Principle Factor Analysis

PhD - Doctor of Philosophy

PIS - Participant Information Sheet

PMINZ - Project Management Institute New Zealand

PPP - Purchasing Power Parity

PPSR -Personal Property Securities Register

PSA - Product Service Administration

PWC - Price Waterhouse Coopers

QA - Quality Assurance

Qld - Queensland

QUAL - Qualitative

QUANT - Quantitative

RIBA - Royal Institute of British Architects

SA - South Australia

SCM - Supply Chain Management

SD - Standard Deviation

SDI - Subcontractor Default Insurance

SEC - Specialist Engineering Contractors

SME - Subject Matter Expert

SOP - Security of Payment

SPSS - Statistical Package for Social Sciences

SRM - Supplier Relationship Management

SSL - Secure Sockets Layer

UK - United Kingdom

URL - Uniform Resource Locator

US - United States

USA - United States of America

UV - Ultra Violet

Vic - Victoria

LIST OF PUBLICATIONS AND AWARDS

Conferences (Peer-reviewed)

1) Samarasinghe, D. A. S., Tookey, J. E., & Rotimi, J. O. B. (2013). Supply Chain Collaboration in the New Zealand House Construction. In T. W. Yiu & V. Gonzalez (Eds.), 38th Annual Conference of the Australasian Universities Building Educators Association (AUBEA), Auckland, New Zealand.

2) Samarasinghe, D. A. S., Tookey, J. E., Rotimi, J. O. B., Windapo, A. O., & Thiruchelvam, S. (2012). Examining construction materials purchasing practices. In I. Kamardeen, S. Newton, B. Lim, & M. Loosemore (Eds.), 37th Annual Conference of Australasian Universities Building Education Association (AUBEA) (pp. 565-574). Sydney, Australia.

3) Samarasinghe, D. A. S., Tookey, J. E., Rotimi, J. O. B., & Thiruchelvam, S. (2012). Securing Best Prices for Construction Materials: An Exploratory Study of the New Zealand Construction Industry. In T. Hoque (Ed.), Proceedings of Fourth Annual American Business Research Conference (pp. 1-15). Australia: World Business Institute. Retrieved from http://www.wbiconpro.com/515-Amila.pdf

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Symposiums

1) Samarasinghe, D. A. S (2012, 28 August) Improving materials supply chain in New Zealand residential construction industry: An exploratory study – PhD work in-progress, 6th Annual postgraduate symposium, AUT University, Auckland, New Zealand.

2) Samarasinghe, D. A. S., Tookey, J. E., & Rotimi, J. O. B. (2012). Securing best prices for construction materials - PhD work in-progress: An exploratory study of the New Zealand construction industry. In J. Mbachu (Chair), Massey University, Auckland, New Zealand. Symposium conducted at the meeting of the 2nd New Zealand Built Environment Research Symposium (NZBERS), Albany, Auckland, New Zealand.

3) Samarasinghe, D. A. S (2011, 2 September) Securing best prices for construction materials: An exploratory study of the New Zealand construction industry – PhD work in-progress, 5th Annual postgraduate symposium, AUT University, Auckland, New Zealand.

4) Samarasinghe, D. A. S (2011, 23 September) Securing best Prices for construction materials: An exploratory study of the New Zealand construction industry – PhD work in-progress, 1st New Zealand Built Environment Research Symposium (NZBERS), Massey University, Albany, Auckland, New Zealand.

Awards

1) Runner-up, 3MT competition at 7th Annual postgraduate symposium, AUT University, Auckland, New Zealand, 2013.

2) Winner, Poster competition at 6th Annual postgraduate symposium, AUT University, Auckland, New Zealand, 2012.

ATTESTATION OF AUTHORSHIP

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

Don Samarasinghe

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“Life is an interesting journey. You never know where it'll take you. Peaks and valleys, twists and turns. You could get the surprise of your life. Sometimes on the way to where you’re going you might think this is the worst time of my life but you know what at the end of the road through all the adversity if you could get to where you wanted to be you remember whatever don't kill you make you stronger and all the adversity was worth it.”

“So keep on getting your paper and keep on climbing
Look in the mirror and keep on shining (☺)
Till the game ends, till the clock stop
We gonna post up on the top spot!!!”
(T.I. & Rihanna)

DEDICATION

To

My Loving Father (Don Shelton Joseph Samarasinghe)
&
My Loving Mother (Hewagamage Eugene Isabel Gunesekara).

Your Sweat, Sacrifices, and Great Support Have Sustained me throughout My Life.

ETHICAL APPROVAL

The ethics application for this research project was approved by the Auckland University of Technology Ethics Committee, AUTEC Reference number 12/112.

ABSTRACT

Concurrent with the development of interest in supply chain management in the broad manufacturing sector, there has been an increasing interest in supply chain management research in construction. The New Zealand construction supply chain comprises a network of project parties connected upstream and downstream to produce what the end consumer wants -much like in any production process. However there is little by way of aggregation or integration in the construction supply chain. Indeed historically disintegration has been its default state. Construction of buildings or structures incorporates a diversity of different materials/products that have to be properly selected, procured and utilised. Materials selection is vital as it influences the cost, durability, serviceability and aesthetic values of buildings or structures wherein these materials are embedded.

The study reported here investigates the nature of the materials supply chain in the New Zealand residential construction sector and suggests possible mechanisms that could improve current materials supply chain practices. The study investigated the subject matter from the perspectives of building materials suppliers, residential building contractors, architects, and homeowners. Firstly, the study conducted 30 semi-structured interviews across the supply chain in the Auckland region. Based on the results obtained, a New Zealand wide questionnaire survey was then administered to a wider population of similar stakeholders. Both the qualitative and quantitative information gathered were then synthesised and the research findings were verified using subject matter expert interviews.

The study found that the New Zealand construction industry mostly practices traditional procurement strategies and materials supply chain management processes are sub-optimal, leading to a plethora of knock-on effects on industry practice. Further, the New Zealand construction supply chain is fragmented and characterised by poor communication, resulting in a misalignment of needs among materials supply chain stakeholders. Moreover, the residential construction sector is characterised by high building materials prices, inferior products, very-customised houses, high transport costs, high labour costs, materials substitution (non-adherence to materials specified), and materials delivery issues.

The research proposes among others, increased standardisation of residential buildings, greater collaboration in the supply chain, a centralised web-based building materials information system, more competition in the supply chain, education of homeowners regarding materials, a government body to control materials suppliers payment problems, adoption of modern technology to perform better supply chain decisions, and consideration of performance warranties on building materials to improve the current materials supply chain in the New Zealand residential construction sector. On the whole, the study integrates the materials selection, purchasing and supply behaviours of all construction stakeholders, emphasising the benefits of collaboration in the supply chain. It is anticipated this will improve the current materials supply chain in the New Zealand residential sector. Finally, the study provides new insights on the building materials supply chain in New Zealand from the perspectives of supply chain stakeholders in the housing sector. Overall the study reported here adds significantly to the understanding of contemporary perceptions on supply chain dynamics in the New Zealand construction industry.

CHAPTER ONE

Introduction

1.0 Background

The design, construction, and management of human made structures are described as the built environment. The built environment provides better settings for humans to manage their daily lives in terms of social, economic, and environmental development. Buildings and other physical structures (that is, architecture) are one of the key elements in the built environment. The construction of buildings or structures incorporates a diversity of different materials and products. Therefore material selection is vital for any type of construction.

The values of buildings or built structures relies on a careful understanding of construction materials in terms of their properties (e.g. strength, stiffness, toughness, durability, etc.), availability, fabrication, the energy required to produce the structure and consumed during its lifetime, required maintenance, end-of-life properties, and costs (Domone & Illston, 2010). Consequently the selection of materials influences the durability, serviceability, cost, and aesthetic values of the building or structure in which those materials are utilised. The construction industry typically utilises a large quantity of construction materials. Studies conducted by Van Wyk (2003) and Lazarus (2005) reveal that the Earth's resources are substantially consumed by the construction industry, utilising circa 50% of all materials extracted from the Earth's crust. In fact, materials in construction make up over half of all resources (by weight) used in production (Lazarus, 2005). This significant material usage is further exemplified in the United States. In the year 2000 the United States consumed 2,851,420,000 tonnes of building materials including cement, crushed stone, dimension stone, coal combustion products, iron and steel slag, construction sand, and gravel (Horvath, 2004).

Buildings are a key component in the construction sector in any country. The sourcing, procurement and use of building materials should therefore be important in the pursuit of successful building project outcomes. Appropriate management practices in the purchasing of and paying for such materials are essential to accomplish successful construction work (Abdul-Malak, Nadim, & Ghassan, 2000; Hadikusumo, Petchpong, & Charoenngam, 2005; Zavadskas, Trinkunas, & Kaklauskas, 2008). However, in spite of improvements to general management and procurement systems in the construction industry (Tookey, Murray, Hardcastle, & Langford, 2001), building material procurement strategies do not seem to have achieved similar positive developments, considering the centrality of materials in construction.

Examination of the cost structures of construction projects reveal that construction materials comprise a significant part of construction value, approximately 50% of the total construction cost for many types of projects (Abdul-Malak et al., 2000; Agapiou, Clausen, Flanagan, Norman, & Notman, 1998; Agapiou, Flanagan, Norman, & Notman, 1998; CII, 1988a; Zavadskas, Kaklauskas, Banaitis, & Trinkunas, 2005; Zavadskas et al., 2008). Although there is a strong relationship between various project types and their main input contributions (Hillebrandt, 1988), the proportional contribution of materials is significant in all circumstances. Bernold and Treseler (1991b) argue that the contribution of materials to total construction costs could become even greater in the future due to their increasing cost and increasing usage of materials input in building production. Not only the cost, but also the quality and durability, the aesthetic values and functionality of the building or structure, are also basically determined by the types of materials used in the construction process.

Choosing the right building materials for a construction project is a result of a combination of decisions taken by different key personnel involved in the project. The correct building materials should satisfy the required specifications, quality, and durability, aesthetic sensibilities, specific conditions, and the client’s various requirements (e.g. budget and living style, etc.). Building materials originate from materials manufacturers and are passed through suppliers to contractors. Building contractors’ decisions on sourcing materials are influenced by their clients and designers as well. To this end, it is clear that finding the “right” building materials is based on the materials supply behaviour of manufacturers and suppliers, the materials selection behaviour of clients and designers, and the materials purchasing behaviour of contractors. In other words materials selection decisions are based on a network of key project participants, i.e. the construction supply chain. The construction supply chain connects upstream and downstream in a network of key participants to produce what the end consumers want (Bowersox, 2011; O'Brien, Formoso, Ruben, & London, 2010; Tan, 2001). The purpose of construction supply chain management (CSCM) is to manage and co-ordinate the complete supply chain from raw materials supplier to end user (Pryke, 2009; Ryan & Bernard, 2003). Therefore, understanding the nature of the construction supply chain would enable its key players to make the right decisions on selecting, purchasing and supplying the appropriate construction materials.

Managing the relationships with these different organisations in the supply chain is called supply chain management (SCM) which targets cost effective delivery of what the final customers' wants (Bowersox, 2011; Christopher, 2010; Mentzer et al., 2001). SCM aims to understand and improve the synchronisation of the numerous supply chain partnerships embedded in the supply chain. To this end, it is essential to manage and coordinate all the activities involved in the entire supply chain. Concurrent with the development of interest in SCM (particularly in the manufacturing sector), there has been increasing interest and research in SCM in the construction industry.

This interest became more apparent after the publication of The Egan Report: Rethinking Construction (1998) and The Latham Report: Constructing the Team (1994) in the UK. Subsequently SCM principles spread rapidly around the world in the construction industry. The Egan Report and The Latham Report played a central role in improving collaborative practices in the UK construction industry where government, industry, and clients work together towards achieving better performance, efficiency, and quality in the construction sector (Akintoye, McIntosh, & Fitzgerald, 2000). These reports identified that an integrated approach to the construction supply chain is essential, rather than considering the various activities and processes involved in a construction project separately. Subsequently, a significant amount of research has been conducted aiming to understand the nature, functions, and components of the construction supply chain (Agapiou, Clausen, et al., 1998; Briscoe, Dainty, & Millett, 2001; Cain, 2004; Cartlidge, 2006; Voordijk, 1999; Vrijhoef & Koskela, 2000).

Researchers in the construction industry have been investigating the concept of SCM since the mid-1990s (O'Brien, London, & Vrijhoef, 2002). As a result SCM has become one of the key research areas in construction management. Consequently, the significance of the materials supply chain in construction is widely acknowledged. Traditional building procurement in the construction industry had considered to be an uncoordinated, inefficient, consecutive, wasteful, and adversarial process (Cartlidge, 2006; Fellows, Langford, Newcombe, & Urry, 2009; Morledge, Knight, & Grada, 2009). The key reason for these unfavorable characteristics in traditional procurement is the lack of collaboration between the clients, designers, contractors, and suppliers at the beginning of the construction process (Masterman & Masterman, 2003). This causes risks, delays, cost overruns, and contractual conflicts in construction projects (Egan, 1998; Roper, 2009). Due to the project based nature of the construction industry, SCM principles have been difficult to successfully incorporate in construction. However, after the Latham (1994) and Egan (1998) Reports, a radical change occurred with the application of the concepts of SCM and integration in the construction industry (Cartlidge, 2006; Fellows et al., 2009).

SCM is considered an integrated methodology for building projects to overcome the current issues facing the construction industry. For example, Carley (1997) stated that SCM philosophy could enhance the efficiency and effectiveness of the construction industry. Agapiou, Clausen, et al. (1998) and Ryan and Bernard (2000b) also explained that SCM is a central component in the achievement of cost effectiveness in construction projects. The benefits of CSCM are applicable across the whole construction supply chain in terms of increased efficiency and increased competitiveness. As the construction supply chain comprises clients, designers, contractors, suppliers and manufacturers, possible improvements in the supply chain should look at all these players' points of view. The overall performance of the construction supply chain is based on information and material flows between these key project participants.

A study conducted by Vrijhoef and Koskela (2000) introduced four roles of CSCM, focusing on reducing costs and supply chain time. The four roles were: improving the interface between site activities and the supply chain, improving the supply chain, transferring activities from the site to the supply chain, and integration of the site and supply chain. These four roles are related to clients, architects and consultants, contractors, and suppliers, and their relationships are the key to managing materials and labour flows. Similarly the building materials flow can be properly controlled through good co-ordination and communication between the project stakeholders (Agapiou, Clausen, et al., 1998). Akintoye et al. (2000) showed that building contractors experience better quality service, cost benefits, a simpler construction process and simpler ordering process when supply chain relationships are built with suppliers. However, Franzosi (2004) and Carley (1997) stated the challenges to achieving project team collaboration in construction are the fragmented nature of project delivery systems, lack of trust, and adversial contractual relationships.

The residential building sector is one of the most important sectors in any country as it directly connects with national economic development (Wen, 2001). The residential construction industry contributes greatly to people's living standards, the functionality of the environment, the aesthetic values of nature, etc. Theories and concepts related to CSCM discussed above can be applied to the residential construction sector without exception to achieve the goal of obtaining the right building materials for houses. Again, when the principles of SCM are applied to the residential construction industry, the entire supply chain's decisions by manufacturers/suppliers, contractors, architects, and homeowners, regarding materials should be considered. Therefore, it can be argued that the application of SCM practices into the residential building materials supply chain will assist in acquiring the most appropriate materials for houses.

1.1 Rationale and Significance of the Study

The construction industry is one of the key sectors in the New Zealand economy (Burghout, 2011), and comprises both residential and non-residential sub-sectors. The residential construction sub-sector involves businesses that operate as small, medium, and group builders. On the other hand, the non-residential construction industry includes light commercial and non-commercial organisations (< NZ$10 million annual turnover), commercial and non-commercial organisations (> NZ$10 million annual turnover), and light and large infrastructure building organisations (< NZ$10 million annual turnover and > NZ$10 million annual turnover respectively) (BCPP, 2012a). The sector represents more than 8% of the work force (171,100 employees), 4.7% of GDP, and more than 12.9% of the added value assets of GDP (Building a Better New Zealand, 2013; CENZ, 2008; MBIE, 2013b). The contribution to New Zealand GDP from the construction industry was NZ$1.8 billion in the March 2013 quarter, which was a 5% increment on the December 2012 quarter (MBIE, 2013a). Moreover, construction is the third largest industry in New Zealand with over 50,000 related business enterprises (Statistics New Zealand, 2009b). The sector plays an essential function in the New Zealand economy, contributing over $9 billion per annum (BRANZ, 2010). A substantial growth in the construction industry occurred from 2002 to 2006, mainly because of residential building construction.

Previous studies in New Zealand have indicated that a 1% increment in GDP can be achieved by a 10% efficiency increment in the building and construction processes which translates to an improvement of GDP of over $1 billion per annum (DBH, 2008). Therefore, it can be argued that improved efficiency in construction procurement would directly benefit New Zealand's GDP.

As already noted, the residential construction sector in New Zealand basically comprises many small to medium organisations and a very few large organisations. The residential construction sector in New Zealand is dominated by a small number of volume builders (BCPP, 2013), suppliers/builders merchants (BMs), finished product manufacturers and a few but large manufacturers of specific costly materials/products such as concrete. Many local suppliers are subjected to international market conditions as they always import materials from overseas. This suggests that the New Zealand residential construction sector is fragmented, which leads to management issues in the supply chain, decreased innovation, high building costs, and lower building quality (CENZ, 2008). As a result of the fragmented nature of the industry, small to medium size builders struggle and they are generally unable to generate economies of scale (MBIE, 2013b). The residential sector is also characterised by a lack of support from the government, minimal funding, and skill issues at management level (CENZ, 2008). There are a number of other issues highlighted by CENZ (2008), including health and safety, quality, and predictability of project delivery time and to budget, that are also applicable to the residential construction sector.

A BRANZ (Building Research Association of New Zealand) report produced by Boon (2007a) suggested that the New Zealand construction industry should adopt collaborative procurement practices (as in the UK construction industry), rather than separate design and construction practices. In other words, construction supply chain parties should be encouraged to work together rather than simply aiming to achieve each individual party's needs. The CCG (2010) explains that collaboration can give the best value in terms of design, buildability, construction methods, health and safety performance, and sustainable development. It would eliminate unnecessary activities in construction projects and total construction costs would be reduced. This therefore implies the adoption of SCM principles in the New Zealand construction industry.

One of the biggest challenges in the New Zealand construction is its relatively high cost, and MBIE (2013b) explains that recent increases in cost are attributable to the current housing expansion. An examination of the cost structure of new housing and some performance aspects of the New Zealand residential construction sector reveal that building materials account for about 29% of the total cost of a house, including land cost (Page, 2009). Building materials in New Zealand appear to be expensive due to high manufacturing and transportation costs. In comparison with Australia, both building materials and construction costs in the residential sector are substantially higher in New Zealand (BIFNZ, 2013). However, CCANZ (2013) argues that comparisons of building materials and building costs between New Zealand and Australia are not practical as New Zealand has unique climate conditions.

The New Zealand residential construction industry is characterized by low productivity, growing building costs, poorly informed homeowners, inappropriate procurement strategies, complicated and long consenting procedures, and poor building quality (BCPP, 2013). Especially, it appears that building materials costs are relatively high compared to the cost of design, building products, building services, and equipment (MBIE, 2013b). The characteristics and issues under discussion in the residential construction industry imply that a substantial amount of improvement could be addressed by the application of SCM practices focusing on the building materials supply chain (BMSC). Therefore, in contrast with the current fragmented nature of the residential sector, more collaborative procurement practices deserve attention. Collaborative materials procurement strategies seek the engagement of all project participants with regards to selecting, purchasing, and supplying materials. This means building materials should be carefully selected, incorporating all participants (clients, architects/designers, contractors, suppliers, and manufacturers) in construction, in order to find the right materials. Consequently, improvements in the New Zealand housing sector in terms of costs, performance, and quality of the houses would follow.

1.2 Statement of the Research Problem

Past literature shows that the material supply chain in the New Zealand residential construction industry would need to adopt SCM principles in order to improve the performance of the house building sector. This could be achieved by making right decisions on materials considering the total supply chain. Despite the significance of materials in construction projects, there is a lack of understanding and insufficient research has been conducted in the New Zealand BMSC, especially in the residential sector. The poor performance of the current residential sector in New Zealand needs to be improved by carefully examining BMSC related decisions. Therefore the problem being addressed by the current research can be stated as:

Current building material procurement and use practices do not confer the most benefits to end users.

This would produce a foundational knowledge base for both academia and industry to understand the nature of the BMSC, and subsequently achieve mutual understanding on the right building materials for New Zealand houses.

1.3 Research Aim and Objectives

The primary aim of this research is to identify system weaknesses limiting the performance of the residential construction sector in New Zealand, and potential ways to address these, using interventions operating at the whole-of-supply chain level, including barriers to be overcome. The following objectives were formulated to help achieve the overarching aim of the study.

1. To review the nature of the building materials supply chain in the New Zealand residential construction sector
2. To identify the building materials supply, purchasing, and selection behaviours of supply chain stakeholders (materials suppliers, building contractors, architects, and homeowners)
3. To integrate buyer and supplier behaviours to improve the building materials supply chain
4. To suggest an improved framework for current building materials supply chain practices for selecting appropriate building materials

1.4 Research Questions

The following are the principle research questions formulated in order to achieve the research objectives described above. Table 1.1 shows how these research questions relate to with the objectives listed above. This list of questions will be addressed at different stages in the course of the research.

1. How does the New Zealand residential construction sector operate?
2. What are the current issues in the materials supply chain?
3. Who are the people involved in the building materials supply process?
4. How do materials suppliers transport building materials?
5. How do materials suppliers supply building materials?
6. What are the key criteria considered by building materials suppliers in making their materials supply decisions?
7. Who are the people involved in the building materials purchasing process?
8. How do contractors purchase building materials?
9. What are the key criteria considered by residential building contractors in making their materials purchasing decisions?
10. What are the key criteria considered by architects in making their materials selection decisions?
11. What are the key criteria considered by homeowners in making their materials selection decisions?
12. What are the key benefits of collaboration in the materials supply chain?
13. How can buyer and supplier behaviours be integrated to improve the materials supply chain?
14. What would be the possible mechanism to improve the current building materials supply chain?

1.5 Summary of Research Methodology

The research problem addressed in this study is primarily based on the researcher's interest, a comprehensive literature review undertaken on SCM in construction, as well as a selection of exploratory interviews with subject matter experts (SMEs) from the New Zealand construction industry. Accordingly, research questions were formulated (as stated in section 1.4), all of which will help to improve building materials supply chain practices in a way that all stakeholders derive the optimum value for the materials used, in residential buildings in New Zealand. Based on the nature of the research problem investigated, a research philosophical position was defined. It was established that this research belonged to the pragmatism paradigm after examining the ontological, epistemological, axiological, and rhetorical aspects of the philosophical assumptions. Prior to data collection, full approval from Auckland University of Technology Ethics Committee (AUTEC) was obtained to ensure that the privacy and confidentiality of all research participants was respected. The research approach selected for the study was a mixed methods approach. The selected mixed methods comprised three survey strategies.

The first stage was an exploratory qualitative survey involving semi-structured interviews to explore the nature of the New Zealand residential materials supply chain, and the building materials purchasing and supply behaviours of various stakeholders within the supply chain. Thirty interviews were conducted among building materials manufacturers, suppliers, residential contractors, architects, and homeowners in the Auckland region. The results of the interviews were analysed using content analysis. These findings were used to form a questionnaire targeting a wider population. The second stage involved a questionnaire survey. The questionnaire was prepared from the findings generated during the first stage of the exploratory interviews. The questionnaire was administered addressing the key research questions among the aforementioned parties around New Zealand. The results of the questionnaire were analysed using descriptive statistics, ANOVA (analysis of variance), and factor analysis. Finally, a qualitative survey involving interviews with subject matter experts (SMEs) was conducted. The SME interviews validated and extended both qualitative and quantitative research findings from the first two stages of this study. Following the research validation, the collated findings from the three stages of data collection and relevant past literature were synthesised. Finally, conclusions and recommendations were drawn on the strength of the syntheses of the research findings.

The Table 1.1 shows how each research objective was achieved through research questions and data collection techniques. Figure 1.1 gives a summary of the overall research design following the establishment of the research problem, and the data collection techniques that have been discussed are also indicated in the figure.

Table 1.1: Relationships between the research objectives, research questions, and adopted data collection techniques

Research objectives	Research questions	Data collection techniques
1. To review the nature of the building materials supply chain in the New Zealand residential construction sector	1) How does the New Zealand residential construction sector operate? 2) What are the current issues in the materials supply chain?	Literature review; Semi-structured interviews (Auckland region); Questionnaire survey (New Zealand wide); SME interviews
2. To identify the building materials supply, purchasing, and selection behaviours of supply chain stakeholders (materials suppliers, building contractors, architects, and homeowners)	3) Who are the people involved in the building materials supply process? 4) How do materials suppliers transport building materials? 5) How do materials suppliers supply building materials? 6) What are the key criteria considered by building materials suppliers in making their materials supply decisions? 7) Who are the people involved in the building materials purchasing process? 8) How do contractors purchase building materials? 9) What are the key criteria considered by residential building contractors in making their materials purchasing decisions? 10) What are the key criteria considered by architects in making their materials selection decisions? 11) What are the key criteria considered by homeowners in making their materials selection decisions?	
3. To integrate buyer and supplier behaviours to improve the building materials supply chain	12) What are the key benefits of collaboration in the materials supply chain? 13) How can buyer and supplier behaviours be integrated to improve the materials supply chain?	
4. To suggest an improved framework for the current building materials supply chain practices for selecting appropriate building materials	14) What would be the possible mechanism to improve the current building materials supply chain?	

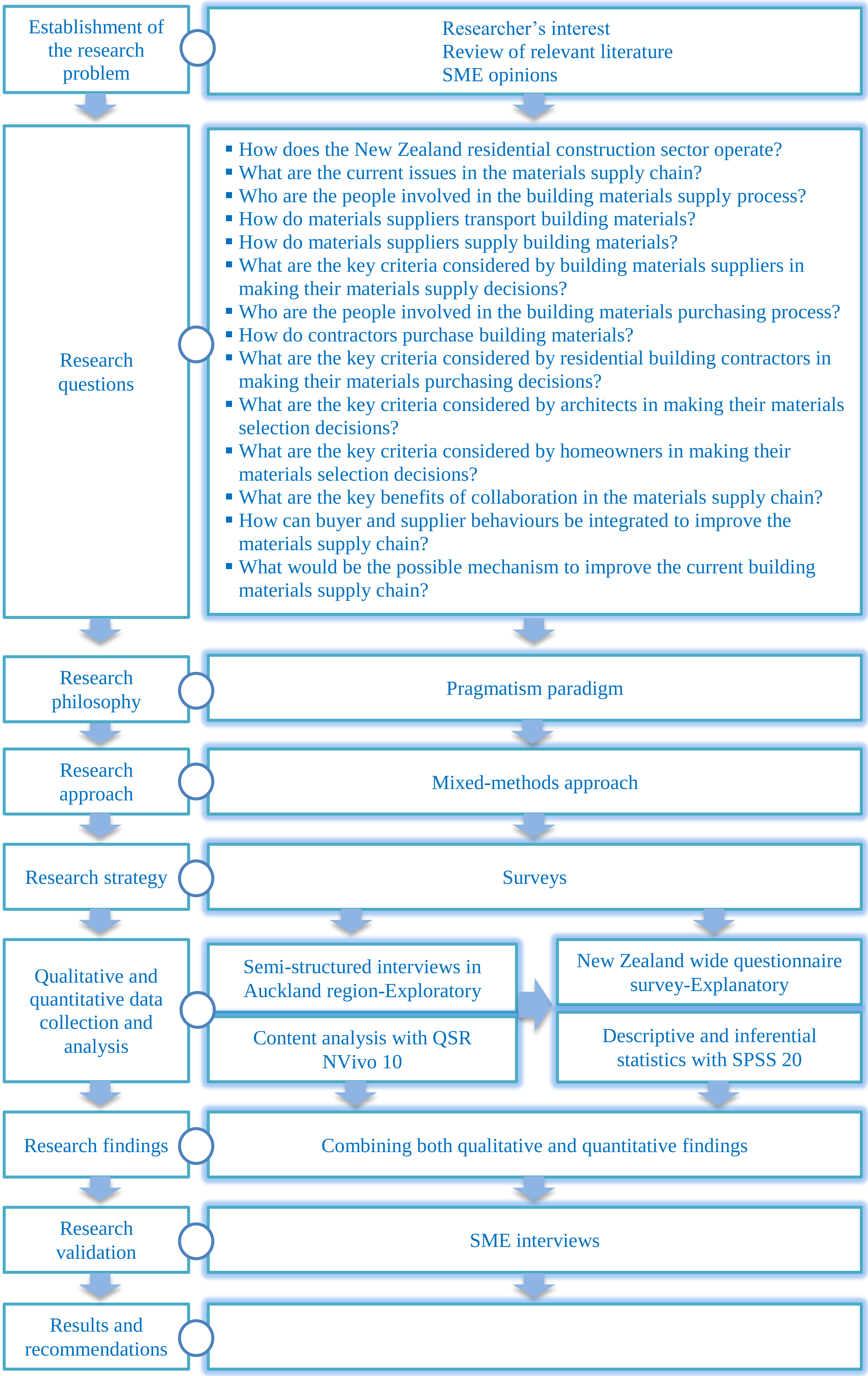


Figure 1.1: Overview of the research methodology

1.6 Limitations

It is important to state the possible limitations of the study so that the research findings can be appropriately interpreted. As the study was based on a multi-faceted survey strategy, the validity of research findings was subject to the accuracy of responses provided by interviewees and the reliability of the questionnaire survey. The reliability of any survey employed is based on the way participants interpreted survey questions (Creswell, 2012). The semi-structured interviews were limited to 6 participants from each group of stakeholders in the BMSC (totaling 30 participants), in the Auckland region. The interviews were limited to 30 because of time and resource constraints. It should be noted that the attributes included in the questionnaire were limited to the literature review and semi-structured interviews.

The questionnaire responses were not consistent across the groups of participants: 25% of participants were manufacturers and suppliers, 19% of participants were contractors, 40% of participants were architects, and 11% of participants were homeowners. However, the questionnaire had a 23% overall response rate. Therefore it should be stated that the perceptions offered by participants in this study will form only part of the real situation; there will be some important issues that are not clearly mentioned in the study process. Also the study in particular explored the nature of the BMSC in the residential construction sector in New Zealand. As the New Zealand construction industry is unique, there may be potential limitations to the generalisability of the study's findings.

1.7 Key Assumptions

Firstly, the study assumes that both survey instruments were valid and reliable. Also the variables derived from the review of past literature and semi-structured interviews were assumed to be the key criteria which represent manufacturers/suppliers' materials supply decisions, contractors' materials purchasing decisions, and architects and homeowners' materials selection decisions. However, the associated risks for selecting the right constructs for the questionnaire was reduced through peer reviews and pilot surveys.

Secondly, the study assumes that all the responses received were accurate, honest and trustworthy. The demographic information shown in chapters 4, 5 and 6 show that the research participants had substantial experience in the construction industry and good educational qualifications. The study therefore asserts that information obtained from the research participants is accurate and trustworthy, although these assumptions are common with all research.

1.8 Synopsis

Chapter 1 (Introduction) introduces the research study and provides background information on SCM in construction. This is followed by a justification of the study and the magnitude of the research problem investigated. It goes on to explain the research problem in terms of the principal aim, objectives, and questions of this study. The chapter also provides a summary of the adopted methodology, limitations, and assumptions of the research.

Chapter 2 (Literature Review) presents literature relating to CSCM and the significance of building materials in the supply chain. It goes on to review the significance of the selection, purchase, and supply decisions made in the BMSC. The chapter shows the importance of considering decisions within the total supply chain, with an emphasis on collaboration in supply chain practices. Various criteria for making right decisions on materials are then discussed further. In addition the chapter presents the nature of the New Zealand residential construction industry. The chapter concludes with the identification of the materials selection behavior of architects and homeowners, the materials purchasing behavior of contractors, the materials supply behavior of manufacturers/suppliers, and current issues and challenges in the BMSC in the New Zealand residential sector.

Chapter 3 (Research Methodology) describes the research methodology. It begins with an explanation of the research process and different categories of research available. This is followed by an explanation of the importance of understanding research methodology. Subsequently, the chapter establishes the research problem and research philosophy for this study, and then justifies the adopted research approach, research strategies, and data collection techniques for this study. The data collection and analysis processes of the study reported here are then described. This is followed by a justification of the credibility of the research findings and research ethical considerations. The chapter concludes with a statement of the scope and limitations of the research methodology.

Chapter 4 (Semi-Structured Exploratory Interviews: Report of Findings) presents the findings of the semi-structured interviews. The chapter begins with an outline of the interview questions and profiles of participants. The participants' views are presented according to their various groups. The themes of each group of participants comprises the participants' decision making process regarding building materials, issues in the BMSC, suggestions for improving the BMSC, and the significance of collaboration in the BMSC.

Chapter 5 (Questionnaire Surveys: Report of Findings) presents the findings of the four versions of the questionnaire survey. It begins with the survey response rate and demographic information of survey participants. The chapter then reports suppliers' building materials supply behaviour, contractors' building materials purchasing behaviour, architects' building materials selection behaviour, and homeowners' building materials selection behaviour. This is followed by presentations of the participants' views on issues in the BMSC, the significance of collaboration in the BMSC, and suggestions to improve the BMSC.

Chapter 6 (Validation of Key Research Findings) presents the views of the SMEs obtained in the research validation. Four sets of research findings appropriate to building materials suppliers, residential contractors, architects, and homeowners are critically examined and extended in this chapter.

Chapter 7 (Research Findings and General Discussion) presents a synthesis and discussion of the research findings reported in chapters 4, 5, and 6. The chapter also refers to the appropriate literature to support the current research findings where necessary. The overall research findings are presented and discussed on the basis of the research questions.

Chapter 8 (Conclusions and Recommendations) concludes the research by integrating the key research findings in relation to the research objectives. The research contributions to knowledge and practice are presented. The chapter provides a list of recommendations for the improvement of the current BMSC in the New Zealand residential construction industry. Finally, the chapter suggests opportunities for future research arising out of the study reported here.

CHAPTER TWO

Literature Review

2.0 Introduction

This literature review chapter is structured into three key sections that provide an overview of SCM, CSCM, and the New Zealand construction supply chain. It therefore firstly introduces the SCM concept with an emphasis on the purchasing function and collaborative supply chain practices. The chapter then discusses SCM in the construction industry, focusing on the materials flow among different project participants, and presents the fundamental concepts connected with the construction materials purchasing process. Collaborative practices in regard to the construction supply chain are also emphasised in this section. Finally, the chapter presents an holistic picture of the New Zealand construction supply chain. This last section covers building materials in the residential construction sector and the current issues that need to be addressed in future research.

2.1 Overview of SCM

The current global economy is expanding rapidly and becoming increasingly competitive. In order to cope with this highly competitive business environment, business organisations in any industry have to improve their performance. Performance improvements in an organisation should be based on a careful consideration of many factors, one of the most important being the entire supply chain to which an organisation belongs. In doing so, an` organisation will be able to improve its performance and gain a competitive advantage. The supply chain in its simplest form consists of the principal company, and its suppliers (upstream) and customers (downstream) (Figure 2.1).

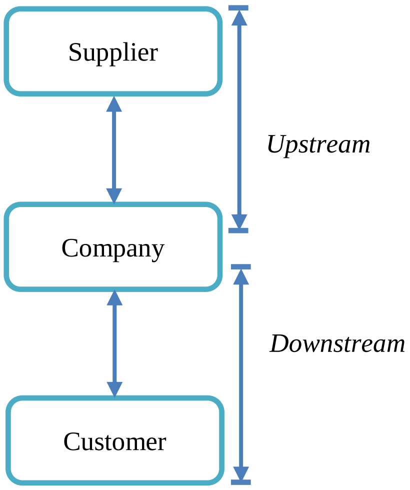


Figure 2.1: Simple supply chain

Source: (Hugos, 2006)

However a supply chain can be extended to include suppliers' suppliers and customers' customers and these key participants in the supply chain are in turn connected to service providers such as logistics, finance, market research, product design, and information technology. For any supply chain, there could be a combination of different firms who are considered to be key participants. The key participants include: producers, distributors, wholesalers, customers, and end consumers.

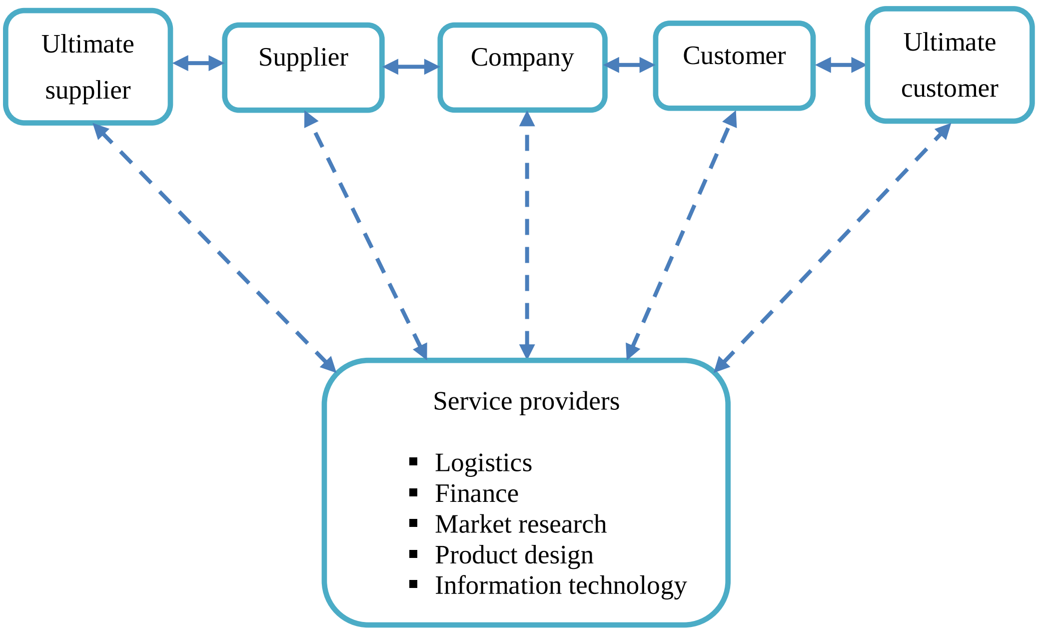


Figure 2.2: Extended supply chain

Source: (Hugos, 2006)

Generally, a supply chain represents two or more legally separated organisations connected by means of materials, information, and financial flows (Stadtler, 2008). However, with the development of the concurrent global business environment, the elements of supply chains have begun to increasingly integrate and co-ordinate with each other in order to ensure the lowest price and increased customer satisfaction (Elmuti, 2002). Cooper and Ellram (1993) identified three key reasons for SCM practices: to reduce inventory investment in the supply chain; to increase customer service; and to help build a competitive advantage for the company. Management of these elements and associated processes in the supply chain is widely known as supply chain management (SCM). Past literature shows various definitions of SCM, based on management philosophy, implementation of management philosophy and management processes. Trent and Monczka (1998), Londe and Masters (1994), Stevens (1989), Houlihan (1988), Jones and Riley (1985), and Cooper, Lambert, and Pagh (1997) are considered by Mentzer et al. (2001) as the key authors that have provided definitions of SCM. Mentzer et al. (2001) provide a more comprehensive definition based on these earlier authors. They define SCM as:

> "The systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long term performance of the individual companies and the supply chain as a whole (Mentzer et al., 2001, p. 18)."

SCM reflects the collaborative management of every element and of the supply chain and their associated processes rather than isolated management aspects. However, the concepts of SCM are different from complete vertical integration where each channel of the supply chain defines and operates within one organisation (Cooper & Ellram, 1993). SCM has been practiced in many disciplines such as purchasing, operations management, logistics, finance, accounting, organisational behaviour, human resources, etc (Burgess, Singh, & Koroglu, 2006 ; Frankel, Bolumole, Eltantawy, Paulraj, & Gundlach, 2008). Cooper et al. (1997) and Ketchen, Rebarick, Hult, and Meyer (2008) further said that the concepts of SCM, which originated in the manufacturing industry, have been used by world leading companies such as Wal-Mart, Toyota, Hewlett-Packard, and Xerox. In fact Wal-Mart took over its competitor Kmart in 10 years as a result of successful implementation of SCM principles (Hugos, 2006). Therefore the study reported here uses the above definition provided by Mentzer et al. (2001), considering its applications and successfulness in other industries as explained above.

The scope of the supply chain depends on the number of firms, activities, and functions that are connected with it (Cooper et al., 1997). Further, the scope of the supply chain can be explained in terms of upstream (source of supply) and downstream (point of consumption), which is the span of logistics as defined by the Council of Logistics Management (CLM) (Stevens, 1989).

Understanding the objectives of SCM is very important as it guides the members of the supply chain in how they work. Jones and Riley (1985) explained the objective as minimising the total number of resources in order to achieve customer satisfaction for a specific section of the supply chain. This explanation is further supported by Cavinato (1991), who stated the objectives of SCM should be satisfying customer necessities through the materials flow from suppliers, and La Londe (1997) who stated that the objective of SCM is to reduce inventory investment, and increase customer satisfaction and competitive advantage.

2.1.1 SCM Process

There are different business processes that occur within a supply chain (Cooper et al., 1997). SCM concerns itself with the integration of these processes in order to ensure that customers and stakeholders are satisfied. Cooper et al. (1997) introduced eight key processes that the core supply chain consists of, as shown diagrammatically in Figure 2.3.

1. Customer relationship management
2. Customer service management
3. Demand management
4. Order fulfilment
5. Manufacturing flow management
6. Procurement
7. Product development and commercialisation
8. Returns channel

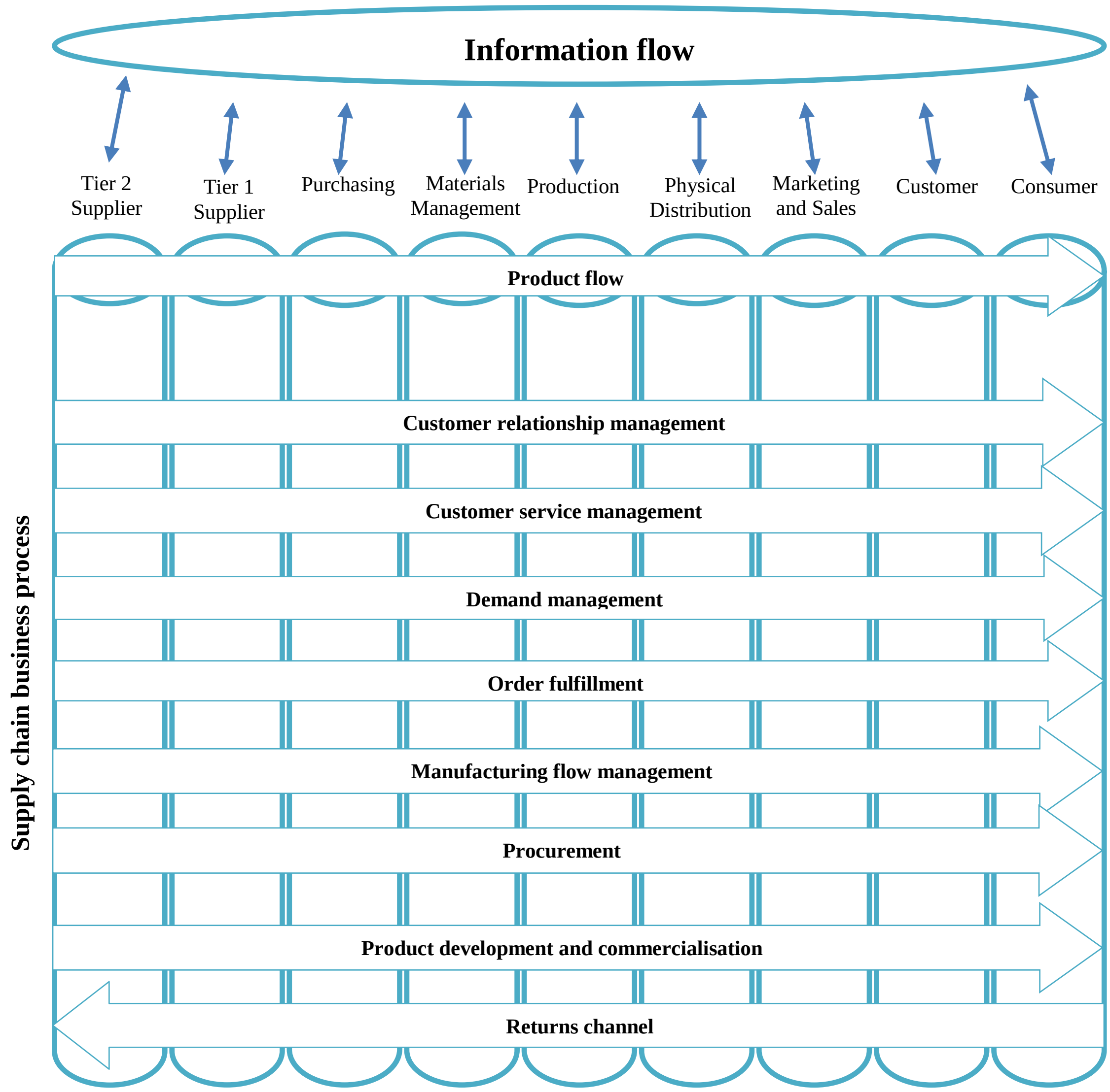


Figure 2.3: A framework of supply chain management

Adapted from: (Cooper et al., 1997)

The next paragraphs briefly explain each process of the eight key processes stated above.

Customer relationship management refers to the development and maintenance of customer relationships and the identification of main customers; it is a part of a business's aims and is also a part of the responsibilities of management (Berry & Parasuraman, 2004). The key to improving customer relationships and eliminating both control variability and non-value added activities is team work (Croxton, García-Dastugue, Lambert, & Rogers, 2001). Customer service management offers customers information on product availability, shipping dates, and order status through customer interfaces such as manufacturing and logistics. Product Service Administration (PSA) is also administered through customer service management (Croxton et al., 2001). Balancing customer necessities against a firm's supply competences is demand management. Demand management comprises demand forecasting, coordinating demand with production, procurement, and distribution (Vollmann, Berry, & Whybark, 1997). It is also responsible for generating and implementing plans when operations are not functioning well.

Order fulfilment is considered as effective in SCM when customer necessities are satisfied (Kumar & Sharman, 1992). In achieving effective order fulfilment, it is required to integrate manufacturing, logistics, and marketing plans to meet customer demand and reduce delivery costs (Croxton et al., 2001). Manufacturing flow management refers to various activities in the production process, and maintaining flexibility in manufacturing in order to fulfil market requirements. Procurement is the functioning of purchasing goods and services, consumption management, supplier selection, contract negotiation, and contract management (Hugos, 2006). Product development and commercialisation determines the long run success of a firm (Cooper, 1998). Efficient product development is the main determinant to reduce time to market (Hutt & Ross, 2000) and keeps a firm competitive. Returns management contributes to achieving sustainable competitive advantage through productivity improvements (Rogers & Tibben-Lembke, 2001).

The aforementioned business processes, the supply chain and its structure are directed by the key components of SCM. The next subsection describes the key components of SCM which are common for all eight processes described above.

2.1.2 Key Components of SCM

The key components of SCM are common among all the members and processes of the supply chain (Andrews & Stalick, 1994; Cooper et al., 1997). A synthesis of past literature on SCM's key components is given in Table 2.1. In addition these key components are diagrammatically shown with supply chain business processes (as discussed in section 2.1.1) in Figure 2.3. Of the ten management components provided, only six - planning and control, work structure, organisation structure, product flow facility structure, information flow facility structure, and product structure - are considered as more tangible and measureable compared to the other four. This is because these components are directly affected by organisations and the supply chain. The rest of the components: management methods - power and leadership structure, risk and reward structure, and culture and attitude - also contribute to organisations and the supply chain for their success. However these components are difficult to assess and vary in the short term.

Table 2.1: Key components of SCM based on the literature - Adapted from: (Cooper et al., 1997)

Authors	Planning and control	Work structure	Organisation structure	Product flow facility structure	Information flow facility structure	Product structure	Management methods	Power and leadership structure	Risk and reward structure	Culture and attitude
Houlihan (1985)	✓	✓	✓	✓	✓	✓	✓			✓
Jones and Riley (1985)	✓	✓	✓	✓	✓		✓			✓
Stevens (1989)	✓	✓	✓	✓	✓					✓
Ellram and Cooper (1990)	✓	✓		✓	✓				✓	
Lee and Billington (1992)		✓		✓	✓					
Cooper and Ellram (1993)	✓	✓	✓	✓	✓			✓	✓	✓
Hewitt (1994)	✓	✓	✓	✓	✓				✓	
Scott and Westbrook (1991)		✓		✓	✓	✓	✓			
Towill, Naim and Wikner (1992)	✓	✓		✓	✓	✓	✓			
Hammer (1990)	✓	✓	✓	✓	✓				✓	✓
Andrews and Stalick (1994)	✓	✓	✓		✓			✓	✓	✓
Cooper and Gardner (1993)	✓	✓		✓	✓				✓	✓
Gardner (1996)	✓				✓				✓	✓

Planning and control indicate the direction in which the supply chain is directed and its level of success. The work structure is the key indicator of the performance of a firm's activities. Organisational structure relates to the individual firm and the supply chain, which is usually measured by the level of integration across the supply chain.

Product flow facility structure is the network of sourcing, manufacturing, and distribution throughout the supply chain. It is apparent that past literature generally speaks about the significance of information flow in facilitating structure. Good communication (which is facilitated by the flow of information) between the channel members directly influences the efficiency of the whole supply chain. Product structure is the way of coordinating the issues related to the development of new products in the supply chain. The degree of a product's complexity determines the number of suppliers required and the various challenges in integrating the supply chain. Management methods refer to the business missions, values, and techniques that management can engage in the supply chain. The power and leadership structure determines the key direction in which the supply chain moves. This is usually determined by the leaders (upper level management) in the supply chain. The risk and reward structure embedded in the supply chain influences the channel members in their long term commitments. Understanding culture and attitude is very important as it helps to improve the performance of the overall supply chain. All supply chain members should be valued and incorporated in the management system in order to achieve better performance.

2.1.3 Characteristics of SCM

Cooper and Ellram (1993) describe the characteristics of SCM based on past literature and executive discussions. The characteristics are: inventory management approach, cost efficiencies, time horizon, and amount of mutual information sharing and monitoring, amount of coordination of multiple levels in the channel, joint planning, compatibility of co-operative philosophies, breadth of supplier base, channel leadership, amount of sharing of risks and rewards, speed of operations, information, and inventory flows. The aforementioned characteristics are briefly described in Table 2.2.

Table 2.2: Key characteristics in SCM - Adapted from: (Cooper & Ellram, 1993)

Characteristics	Description
Inventory management approach	▪ Channel-wide management of inventories ▪ Only redundant inventories remain in the system ▪ Inventory reduction
Total cost approach	▪ Channel wide costs evaluation ▪ Total cost advantages ▪ Lower rates for some channels ▪ Lowest labour rates ▪ Effective processes ▪ Availability of more capital ▪ Lowest cost of capital ▪ Lowest tax rate ▪ Most advantageous logistics costs ▪ Highest depreciation/other tax advantages
Time horizon	▪ Long relationship life cycle in the supply chain
Amount of information sharing and monitoring	▪ Information monitoring occurs from both manufacturer to customer and customer to manufacturer ▪ Not all information is shared across all members of the supply chain but each channel is able to access only necessary information to manage supply chain linkages

Amount of co-ordination of multiple levels in the channel	▪ Multiple contacts between levels in firms and levels of channels (cross channel members co-ordination, cross management levels co-ordination, and across functions co-ordinations)
Joint planning	▪ Continuous process of planning, evaluation, and improvement in the long term
Compatibility of corporate philosophies	▪ Agreement on the basic directions for the channel
Breadth of supplier base	▪ Reduced supplier base (fewer numbers of pool of suppliers) ▪ Strong relationships and closer co-ordination with a few suppliers
Channel leadership	▪ Well-structured top management ▪ Co-ordination focused
Amount of sharing of risks and rewards	▪ Long term risks and rewards sharing system
Speed of operations, information and inventory flows	▪ Electronic Data Interchange (EDI) and barcoding are employed for quick responses across channels

2.1.4 Facets of SCM

The concepts of SCM were explained by Stadtler (2008) using the concept of the “house of SCM” as shown in Figure 2.4. The final goals are customer service and competitiveness as indicated by the roof of the “house of SCM”. The two pillars represent the main elements in SCM’ that is, “integration” and “coordination”, which enable the achievement of the key goals (roof) of SCM. Integration refers to a network of different organisations linked with the supply chain. Coordination refers to the management of information, materials and financial flows. The foundation of the “house of SCM” compromises the aspects of logistics, marketing, operations, organisational theory and purchasing and supply.

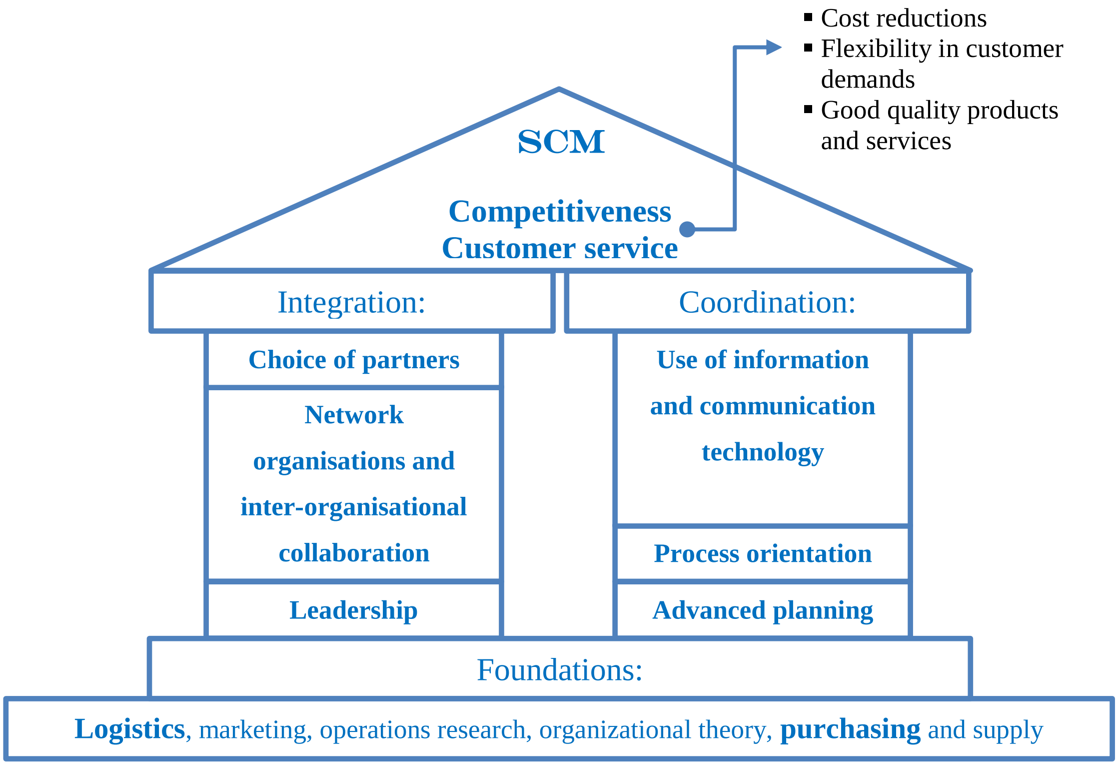


Figure 2.4: House of SCM

Source: (Stadtler, 2008)

Purchasing and logistics are two important foundations in SCM as they can be directly connected with inventories. As this study is examining the supply and purchasing behaviours in CSCM, purchasing and logistics will be focused on and discussed in the following paragraphs.

Cooper and Ellram (1993) describe the value of purchasing and logistics in terms of providing co-operative culture assessments, identifying potential supply chain members, evaluating operating efficiencies, and determining the degree of potential collaboration. Subsequently, the potential strengths and weaknesses of the supply chain can be evaluated. Figure 2.5 demonstrates the contribution of purchasing and logistics in SCM.

Purchasing and logistics are the key functions to supply chain operations, providing leadership and management in the supply chain process. The information flow is controlled by purchasing and logistics which enable sharing and monitoring. Purchasing cooperates with the upstream of the supply chain (suppliers) and logistics cooperates with the downstream (customers and third parties) of the supply chain. Also, logistics interacts with purchasing in terms of transportation and warehousing. Both purchasing and logistics also influence supplier relationships. From the above it is clear that both purchasing and logistics determine the functionality of the supply chain. The following sections will look at purchasing and logistics separately.

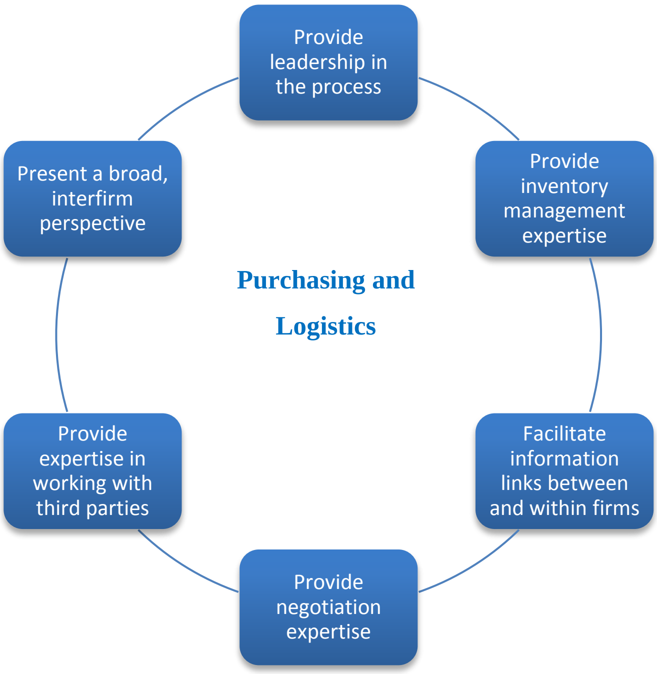


Figure 2.5: Contributions from purchasing and logistics

Adapted from: (Cooper & Ellram, 1993)

2.1.5 The Purchasing Function in SCM

Purchasing comprises both sourcing and supply processes. Hadikusumo et al. (2005, p. 48) define purchasing as "a fundamental function of material procurement that refers to the acquisition of goods and services and an establishment of mutually acceptable terms and conditions between a seller and a buyer". Procurement is an important aspect of logistics in SCM. The term "procurement" is used to describe purchasing, consumption management, vendor selection, contract negotiation, and contract management (Hugos, 2006).

Considerable attention has been paid to the purchasing function in past literature mainly due to its contribution to profitability, the survival of business organisations, and firms' performances (Bayazit, Karpak, & Yagci, 2006). Further, Weber, Current, and Benton (1991) discovered that purchasing materials and services in companies rich in technology represents 80% of the total product cost. Gadde and Hakansson (2001) identified that purchasing is not seen as a separate function but as an integral part of running an organisation. Purchasing within an organization typically involves all activities associated with the buying process. According to Weele (2005), these activities include: determining the need, selecting the supplier, arriving at a proper price, specifying terms and conditions, issuing a contract or order, and ensuring proper delivery. The increasing importance of SCM is motivating companies to fit purchasing and sourcing strategies into their supply chain objectives. Figure 2.6 exemplifies the main activities within the purchasing function.

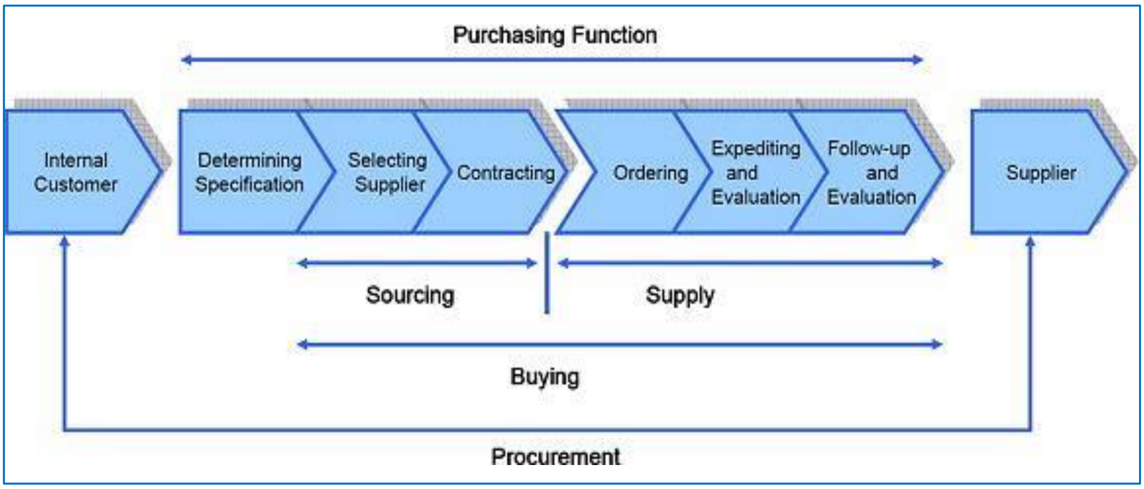


Figure 2.6: Purchasing process activities

Source: (Weele & Weele, 2005)

As explained above, the purchasing function is important as it directly contributes to profitability. In addition, Mendoza and Ventura (2012) expressed the view that efficient purchasing strategies can bring a competitive advantage to the entire supply chain. Sourcing materials or components is a combination of backward vertical integration and forward vertical integration (Yee, 2010). Backward vertical integration deals with upstream materials suppliers, whereas downward integration deals with downstream customers. Therefore, decisions made both upstream and downstream in the supply chain are important in sourcing the right materials.

2.1.6 Logistics in SCM

As explained in section 2.1.4 logistics is an important foundation in SCM as it can be directly connected with inventories. Lambert, Cooper, and Pagh (1998) propounded that logistics is a concept that relates to managing the flow of materials and information across the supply chain. Therefore SCM can be considered as managing the logistics of a firm including managing customers and suppliers. The concept of SCM should therefore consider logistics integration and managing and integrating major business processes across the supply chain. The Council of Logistics Management (CLM) provided a definition for logistics in 1998 (Lambert et al., 1998) as given below:

> "Logistics is that part of the supply chain process that plans, implements, and controls the efficient, effective flow and storage of goods, services, and related information from the point-of-origin to the point-of-consumption in order to meet customers' requirements."

Logistics management is based on two assumptions: of integrating logistics activities across the supply chain, and linking production/operations, transportation and physical distribution, marketing and purchasing (Novack, Rinehart, & Wells, 1992). However, past literature shows that the difference between the integration of logistics management and SCM is still unclear (Cooper et al., 1997). Logistics management is associated with materials supply and purchasing activities and therefore supply chain stakeholders' decisions are connected with logistics management. The study reported here therefore intends to examine logistics in the construction (section 2.2.3.2) industry and its associations with building materials management.

2.1.7 Supply Chain Members

Hugos (2006) states that the members of the supply chain comprise every firm or organisation which directly or indirectly connects with the principal company. Therefore it considers all parties involved from the origin (suppliers) to the end of the supply chain (customers). Having identified all the direct and indirect parties involved in the supply chain as supply chain members, it is clear the supply chain is an extremely complicated network. Hence it is advisable to distinguish between primary and supportive members of the supply chain (see Figure 2.7).

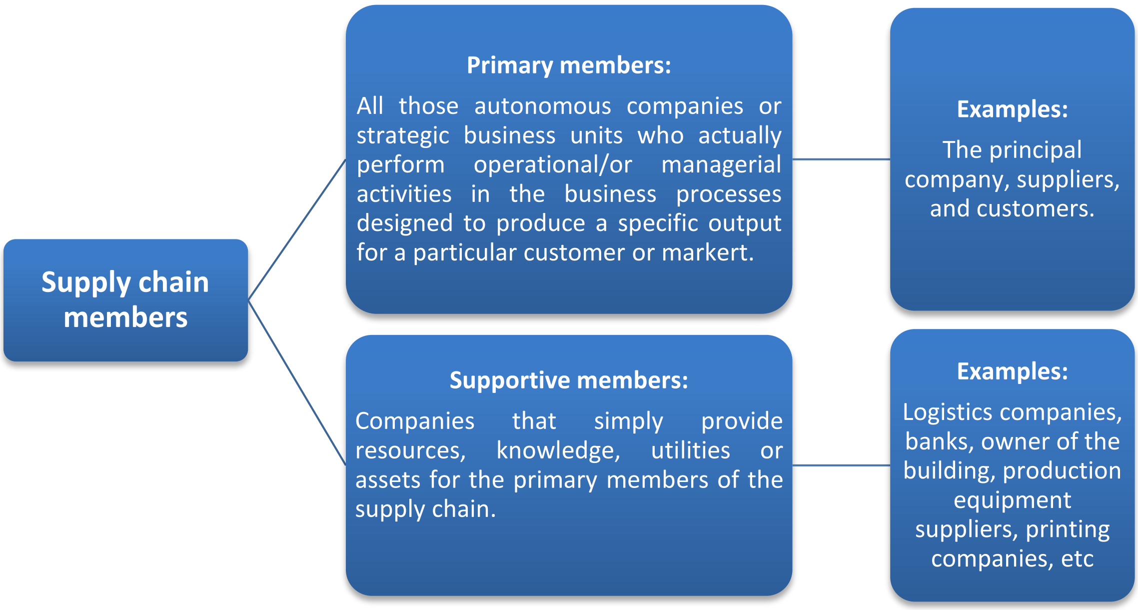


Figure 2.7: Primary and supportive members of the supply chain

Adapted from: (Lambert et al., 1998)

However, it should be noted that the primary and supportive members can be the same company or organisation, as a single company could provide both primary and supportive services. Having defined primary and supportive members of a supply chain, it is possible to clearly identify the origin and end of a supply chain. At the origin (point of origin) of the supply chain, there are no primary suppliers, and at the end (point of consumption) of the supply chain, no further value can be added, and the output of the supply chain is consumed (Lambert et al., 1998).

2.1.8 Integration (Collaboration) in the Supply Chain

Implementation of SCM concepts is based on coordination among the various parties involved in the supply chain (Fawcett, Magnan, & McCarter, 2008). This means that different functions and processes should be integrated across all organisations involved in a supply chain. Cooper (1997) introduced four possible methodologies to accomplish greater integration in the supply chain which were named: dyadic, channel integrator, analytic optimisation, and keiretsu. Dyadic methodology concerns integration with the nearest party (one level up or down) in the supply chain and this could be the actual initiation of the supply chain in most cases. The other methodologies are concerned with the supply chain parties further away. It is important to understand customer requirements and supplier constraints to optimise the operation of the supply chain. This is referred to as collaboration in the supply chain. Collaboration is the key criteria in effective SCM (Horvath, 2001). Collaborative supply chain practices deliver a number of benefits as opposed to isolated/disconnected supply chain practices. Collaborative practices integrate demand and supply, yielding greater forecasting abilities and improved performances throughout the supply chain. Collaboration in the supply chain can be segmented into vertical and horizontal dimensions (Barratt, 2004). Vertical collaboration integrates suppliers and customers whereas horizontal collaboration integrates competitors and non-competitors (see Figure 2.8). In addition, vertical and horizontal collaboration ensures the connection between internal and external collaboration.

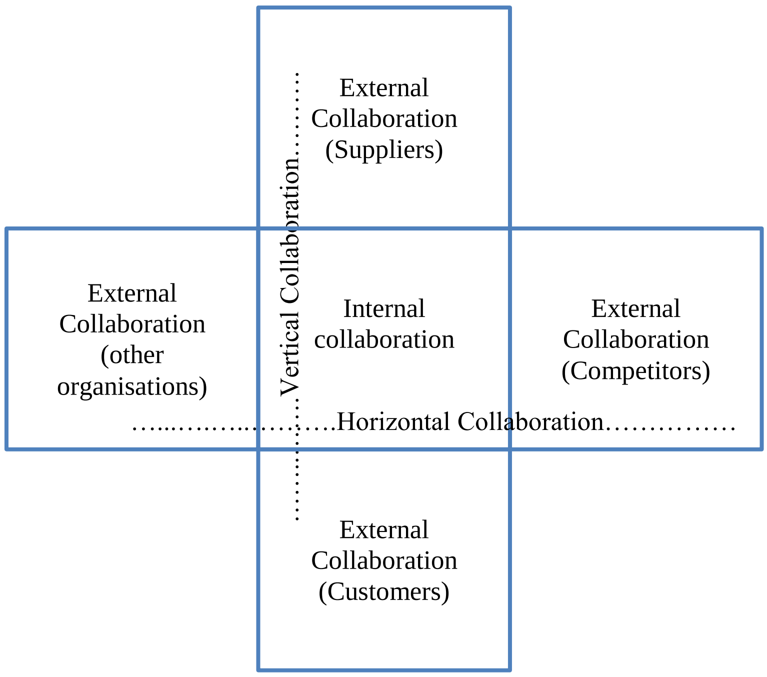


Figure 2.8: The scope of collaboration

Adapted from: (Barratt, 2004)

Complete internal collaboration is related to the purchasing, manufacturing, logistics, and marketing aspects of any organisation (Fawcett & Magnan, 2002). This internal collaboration is based on the interaction between the aforementioned departments and therefore information sharing (e.g. meetings) is the key to achieving internal collaboration (Kahn & Mentzer, 1996). Internal collaboration must be connected with external collaboration by tighter relationships and information sharing with customers and suppliers. Barratt (2002) goes on to explain the relationship between internal and external collaboration: internal collaboration must be associated with drivers and constrains external collaboration. Figure 2.9 shows a possible mechanism for vertical collaboration. The downstream side of vertical integration is connected to demand replenishment, collaborative planning, and shared distribution, all of which deal with customer relationship management. The upstream of the supply chain is connected to production scheduling, supply planning, and new product introduction, all of which deal with supplier relationship management.

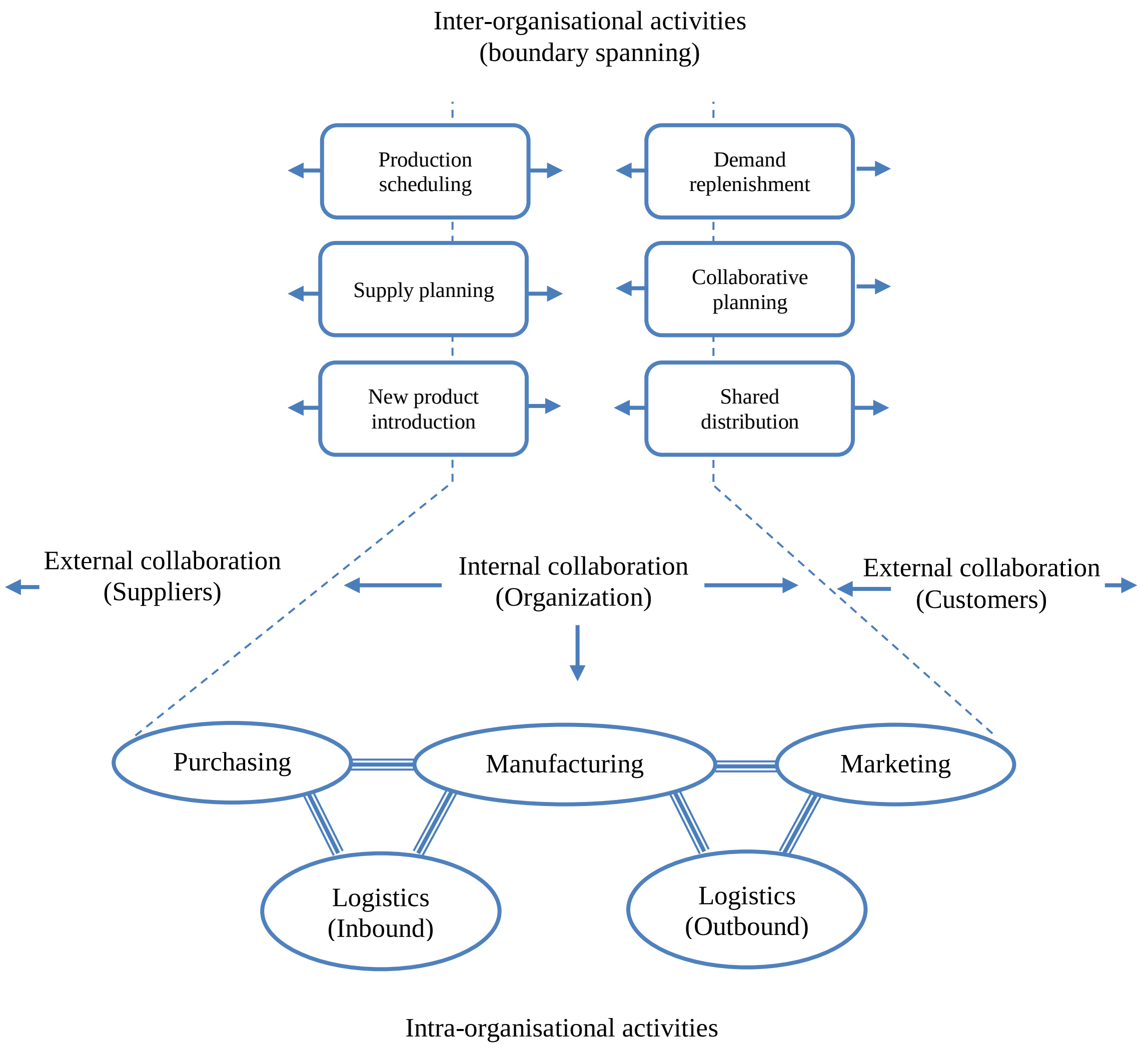


Figure 2.9: Vertical collaboration

Source: (Barratt, 2002)

Modern technology provides various technological infrastructure (see Table 2.3) allowing greater networking and collaboration in the supply chain. This infrastructure facilitates information sharing within the supply chain; for instance, networked SCM applications can significantly improve communication levels. Data storage devices enable accessibility of many types of information by various people in the supply chain. System and channel integration in the supply chain can be achieved by Websites, online market places and intranets, proprietary networks, call centres, physical stores and branches, and snail mail.

Table 2.3: Collaborative technology infrastructure - Adapted from: (Horvath, 2001)

Characteristics	Description
Open, low cost connectivity	Infrastructure should be accessible across the supply chain where necessary. Especially, small bodies in the supply chain should be able to access the infrastructure without major investments.
Very large, flexible, multimedia data storage capabilities	Infrastructure should be able to store all types of data (images, engineering drawings, documents, etc.) related to the supply chain. This enables efficient data accessibility across it.
System and channel integration	All the associated people in the supply chain should be able to integrate and access information irrespective of the application used.
Higher-level self service capabilities	Collaborative technology infrastructure should be self-learnable, easy to use and require little training.
Intelligence gathering and analysis	Individual channels linked in the supply chain should be able to gather necessary information from data storage devices and conduct appropriate analyses. This improves the internal operations of these channels.
Supply chain collaboration exchanges	SCM should offer exchanges in the design and development of products, manufacturing process, logistics and distribution strategies, as well as all forms of supply and demand chain planning. As a result of supply chain collaboration, members will benefit from proven complete collaboration solutions from service industry leaders.
Sophisticated security capabilities	As supply chain collaborative infrastructure allows sharing of sensitive engineering, financial, and customer information, it is necessary to employ strong security media such as digital certification and biometrics.
New electronic commerce capabilities	Collaborative technology infrastructure should employ innovative financial arrangements, such as electronic billing and payments, automatic payments on expensive engineered products, and settlement netting among parties.

2.1.9 Benefits of SCM

Toyota, Dell, General Electric, Cisco, and Ford are good examples of world famous companies that have benefitted from the application of the principles of SCM (Lee & Whang, 2004). Past literature shows the main benefits that have been identified from individual overseas companies are increased gains in market share and reductions in operating costs, as can be seen from the examples of Dell and Wal-Mart in the United States. Dell employed direct customer sales with the aid of internet commerce to increase its market share. Wal-Mart dispatches goods directly to stores without maintaining inventories, thereby drastically reducing sales costs (Simschi-Levi, Kaminsky, & Simschi-Levi, 2003). A study conducted by Stanley E. Fawcett et al.

(2008) identified that the principle benefits of SCM can be in the form of customer focus benefits and company focus benefits. Customer focus benefits include increased customer responsiveness, more consistent on-time delivery, customer satisfaction, and shorter order fulfilment lead times. Company focus benefits include reduced purchasing costs, better asset utilization, ability to handle unexpected events, reduced inventory costs, better productivity, and reduced overall product cost.

2.1.10 SCM Problems

Problems related to SCM arise from uncertainties and lack of coordination across the supply chain, its activities and members (Turban, Wetherbe, & McLean, 1996). Demand variability (difficulties in forecasting the correct demand) is one of the key issues discussed in the literature (Basu & Wright, 2008; Fransoo & Wouters, 2000). Demand variability originates from small variations in demand or inventory levels occurring in the principle company and these fluctuations are reproduced across the supply chain. As a supply chain consists of a large number of firms, each firm's knowledge of the other companies' requirements is poor. This causes disproportionate inventory changes and consequently demand levels could fluctuate on a large scale (Forrester, 1961; Forrester, 1995; Holweg & Bicheno, 2002). The other common problem that can be seen in SCM is of performance optimisation of particular firms connected to the supply chain. The issue here is that as some firms optimise their own performance without considering the effects on the total supply chain, global optimisation cannot be accomplished (Gunasekaran, Patel, & McGaughey, 2004).

As discussed above there has been increasing interest in SCM concepts in many industries including construction. Therefore the SCM issues discussed in section 2.1.10 have been adapted to construction and they are described in the following sections focusing on materials flow in the construction supply chain.

2.2 The Construction Supply Chain

The construction industry is globally very important as it contributes 10% of the world's GDP and 7% of the world's total employment. Also 40% of annual natural resource consumption, 30% of energy consumption, and 25% of all timber consumption are from construction (United Nations Environment Programme, 2010). Further, MarketLine (2013) estimates that the global construction materials market in 2013 will have a value of $1.031005 trillion which is a 37.1% increment on 2012. The industry is project oriented, complex and uncertain in nature, because it is fragmented, trading relationships are short, information flow is weak, and there is a significant dependence between tasks and activities (Briscoe & Dainty, 2005; Wegelius-Lehtonen, 2001a). In line with this, Pryke (2009) explained that the construction industry is characterised by fragmentation, adversarial relationships, project uniqueness, separation of design and construction, and competitive tendering, based on past research conducted in the UK.

Fragmentation causes poor performance in the entire supply chain (Egan, 1998; Latham, 1994). Adversarial relationships in the supply chain occur as different project participants' needs are contradictory. For example, a client's primary goals are low cost and high quality, the designers' and consultants' primary goals are high fees and acceptable quality, the main contractor's primary need is profit maximization, and subcontractors and suppliers look for on-time payments (Cox & Townsend, 1999). These primary goals show contradictory behavior. As construction projects are usually bespoke, resource requirements, specifications and technologies for each project are different. Therefore each project is coupled with discrete demands, and subsequently supply chain relationships tend to be temporary.

As a result of the traditional construction procurement system often used in the industry, design and construction are separated. There are many difficulties that arise in supply chain integration from this distinct design and construction practice. The competitive tendering process adopted by many construction projects is focused on the lowest price, which causes project delays, over-budgeting, and lower quality. The principles of SCM (partnering, alliancing, and public private partnership) have been suggested as remedies for these issues in the literature. Construction industry practices in SCM are due to a number of reasons: to reduce costs; to shorten lead times; to benefit from economies of scale; to manage information flows using new technologies; to increase competence; to increase competition; to support more product development; and to enhance marketing strategies (Olsson, 2000). The performance of construction supply chain operations depend on the various construction parties and the information and materials flow among them. Figure 2.10 represents the demand and supply directions of a typical construction supply chain.

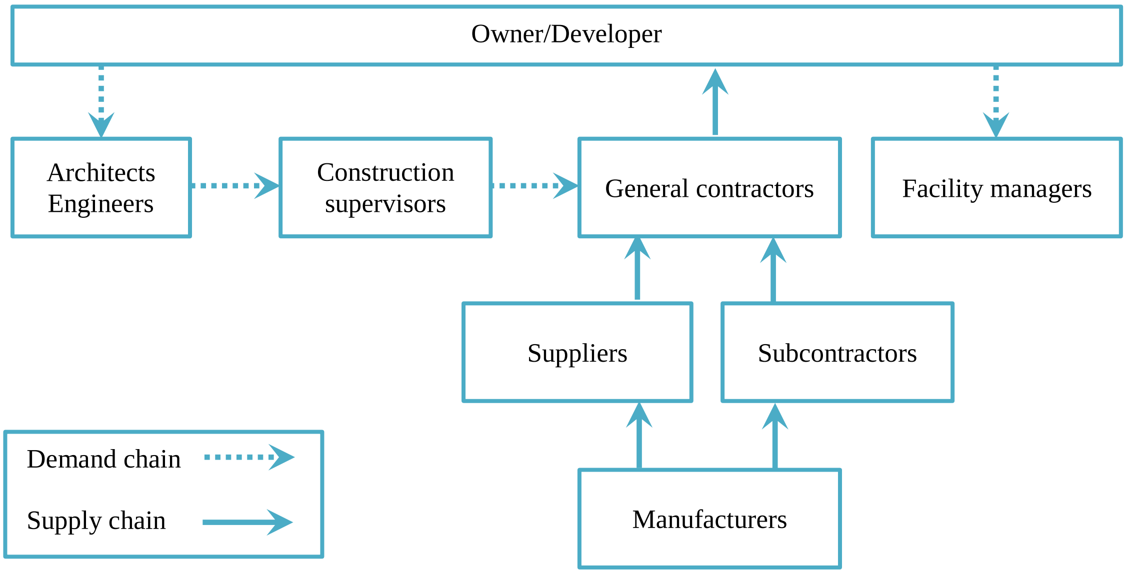


Figure 2.10: Construction supply chain network

Source: (Hu, 2008)

From the above it is clear that a supply chain network comprises various stakeholders such as clients, designers, contractors, and suppliers/manufacturers. Table 2.4 introduces these key stakeholders in a construction supply chain.

Table 2.4: Stakeholders in construction procurement - Adapted from: (Gamage, 2011)

Stakeholder	Description
Client	▪ The organisation, or individual, who commissions the activities necessary to implement and complete a project in order to satisfy its/his/her needs and then enters into a contract with commissioned parties ▪ The characteristics of clients influence the implementation of construction projects and affect the choice of the most appropriate method of procurement ▪ E.g. individuals, groups or partnership of people, corporate bodies; private and public clients; clients who build once or rarely; those who build often; those who build for owner occupation; those who build for investment or as developers; those who act as agents or agencies for those who will eventually occupy the building
Designers	▪ Designers, often considered as design consultants, and key professionals such as architects, engineers (structural and services), surveyors and technology experts ▪ The composition of the design team varies for several reasons such as project characteristics (type, size, etc.) and adopted construction procurement systems (CPS) ▪ Prepare necessary designs, specifications (e.g. materials, services work; mechanical and electrical), and other relevant documents; supervise work on site and retain responsibility for coordinating it
Contractors	▪ Undertakes the responsibility of completing a building project in accordance with the contract documents on behalf of the client ▪ Depending on the procurement system selected, contractors undertake design services and construction management services ▪ Holds control of all operations on site, including work carried out by sub-contractors.
Suppliers	▪ Supply materials or equipment; may provide advice or design services to the design team ▪ Appointment: nomination by client or the principal contractor; depends on the procurement system adopted

Information flow and material flow are the key processes involved in any supply chain. In construction, information flow initiates from the client and designers and continues through the main contractor (procurement) to the suppliers. Materials orders, schedules and forecasts are some of the examples of information flow. Materials flow from manufacturers and suppliers to the construction site and they are ultimately used by the client. Figure 2.11 shows the two processes of flowing information and materials across the supply chain.

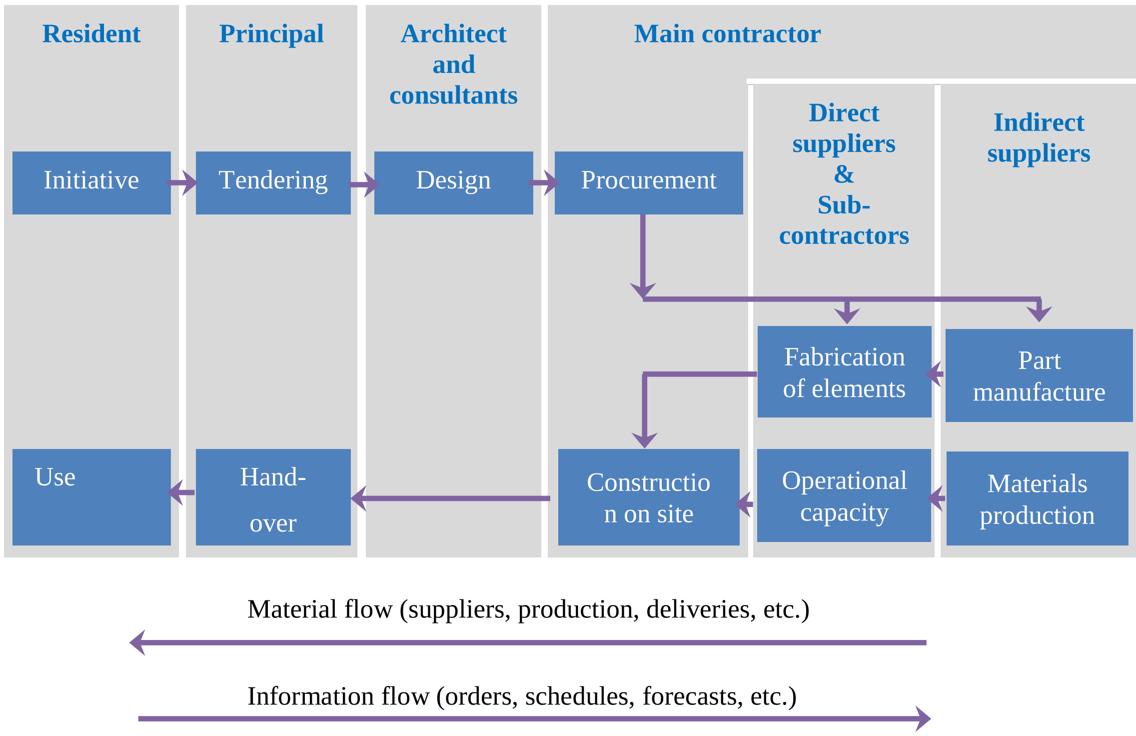


Figure 2.11: Configuration of a construction supply chain
Source: (Vrijhoef & Koskela, 2000)

Communication plays a major role in sharing information accurately and efficiently (Hu, 2008) across any supply chain. Therefore the key to effective collaboration in the supply chain is good communication between the various supply chain stakeholders. The supply chain system attached to a construction project is complex; there are numerous supply chain clusters that overlap with other clusters. The main objectives of a cluster that has a limited number of designers, materials suppliers or components is to design and deliver a substantial, recognizable element of the overall building, working to reduce costs, improve value and minimise waste (Nicolini, Holti, & Smalley, 2001). Further, clusters are considered as semi-independent groups of the project and they are under the overall coordination of the project management team.

Figure 2.12 shows the organisational arrangement of a construction project together with a number of different arrangements of supply chains, number of echelons, and company types.

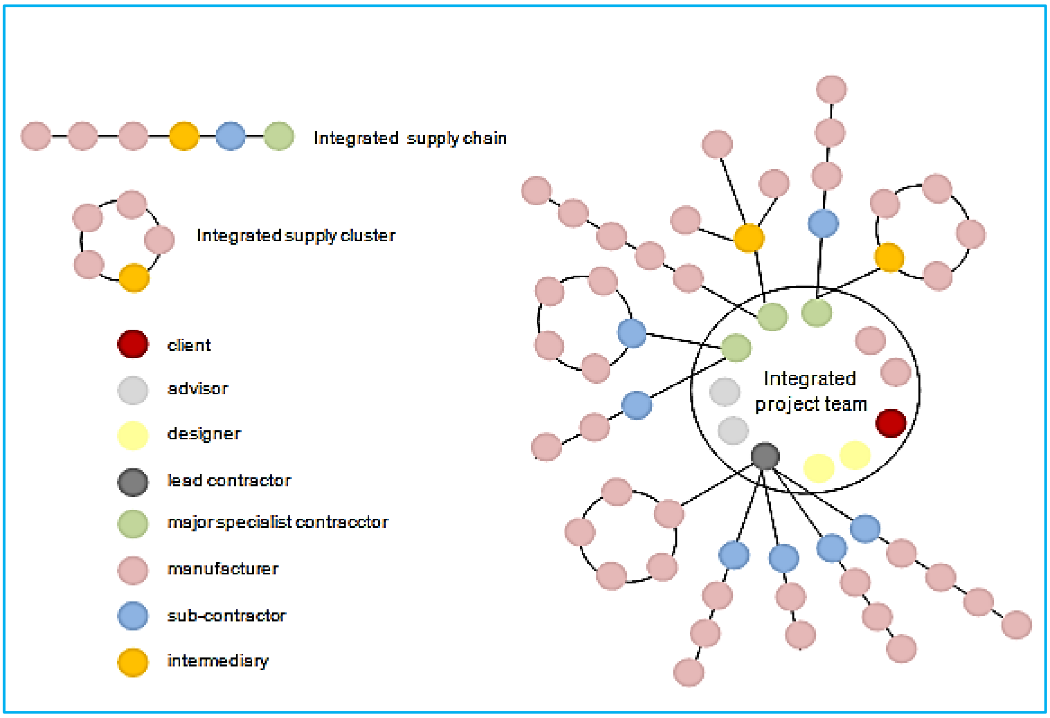


Figure 2.12: Structure of construction project supply chains

Source: (The strategic forum for construction, 2003)

Whenever a new project commences these clusters are restructured mainly due to different project and organisational requirements. The increased complexity of the system becomes more obvious when considering that each contractor working on site has a different supply chain. This resulting complexity is called the unique behaviour of construction supply chains (Vrijhoef & Koskela, 2000). In this case, materials that move through successive stages in the supply chain are characterized by flow or transformation until reaching the client. Materials play a key role in both the procurement and supply sides of any construction project. The next sub-section discusses the significance of materials in the construction supply chain.

2.2.1 Materials in the BMSC

Construction utilizes large quantities and varieties of materials including concrete, steel, masonry, timber, and different types of decorative materials (Chen, Zhou, & Zhang, 2011). Any material/product consumed or used in a construction project and incorporated in the constructed building or structure is referred to as a construction material. There are different ways that construction materials can be categorized, depending on their purpose. Domone and Illston (2010) categorised construction materials on a dimensional scale (see Figure 2.13). The sizes vary from the smallest, atomic or molecular, through structural material to the largest engineering materials.

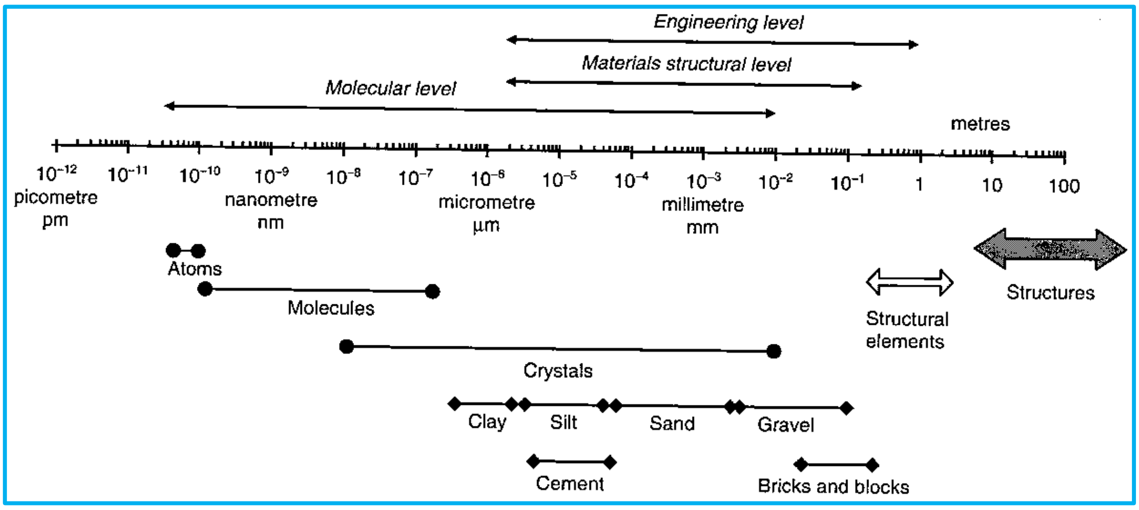


Figure 2.13: Sizes of constituents and components of construction materials

Adapted from: (Domone & Illston, 2010)

At the engineering level of material definition, the total material is considered, and is traditionally recognised as such by construction practitioners. Three main categories of materials/products are incorporated in the building construction industry (Dobler & Lee, 1984) as given in Table 2.5.

Table 2.5: Main categories of construction materials - Source: (CII, 1999)

Material category	Description
Raw materials	These are bulk materials that are inputs to processes and activities that take place on construction sites (e.g. sand, aggregates).
Finished products	These are off-the-shelf materials that are readily purchased from suppliers with minimal lead-time. They do not require excessive fabrication on site, and can be installed or applied directly (e.g. electrical and mechanical components).
Fabricated materials	Refers to those materials that require extensive fabrication before or after they are brought to site. Such materials are especially fabricated in line with project drawings and specifications.

Therefore this study incorporates both categorisations provided by Domone and Illston (2010) and CII (1999) and considers all raw materials, finished products, and fabricated materials as materials in the building construction industry. The next sub-sections review building materials and their applications in both procurement and supply practices.

2.2.2 Construction Materials Management

The first substantial research determination on materials management in the construction industry was commenced by the The Business Roundtable (1982) which defined materials management as a system, not the organization responsible for performing the task involved. Managing the integrity of the vendor's progress on purchasing, expediting and controlling can be summarised as materials management. Materials management consists of seven stages of planning, preliminary design, final design, procurement, vender control, construction, and closeout (Kini, 1999). An effective materials management system can reduce bulk materials surplus from a range of 5-10%. An 8% potential improvement in productivity also can be obtained by having an efficient materials management and control system (Akintoye, 1995). Researchers have shown that a considerable reduction in cost of materials can be achieved by reducing construction materials waste or by controlling the efficiency of the materials management system.

Having a well-defined cohesive project team ultimately makes an effective organisation that is able to carry out proper materials management according to a hierarchy level distribution. In addition, the functional relationships between each hierarchy level make materials management more effective. The project team path (see Figure 2.14) for managing construction materials runs from the project manager and materials manager, and finally reaches the third hierarchy level of buyers, subcontractors, administrators and expediters, and proper decisions taken by these personnel ultimately create a successfully completed project.

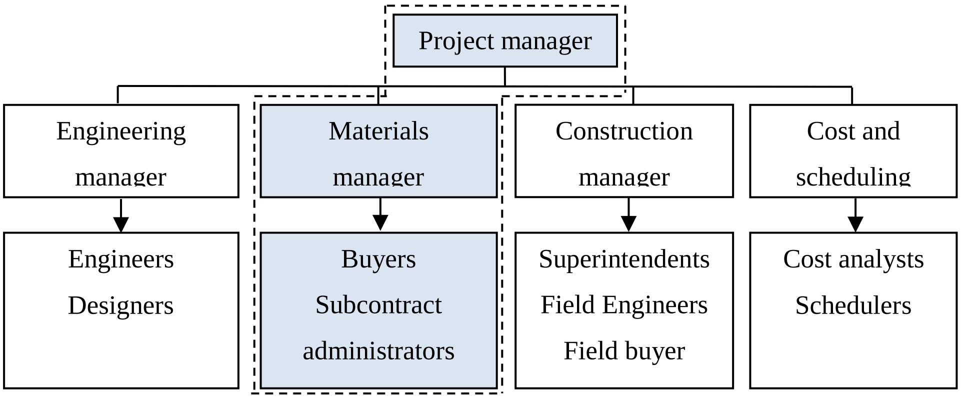


Figure 2.14: The project team involved in material purchasing decisions
Adapted from: (Akintoye, 1995)

On the other hand, the past literature highlights the consequences of having an improper materials management: the occurrence of materials shortages, surpluses, and cash flow problems. Therefore it is implied that construction materials costs, which significantly contribute to final construction costs, can be minimised by implementing a proper materials management structure.

Expediting is also an extremely important materials management function (Bell & Stukhart, 1986) as explained in section 2.2.2. In regards to the supply chain, or procurement is a strategy to ensure that purchased goods and items arrive in a timely fashion and meet quality control standards. The main functions of the expeditor are predicting accurate vendor delivery dates, workloads and labour availability. Sometimes expediting is done by an external “expediter” or it can be done within the procurement department. Several types of expediting methods (simple status of reporting, reactive expediting, and proactive expediting) exist for the process of purchasing construction materials, each with a different level of intensity and cost.

Simple status reporting: this is the least intense type of expediting and in this case, the status of an order is determined by periodic telephone contacts with the supplier. The information is systematically recorded afterward. Since this type of expediting delivers only basic information to the project, it contributes to coping with orders (e.g. overcoming delays). Reactive expediting: this expediting method is more intensive compared to simple reporting and can only be initiated as a response to an issue (e.g. delivery delay). Proactive expediting: in this type of expediting, initiation of contact with suppliers or builder’s merchants’ suppliers takes place as soon as the material order is issued, and it continues through the order’s life. The expeditor will closely examine all the rudiments of the order to get optimum delivery from the suppliers.

Expediting the suppliers' performance is essential to make a key link between the engineering and construction materials purchasing activities. Further, such expediting of information can make the contractor and supplier more mobilised in response to problems or delays (CII, 1988b).

2.2.3 Materials vs Total Construction Costs

Generally the overall building construction cost is distributed over materials, labour, plant and equipment, transport, energy and other components. However construction materials comprise a significant part of construction value, approximating 50% of the cost of all construction work (Abdul-Malak et al., 2000; Agapiou, Clausen, et al., 1998; The Business Roundtable, 1982; Zavadskas et al., 2005). Further, Bernold and Treseler (1991a) commented that the contribution of materials to total construction costs could become even greater in the future, due to the increasing cost of materials and increasing usage of materials input in building production. Therefore any opportunity to minimise the materials cost could significantly increase the value of the contractor's profit. Fellows, Langford, Newcombe, and Urry (2002) confirm that a small percentage reduction in materials costs could bring about a sizable increase in profits. However, questions have been raised about the manageability of construction materials prices since they are affected both by trade deals between merchants and contractors, and also by factors external to construction (e.g. political, social, etc.) (Vidalakis & Tookey, 2005). Thus, when selecting construction materials, it is essential that careful decisions are made. The following sub-section explains the various materials related cost categories in the construction industry and their importance in minimizing total construction costs.

2.2.3.1 Materials Cost Categories

The purchase of construction materials may involve a variety of cost types, which could arise at different stages of the construction procurement process. These cost types can be categorised into three main types, namely purchase costs, holding costs and shortage costs (Barrie & Paulson, 1992; Pilcher, 1967). A brief outline of each cost component with their types, along with some examples is detailed in Table 2.6.

Table 2.6: Cost types associated with construction materials purchasing process - Adapted from: (Abdul-Malak et al., 2000)

Type of cost	Sub types	Examples
Purchase cost	Material price	Effective negotiation
	Overhead incurred	Solicitation and evaluation of quotation Issuance and expedition of purchase orders
	Transportation cost	Shipping materials to site Insurance during shipping Customs fees for imported materials
Holding costs	N/A	Financing Storage Protection and Maintenance Misplacement Handling Obsolescence
Shortage costs (Less production compared to demand)	Direct cost Indirect cost	Liquidated damages Activity crashing costs Increased overhead costs Loss in productivity Loss of flexibility in project schedule Premium resulting from remedial action

Out of the above, the purchase cost is the largest part, and a substantial amount of the purchase cost is comprised of transportation costs. Formoso and Revelo (1999) conducted a study to demonstrate the cycling and processing times of the construction material supply tasks. The study shows that transport and delivery cost components are more significant over other cost components, as illustrated in Figures 2.15 and 2.16.

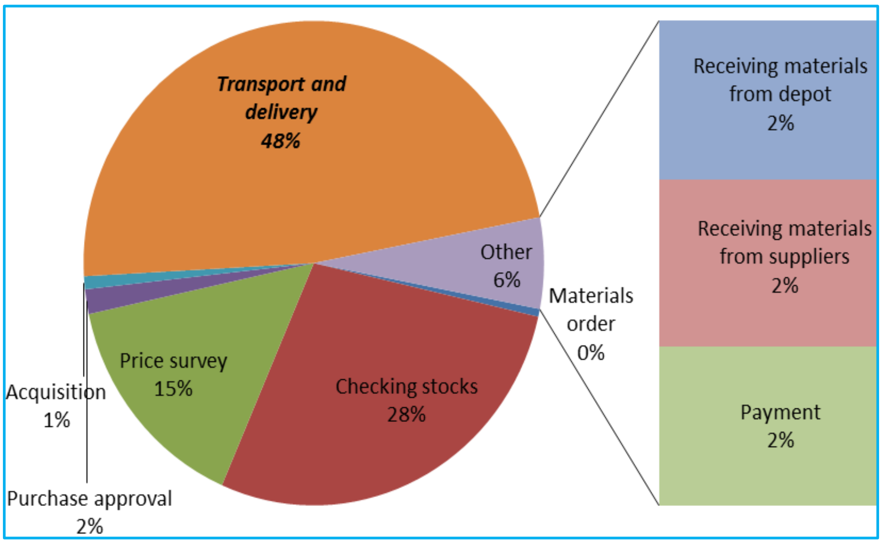


Figure 2.15: Average cycle time percentage variation

Sources: Formoso and Revelo (1999)

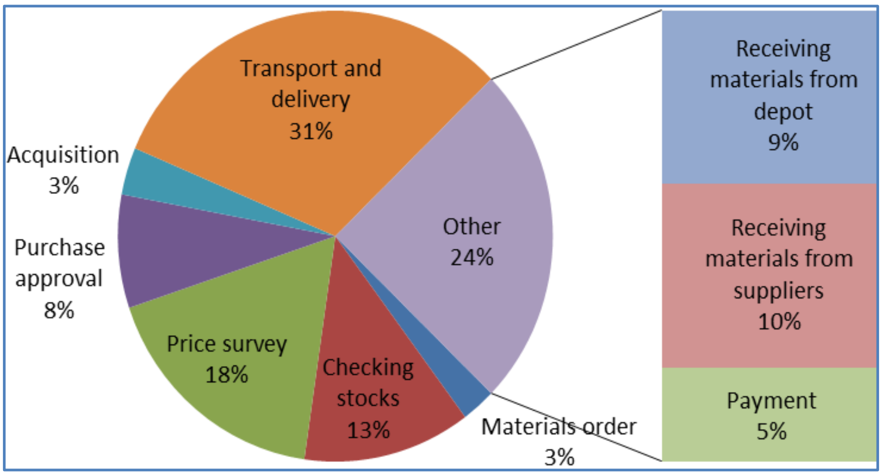


Figure 2.16: Average process time percentage variation

Sources: Formoso and Revelo (1999)

According to the information shown in Figures 2.15 and 2.16, the largest cycling time and largest processing time are in the "transportation and delivery" stage. This stage seems to have the most potential for improvements in the construction materials delivery process. Therefore, there can be a substantial opportunity to reduce the construction materials cost by considering transportation and delivery aspects. Generally for whole truck loads, the material purchasing cost consists of transportation costs and therefore the purchasing party is in a position to save the cost of inappropriate forms of delivery (Bertelsen & Nielsen, 1997). Transportation costs are mainly affected by manufacturers and traders, as they generally include their transportation costs in final construction material prices.

The material cost can also be significantly affected by the logistical costs associated. There is a possibility of high materials handling costs by contractors if they do not pay considerable attention to the logistics system on the building construction site. Hence adopting a proper logistical system to the construction site can reduce unnecessary expenses. Moreover, Banister and Button's study (as cited in Shakantu, Muya, Tookey, & Bowen, 2008) showed that unnecessary material deliveries can also cause a wide range of negative environmental impacts (e.g. pollution and waste generation). Therefore it is implied that adopting proper methods of purchasing construction materials can eliminate substantial unnecessary costs which are directly related to the cost of materials. The next two sub-sections describe the influence of the logistics costs to the total construction cost.

2.2.3.2 Logistics Costs

Managing logistics is a multifaceted task in both the manufacturing and construction industries (Shakantu, Tookey, & Bowen, 2002). In construction projects, the mobilisation of various resources (labor, material and machines) is considered as logistics management and it includes ensuring that these resources are in the right place, at the right quantity and at the right time to ensure the enhanced quality, safety and efficiency of the project. Further, sourcing, subcontracting, equipment, storage, stocks management, transport of materials, process control, communication and information, and infrastructure management are the key logistic activities involved in the construction industry (Nuno & Vitor, 2002). Clausen's study describes (as cited in Agapiou, Clausen, et al., 1998) that from the extraction of raw materials until the building is constructed, logistics costs apply in different stages such as the planning, organisation, coordination and control of materials. As this study addresses the issues around the BMSC, certainly the logistics costs in materials management is an important issue to consider. Wegelius-Lehtonen (2001b) pointed out that logistics costs related to construction materials are significant and are highly varied among different material groups as indicated in Figure 2.17.

Material group	Average logistics costs (approximate
Windows, Concrete elements, Kitchen cabinets and doors	5-15%
Plasterboard and Mortar	25%
Timber	50%

Figure 2.17: Logistics costs (% of the purchase price) between different material groups

This data confirms that construction material costs can be intensely affected by the indirect costs associated with intermediaries' logistics costs. Fairs's study (as cited in Asnaashari, 2010) demonstrated that enhanced simple logistics techniques can reduce 15% of a construction firm's materials and labour costs. It can be seen, therefore, that the varying nature of logistics costs should be considered in order to minimise the costs associated with construction materials.

The final cost of construction materials purchased by a construction contractor is accumulated until they are used on site. This accumulated cost can be identified during the two main phases of before and after the delivery of materials. The increase of construction material prices during the time they are ordered by the contractor until the materials are incorporated in the project is graphically illustrated by the “cost staircase” as shown in Figure 2.18.

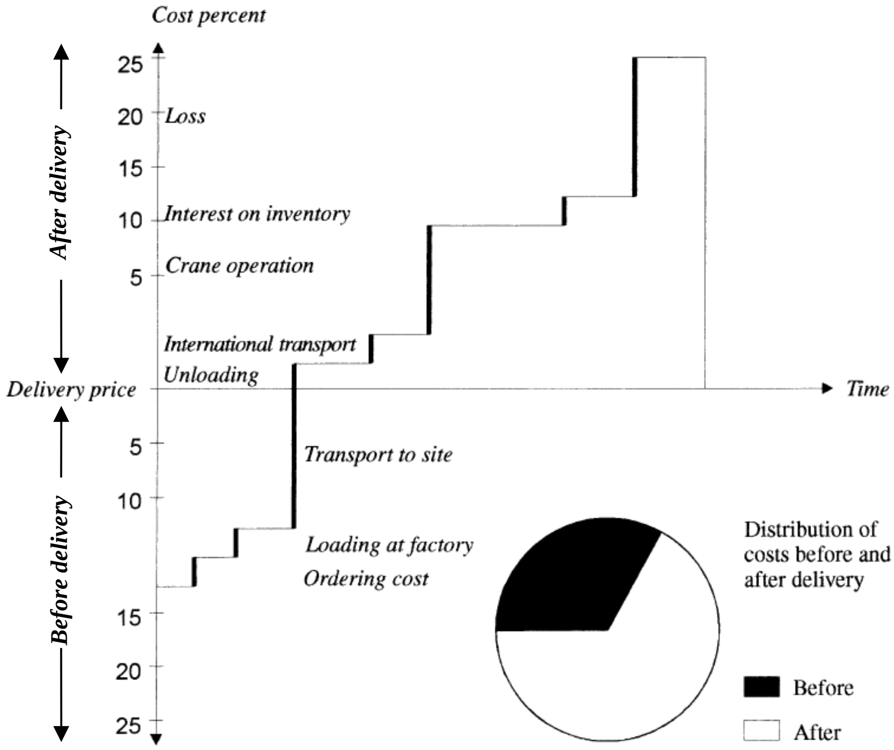


Figure 2.18: The cost staircase

Source: (Bertelsen & Nielsen, 1997)

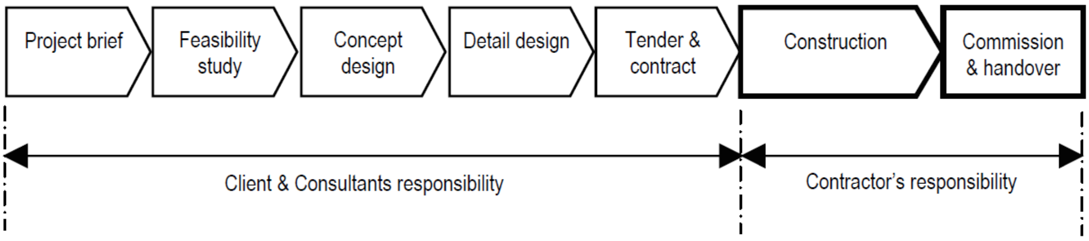
Figure 2.18 shows that the two main activities of onsite handling and transportation seem to result in a remarkable increase in material prices. Therefore, contractors have opportunities to secure better prices for materials by closely considering transportation and onsite handling activities. It seems that there are opportunities for contractors to shrink the materials cost further, by selecting the best builders’ merchant based on the key cost aspects specified by the “cost staircase”. Interestingly, data from Figure 2.18 shows approximately 33.33% of material indirect costs arise before their onsite delivery. This shows that there are many opportunities to minimize materials costs considering the indirect costs associated with the materials delivery process. Therefore building materials supply behavior, in particular to materials deliveries, deserves attention. The next section reviews the demand side of the materials supply chain, particularly the selection of appropriate materials procurement strategies by building contractors.

2.2.4 Selection of Appropriate Procurement Strategies

Tookey et al. (2001, p. 20) define procurement selection as "a set of rationalistic decisions within a closed environment, aiming to produce generic, prescriptive rules for clients and advisers to use to select the 'best' procurement route for their project." In addition, Naief-Turki (2002) recognized construction procurement as on time acquisition of construction materials and equipment, from the stage of design to construction, which covers purchasing, transportation, warehousing, and moving goods towards the production process. Choosing an appropriate procurement strategy is important because it can reduce the construction cost by up to 5% (Love, Davis, Baccarini, Wilson, & Lopez, 2008) and it contributes to project success. Construction procurement methods can be mainly characterized into the traditional procurement approach, integrated approach, management oriented approach, and project management (Hinton, 2011). Table 2.7 describes each key procurement method (with examples) in terms of their advantages, disadvantages, and procurement processes.

Table 2.7: Construction procurement methods – Adapted from: (Hinton, 2011, pp. 19-22)

Key Procurement methods	Description
Traditional procurement approach Examples: ▪ Traditional lump sum **(Love, Skitmore, & Earl, 1998)** ▪ Design-bid-build **(Wilkinson & Scofield, 2010)**	▪ Design and construction responsibilities are isolated ▪ Architects and consultants employed by the client create the design and tender documents (Rashid et al., 2006) ▪ Contractors bid on the tender documents ▪ Client nominates subcontractors ▪ Usually lowest tendered price is accepted ▪ Majority of design is completed before construction work starts ▪ Project is managed by clients and their advisers (architect and consultant) and main contractor ▪ Architect is paid a percentage of the project value ▪ Contractor is paid based on the pre-determined schedule of quantities or rates (Masterman & Masterman, 2003)

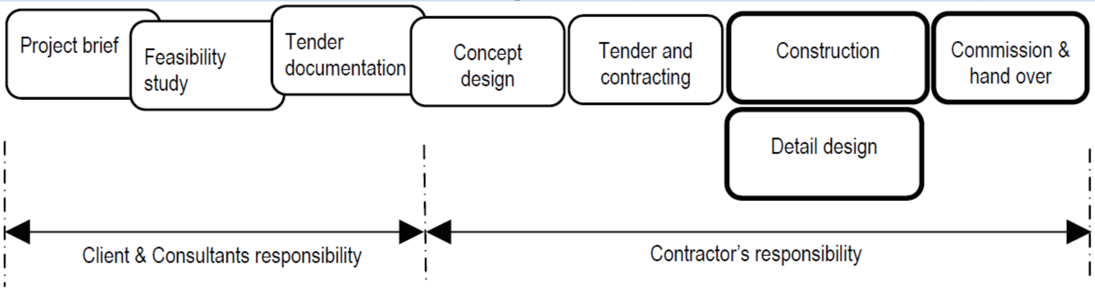


Source: (Rashid et al., 2006)

Integrated approach

Examples:
- Design and build **(Love et al., 1998)**
- Novation and turnkey (Masterman & Masterman, 2003)

- Design and construction responsibilities are undertaken by one organisation
- Client and advisers invite interested parties to apply with their own design and costing
- The client maintains only one point of contact
- Cost is often less than other methods, given that client clearly defines his requirements
- Shorter project duration as design and construction usually overlap
- Tender evaluation is usually difficult because it consists of both design and construction detail
- The client may relinquish control of his aesthetic requirements (Masterman & Masterman, 2003)

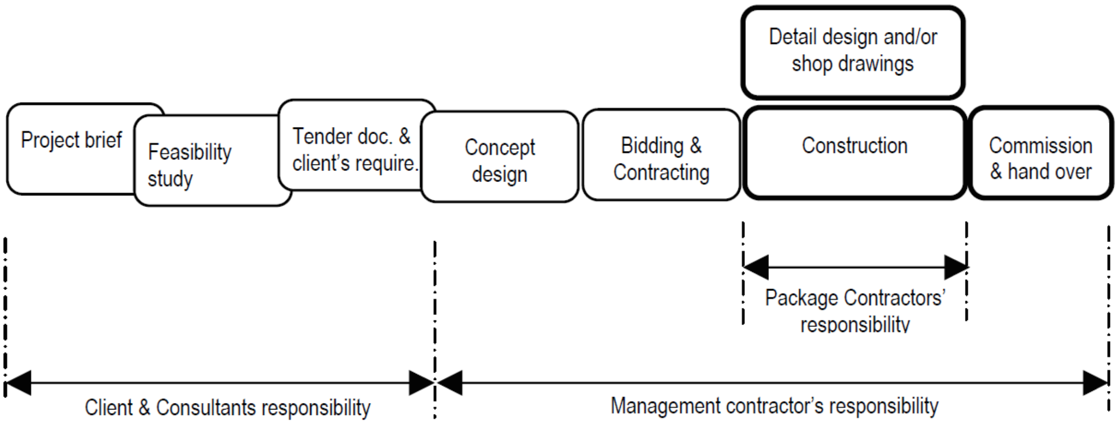


Source: (Rashid et al., 2006)

Management oriented approach

Examples:
- Management contracting
- Construction management
- Design and manage

- Design is produced by consultant responsible directly to the client
- This procurement system contracts both the management of the design process and of the construction project to a contractor (client's management consultant)
- Client's management consultant is responsible to manage both design and construction
- Works carried out by package contractors (Masterman & Masterman, 2003; Wilkinson & Scofield, 2010)
- As the system is very flexible, variations and delays are more easily accommodated
- Relatively less financial risk as the project is not reliant upon one main contractor
- There is a huge risk to the client when subcontractors fail to perform effectively as management contractor's liability is limited
- Client may need to employ separate parties to ensure quality control
- Final project is an unknown fact prior to project commencement (Masterman & Masterman, 2003)



Source: (Rashid et al., 2006)

Project management	▪ A separate project manager who is not an active person in design or construction, is employed by the client to communicate with stakeholders (Wilkinson & Scofield, 2010)

Despite its disadvantages to overall supply chain stakeholders, the literature shows that traditional procurement methods are still being used as the predominant medium of purchasing construction materials in many countries. As the Web and computers are becoming increasingly popular, Ng (2005) has made a comparison (see Table 2.8) on the traditional and electronic materials procurement systems in relation to definitions, tools/methods, and key processes in the Malaysian construction industry.

Table 2.8: Comparison between traditional material procurement and E-procurement in Malaysia - Source: (Ng, 2005)

	Tradition procurement	Electronic procurement
Definition	Getting or buying using paper based system	Getting or buying using internet technology
Tools/Methods	Paper writing, face to face, fax, telephone, trade directories, trade journal, sales catalogue, sales representative, letter of credit, cash, and cheque	Personal computer, world wide web, E-procurement software, electronic catalogue, electronic fund transfer
Key process	Supplier selection, negotiation, issuance of purchase order, material delivery tracking, and issuance of payment	Supplier selection, negotiation, issuance of purchase order, material delivery tracking, and issuance of payment

A study conducted by Hinton (2011) argues that the issues related to the New Zealand construction industry in terms of the procurement systems are in line with issues and concerns raised by Latham (1994) and Egan (1998) in the UK construction industry. For example, low margins for contractors, the client-driven nature of the traditional procurement system, the fragmented nature of the supply chain as each party's aim is to maximize their own profits as opposed to the total supply chain, all are features common in New Zealand as well. Ninety percent of New Zealand construction projects use the traditional procurement system. "Traditional procurement" is usually based on the "lowest price" tendered for elements and services (Naoum, 2003), and not the best outcome for the all project stakeholders.

Therefore it is advisable to adopt other procurement methods such as partnering or collaborative procurement, and performance information procurement systems in order to achieve better productivity and performance. Collaborative procurement is called integrated project delivery (IPD) by the American Institute of Architects (AIA, 2007) and the Construction Users Round Table (Curt, 2000). The nature of IPD is compared with traditional project delivery in Table 2.9 in terms of the teams, processes, risks, compensation, communication, and agreements.

Table 2.9: A comparison of traditional and integrated procurement - Source: (AIA, 2007)

Traditional project delivery		Integrated project delivery
Fragmented, assembled on "just-as-needed" or "minimum-necessary" basis, strongly hierarchical, controlled	**Teams**	An integrated team entity composed of key project stakeholders, assembled early in the process, open, collaborative
Linear, distinct, segregated: knowledge gathered "just-as-needed"; information hoarded; silos of knowledge and expertise	**Process**	Concurrent and multi-level; early contributions of knowledge and expertise; information openly shared; stakeholder trust and respect
Individually managed, transferred to the greatest extent possible	**Risk**	Collectively managed, appropriately shared
Individually pursued; minimum effort for maximum return; (usually) first cost based	**Compensation or Reward**	Team success tied to project success; value-based
Paper-based, two dimensional; analog	**Communications or Technology**	Digitally based, virtual; building information Modeling (3, 4 and 5 dimensional)
Encourage unilateral effort; allocate and transfer risk; no sharing	**Agreements**	Encourage, foster, promote and support multi-lateral open sharing and collaboration; risk sharing

Hinton (2011) further stated the benefits of IPD based on the guidelines provided by the Associated General Contractors of America (AGCA), American Subcontractors Association (ASA), and Associated Specialty Contractors (ASC) (AGCA, ASA, & ASC, 2008). They are given as better health and safety provisions, fewer opportunities for taking legal action, better productivity, decreased risks in terms of budget and time, better innovation, fewer opportunities for disputes and payment problems, the ability to make better decisions, more opportunities for conflict resolution, and long term supply chain relationships.

In the New Zealand context CCG (2008, p. 1) discussed the significance of integrated procurement decisions in terms of transparency in procurement decision making, selection of best value as opposed to lowest cost, early contractor involvement, integrated and collaborative working principles, use of fair payment policies, use of risk management principles and policies, having non-confrontational mechanisms to manage disputes, having fair employment practices, and employing non-adversarial working practices. As a result of adopting integrated procurement decisions, there could be numerous benefits to clients such as: better whole life value from a construction project, better investment decisions, better control of risks, enhanced predictability of cost and time, improved health and safety on project, reduced disputes and their associated costs, greater stability and security of the supply chain, competitive and sustainable supply chains, and enhanced reputation as a construction client. This demonstrates the need for construction industries to move away from traditional procurement systems and practice more collaborative procurement methodologies or SCM practices.

2.2.5 The Material Purchasing Process

According to the definition provided by McConville (as cited in Hadikusumo et al., 2005), purchasing is “a fundamental function of material procurement that refers to the acquisition of goods and services and an establishment of mutually acceptable terms and conditions between a seller and a buyer”. Considerable attention has been paid to the purchasing function in past literature, mainly due to its contribution to profitability, survival of businesses and firms’ performances (Bayazit et al., 2006; Carr & Pearson, 1999). Gadde and Hakansson (2001) found that purchasing is not seen as a separate function and is an integral part of running a company. As far as the construction industry is concerned, purchasing can occur in all phases of a construction project. Anderson and Katz (1998) stated that when a sourcing strategy is developed, particularly to secure the best prices for construction materials, the essential question “How to buy?” should be answered at the beginning. The sourcing strategy basically depends on whether materials are purchased internally or externally. The next priority should be given to the purchasing function and its associated factors. The purchasing function of a construction firm is a central part of materials management and it especially includes the commitment of project funds for construction materials. The general functions of a purchasing department are defined below (Barrie & Paulson, 1992; Dobler & Burt, 1996; Hadikusumo et al., 2005):

- Identification or recognition of need via coordination with user departments
- Issuance and processing of internal requisitions
- Discussion with sales representatives
- Identification of potential suppliers
- The conduct of market studies for important materials
- Solicitation of bids and price quotations
- Negotiation with potential suppliers
- Analysis and evaluation of proposals
- Select and award suppliers
- Issuance of purchase orders, subcontracts or leases
- Administration of contracts and resolution related problems
- Tracking and expediting
- Delivery and inspection of goods supplied
- Maintenance of a variety of purchasing records

Economic Order Quantity (EOQ) and Just In Time (JIT) are the two main philosophies that are used in the materials purchasing function. The conventional way of purchasing materials can be considered as the EOQ model (Min & Pheng, 2005). EOQ is related to the variable costs associated with purchasing orders. The EOQ model determines the amount of orders that minimises total variable costs required to order and hold inventory. JIT is a concept that originated from the manufacturing sector to address complex communications, coordination and waste minimisation. Recent exploraty studies have shown that JIT techniques are applicable to the construction industry with some modifications (Pheng & Hut, 1999). One important characteristic is that JIT introduced an efficient materials handling system in order to smooth the production process. JIT includes proper materials selection with the right quantities and the right quality at the right time (Pheng & Chuan, 2001).

Some contractors seem to prefer JIT delivery though it has been found to be more costly than EOQ delivery strategies (Min & Pheng, 2005). More effective output from JIT purchasing can be taken when the suppliers' locations are near construction sites.

Supplier selection criteria should be linked with purchasing methods to obtain the best value for the given price of materials. Applicable weighted factors should be considered for each item to be purchased, and the weighting of the factors considered should reflect the comparative importance of each factor depending on the requirements and constraints given by the project specifications and the actual construction. Finally, the best buy concept is dependent on a cost benefit analysis, which aggregates positive (benefits) and negative (costs) factors to reach an optimal value.

However few writers have been able to draw on any structured research on purchasing functions and strategies adopted in construction (Hashim & Ahmad, 2006). The initiation of purchasing construction materials starts at the tender stage (when the design stage is completed) in a traditional contractual environment. Once the tender document is received, contractors consistently start estimating and sending enquiries to their selected suppliers. The supplier selection process in the construction industry is detailed in the following section.

2.2.5.1 The Supplier Selection Process

The initiation of supplier selection is the choosing of potential suppliers for each type of material for a specific project. In general, the past performance of suppliers is a key criterion in the selection process. Once a pool of potential sources is formed, requests for quotations are sent out, negotiations conducted, and specific suppliers are selected. Presently, the trend by contractors is to reduce the supplier base and in the meantime the percentage of purchased materials has vastly increased (Benton & McHenry, 2010). Ma and Yang (2010) suggest that it is essential to establish different relationships with different material suppliers, which means that the assessment methods are dependent on the type of material purchased. Therefore, in order to select suppliers who continually outperform the competition, they must be carefully analysed and evaluated. Usually the detailed process of supplier selection involves seven major steps (see Figure 2.19): recognition of the need for supplier selection, identification of key sourcing requirements and criteria, determination of sourcing strategy, identification of potential supplier sources, limit suppliers in a selection pool, determination of methods for final selection, and final supplier selection (Mendoza, 2007).

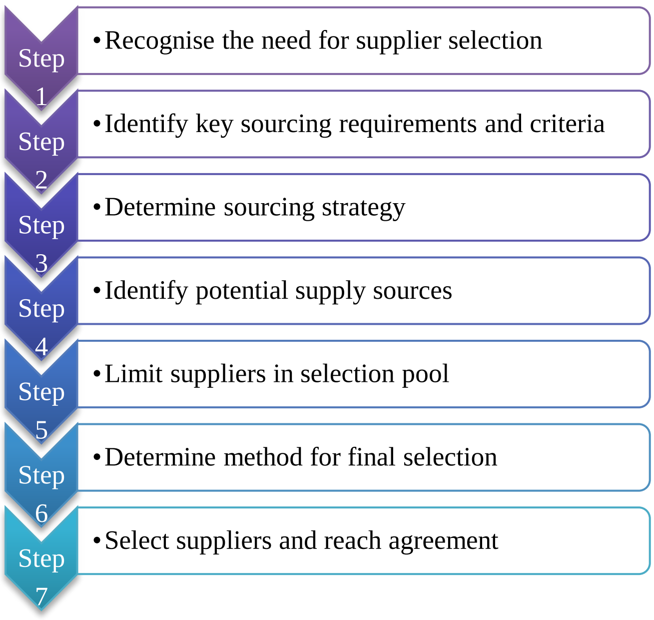


Figure 2.19: Supplier Selection Process

Source: (Mendoza, 2007)

More information about these key steps is explained in Table 2.10 with appropriate examples where applicable.

Table 2.10: The key information on each step of the supplier selection process – Source: (Mendoza, 2007)

Step	Key information
Identification of the need for a specific product	Different situations may trigger the need for supplier selection. For example, new product development, modifications to a set of existing suppliers due to bad performance, the end of a contract, expansion into different markets, or current suppliers' capacity is not sufficient to satisfy increases in demand.
Identify key sourcing requirements and criteria	Defining the proper criteria becomes critical since the nature of supplier selection involves multi-criteria decision making. The set of criteria to be chosen largely depends on the company's objectives and the type of industry in which the company competes.
Determine Sourcing Strategy	Sourcing requires that companies clearly define the strategy approach to be taken during the supplier selection process. Examples of sourcing strategies are: single versus multiple suppliers, domestic versus international and short term versus long term.
Identify Potential Supply Sources	The importance of the item under consideration influences the resources spent on identifying potential suppliers.
Limit Suppliers in Selection Pool	Given the limited resources of a company, a purchaser needs to pre-screen the potential suppliers to reduce their number before proceeding with a more detailed analysis and evaluation.
Determine Method for Final Selection	There are some multi-criteria techniques which are widely used to evaluate the suppliers (these will be discussed in this paper).
Select Suppliers and Reach Agreement	The final step of the supplier evaluation and selection process is to clearly select those suppliers that best meet the company's sourcing strategy. This decision is often accompanied with determining the order quantity allocation to selected suppliers.

Process-based evaluations and performance-based evaluations are the main categories of supplier evaluations. In the process-based evaluation, a supplier's production or services process is evaluated. Numerous factors are considered for this evaluation procedure. Figure 2.20 demonstrates the key factors which affect the supplier selection process.

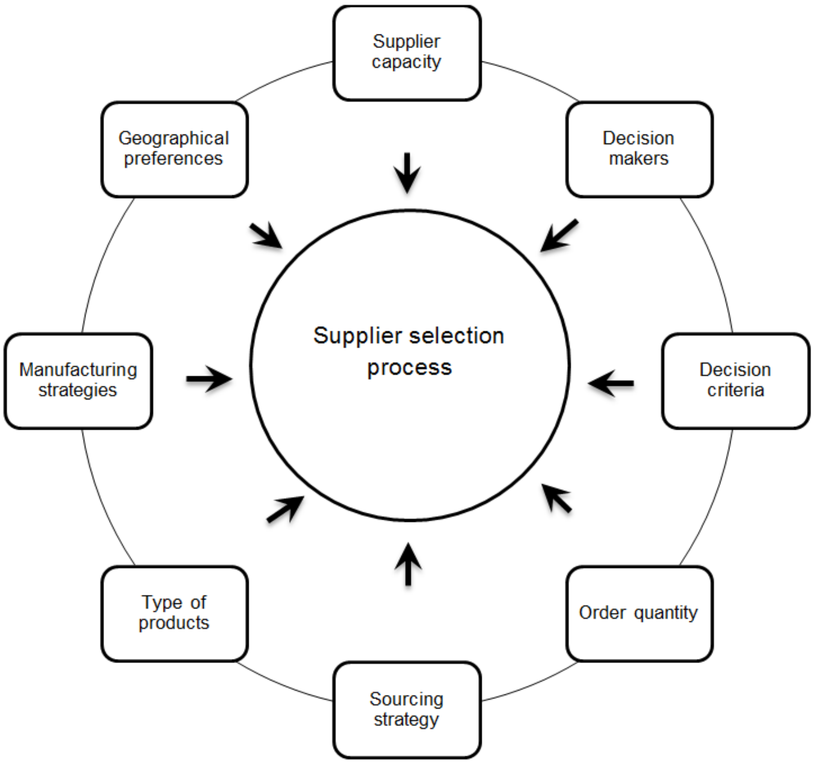


Figure 2.20: Factors affecting supplier selection

Source: (Khaled, Paul, Chakraborty, & Ayuby, 2011)

Supplier evaluation is carried out by the construction organisation as an inspection at the supplier's site to measure the capability level of the operating system. As a result, non-value-added activities can be eliminated to enhance business efficiency. In performance-based evaluation, a supplier's actual performance is evaluated based on different criteria (delivery reliability, cost, defect rate etc.). This evaluation measures the daily performance of the supplier and hence it is known as after-the-fact-evaluation. In general, performance-based evaluation is more common and practical than process-based evaluation. This could be due to the ready availability and easy measurement of objective data. In the selection of suppliers, the cost of the material is not the only criteria but quality and service of the supplier and the previous history should also be taken in to account. However, an appropriate set of criteria should be included in the supplier selection process, based on which, the project manager would be able to define the best supplier for the job under consideration (Aretoulis, Kalfakakou, & Striagka, 2009). Benton and McHenry (2010) explain that the critical criteria for supplier selection in the construction industry are material quality, delivery dependability and price, although the degree of importance varies in line with the nature of individual firms (Ho, Nguyen, & Shu, 2007).

Materials quality: Generally, high-quality materials are expected from every potential supplier and it is assumed that the suppliers' quality performance is continuing, as shown in the past. It is hard to find any formal measures taken to ensure the quality of materials delivered on the site other than by visual inspection. The specifications that should be complied with by the supplier should make quality an issue which does not cause problems.

Delivery dependability: Today's fast-track construction environment heightens the importance of delivery dependability as construction often begins before the architect's final design is completed. Loss of delivery deadlines can have costly consequences (loss of time and additional labour costs) for both the owner and contractor, as time is considered as money in the construction industry. The company with faster delivery will have a greater chance of being selected as the supplier. Therefore, delivery dependability is a key criterion used in selecting suppliers for the construction industry.

Price: Price has a significant effect on the process of supplier selection, although it is not given the chance to overshadow other criteria by the nature of the supplier selection practice. A balanced view should be maintained between price and the other criteria to engage the best supplier for a given material. Subsequently, negotiation may bring about a price agreement that satisfies both the contractor and the supplier.

Studies conducted in the American, Taiwanese, and Vietnamese construction industries recognised a number of selection criteria as being the most important ones (Ho et al., 2007). These are presented in Table 2.11.

Table 2.11: Comparison of five most important supplier selection criteria

Rank	(Kannan & Tan, 2002) USA	(Ho & Nguyen, 2007)	
		Taiwan	**Vietnam**
1	Ability to meet delivery due dates	Commitment to quality	Commitment to quality
2	Commitment to quality	Ability to meet delivery due dates	Prices of materials, parts and services
3	Technical expertise	Prices of materials, parts and services	Ability to meet delivery due dates
4	Prices of materials, parts and services	Reputation of supplier	Technical expertise
5	Honest and frequent communication	Supplier's process capability	Industry knowledge

Further, Aretoulis et al. (2009) suggest other pertinent criteria include: discount, progress payments/cost of money, special charges, freight charges, total evaluated cost to destination, terms of payment, escalation, acceptance of project terms and conditions, promised delivery date based on award, shipping weight, and expiration date of bidder's quotation. However, it is apparent that specific criteria and their relative importance are highly dependent on the type of purchase being made.

Quantity Discounts Offered to Building Contractors

Offering quantity discounts is a long established business tradition. When buyers purchase anything in bulk they would normally expect a price reduction. In general, suppliers offer quantity discounts mainly to create price discrimination or to reduce operating costs. Many contractors are currently striving to reduce the number of their suppliers in order to promote better relationships with a few selected ones. Charles and Meir (1998) categorised quantity discount literature into buyer's perspective models, seller's perspective models and joint buyer-seller models. Traditionally there are two types of discounts involved with the classical inventory models, namely quantity discounts and business volume discounts. Quantity discounts are based on the quantity of each component ordered from a supplier. In this case, cost minimisation for the materials purchased should be done by considering independent discounts for each construction material, since the discounts differ according to the type of material. Business volume discounts are based on the total value of all components ordered from a supplier (Crama, Pascual, & Torres, 2004), and yield advantages both to the buyer and to the supplier. Therefore it benefits the buyers because they reduce the number of active suppliers, which leads to saving in administrative costs and better relationships with the remaining suppliers (Nicholas & Holt, 1999). In addition, larger orders reduce order processing costs both for buyers and suppliers (Nicholas, Holt, & Mihsein, 2000), and there are distinct price differences for each component and each supplier. According to Shah and Dixit (2005) quantity discounts have four characteristics as given below:

- Form: this can be either all-units or incremental. In the case of all-units, the discounts apply to all units purchased, and in the case of incremental, only those units within a price break interval receive that interval's discount. A lower unit price for the entire amount can be achieved by purchasing a large quantity on all the units discount schedule. Lower unit facility is available only to units purchased above a specified quantity for the incremental discount schedule.
- Aggregation: this expresses the number of discounted products. In other words, whether the discount applies to one or multiple products.
- Time aggregation: this describes aggregation in a time period. Further, the discounts may apply to individual purchases or multiple purchases over a given period.
- Number of price breakpoints: this can be one, multiple, or infinite as represented by a continuous price schedule.

The study conducted by Wilcox, Howell, Kuzdrall, and Britney (1987) identified various opinions on reasons for the use of price quantity discounts. Crowther (1964) presented his argument from the sellers' perspective whereby they provide quantity discounts to sell fewer but larger orders. Jeuland and Shugan (1983) discussed quantity discounts as a tool for accomplishing channel operations (as a subtle form of profit sharing between levels in the channel). According to Lal & Staelin (1984), basically quantity discounts are offered at small quantities due to high pressure from large buyers. However, economists perceive that discounts are given as a method of price discrimination. Charles and Meir (1998) argued that cost saving and marketing are the main reasons for discounts.

Discounts exist mainly due to economies of scale in purchasing or manufacturing. Suppliers prefer to give quantity discounts in order to obtain quantity discounts for their own inputs when their production runs are significant, or due to the lower unit variable cost of larger production runs. In addition, the high fixed cost of some production can be distributed among more units if the annual demand increases due to the significance of the discounts given. Offering discounts for bulk purchases also gives additional benefits to suppliers because of the large orders which buyers are willing to buy. In this case suppliers can buy greater amounts of raw materials for a cheaper price. Sometimes discounts are given to stimulate sales and sometimes they are determined by demand and supply market forces. The discounts given by BMs sometimes depend on the amount of materials purchased by the construction contractors (Zavadskas et al., 2005). However, there have been no studies which discuss the different range of discounts given by BMs to construction contractors. Therefore, the reasons for these multiple tiers of discounts, how they impact on a contractor’s competitiveness and profitability, how contractors manage such price discounts, how they could secure better prices to be more competitive, and what strategies they could adopt to be more competitive should be answered by future research studies.

Supplier Selection Methods

Linked with supplier selection in the construction industry, literature shows a number of studies have been devoted to examining performance based supplier selection methods. However, there has not been any general set of standards for supplier selection and evaluation. That is, the characteristics of the firms, their goals and many other reasons actually decide the criteria for supplier selection and these are very subjective (Ho & Nguyen, 2007). Multi-criteria decision making (MCDM) process is common to supplier selection in previous studies (Boer, Labro, & Morlacchi, 2001; Ghodsypour & O'Brien, 1998; Karpak, Kumcu, & Kasuganti, 2001). A set of objectives needing to be achieved for a given project should be addressed as multi-objectives in the supplier selection process. The categorical method, the cost ratio method, and the linear averaging method are the three general types of supplier evaluation systems used today (Benton & McHenry, 2010). Implementation and overall reliability are the guiding factors of the system that basically determine the most fitting method.

Excellent performance by material suppliers is most crucial for the smooth procurement of materials. Supplier evaluation and selection is a usual MCDM issue. Interestingly, the multi-criteria signify both qualitative and quantitative characteristics. Construction contractors should be able to select the appropriate decision making tool which is easiest, most reliable and affordable. It is essential to have an applicable structured decision making system in today’s complex construction industry. This particularly helps quality decisions and consistency and transparency under complex multi-criteria (tangible and intangible) conditions. The stages of preliminary design, procurement and vender control in the material management process are directly linked with material procurement decisions, and appropriate actions should be taken from those stages for the material purchasing function. Finding the best materials requires consideration of various financial and non-financial factors. It includes cost efficiency, quality, impact on communities and environment, design integrity, innovation, maintenance, training and development opportunities, excellent health and safety practices, and capital investment (NZCIC, 2006).

2.2.6 The Client's Role in Selecting Materials

The roles of the construction client are complex and widespread, as the client can act as a purchaser, project manager, planning manager, and construction manager. Therefore a construction client should be educated in technology, architecture, economics, social sciences, law, and leadership skills (R&D and University Relations, 2006). The client's responsibilities include determining the long term quality offered to customers purchasing products and services for the buildings or structures, and choosing the partners involved in the construction process. These responsibilities are achieved by using the client's own resources or using consultancy services. Overall a construction client manages the owner (core business), society (regulations), construction industry and customer (end-users) in order to make sure that the right outcome (building or structure) is achieved in the right place at the right time for the right price (R&D and University Relations, 2006).

Abdul-Malak et al. (2000) discussed client intentions for managing construction materials purchasing activities. Control of a contractor's ordering policies and scheduling contractors' payments should be carried out by the client in order to reduce the overall costs of acquiring materials for construction. Due to the clients' responsibility, it is important to ensure that contractors adopt wise procurement plans. However, this depends on the contractual types as well. In order to do this, clients should require the submittal of a procurement schedule (e.g. shop drawings, material data, samples, and product data, etc.) of all major materials against partial payments that apply, along with a schedule of work. This can be done through the conditions of the contract. After this schedule is approved by the owner, the contractor is expected to follow it during purchasing of the required construction materials. When the schedule of work is updated, the procurement schedule should also be updated. The contractor's payments for the purchased materials are done in accordance with this schedule to avoid paying for materials that are prematurely delivered to the site. For example, if we assume the case that the contractor has already ordered materials according to the approved schedule, but work schedule delays were experienced due to reasons outside the contractor's control. In such a case the owner will have to issue payments against such delivered materials even if these arrive earlier than required.

2.2.7 Materials Decision Making Process

This decision-making includes the selection of necessary construction materials, relevant suppliers, and booking and delivery terms. Project participants (clients, contractors, architects and suppliers) should be involved in the materials selection process in order to accomplish the best value for a particular project. Their intentions can be associated with economic, technical and aesthetic requirements as well as comfort and prestige. Therefore for construction material selection, the methods that should be selected are those that are suitable to perform tasks with several functional purposes, and which can satisfy all project participants. Because of this complexity, the buyers may face many problems when construction materials are chosen from different sources. A study conducted by MarketLine (2013) shows that buyer power in the global construction materials market is moderate and buyers mainly consider product quality and price when they make purchasing decisions. Further, buyers are willing to shift to new products provided the switching cost is low. However, insufficient attention is paid to the construction materials selection process, considering that it is the largest single element of a project's cost (The Business Roundtable, 1982; Zavadskas et al., 2005). Therefore there are some opportunities to reduce construction costs by looking at the construction materials selection aspect.

Purchasing construction materials involves a decision making process carried out by clients, consumers, contractors, architects, designers and others to satisfy different aims. Further, they set their sights on construction costs, technical and aesthetic requirements, and comfort and prestige demands (Zavadskas et al., 2005). Therefore, material purchasing decisions in choosing and evaluating supply sources should satisfy multifunctional purposes. This multipurpose decision-making process is strengthened by collaborative working principles in the supply chain.

These collaborative decisions also provide opportunities for supply chain partners to improve their versatility and adaptability, which finally creates better value on the project (Business Vantage, 2008). Past literature shows many decision supporting systems (DSS) around the world including symbiotic, expert, holistic and adaptive (Mirchandani & Pakath, 1999).

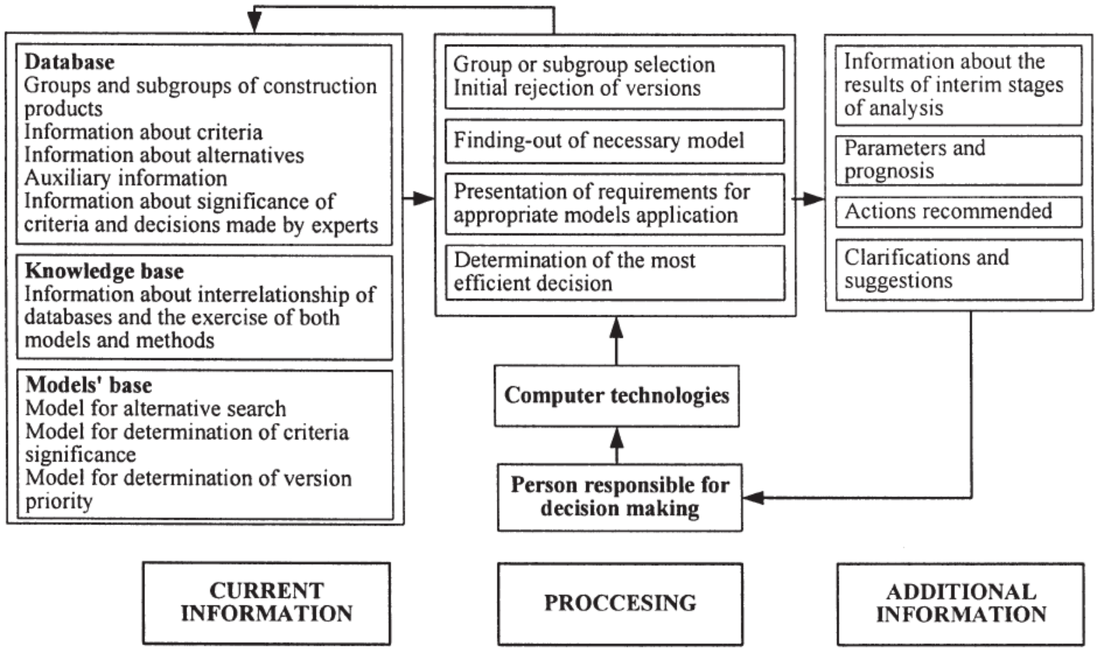


Figure 2.21: Selection system architecture for construction materials

Source: (Zavadskas et al., 2005)

Zavadskas et al. (2005) observed that all these DSS's are based on particular general functioning principles and have created the architecture of a construction materials selection system (the general composition of principles of a DSS), after evaluating the available decision making methods. The architecture of the system includes the main functions and characteristics of the DSS and is presented with the help of general algorithms.

Figure 2.21 shows a model that demonstrates that the database, knowledge base and model bases are the key information (shown as "current information" above) required to evaluate construction materials purchasing decisions. The evaluation process in this model is based on a multiple criteria complex assessment method. Criteria and significance should be determined by experts who can use current information and computer technologies as information sources for the decision-making process. As an output of this decision supporting process, model reports, prognoses, recommendations and clarifications of the situation can be obtained.

By considering a repetitive process, decisions that are more accurate can be made to support the construction materials selection system. This study also mainly involves the decision-making process of building contractors' materials buying behaviour, suppliers supply behaviour and architects' and homeowners' procurement behavior. Presently, in seeking to facilitate the work of decision-makers, electronic and web-based tools are increasingly used. One of the major benefits of adopting a computer based DSS is that it allows the incorporation of many variables based on special mathematical models. Zavadskas et al. (2005) discussed e-commerce systems for purchasing construction materials. As it can engage many variables, the system considers all the major participants involved in the construction process. Therefore, the objectives and functions of different interested groups can also be signified in this model (see Figure 2.22).

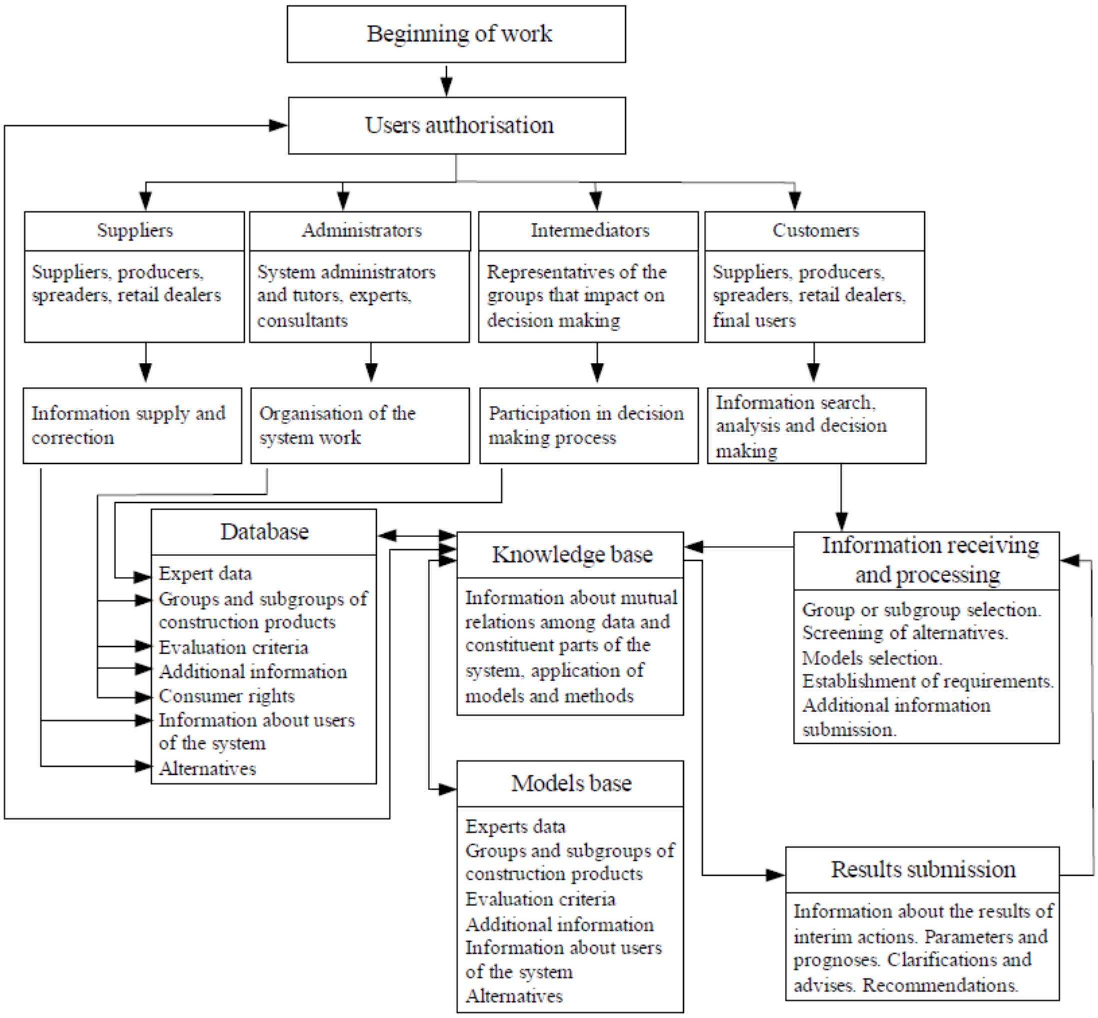


Figure 2.22: Theoretical framework for DSS-purchasing construction materials

Source: (Zavadskas et al., 2008)

This system's model consists of six main portions; authorisations of users of the system, database, knowledge base, base of the models, requests and analyses of information, and results presentation. Four underlying groups regarding the system's users are identified as sellers, brokers, system administrators and buyers. The role of each group is different in the model developed. As an example, sellers can be the persons who express their will to present information about construction materials on sale. The information saved in the knowledge base performs all the intellectual functions of the system. In addition, it creates mutual relations of information kept in the database. The functions of this model consists of getting goods to various groups, goods selection, significances of criteria, multiple criteria analysis, level of utility, submission of recommendations and models of additional information. The concept underlying this e-commerce system is important for selecting the best materials for a particular construction project. Since all the characters involved in the construction process are included in this model, materials purchasing decisions can be supported from this algorithm.

2.2.8 Collaboration in the Construction Supply Chain

Generally, the building construction industry is project oriented and each project can be considered as unique even though there are common parallel sets of phases. In other words, each construction project is named as a prototype due to its unique site layout and designs. Because of this uniqueness, a project team's perspective on the entire construction process could be different from another project. Each project team member such as architects, engineers, contractors and subcontractors all have their own requirements on each construction project. Therefore a construction project is regarded as an order-delivery process (see Figure 2.23) and it involves all the parties along the logistics chain.

Materials play an important role throughout this order delivery process for the ultimate satisfaction of the customer. When customers' needs are satisfied through the suppliers, contractors, architects and clients, construction materials also transfer among them. In most industries, one key objective is to achieve the best value for money and the construction industry is no exception. Having realised this, the industry is starting to move away from the limitations of traditional project relationships and lowest-price tenders to other, more collaborative forms of contract procurement. For example, greater collaboration can be seen from the Australian, Canadian, and UK construction industries (CENZ, 2008).

Many disciplines are concerned with supply chain relationships which together create supply chain collaboration, as it delivers a competitive advantage. A study conducted in the UK revealed that construction contractors have more collaborative contractual relationships with their clients rather than with those on the supplier's side (Akintoye et al., 2000). This is because the contractors' main objective is in fulfilling their clients' requirements. In other words, the upstream of the supply chain (suppliers' side) is not as strongly connected as the downstream, as "contractors regard suppliers as on a par with employees" (Akintoye et al., 2000, p. 167).

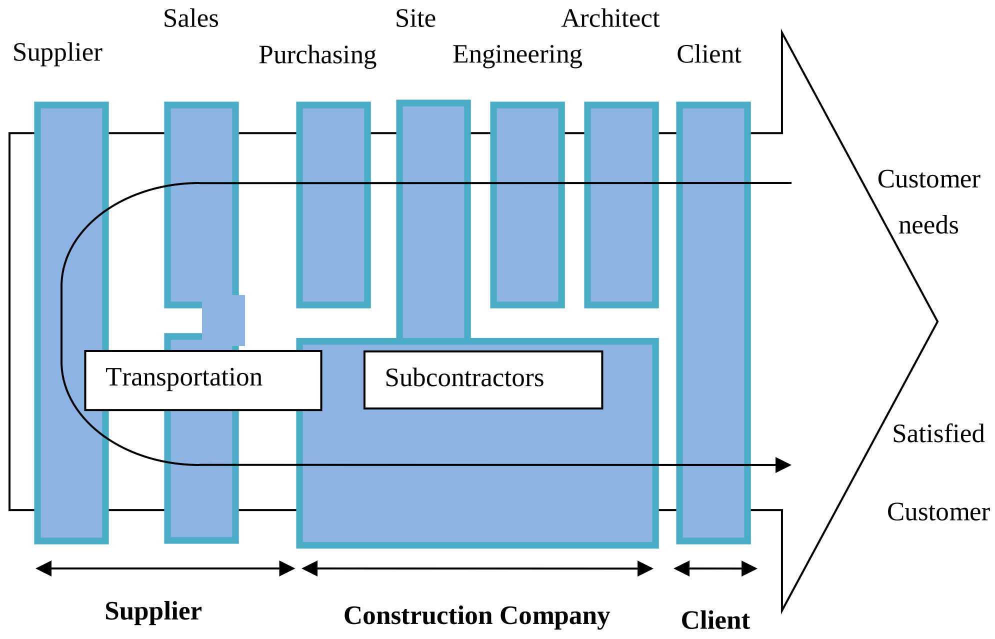


Figure 2.23: Order-delivery process of the construction project

Source: (Wegelius-Lehtonen, 2001a)

Collaboration in the construction supply chain is based on a number of maxims. Essentially integrity (following agreed norms) and trust (believing what other participants say) are the keys to good collaboration. Effective collaboration considers the long term consequences rather than the short term. A collaborative supply chain always believes that teams have the advantage of making better decisions compared to individuals. As a team consists of a diverse group of people, it tends to create more alternative ideas with multiple capabilities. This can identify the best solutions for a given situation. When people are selected for a team, their personalities, capabilities and team working skills should be considered. A team effort is usually more creative than individual work, which is also applicable in the construction supply chain. As construction projects continue, it is normal to expect changes at different stages. A team could face these changes as challenges and propose multiple solutions and find the best possible outcome. Finally, a project team tends to make decisions based on facts, rather than individuals who tend to make decisions on opinions and emotion (DPR Construction, 2000).

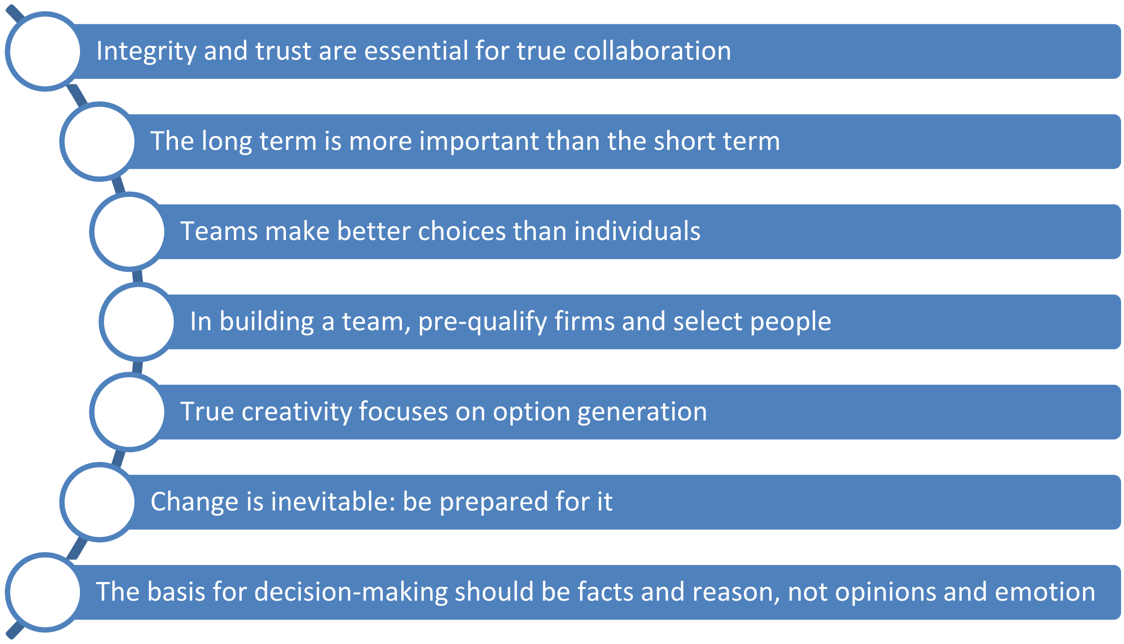


Figure 2.24: Maxims of the collaborative process

Adapted from: (DPR Construction, 2000)

Compared with traditional construction procurement systems, collaboration offers greater opportunities and benefits for the client, contractors, and all other parties that commit themselves to construction project objectives. Boon (2007b) reported that inter-relationship between clients and contractors leads to greater client satisfaction, better project quality, shorter construction periods and reduced project costs. In the existing aggressive business mentality of the industry and the non-trusting climate, contractors have a greater tendency to pay attention to their clients because they provide their income.

CCG (2008) asserted the key purposes of collaboration between construction project teams is to improve industry efficiency, eliminate waste, raise safety standards, and reduce project risks. However the perspectives of collaboration may vary depending on the type of stakeholders. Table 2.12 summarises the different perspectives (objectives, benefits, and barriers) held by key stakeholders in the construction supply chain.

Overall collaboration is the key to achieve effective and efficient supply chain practices. A study conducted by Khalfan, McDermott, and Cooper (2004) showed that the degree of supply chain effectiveness and efficiency have a direct relationship with the degree of interaction and collaboration within a supply chain (see Figure 2.25).

Table 2.12: Collaboration from different stakeholders' perspectives - Source: (Boyd, 2011)

Stakeholder	Objectives	Benefits of collaboration	Barriers to collaboration
Client	Quality of provision Speed response Minimum cost	Cost savings	Nonuse of local firms
Designer/Specifier	Flexibility to select high quality Renowned for quality	Cost savings give more work Fewer problems in specifications Attention from suppliers	Loss of choice Unfamiliarity with products Worry of blame for failure Belief that product selected on price rather than quality
Construction	Reliable profit Renowned for achievement Timely delivery	Correctness of specifications Fluid planning Fewer materials' complaints	No control of product Loss of relationship with supplier Loss of own aggregation Failure of delivery No flexibility if errors
Sub-contractor	Reliable work Reliable payments	Familiarity with products Reliable work planning	Failure of delivery No flexibility if errors
Supply companies	Margins Order quantity Flow of orders	Order quantity Flow of orders Planned lead times	Lower margins
Manufacturers	Margins Order quantity Flow of orders	Clear goals Lower costs Easier management	Lower margins More demands on products

Parsanejad, Momeni, and Jafarnejad (2010) reported that a lack of coordination within the supply chain can cause a significant waste of construction materials. Lack of coordination could occur between purchasing and construction sections or design and materials production sections. Lack of coordination between the purchasing and construction sections results in wrong estimations of amounts of needed materials, while a lack of coordination between the design and materials production sections causes a lack of production of materials. Consequently, lack of coordination causes waste in materials.

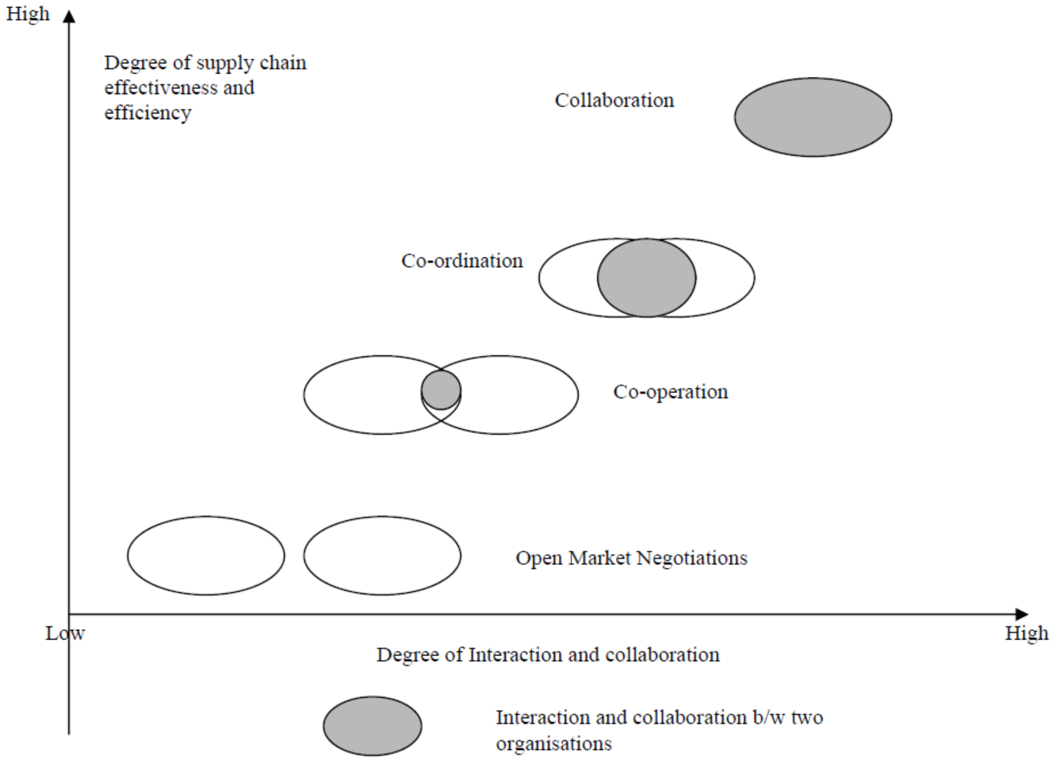


Figure 2.25: Supply chain effectiveness and efficiency vs degree of integration and collaboration

Source: (Khalfan et al., 2004)

2.2.8.1 Web-based Construction Collaboration

Hu (2008) introduced a model to describe innovative collaboration in the construction supply chain which is very different from traditional thinking. This concept is based on the internet and greater management of time and expenses can be achieved using this system. The system needs to be capable of storing multiple documents related to the supply chain such as design drawings, submittals, meeting minutes, etc. This information is centralized for all supply chain participants to access as shown in Figure 2.26.

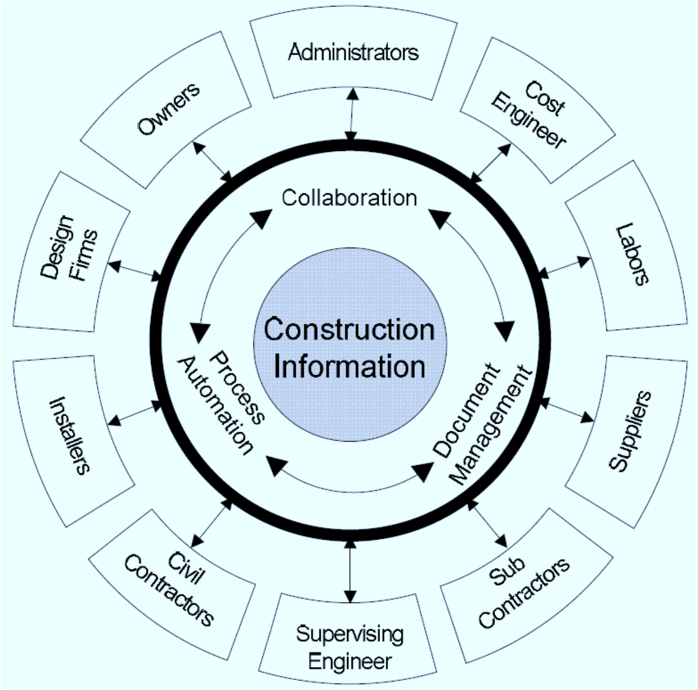


Figure 2.26: An innovative collaborative model

Source: (Hu, 2008)

In Hu's (2008) model, various parties in the supply chain would be able to find the right information at the right time. This system assists project participants to find the project status and produce various reports where necessary. Moreover, it provides a platform to communicate and collaborate across the supply chain more efficiently and effectively. The system can operate in all project stages such as design, bidding, procurement, and construction. Another example of a web-based collaboration model is the application Autodesk Buzzsaw, which includes informative reports, task assignments, project tracking in order to improve supply chain collaboration, and construction management performance (Hu, 2008).

The information discussed above (construction supply chain collaboration) are summarized in Figure 2.27 in terms of its principle objectives, key factors in effective supply chain relationships, benefits to parties both upstream and downstream in the supply chain, and major barriers to collaborative supply chain practices.

Principle objectives of construction supply chain collaboration

- Benefits to the client
- Improved customer service
- Reducing bureaucracy/paperwork
- Increased profitability
- Cost reductions within organisation
- Increased market competitiveness
- Benefits to the supplier
- Improved quality assurance
- Overall supply chain reduction

Key factors in effective construction supply chain relationships

- Trust
- Reliability of supply
- Top management support
- Mutual interest
- Free flow of information
- Joint business planning
- Closer links between demand and supply
- Integrated information systems
- Manpower development
- More frequent meeting

Client
Designers

Main contractor

Manufacturers
Suppliers
Subcontractors

- Cost benefits
- Simplifying the tendering process
- Simplifying the design stage
- Creating standardisation of process

- Better quality services
- Cost benefits
- Simplifying the construction process
- Simplifying the ordering process

Major barriers

- Lack of top management commitment
- Poor understanding of the concept
- Inappropriate organization of structure to support system
- Low commitment of partners
- Strategic benefits unclear
- Lack of appropriate information technology

Figure 2.27: Supply chain relationships

2.3 The Construction Industry in New Zealand

The construction industry comprises more than 50,000 businesses, is the third largest industry in New Zealand (Statistics New Zealand, 2009a), and is made up of construction companies and construction trade services. Construction services contribute 45% of the production of the industry while the contribution received from construction trade services is 55% (Allan, Yin, & Scheepbouwer, 2008). These two main sectors represent eight subsectors of: residential building construction, non-residential building construction, heavy and civil engineering construction, land development and site preparation services, building structure services, installation trade services, building completion services, and other construction services. The construction industry is considered to be one of the principle contributors to the New Zealand economy (Rice & Shewan, 2011; Ying, Tookey, & Roberti, 2013), and is considered the most crucial industry for future economic performance (BCPP, 2013) as well. For example, the construction industry contributed 4.3% to New Zealand GDP in 2010; comparably, the figure was 8% in Australia, 7% in the UK, and 8-10% in the USA in the same year (BCSPP, 2011; CENZ, 2010).

The performance of the construction industry contributes to the economy in terms of investment (Gross Fixed Capital Formation), employment, and other aspects of the economy. As shown in Figure 2.28, the construction industry is the largest investor (45%) in other industries in New Zealand. In addition the industry utilizes a vast amount of energy. For instance, commercial buildings in New Zealand account for 9% of total energy use and 21% of electricity use, costing $1.25 billion annually (Building a Better New Zealand, 2013). It is apparent from Figure 2.28 below, showing investment by various individual sections, that construction plays an important role in the development of the New Zealand economy. Also, New Zealand’s construction industry has a significant multiplier effect on various other economic activities. For example, PWC (2011) showed that a $1 investment in construction could contribute $3 to the entire economy.

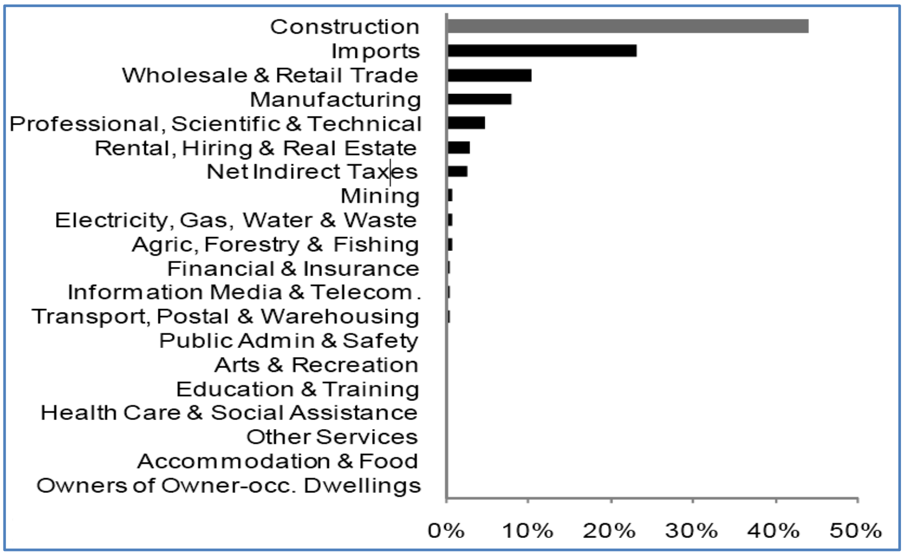


Figure 2.28: Investment by industries in the New Zealand economy

Source: (PWC, 2011)

The above factors show the significance of the construction industry in the New Zealand economy. As is common in other countries, the New Zealand construction industry is characterised by fragmentation, uniqueness, complexity, dynamism, lack of flow of information, and lack of standardization (Rotimi, 2013). Also the construction industry is driven by a low cost culture mainly based on traditional procurement practices.

2.3.1 The Demography

The New Zealand construction industry is made up of a large number of small businesses and a few large firms, which is similar to the demography of other Organisation for Economic Co-operation and Development (OECD) countries (Hinton, 2011). However, the New Zealand Productivity Commission (2012) and Page (2013b) report that the New Zealand construction industry is "cottage type", meaning that it has a unusually low concentration for a very small country. The industry can be categorized into residential and non-residential sectors based on financial turnovers, as shown in Table 2.13. Further, both residential and non-residential sectors employ approximately 25000 people.

Table 2.13: Characteristics of residential and non-residential construction sectors. Adapted from: (BCPP, 2013)

Residential sector	Non-residential sector
Dominated by small building companies, sub-contractors (<5 employees per company), and group builders	Serviced by medium sized companies
High volume and value	International competition
Demand volatility	Light commercial and non-commercial (< NZD 10million)
	commercial and non-commercial (> NZD 10million)
	Infrastructure light (<$10m) and infrastructure light (>$10m)

2.3.2 The Residential Construction Sector

The New Zealand Productivity Commission (2012) reported that the residential construction sector in New Zealand contributes 24,000 new homes and renovates 32,000 existing homes annually. Significant new housing growth can be seen in Auckland and Canterbury as shown by Page (2013a) and Auckland housing demand is expected to double over the next few years. BRANZ estimates that the total number of new dwelling units demand in Auckland will be about 10,500 per annum by 2021 (see Figure 2.29). Demand in Canterbury is expected to increase in the aftermath of the earthquakes there in 2010 and 2011.

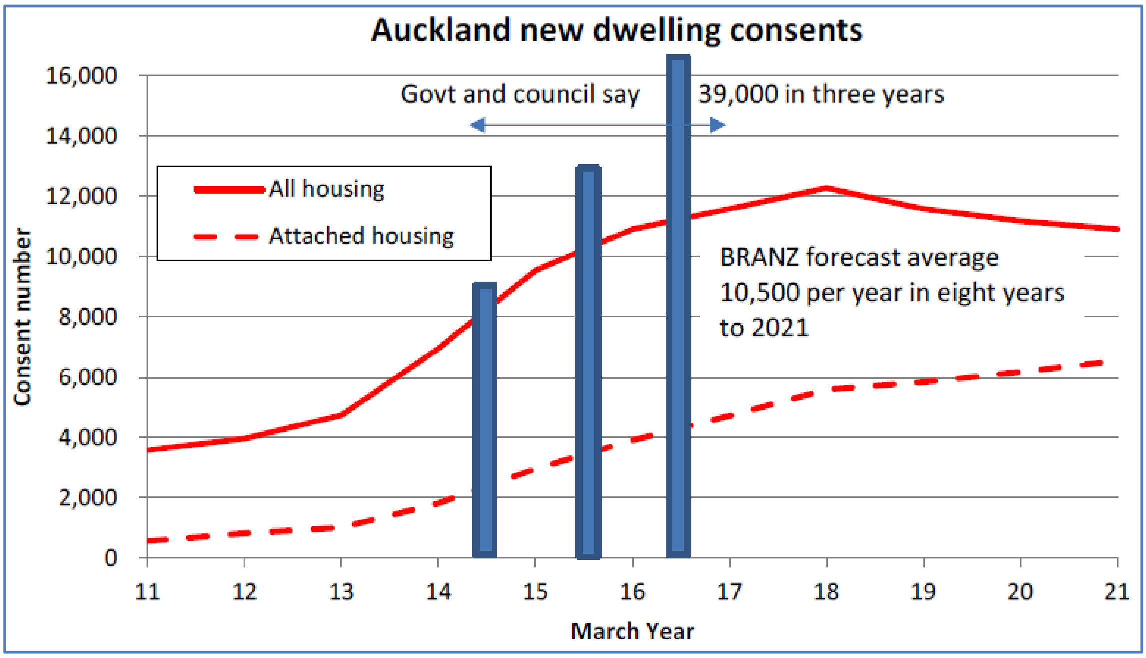


Figure 2.29: Auckland housing forecasts

Source: (Page, 2013a)

Residential construction industries are generally characterised by their cyclical nature of construction, small firm dominance, fragmentation, and inefficient information transmission (Duncon, 2002; Hassell, Wong, Houser, Knopman, & Bernstein, 2003; Koebel, 1999). In line with this, residential building contractors are generally small scale in New Zealand. For example, out of 14845 builders in 2010, there were only 597 builders with more than 5 employees (Statistics New Zealand, 2010). The proliferation of builders is very significant to the extent that only 25% of new houses are built by the largest 50 builders (Page, 2013b). Also, 60% of all new houses are constructed by builders who build less than seven houses per annum (Page & Fung, 2011). The supply side of the residential construction sector is made up of a few large materials manufacturers and BMs. For example, there are just four main BMs who provide a reasonable level of competition (Page, 2008) in the housing sector.

2.3.2.1 The Housing Input Chain

The multiplicity of the residential construction sector represents design (architecture, engineering, quantity surveying and project management), construction (site works, building, roofing and concrete), installation (plumbing, electrical, heating and ventilation), and various services (plastering, painting, glazing and fit out), as well as the supply chain of building materials, products, and equipment (MBIE, 2013b). Figure 2.30 shows the New Zealand housing input chain with different associated segments. The key housing inputs are land, local infrastructure, building and construction, regulatory consents, and finance.

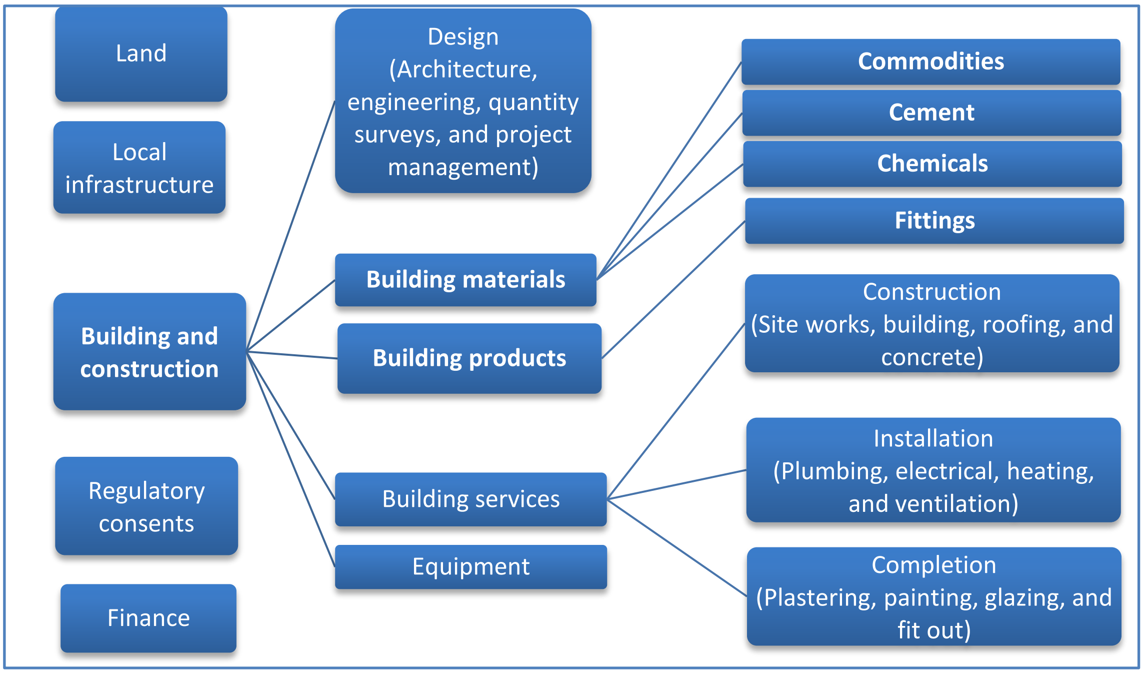


Figure 2.30: New Zealand housing input chain

Source: (MBIE, 2013b)

The segment of building and construction can be defined in terms of design, building materials, building products, building services, and equipment. The materials flow has received key attention in the SCM practices of the New Zealand construction industry (Ying et al., 2013) as it can impact on costs, quality/durability, and the aesthetic value of houses. New Zealand housing cost increased by 727% (11.1% per annum on average) from 1969 to 1989 and 128% (4.2% per annum in average) from 1989 to 2010 (CHRANZ, 2011). According to Page (2008) land (40%), materials (30%), and labour (20%) are the key inputs of new housing.

2.3.2.2 Component Costs in House Construction

CHRANZ (2011) found that the key components of house construction costs (excluding land) are labour costs, materials costs, compliance costs and builder's profit. Figure 2.31 shows the variation of dwelling component costs from 1999 to 2010 in New Zealand. It should be noted that the data from the 1999 to 2004 period (materials, labour and margin) represent small dwellings (~100 m^2) whereas the data from the 2008 to 2010 period (materials, labour, margin, and sub-contractors / preliminary and general / contingency) represent large dwellings (~182 m^2).

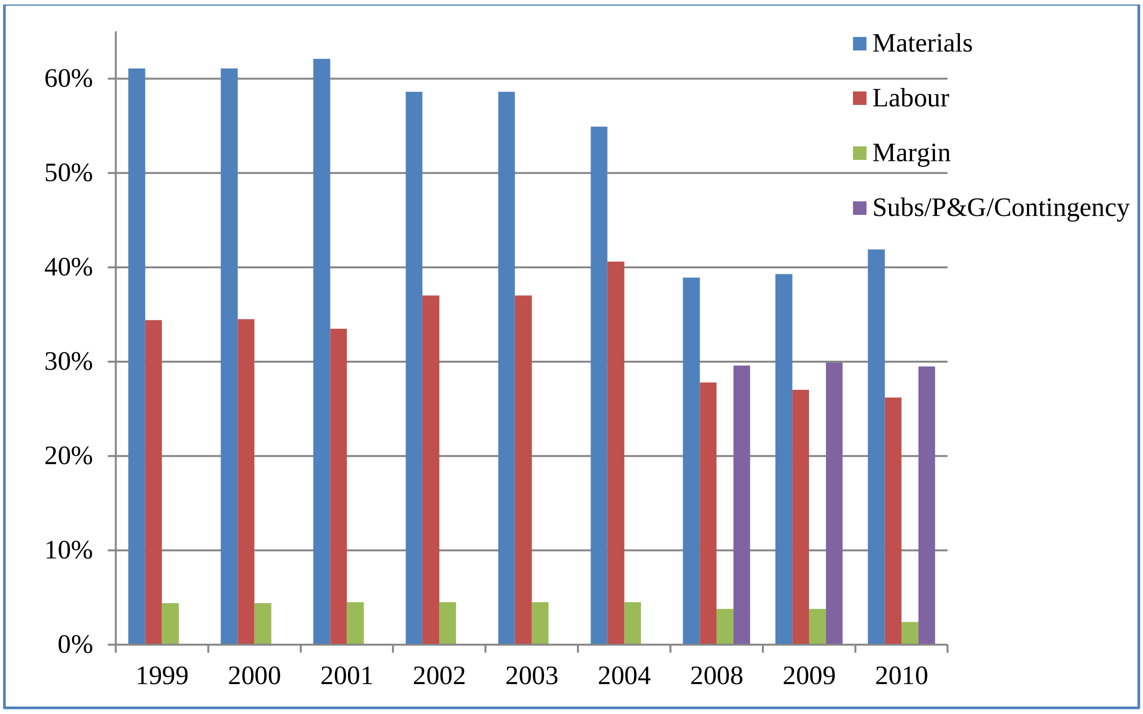


Figure 2.31: Dwelling component costs

Adapted from: (CHRANZ, 2011)

It can be seen from Figure 2.31 that materials represented more than 50% of the total construction cost for small dwellings from 1999 to 2004, and approximately 40% for large dwellings from 2008 to 2010. A study conducted by DBH (2008) also shows that the materials costs are approximately 60% of total house construction costs in Christchurch. In line with this, the New Zealand Productivity Commission (2012) stated that half of the construction cost comes from materials in the New Zealand residential building sector.

2.3.2.3 Building Materials in House Construction

New Zealand houses are generally made of timber with different wall and roof cladding types (Page, 2013b). Page (2008) presented an approximate figure on the significance of different materials used in New Zealand houses. It was stated that an average house (195m^2) consists of 19.6% structural and finishing timber, 9.1% concrete, 7.6% roof claddings, and 6.1% wall claddings. As materials represent approximately half of house construction costs it is important to identify key cost contribution materials. New Zealand residential construction utilizes seven key building materials in house construction (see Table 2.14). These comprise concrete (flooring), timber (framing), interior wall linings, wooden windows, aluminum windows, roofing tiles, and iron roofing, on the basis of their importance and cost contribution in house construction (NZBE, 2010).

Table 2.14: Key materials in New Zealand house construction. Source: (NZBE, 2010)

Material	Description
Concrete	Reinforced concrete in ground floor slabs 17.25 MPa. Change to 17.5 MPa from 1976 onwards
Framing timber	4' x 2' boron treated (100 x 50mm). Change to 100 x 50mm H1.2 treated, from 2009 onwards
Interior Wall Linings	3/8" (9.5mm) Gibraltar board to walls (fixed and stopped). Change to 10mm in 2002
Wooden windows	3' 6" x 2' 4", with top split rail sash, whitco hung. Change in 1975 to 1060 x 710mm wide with one 530 x 710 mm wide top hung sash with whitco stay & one fixed light
Aluminium windows	4' x 3' 4" (1200 x 1000mm), satin anodised awning windows.
Roofing Tiles	Monier Concrete Tiles (per 100 sq ft). Change to $/per 10 m2 in 1975. All prices are for fixing to timber purlins and do not allow for netting and paper.
Iron Roof	Orb. Galvanised. Corrugated Iron. 26g/ 0.5 mm long run iron. Change to 0.55mm Plain Galvanised, corrugated in 1984 (per 10 m2). All prices are for fixing to timber purlins and do not allow for netting and paper.

However, thirteen key materials which principally contribute to materials costs were recognized by Statistics New Zealand and their price variations from 1994 to 2010 are given in Figure 2.32.

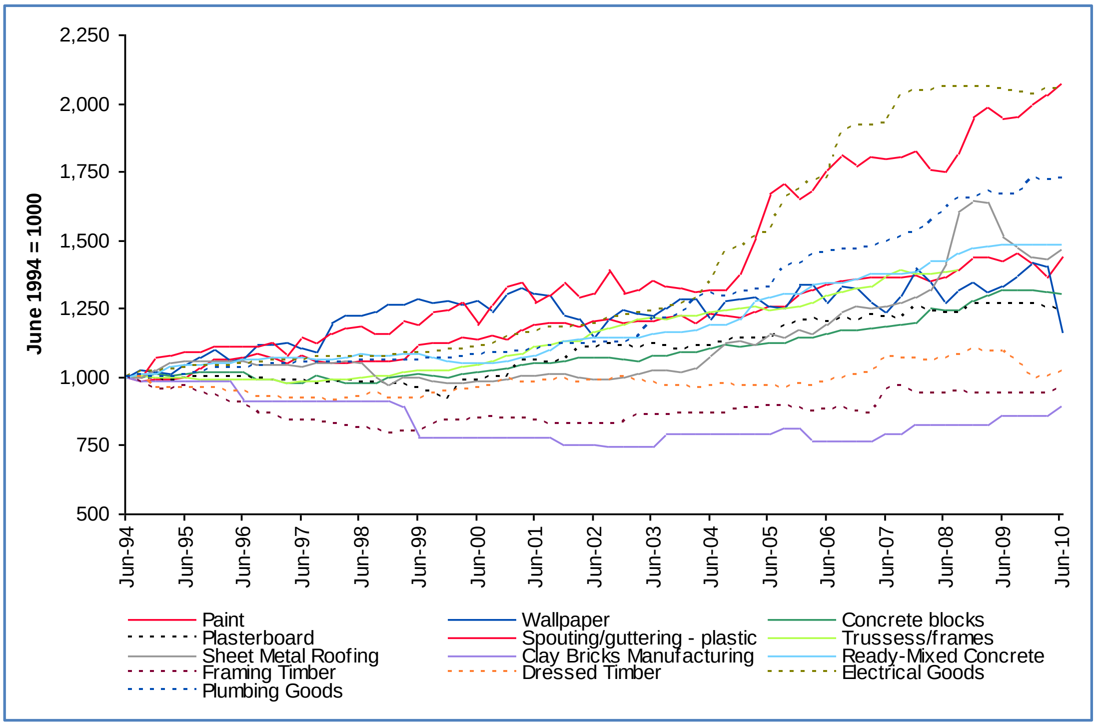


Figure 2.32: Material prices - 1994 to 2010

Source: (CHRANZ, 2011)

Regarding the three highest components, it can be seen that electrical goods increased by approximately 2.5%, plastic spouting and guttering by 2.2%, and plumbing goods 1.4% per annum.

2.3.3 Issues in the New Zealand Construction Industry

The New Zealand construction industry is diverse, fragmented, has low productivity and a proliferation of different industry associations endorsing their own sources (BCSPP, 2011; CHRANZ, 2011; Hinton, 2011). The reason for its fragmented nature is because of easy industry entry and exit, as builders' initial set up costs are very low (BIFNZ, 2013). As the sector is dominated by small firms which build one-off houses, economies of scale are hard to achieve (BIFNZ, 2013). In addition the industry also generates 50% of total waste generated in New Zealand (Ministry for the Environment, 2007). As construction parties are dependent on short-term resourcefulness (Cox, Ireland, & Townsend, 2006), unpredictable demand and supply characteristics can be seen in the New Zealand construction industry. This is mainly because most of the projects are small scale and one-off (Hinton, 2011). The fragmented nature of the residential construction sector is characterised by small sized firms, causing some outsourcing of processes and ultimately time delays, quality variations, lower productivity gains, dampening of innovation, and high construction costs (BIFNZ, 2013; CHRANZ, 2011). For example 70% of the residential construction sector engages fewer than six staff (Page, 2009). Also three quarters of new houses are constructed by small sized contractors (Curtis, 2011). Page (2013b) compares building firms' concentration in Australia, the UK, the USA, and New Zealand as given in Table 2.15. Being a small country, New Zealand's top 50 builders have only 13% of the construction share and they share 25% of total construction. This demonstrates the fragmented nature of the construction industry.

Table 2.15: House building firm concentration - Source: (Page, 2013b)

	Percentage share			
	Australia	**UK**	**USA**	**NZ**
Top 10 firms	15%	28%	15%	13%
Top 50 firms	33%	66%	23%	25%

Sources:

- Ball (2007) Firm size and competition: A comparison of the house building industries in Australia, UK and USA.
- Working papers in Real Estate and Planning 02/07.
- Page (2011) Cost efficiencies of standardized housing.
- Study Report No196, BRANZ, Wellington.

On the supply side for example, there are 45 concrete suppliers with 170 batching plants around New Zealand, as there are low barriers to entry in the ready-mixed concrete industry (CCANZ, 2013). Having a larger number of small firms causes lower economies of scale as a result of high overheads, high raw materials prices, and high investment expenditure (DBH, 2011). Consequently, the construction industry is less productive and it shows relatively higher cost structures (overheads, raw materials prices, and investment expenditure) in the New Zealand economy (DBH, 2011). The New Zealand construction industry follows a complex consenting process (BCPP, 2013) which is both time consuming and expensive.

Usually there are three procurement methods followed by the New Zealand construction industry: traditional procurement; integrated procurement or the management oriented approach, or a variant of at least one (Hinton, 2011). The majority of construction projects use the traditional procurement method, in which these projects are based on cost driven competitive tenders (Wilkinson & Scofield, 2010). Therefore the various parties involved in the supply chain try to achieve a competitive advantage. For example, a study conducted into the specific procurement selection criteria of Auckland interior fitout clients showed that the most influential parameters in selecting a procurement method are: client's budget; client's requirements for on time completion; client's experience; client's requirements in terms of value for money; market conditions; client's financial position; availability of experienced contractors, client's risk profile; level of client's involvement; access to in-house construction expertise; and client's types (Mahon, 2011). This shows the strong client and price driven nature of the construction industry, as opposed to SCM.

Use of the traditional procurement method does not provide best results as it tends to depend on the best price (Hinton, 2011) rather than best outcome. Further, project overrunning, over-budgeting, defects and disputes between project parties, and poor performance are some of the other key issues that can be seen in the New Zealand construction industry, mainly because of traditional procurement methods. Also, employing the traditional procurement system can lead to adversarial relationships in the supply chain (Hinton, 2011). That is, the objectives and goals of different parties in the supply chain are contradictory in the traditional procurement system (Love et al., 2008), for making less collaboration between the various project participants. The main contractors' principle aim is to maximize their profits, and clients often receive additional costs included by them. On the other end of the supply chain, suppliers may not be paid by contractors, causing payment problems and other issues. Therefore it can be argued that the New Zealand construction industry employs inappropriate tendering/procurement methods (BCPP, 2013).

As a result of the extremely competitive nature of the traditional procurement process, contractors adopt various strategies in order to secure projects. In regard to materials, offering alternative products (inferior products) is a common practice in New Zealand (Hinton, 2011). These alternative materials are included in the tenders to reduce the materials' cost. The aim of having them is to increase contractors' margins, but they can also significantly reduce the quality of the building or structure.

It is well-known that New Zealand constructions are generally expensive and low in quality compared to the neighbour country Australia, without exception, in the residential sector. More precisely, New Zealand houses are at least 10% more costly than the same types of Australian houses (Page, 2013b). Also, New Zealand's house construction costs (per square metre) are higher than Australia's (CHRANZ, 2011). One of the key factors to this price difference is building materials, as they are the main contributor (~50%) to construction costs. New Zealand building materials are more expensive than in Australia (BIFNZ, 2013); for example, Kenley (2003) showed that for ten common building materials, the price is 55% more expensive in New Zealand than in Australia, after exchange rate adjustments are done. Over the past five years, building material costs have increased by nearly 12% in New Zealand (CCANZ, 2013). Table 2.16 compares the price of key building materials between New Zealand and Australia.

Building materials in New Zealand are somewhat higher than average world prices as well. Some of the reasons for these relatively high prices could be New Zealand's geographical isolation, its small population (less demand for materials outside of Auckland), and a lack of competition amongst materials suppliers (CHRANZ, 2011). Usually for most of the key materials, there seems to be very few manufacturers in New Zealand, which causes high material prices.

Table 2.16: Material prices for a typical house in New Zealand and Australia - Source: (Page, 2013b)

Material	New Zealand price (in $NZ)	Australian Price (PPP adjusted to $NZ)	Australian Price as a %
Bricks	4,978	4,051	81%
Framing hardware	2,428	344	14%
Pre-nailed frames	10,575	7,920	75%
Eaves/ gable materials	3,524	1,395	40%
Finishing materials	1,032	978	95%
Finishing timber	677	867	128%
Internal doors	526	526	74%
Carpenter frame	6,870	6,142	89%
Trusses	8,111	7,158	88%
Metal fascia/ spouting	2,148	2,777	129%
Metal roofing	11,567	12,226	106%
Windows	12,873	5,325	41%
Cupboards	5,442	4,758	87%
Insulation	2,227	1,699	76%
Plasterboard	12,713	8,973	71%
Total	**85,878**	**65,139**	**76%**

Notes:
- Framing hardware in New Zealand houses includes metal straps, angles, bolts and weatherproof wraps at exterior openings. New Zealand windows are double-glazed while
- Australian houses generally have single-glazed windows.

These prices include labour costs for installation.

The lack of competition in some materials production has become a reason for relatively high materials prices in New Zealand (CHRANZ, 2011). The most significant determinant of lack of competition is described as barriers to entry and expansion. These barriers are the costs and risks confronted by manufacturers/suppliers which prevent them entering and expanding against market conditions. For example, these include natural barriers such as technology and resources required to sustain a company in the market, legal activities which limit the number of manufacturers/suppliers, and strategic barriers such as predatory pricing (BIFNZ, 2013).

The residential construction sector is subject to fluctuations in the business cycle, mainly due to Auckland's housing demands and the Christchurch rebuild project. As a result, the sector undergoes large variations in activity levels over the short term (BIFNZ, 2013). Also, concurrent peaks in residential and commercial activities increase demand for building materials which can cause higher materials prices (CHRANZ, 2011).

New Zealand houses are usually unique and customised (New Zealand Productivity Commission, 2012; Page, 2013b; Page & Fung, 2011), as homeowners prefer to select one-off builders rather than franchise builders (Curtis, 2012). According to Figure

2.33, 40.4% of homeowners prefer one-off designs (major/totally client driven) and 50.2% of homeowners prefer to make some changes to pre-existing designs. Consequently, the degree of customisation in New Zealand houses is very high.

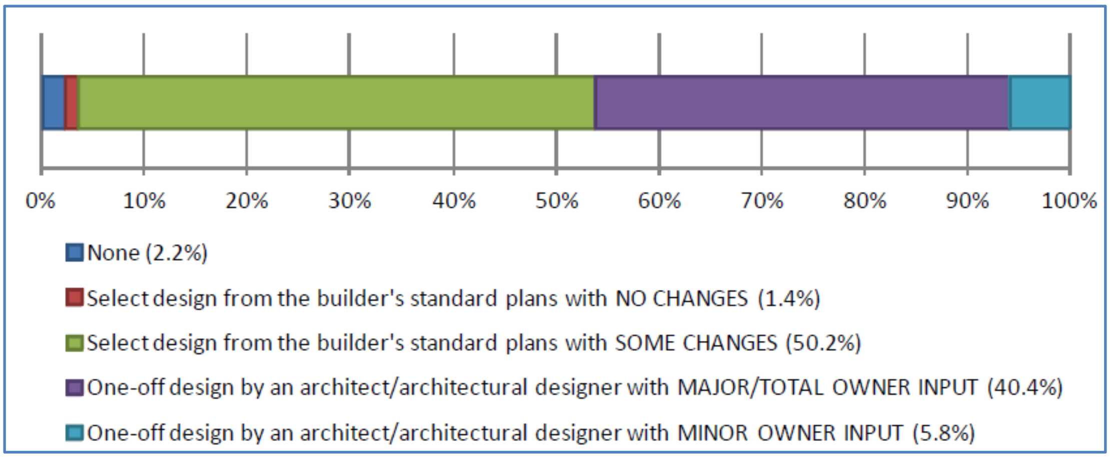


Figure 2.33: Types of input into house design

Source: (Curtis, 2012)

It is obvious that the use of standardised designs and fewer types of materials in construction can produce greater savings. However, New Zealand does not practice house standardization as in the USA and Australia (CHRANZ, 2011; Kenley, 2003). For example, Australian buildings are in simple shapes (rectangular) with brick veneer walls and tiled roofing. Also, Curtis (2011) reported that 85% of the wall claddings in new Australian houses in New South Wales and Victoria are made of clay brick while in New Zealand the figure is 41%. It is challenging to builders that New Zealand new homeowners look for highly-customised houses. For example, Curtis (2011) reported that 48% of New Zealand new houses have single wall cladding, 45% have two wall claddings, and 7% of them have three or more wall claddings. This illustrates the extent of less house standardisation in New Zealand. Making homeowners choose standardised house forms is always difficult and challenging, as it is a matter of aesthetics and expression of individuality.

Page (2013b) commented that this customized nature of house designs induces the use of different, nonstandard materials, making construction expensive. Roofing, windows, and claddings were recognized as the key contributors to increasing construction costs when they are customized. This bespoke nature of houses in New Zealand also creates inefficiencies and added costs to the construction process as a whole (CHRANZ, 2011). For example, this can create a lot of changes in formwork systems before concreting, thereby increasing the construction costs that come from concrete work (CCANZ, 2013). As upper storeys, complex roofs, sloping sections, and poor foundations add extra costs to house construction, Page and Fung (2011) recommended avoiding these design aspects.

New Zealand is lightly populated and geographically spread, therefore transport costs are comparatively high. This adds to materials prices (BIFNZ, 2013), so that even though manufacturers achieve economies of scale, they are mitigated by such extra transport costs. Consequently many manufacturers/suppliers operate as regionally-based small scale businesses to minimise these high transport costs (BIFNZ, 2013). CCANZ (2013) stated that the low axle loading limits on trucks imposed by the New Zealand Transport Agency (NZTA) is one of the reasons for this (for example, 9-12% more weight can be carried in NSW on the same sized vehicle). Also because of the geographical spread, a lot of cement in New Zealand is transported by ships, which again is expensive.

BIFNZ (2013) explains the current market dynamics in the residential construction industry in terms of the trend of importing non-traditional building materials (e.g. wall boards and insulation) and the higher degree of substitution (e.g. bathroom and plumbing materials). Imported materials provide a significant challenge for local manufacturers as they can be comparatively cheap. Accordingly, local manufacturers are forced to compete against such imported materials by offering better quality, a greater degree of technical support, quality service, and on-time delivery (BIFNZ, 2013)

Skilled labour shortages compared to other industries is another issue in the New Zealand construction industry. In addition, the sector does not practice cost saving mechanisms as the investments in project management and assurance processes are insignificant (CHRANZ, 2011). Therefore as Ying et al. (2013) argue, there is an imperative need to improve the SCM related skills in the New Zealand construction industry.

Imported materials should be able to withstand the extreme climatic conditions that New Zealand has. High UV, high humidity, high atmospheric sea salt levels, and strong wind conditions may not be similar to the home countries in which imported materials are manufactured. For example, BIFNZ (2013, p. 9) reports on two examples:

> "Imported from Europe clear uPVC sheet with a 25 year track record in its home country failing within five years in New Zealand, and imported from Europe PVC plastisol coated roofing, again with a successful home track record but failing in New Zealand within 10 years due to UV and salt effects".

However, it should be remembered that New Zealand is a unique country with cool temperatures, strong winds, and seismic activities which require a comparatively large amount of very strong materials which in turn make construction expensive (CCANZ, 2013). Also, material specifications between New Zealand and Australia, (e.g. 45mm wide timber framing in New Zealand as opposed to 35mm in Australia because of the extreme climate conditions in the former), transport costs and infrastructure, market size and volume, population concentration, and customised one-off houses, are some reasons why New Zealand materials are more expensive than the rest of the world (BIFNZ, 2013).

2.3.4 Suggestions for Improving the Current BMSC

Hinton (2011) and Boon (2007a) suggested that the New Zealand construction industry should move towards collaborative procurement practices, as opposed to traditional procurement practices. For example, better integration among homeowners, designers, builders, suppliers, and sub-contractors in procurement should be encouraged (Page, 2013b). Therefore effective communication and increased collaboration across the supply chain is greatly required (BCPP, 2012b; MBIE, 2013c). This will result in achieving better quality and value for money, as opposed to securing lowest cost (NZCIC, 2004). Consequently, educating the industry on the benefits of collaborative procurement methods is a prerequisite.

Increased house standardization in New Zealand would be a good practice to reduce construction costs, by making such houses approximately 15% cheaper than the usual one-off houses built by small contractors (Curtis, 2011; Page, 2008). Further, MALTBYS (2010) argued that the cost savings from house standardisation could be even up to 20% of the final cost. House standardisation was also recommended by Page (2013b) and BCPP (2013) with the use of pre-fabricated materials and standardised claddings and windows. BIFNZ (2013), which represents the supply chain of the building industry says that more standardised materials and designs are the keys to substantial cost reductions. Therefore standardisation can be supported through greater collaboration between architects and manufacturers. This will assist in accomplishing onsite economies and waste minimization, ultimately leading to minimized construction costs. However, it is necessary to first educate architects, manufacturers, and homeowners in the value of the use of prefabricated materials and house standardisation (BIFNZ, 2013). As New Zealand is a small country, big investments in manufactured housing plants are not feasible. However modulisation and prefabrication would certainly reduce construction costs.

The use of group builders/medium-sized builders with standard house plans is recommended by Page and Fung (2011) in order to minimize house construction costs. In line with this, BIFNZ (2013, p. 13) elaborated: "the active participation by Licensed Building Practitioners (LBP), the need for a catalyst for the creation of larger companies, and the need for industry's greater capitalization" to lessen the fragmented nature of the residential industry. More precisely, the use of group builders who build 8-30 houses per annum could bring down construction costs by 8% compared to one-off designs.

CHRANZ (2011) and Page (2013b) suggest improving national training schemes for skilled workers in construction, or allowing skilled migrants to fill these roles in order to overcome the skilled labour shortage in the New Zealand construction industry. Ying et al. (2013) also showed that there is a significant necessity for improving and expanding skills training in the New Zealand CSCM.

The New Zealand Productivity Commission recommends that local councils should make changes to consenting processes so that they are simple, fast, and cheap (New Zealand Productivity Commission, 2012; Page, 2013b).

As building material prices are relatively high in New Zealand due to the low level of demand, lack of competition, and geographical spread (Page, 2013b), it is necessary to improve productivity and efficiency in the supply chain to reduce the extra costs incurred. For example, Page (2013b) said that average house demand per annum in New Zealand is 20,000 units and consequently many building materials manufacturers here are below the world scale.

2.4 Research Gaps and Motivations

This chapter has reviewed the literature on the subject of SCM and CSCM. Also the chapter presented useful background information on the New Zealand residential construction sector, focusing on the significance of materials in the residential construction supply chain. The literature has highlighted the significance of materials in the New Zealand house construction sector. It would appear that one of the key reasons for high house prices in New Zealand is the high cost of building materials. Not only the house cost, but also the durability, weather tightness, and appearance are also mainly governed by the type of materials selected. Therefore appropriate materials selection is a priority.

The selection of building materials is not just the building contractors' task. It is a combination of decisions made by homeowners and architects when they choose materials at the beginning of a construction project. Also, supplying the right materials is a part of the responsibilities held by materials suppliers and manufacturers. Therefore, making right decisions in regards to materials when they are selected, purchased, and supplied needs to be addressed. This means that appropriate building materials can be secured when all the decisions made by the aforementioned parties are considered.

Usually the New Zealand construction industry employs traditional procurement methods which separate design and construction. As such, the decisions related to building materials are distinctly made by different parties involved in the supply chain. Therefore it is necessary that the New Zealand construction industry moves away from traditional procurement practices and into SCM concepts. Moving into SCM concepts requires integrating the various behaviours with regard to materials. For example, homeowners and architects' materials selecting behaviour, contractors' materials purchasing behaviour, and manufacturers'/suppliers' materials supply behaviour.

The past literature does not show any integrated and holistic approach to understanding material procurement issues in New Zealand. There are also other issues regarding the involvement of homeowners, architects and suppliers in selecting building materials. Since their involvement makes more opportunities to secure best materials, there should be well defined criteria that they consider when they choose or supply building materials (that is, the integration of the aforementioned three behaviours). This reinforces the need for a study which integrates material selecting, purchasing, and supplying behaviors in the New Zealand housing sector.

These gaps need to be addressed in order for the New Zealand housing sector to move towards a more efficient and effective SCM process, as opposed to the traditional procurement method. This study attempts to address these gaps by proposing a decision-making framework that can be implemented organisation-wide. To do this, the study will employ mixed methods research incorporating semi-structured interviews and a questionnaire to collate information from manufacturers/suppliers, contractors, architects, and homeowners, on their decisions related to building materials. This will enable the study to identify the key criteria that each of these groups think is the most important in selecting, purchasing, and supplying building materials. Also, the study will collect information on the issues in the New Zealand residential BMSC from the aforementioned key players' perspectives. The study will also obtain their suggestions for improving the current BMSC.

This decision-making framework (the key criteria that the entire supply chain thinks are the most important in selecting, purchasing, and supplying building materials), with the identified key issues and suggestions to improve the current BMSC, will provide a comprehensive description of the New Zealand residential BMSC. It is hoped that with this decision-making framework, the construction industry and academia in New Zealand can address some of the existing gaps in its supply chain management that may eventually result in finding appropriate building materials and improved supply chain practices.

CHAPTER THREE

Research Methodology

3.0 Introduction

This chapter presents a review of the methodological arguments for the conduct of the entire research process. The chapter begins by defining research and the research process followed by an attempt to understand the meaning of research methodology. Thereafter, the procedure followed to establish the current research problem is discussed, and then the problem investigated is presented with an overarching research aim, objectives, and questions. Subsequently the philosophical position taken for the research is described with its accompanying assumptions. This step is followed by a justification of the appropriate research approach and strategy. The three phase triangulated research design is then explained, and thereafter, the data collection and analysis techniques for the research are explained. The chapter then discusses the issues surrounding the reliability, validity, and generalizability of the research findings. The chapter concludes by considering the ethical issues and methodological limitations of the study.

3.1 Definition of Research

In simple terms research is *"a logical and systematic search for new and useful information on a particular topic. It is a search for knowledge, that is, a discovery of hidden truths"*(Rajasekar, Philominathan, & Chinnathambi, 2006, p. 1). Fundamentally, research deals with the production and legitimization of different forms of knowledge associated with the practices of different subject areas. From a broader perspective research has been defined as:

> *"a multiple, systematic strategy to generate knowledge about human behavior, human experience, and human environments in which the thoughts and action*

process of the researcher are clearly specified so that they are logical, understandable, conformable and useful"(Depoy & Gitlin, 2005, p. 5).

It is important that research is undertaken in a systematic way to develop knowledge along with theory and practice (Amaratunga, Baldry, Sarshar, & Newton, 2002; Saunders, Lewis, & Thornhill, 2011). Moreover, good research should be systematic, organized, critical, analytical, and effectively communicable in terms of its outcomes (Gray, 2009).

3.2 The Process of Conducting Research

The process of conducting research is in effect, examining and understanding the environment around a particular problem in order to find possible solutions (Cavana, Delahaye, & Sekaran, 2001). Consequently, research is, in a very real sense, a voyage of discovery (Fellows & Liu, 2008; Stebbins, 2001). The key "legs" of the "voyage" commences with curiosity and continues using a logical process in order to find a solution for a contemporary problem. This process is illustrated in Figure 3.1 and shows the key stages in every research process.

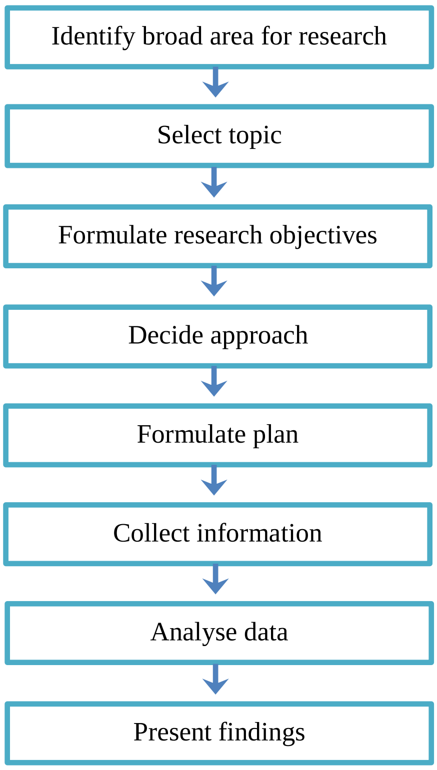


Figure 3.1: Overview of the simplified research process

Source (Gray, 2009)

Therefore, the researcher is guided by this logical process throughout the research journey from problem identification to the reporting of the research findings (Punch, 2005; Sekaran, 2005). O'Leary (2004) argued that a researcher should aim to address the following questions during the research process.

1. What needs to be done?
2. What research methods are needed to generate the knowledge, validate, and refine this knowledge?
3. What can be extracted from the research to build a knowledge base?

The study reported here followed a systematic research process of defining the research problem based on the past literature, and three informal discussions with highly experienced construction industry professionals. This was the foundation to deciding what needed to be done. Based on that, the researcher firstly explored the literature around the subject area. Thereafter, the research was designed to gather qualitative information on the research problem and a quantitative data collection was then conducted to extend the findings of the qualitative study. Thirdly, the research findings were validated through SMEs. Figure 3.2 summarises the research process of this study.

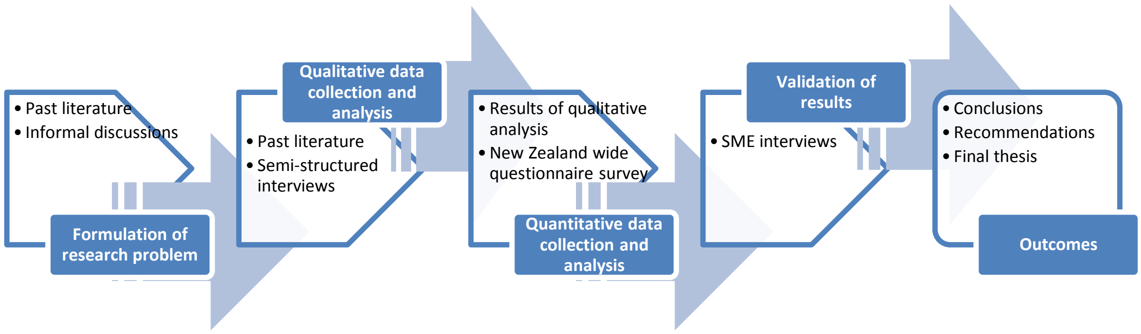


Figure 3.2: The research process for the study reported here

3.3 Types of Research

Depending on the purpose of the study, research can be exploratory, explanatory, or descriptive (Bernard, 2012). Exploratory research explores new phenomenona, explanatory research discovers causal relationships with variables, and descriptive research describes a phenomenon as it naturally occurs. However research could comprise a combination of the aforementioned three types even though one type is usually shown to be dominant (Neuman, 2006).

This study seeks to explore the nature of the BMSC in the New Zealand residential construction industry by identifying supply and purchasing behaviors, issues, and possible improvements. A literature review was conducted to explore the nature of the BMSC in New Zealand and within the international context. This was followed by 30 semi-structured exploratory interviews to gain some understanding of the materials purchasing and supply chain practices in the New Zealand construction industry. Details of the results from these exploratory interviews are presented in chapter 4. Therefore, these first two stages of the current research can be considered as an exploratory study. However, the third stage of the study was to extend the research findings from the first two stages in the form of a New Zealand-wide questionnaire survey. The purpose of the survey was to understand the nature of the New Zealand materials supply chain by discovering and measuring constructs established from the exploratory research stage. Therefore, the latter part of this study should be considered as explanatory research. From this, it is apparent that the study reported here is a combination of both exploratory and explanatory research. This confirms that most doctoral research comprises exploratory research at the beginning and explanatory research in the later stages (Bhattacherjee, 2012).These two research types are explained in the following sub-sections.

3.3.1 Exploratory Research

Exploratory research is employed when comparatively little is known about the topic and existing theories or knowledge are not useful (Teddlie, 2009). The key focus of exploratory research is to discover appropriate information on a subject matter in order to form an initial hypothesis. Bhattacherjee (2012) explains that the exploratory researcher's goals are:

1. To scope out the magnitude or extent of a particular phenomenon, problem, or behaviour

2. To generate some initial ideas about the phenomenon, and

3. To test the feasibility of undertaking a more extensive study regarding the phenomenon

Therefore exploratory research should elucidate problems, gather information and produce initial hypotheses and theories about subjects which decide the usefulness of the particular research area (Gray, 2009). However, a limitation of exploratory research is the lack of deep understanding in the research area. But the discovery of the nature and extent of the problem is useful for further in-depth research. Therefore exploratory research is qualitative. Saunders et al. (2011) argue/posit that exploratory research incorporates reviewing past literature, data gathering by talking to SMEs (interviews), and focus group interviews. As stated in section 3.3, the exploratory section of this study used a comprehensive literature review and a set of exploratory semi-structured interviews as its research data collection methods.

3.3.2 Explanatory Research

On the other hand when the research area/subject is very clear, explanatory research can be conducted to explain observed phenomena, problems, or behaviours. Neuman (2006) stresses that explanatory research should be used to explain theories. The researcher therefore, must examine and explain why and how a phenomenon occurs by describing its characteristics in explanatory research (Mohammed, 2009). Usually, explanatory research is therefore quantitative; for instance, the adoption of surveys to collect research data. The latter part of this study evaluates the findings from past literature and semi-structured interviews. A questionnaire survey was conducted to signify the constructs found in the exploratory stage of research. The data from the survey described the materials supply and purchasing behaviors in the New Zealand residential building industry. This is a further explanation and extension of what was found in the initial stage of the research. Therefore, it is clear that the latter part of this study belongs to an explanatory type of research.

For any type of research, it is essential to study and identify the most appropriate research methods in order to achieve the overarching aim of a study (Mackenzie &

Knipe, 2006). The next sections describe research methodology in general, together with selecting the methodology for the study reported here.

3.4 Establishment of the Research Problem

Research questions connect the researcher's knowledge with relevant information in the subject area so that the research problem can be properly addressed (Colorado State University, 2006). The research problem being addressed by this study was established through the researcher's initial motivation, a review of past literature, and the opinions of subject matter experts. That is the current building material procurement and use practices do not confer the most benefits to end users.

3.4.1 Initial Motivation

A research project should only be initiated with significant interest and competences in the subject area selected by the researcher (Remenyi, 1998; Saunders, Saunders, Lewis, & Thornhill, 2011), and should be completed by engaging the researcher (both heart and head) with the research project (Saunders, Lewis, & Thornhill, 2007). The researcher in this doctoral study has a civil engineering and industrial construction management background. Therefore, the preliminary impetus for this PhD emerged from the past experience and interest of the researcher in SCM.

3.4.2 Literature Review

Current knowledge provided by other scholars on the subject area can be examined by reviewing past literature. Therefore, a literature review is a "building block" to creating effective research (Massey, 1996). In addition, a literature review ensures that the researcher has current knowledge of the subject. Moreover, reviewing past literature enables the identification of any research gap. Consequently research questions can be formulated to address such a research gap (Eisenhardt & Graebner, 2007). The formulation of the research problem is an iterative process of reviewing past literature, reflection and questioning, which should ultimately create a research project. Figure 3.3 shows this iterative process (Collis & Hussey, 2009).

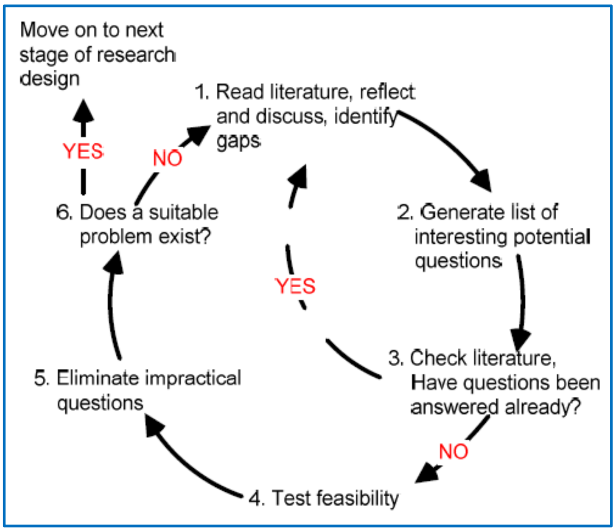


Figure 3.3: Identification of research problem through an iterative literature review

Source (Collis & Hussey, 2009)

As it was discussed in section 3.5.1, this study was initiated within the broader aspect of SCM. This broader aspect of the research area was narrowed down by reviewing the general literature on SCM and its appropriateness in the construction industry. This initial literature review found that SCM practices are not adequately adhered to in the construction industry with regards to supplying and purchasing building materials.

With this focus, the literature survey for this research continued to explore the functions of building materials in the construction supply chain. From there, the two themes generated (construction supply chain management and building materials) were further examined within the New Zealand context. This process ensured that building materials supply chain practices have not been systematically studied, especially in the New Zealand residential building industry. Having identified this, the researcher continued the literature review on building materials supply chain practices in the New Zealand residential construction industry, in particular addressing the following key criteria:

1. Contractors' materials purchasing behaviour
2. Manufacturers'/suppliers' materials supply behaviour
3. Architects' and homeowners' materials selection behaviour
4. Improving the New Zealand building materials supply chain
5. The significance of collaboration in improving the building materials supply chain.

The above five key criteria were further studied to create the research problem in relation to this study. The primary aim of this research is to identify system weaknesses limiting the performance of the residential construction sector in New Zealand, and potential ways to address these using interventions operating at the whole-of-supply chain level, including barriers to be overcome. As Zelditch (1962), Punch (2000), (as cited in Vidalakis, 2010), and Tookey (1998) explained, analysis of the research problem establishes the means of solution. The next sections present information on the scope, nature, and complexity of the research problem formulated above.

3.5 Description of the Research Problem

The problem being addressed in the study reported here is: current building material procurement and use practices do not confer the most benefits to end users. In order to resolve this research problem it is necessary to understand the decision making processes associated with the supply and selection/purchasing of construction materials across the BMSC. Therefore the opinions of the following key members of BMSC were examined: building materials manufacturers/suppliers, contractors, architects, and homeowners. The study also looks at the current issues in the materials supply chain. After which, suggestions for improving the materials supply chain are proposed. As Tyden (1994) stated, it is very important to investigate the three features of scope, nature, and complexity of a research problem, because these could influence the extent to which the research results can contribute to solving the research problem.

3.5.1 The Scope of the Problem (Generalisability)

The regularity and the applicability of the research problem across the industry considered are referred to as the scope of the problem. The issues around materials selecting, purchasing and supply decisions in the residential construction sector are both specific and generalisable. Undoubtedly, some of the issues could vary according to certain circumstances. In an absolute sense, the problem is specific in that it has not been addressed in the New Zealand construction industry. Moreover, to date, there does not appear to be a single study in construction that takes an integrated and holistic approach to understanding material procurement and supply issues that focuses on the total supply chain. This was established during the literature survey. However, the solution of the problem should be as generalisable as possible in the residential BMSC in New Zealand. Thus, the selected methodological approach and methods should be able to deliver broadly generalisable results from this study.

3.5.2 The Nature of the Problem

Defining the nature of the problem is important because it is one of the main factors which drives the selection of the appropriate research methodology or methods (Babbie, 2012). The nature of the research problem should be described in a balanced manner between qualitative and quantitative aspects (Currall, Hammer, Baggett, & Doniger, 1999). Further, this description should answer to both ‘why’ a phenomenon happens against ‘what’ happens. It is obvious that to answer what is happening first should occur rather than answering why it is happening.

For the current research, answering what is happening needs an understanding of the various activities involved in the construction supply chain. Borg, Gall, and Gall (2007) and Guba and Lincoln (1994) argue that an in-depth understanding of a process can be grasped by a qualitative study which cannot be quantified. Therefore, this study initially used a qualitative approach to discover the nature of the problem (building materials purchasing, selecting, and supply practices). Then, the significance findings from the qualitative approach were quantified using a quantitative approach. Thus, a mixed-methods approach was engaged for this study.

3.5.3 The Complexity of the Problem

Choi, Dooley, and Rungtusanatham (2001) placed the fundamentals for research in supply chain management and modelled the supply chain as a “complex adaptive system”. Supply chain complexity is a “level of detail complexity exhibited by the products, processes, and relationships that make up a supply chain” (Bozarth, Warsing, Flynn, & Flynn, 2009, p. 80). When the structure of the construction supply chain is considered, the supply chain for construction projects involves numerous supply chain nodes. Moreover, each construction project being carried out has a different supply chain, highlighting the increased complexity of the system. Therefore, when these aspects are combined within this study, it can be argued that analysis of the building materials supply chain should be considered as a complex process, as it involves decisions taken by a variety of personnel. In summary, the research problem can be described as generic, both qualitative and quantitative, and complex. Having established the research problems, the study refined them through three informal discussions conducted with SMEs.

3.6 Refining the Research Problem Using SMEs' Opinions

The SMEs who participated represented a building materials manufacturer/supplier, a building contractor, and an architect. These discussions were conducted to further strengthen the selected subject area. The objectives of the informal discussions that were carried out were as follows:

1. To obtain the SMEs' views on the significance of materials in supply chain management
2. To understand building materials purchasing, supply, and selection behaviour in New Zealand
3. To identify other areas that may be worthwhile investigating in order to address the scope of the research problem.

Having discussed the subject matter with SMEs, the earlier formulated overarching aims, objectives, and questions of the research were refined.

3.7 Restatement of the Overarching Aims, Objectives, and Questions

In order to address the main research problem stated in section 3.5, the following overarching research aims, objectives, and questions were designed.

3.7.1 Overarching Aim

The overarching aim of this research is to identify system weaknesses limiting the performance of the residential construction sector in New Zealand, and potential ways to address these using interventions operating at the whole-of-supply chain level, including barriers to be overcome.

3.7.2 Research Objectives

The following research objectives were formulated to help achieve the overarching aims of the research study.

1. To review the nature of the building materials supply chain in the New Zealand residential construction sector
2. To identify building materials supply, purchasing, and selection behaviours of supply chain stakeholders (materials suppliers, building contractors, architects, and homeowners)
3. To integrate buyer and supplier behaviours to improve the building materials supply chain
4. To suggest an improved framework for current building materials supply chain practices for selecting appropriate building materials

3.7.3 Research Questions

The following are the key research questions which underpin this study. This list of questions will be addressed at different stages in the course of the research.

1. How does the New Zealand residential construction sector operate?
2. What are the current issues in the materials supply chain?
3. Who are the people involved in the building materials supply process?
4. How do materials suppliers transport building materials?
5. How do materials suppliers supply building materials?
6. What are the key criteria considered by building materials suppliers in making their materials supply decisions?
7. Who are the people involved in the building materials purchasing process?
8. How do contractors purchase building materials?
9. What are the key criteria considered by residential building contractors in making their materials purchasing decisions?
10. What are the key criteria considered by architects in making their materials selection decisions?

11. What are the key criteria considered by homeowners in making their materials selection decisions?
12. What are the key benefits of collaboration in the materials supply chain?
13. How can buyer and supplier behaviours be integrated to improve the materials supply chain?
14. What would be the possible mechanism to improve the current building materials supply chain?

The next section discusses the adopted methodological framework to solve the established research problem.

3.8 Methodological Framework

Tookey (1998) explains that the nature of any particular research problem will dictate its means of solution and therefore, the methodological framework and the methods used in the research should reproduce the features discussed in sections 3.5.1, 3.5.2, and 3.5.3 above. The purpose of research is to contribute new knowledge for the development and establishment of theory and practice. This is usually accomplished via identifying, investigating and finding solutions to attempted research problems (Remenyi, 1998). This research process is basically uncertain and risky and is established through collaboration between the conceptual and empirical world (Booth, Colomb, & Williams, 2003; Gill & Johnson, 2002). A methodological framework should be able to forecast the possible difficulties and issues that the researchers may experience during the research journey. Therefore, the identification of an appropriate methodological framework reduces the probability of failure.

A methodological framework consists of a philosophical construct which helps to identify and justify a research approach and an aspect on appropriate techniques (Easterby-Smith, Thorpe, & Jackson, 2012). Kagioglou, Cooper, Aouad, and Sexton (2000) presented a research design in terms of a hierarchical model consisting of philosophy, approaches, strategies, and methods/techniques, as shown in Figure 3.4.

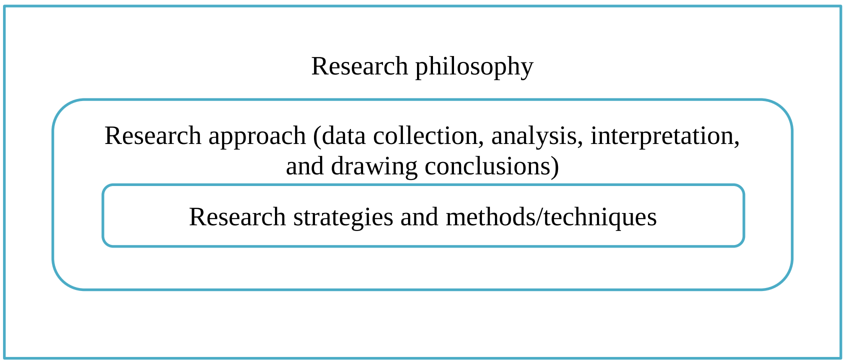


Figure 3.4: Research design hierarchical model

Adapted from: (Easterby-Smith et al., 2012; Kagioglou et al., 2000)

The model in Figure 3.4 shows that basically, the research philosophy guides the research approaches and these research approaches ensure the appropriateness of available strategies and methods/techniques. Thus the methodological framework should establish a philosophical position, select an appropriate research approach, and applicable research techniques and methods. Subsequent sections of this thesis are organized to discuss the philosophical position for this study.

3.8.1 Philosophical Background

Research is a compromise between the possibilities of different approaches obtained from understanding the philosophical background of a topic (Gill, Johnson, & Clark, 2010). Basically, philosophy investigates available theories so that researchers are able to build scientific knowledge from those theories (Gray, 2009; Sarantakos, 2005). Philosophy also forms the foundation for research design which guarantees the quality of a research project (Easterby-Smith, Thorpe, & Lowe, 2002). Collis and Hussey (2009) explain that understanding the philosophical position of the research drives the way of writing the thesis. Therefore it is essential to establish the philosophical position of any research project.

Easterby-Smith et al. (2002) showed that philosophy can be divided into positivism and intrepretivism. Positivism and Interpretivism are considered the main research paradigms and are the foundation of the Western intellectual tradition (Bryman & Bell, 2007; Gray, 2009; Silverman, 1998). The two paradigms of positivism and interpretivism are considered as the extreme ends of a paradigm spectrum. Therefore, along this paradigm spectrum, other paradigms can exist, e.g. pragmatism and post-positivism (Crossan, 2003; Saunders et al., 2011). However, the selection of a research paradigm is based on the assumptions of the ontological, epistemological, axiological, and rhetorical stances of the study (Creswell, 2007). Therefore the following sub-sections briefly discuss the significance of these four philosophical assumptions.

3.8.1.1 Ontology

The term ontology is explained as the nature of knowledge and it answers the question: what really exists? (Creswell, 2007; Saunders et al., 2011; Tan, 2002). The nature of knowledge can be described using two views: objectivism and constructivism (Bryman & Bell, 2007). Objectivism believes social entities exist in reality outside of social actors whereas subjectivism emphasizes that social actors are considered as part of social phenomena, and social phenomena are the result of the actions of social actors.

3.8.1.2 Epistemology

Epistemology is related to how a researcher knows what he/she knows (Creswell, 1994b; Tan, 2002). In other words, epistemology seeks to discover the connectivity between the researcher and the object of study. Epistemological considerations consider the most appropriate research methods to generate reliable and verifiable outputs. During the data collection stage, researchers who follow quantitative approaches appear to be disconnected from the object of study, whereas researchers who follow qualitative approaches seem very connected with the object of study (Creswell, 1994b; Smith, 1983). It can be argued that following both qualitative and quantitative approaches would eliminate the disadvantages of being separate from the object of study. Therefore, epistemological considerations can be satisfied by including a qualitative approach for a research study.

3.8.1.3 Axiology

The nature of the values that a researcher brings to the research is referred to as axiology (Carroll, 2008). As explained in section 3.8.1.2, quantitative research methodology is distinctive from the researcher’s input, that is, the research methodology is based on the evidence gathered in the study (Creswell, 1994b; Sarantakos, 1997). In contrast, both the researcher’s values and the information gathered from the study greatly contribute to the research methodology of qualitative research (Lazarus, 2005; Sarantakos, 1997). Therefore, the adoption of both qualitative and quantitative approaches would eliminate the bias of a single research approach (Creswell & Plano-Clark, 2007).

3.8.1.4 Rhetoric

Rhetoric refers to the characteristics of the language used in the study and its reporting (Creswell, 1994a). The language used in quantitative research (e.g. "comparison" and "relationship") is generally formal and impersonal, whereas qualitative research adopts informal and personal language (e.g. "understanding" and "discover"). Therefore, utilizing both quantitative and qualitative research approaches would allow the use of both formal and informal language in research reporting (Creswell & Plano-Clark, 2007).

3.8.2 Research Paradigms

As discussed in section 3.8.1, based on the philosophical assumptions discussed (ontology, epistemology, axiology, and rhetoric), two main traditions in research paradigms called positivism and interpretivism, exist (Gray, 2009; Massey, 1996). However, it should be noted that various authors have defined other paradigms in-between the two extremes of positivism and interpretivism. These include: critical theory; constructivism; pragmatism; post-positivism; etc. The next two sections will describe the two paradigms of positivism and interpretivism. Subsequently, an appropriate research paradigm was selected to establish the philosophical position of the study reported here.

3.8.2.1 Positivism

Generally quantitative studies engage a positivist paradigm to simplify a wide range of data set by finding causal explanations (Amaratunga et al., 2002). But qualitative approaches can be used within the positivist paradigm given that the quantitative approach is predominant (Crossan, 2003). In positivism, exact logic rules, truth, and predictions exist (Burns & Grove, 2009). Positivism follows the ontological assumption that reality is external and objective. This is called ‘realism’ (Johnson & Duberley, 2000) or ‘objectivism’ (Saunders et al., 2011). In addition, positivism has the epistemological assumption that reality should be assessed objectively, e.g. without sensation, reflection, or intuition (Easterby-Smith et al., 2002). In terms of axiological assumptions, positivism asserts that the research process is inherently free of values (Collis & Hussey, 2009; Saunders et al., 2011). Therefore, it can be stated that the researchers in a positivist paradigm should act independently from the research environment to ensure that the research results are unbiased. Research in the natural science stream generally falls within the positivist paradigm.

3.8.2.2 Interpretivism

Social sciences generally use an interpretivist paradigm which has the ontological assumption that the external world is built by human behavior and does not have a pre-arranged structure (as opposed to positivism), which is called ‘idealism’ (Gummesson, 2000) or ‘subjectivism’ (Saunders et al., 2007). Due to this subjectivity, from the ontological point of view, interpretivists accept the existence of multiple realities. Also, interpretivism has the epistemological assumption that properties of reality should be measured in terms of subjective measures and examined by people’s views (Collis & Hussey, 2009; Easterby-Smith et al., 2002). Therefore, unlike positivism, interpretivism focusses on peoples’ views and knowledge and is regarded as value laden. This makes for interaction between the researcher and research environment. However, interpretivism has potential limitations due to the subjective nature of the inquiry. In terms of methodological positions, interpretivismis more likely to use qualitative approaches (e.g. in-depth discussions with a group of participants) to discover the reality of a research problem (Guba & Lincoln, 1994). Table 3.1 shows a general polarization between positivism and interpretivism, and Figure 3.5 compares the philosophical assumptions of the research paradigm spectrum discussed in this section.

Table 3.1: A comparison of positivism and interpretivism - Source: (Amaratunga et al., 2002; Easterby-Smith et al., 2002)

Constructs	Positivism	Interpretivism
The observer	Must be independent	Is a part of what is being observed
Human interest	Should be irrelevant	Is the main driver of the science
Explanations	Must be demonstrate causally	Aims to increase general understanding of a situation
Research progress through:	Hypothesis and deduction	Gathering rich data from which ideas are induced
Concepts	Need to be operationalised so that	Should incorporate stakeholder

	they can be measured	perspectives
Units of analysis	Should be reduced to the simplest terms	May include the complexity of the whole situation
Generalization through:	Statistical probability	Theoretical abstraction
Sampling techniques	Large numbers selected randomly	Small number of cases chosen for specific reasons
Strengths	Can provide wide coverage of a range of situations	Data gathering methods seen as more natural than artificial
	Can be fast and economical	Ability to look at change process over time
	Where statistics are aggregated from large samples, they may be of considerable relevance to policy decisions	Ability to understand people's meanings
		Ability to adjust to new issues and ideas as they emerge
		Contributes to theory generation
Weaknesses	The methods used tend to be rather inflexible	Data collection can be tedious and require more resources
	They are not very effective in understanding a process or for the significance that people attach to actions	Analysis and interpretation of data may be more difficult
	They are not very helpful in generating theories	Harder to control the pace, progress and end-points of the research process
	Because they focus on what is, or what has been recently, it is hard for policy makers to infer what changes and actions should take place in the future	Policy makers may give low credibility to results from a qualitative approach

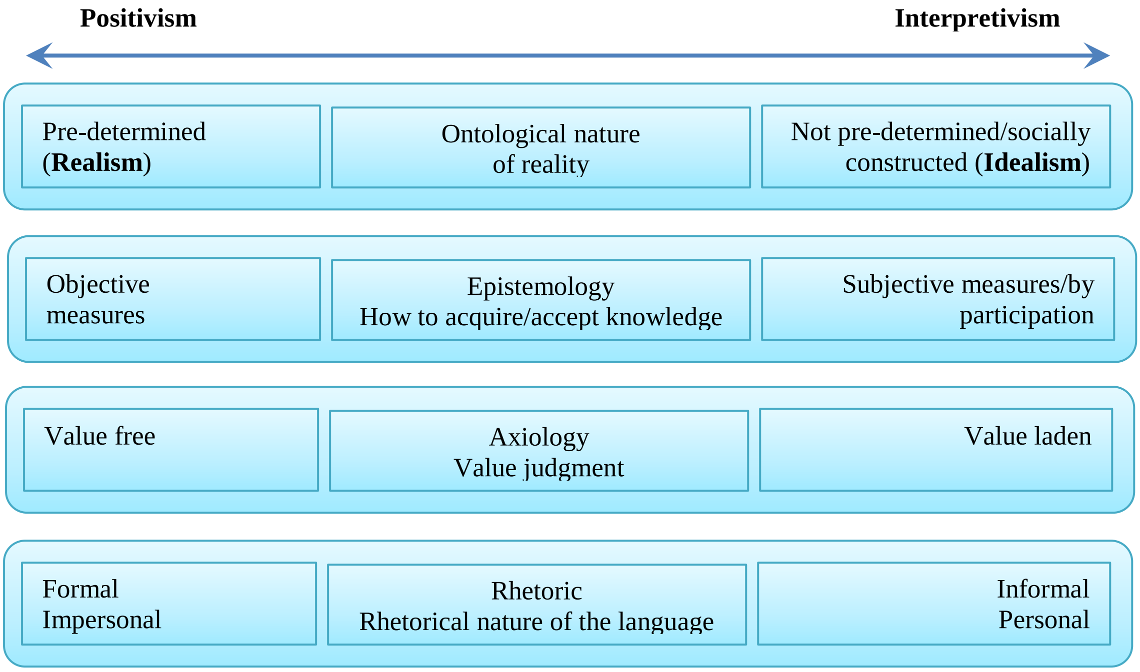


Figure 3.5: Philosophical assumptions and paradigm spectrum

Adapted from: (Kulatunga, 2008)

This study endeavors to identify the behaviors (supply, purchasing, and selection) within the materials supply chain in the New Zealand residential construction industry. Also, the study seeks to find the current issues in supply chain practices and provide recommendations for possible improvements. Therefore the problem investigated in this study does not require testing an existing theory or building a new theory on materials supply chain management. Having identified the characteristics of positivism and interpretivism, it can be argued that neither positivism nor interpretivism is suitable for this study.

3.8.2.3 Pragmatism

The pragmatist paradigm is a newly emerged research philosophy which connects theory and practice together (Denzin & Lincoln, 2011). Creswell (2012) and Pansiri (2005) argue that knowledge exists as a result of actions, situations and consequences, not from preexisting conditions. This is the ontological perspective of pragmatism. From an epistemological point of view, a pragmatist could be considered as both objective and subjective with regards to reality (Tashakkori & Teddlie, 1998). From an axiological perspective a pragmatist believes that values are significant in the research process. Further, the distinction of reality (reality is external) and the need for the explanations which create the best results are accepted by pragmatists. From the perspective of rhetoric a pragmatist would use both formal and informal writing styles (Creswell & Plano-Clark, 2007). A useful theoretical framework of qualitative, quantitative and pragmatic approaches is provided by Morgan (2007) as shown in Table 3.2.

Table 3.2: Pragmatic approach in conjunction with qualitative and quantitative approaches- Source: (Morgan, 2007)

	Qualitative approach	Quantitative approach	Pragmatic approach
Connection of theory and data	Induction	Deduction	Abduction
Relationship to research process	Subjectivity	Objectivity	Intersubjectivity
Inference from data	Context	Generality	Transferability

It can be observed from Table 3.2 that the process of abduction can be placed in-between both qualitative and quantitative approaches. That is to say: the inductive results from a qualitative approach can be regarded as the input for a quantitative approach (or paradoxical) in the pragmatist paradigm. Therefore, pragmatism is widely recognized as a philosophy adopted by researchers who adopt a mixed-methods approach. The reason is that pragmatists believe that a greater extent of reality is reachable using a mixed-methods research method (Rallis & Rossman, 2003; Tashakkori & Teddlie, 2003b). Now it can be concluded that from the philosophical point of view, pragmatists apply characteristics from both positivism and interpretivism in research.

3.8.3 Establishment of an Appropriate Paradigm for this Study

As explained in section 3.8.2, paradigms observe the social world in different ways, based on the philosophical assumptions of: ontology, epistemology, axiology, and rhetoric. The best-suited research paradigm for the current study should be able to create the foundation for an appropriate research methodology, by establishing appropriate philosophical assumptions. This study seeks to explore the nature of the New Zealand building materials supply chain and suggest potential recommendations to improvesupply chain practices in the residential construction sector. The process of establishing the research questions related to this study was based on the past literature and the opinions of the SMEs interviewed. It was identified that this research cannot be addressed by theories, observational experience, or objective reality dimensions. Therefore, it would appear that the philosophy of positivism is not applicable to this study. The research problem was formulated based on the individual views of people in the materials supply chain. This resulted in different perceptions on the reality of the research problem, that is, the existence of multiple realities.

It follows that the current study appears to lie on an interpretivist paradigm or pragmatism paradigm. The current study also requires quantification, e.g. the identification of key factors in a contractor’s purchasing decisions: How many? How significant? etc., of some of the research constructs. However, interpretivism is not in line with the quantification of abstract measures. Interestingly, pragmatism allows the researcher to employ both qualitative and quantitative approaches (mixed-methods), and both inductive and deductive logic to explain reality as much as possible (Tashakkori & Teddlie, 1998). The characteristics of the pragmatist paradigm based on the philosophical assumptions in the current study are demonstrated in Figure 3.6.

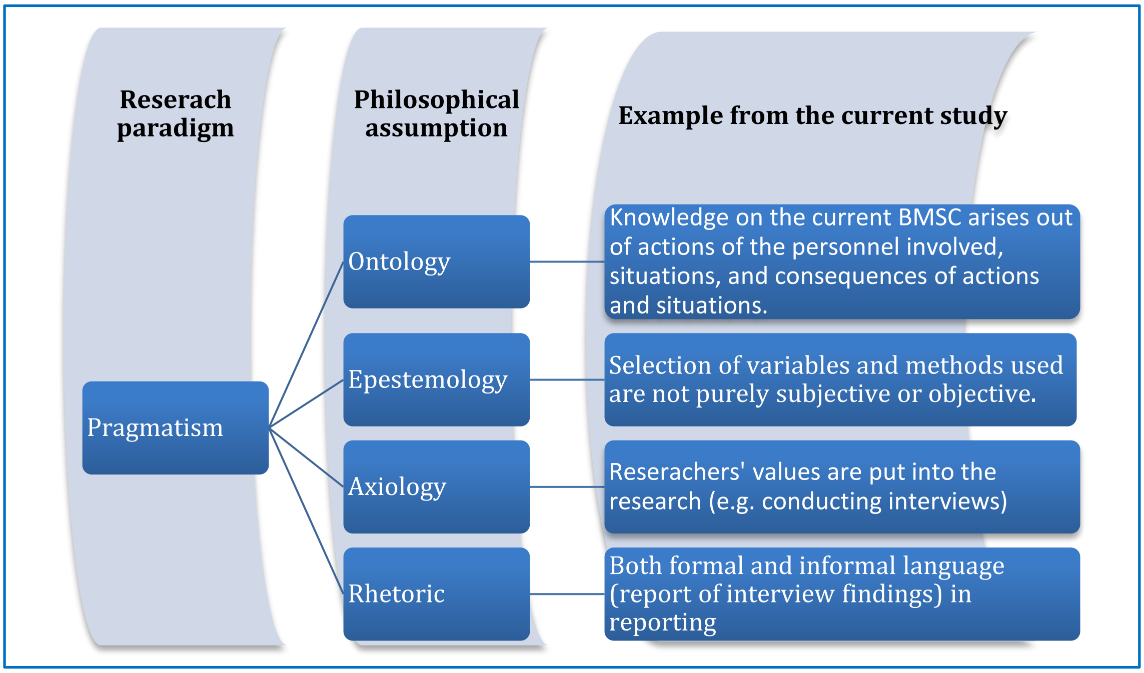


Figure 3.6: Research paradigm (pragmatism) of the current study

As explained in section 3.2 (also see Figure 3.2), the current study collected information through literature (qualitative and quantitative), interviews (qualitative), and surveys (quantitative). Therefore pragmatism allows a synthesis of the findings from these multiple approaches. In other words, the current research employed a mixed-methods approach. Now it is clear that in terms of the methodological position and philosophical assumptions, the most appropriate research paradigm for the current study is pragmatism. This is in line with the fact that construction management research usually positions itself between the natural sciences (which accept positivism) and social sciences (which accept interprevism) (Love, Holt, & Heng, 2002). Having established the research paradigm, the subsequent sections justify the appropriate research approach for this study.

3.8.4 Research Approaches

A research approach is important because it acts as a guide to select the most appropriate research strategies. Subsequently the research approach similarly guides the decisions regarding an appropriate research design so that the researcher can collect the right types of data, and access the right data sources, as well as utilize the most appropriate data collection and analysis techniques (Easterby-Smith et al., 2012). Tashakkori and Teddlie (2003a) and Williams (2007) recognize three research approaches: qualitative, quantitative, and a combination of qualitative and quantitative (mixed methods) approaches. This classification is based on the forms of data required, techniques used in collecting and analysing data, the flexibility of the research design, and the research objectives and questions (Mack, Woodsong, Macqueen, Guest, & Namey, 2005). The following sections describe qualitative, quantitative, and mixed-methods approaches.

3.8.4.1 Qualitative, Quantitative, and Mixed-Methods Approaches

From the philosophical point of view, the qualitative research approach belongs to the interpretivist paradigm. A qualitative researcher is considered as an integral part of the research process, and qualitative researchers understand phenomena by using the information gained from research participants (Fellows & Liu, 2008). Thus, reality is considered to be subjective (Amaratunga et al., 2002).

Quantitative studies on the other hand tend to be inclined towards positivism and seek to gather factual data, to study relationships between facts, and to discuss how such facts and relationships align with theories and the findings of any research executed previously (Fellows & Liu, 2008, p. 27). Therefore a qualitative research approach is more likely to resulting theory development (Leedy & Ormrod, 2005).

Table 3.3 compares and contrasts the philosophical assumptions (ontology, epistemology, axiology, rhetoric, and methodology) of both qualitative and quantitative approaches.

Table 3.3: Qualitative and quantitative approaches-Philosophy- Adapted from: (Baban, 2009)

Philosophical assumptions	Qualitative approach	Quantitative approach
Ontological assumption	▪ Reality is subjective and multiple	▪ Reality is objective and singular and apart from the researcher
Epistemological assumption	▪ The researcher invariably interacts with that being researched (either subject matter or subjects of research)	▪ Researcher is independent from the subject being researched ▪ Knowledge should be phenomena that is observable and measurable
Axiological assumption	▪ Research is value laden and biased, and it is difficult if not impossible to do away with all biases or values	▪ Research is value-free and unbiased ▪ Researchers are completely detached from the objects studied
Rhetorical assumption	▪ Research allows for the evolution or development of a voice and language that reflect the interests and positions of the subject under research	▪ Formal language and impersonal voice
Methodological assumption	▪ Use of inductive process based on an emerging research design where	▪ Deductive process based on cause and effect

	categories are identified during research ▪ Research is always context-bound and at the same time there is room for understanding the phenomena further ▪ Data sources should be verified for accuracy and reliability of the data	▪ Assumes context-free situations ▪ Generalisations may be made to allow predictions, explanations and understanding

As observed from Table 3.3, qualitative research employs a deductive approach. Therefore research strategies like case studies, grounded theory, ethnography, content analysis, in-depth interviews, focus groups, participant observations, etc., are employed (Creswell, 2012; Mack et al., 2005).

Since a quantitative approach adopts an inductive process (see Table 3.3), Creswell (2013) recommended that experiments, and surveys and pre-determined instruments which result in statistical data, should be adopted as research strategies. Table 3.4 shows the key differences between the qualitative and quantitative approaches based on the general framework, analytical objectives, question formats, and flexibility in the design of the study.

Table 3.4: Characteristics of qualitative and quantitative research- Source: (Mack et al., 2005)

Characteristics	Quantitative	Qualitative
General framework	▪ Seeks to confirm hypotheses regarding phenomena ▪ Instruments use more rigid style of eliciting and categorizing responses to questions ▪ Uses highly structured methods such as questionnaires, surveys, and structured observation	▪ Explores phenomena ▪ More flexible, iterative style of eliciting and categorizing responses to questions ▪ Semi-structured methods such as in-depth interviews, focus groups, and participant observations.
Analytical objectives	▪ To quantify variations ▪ To predict causal relationships ▪ To describe characteristics of populations	▪ To describe variations ▪ To describe and explain relationships ▪ To describe individual experience ▪ To describe group norms
Question format	▪ Close-ended	▪ Open-ended
Data format	▪ Numerical (obtained by assigning numerical values to responses)	▪ Textual (obtained from audiotapes, videotapes, and field notes)
Flexibility in study design	▪ Study design is stable from beginning to end ▪ Participants' responses do not influence or determine how and which questions researchers ask next ▪ Study design is subject to statistical assumptions and conditions	▪ Some aspects of study are flexible (for example, the addition, exclusion, or wording of particular interview questions) ▪ Participants' responses affect how and which questions researchers ask next ▪ Study design is iterative; that is, data collection and research questions are adjusted according to what is learned

Despite the clear differences between qualitative and quantitative approaches in research, researchers have recognized the benefits of employing a combination of both approaches (mixed-methods approach) (Bryman, 2012). This enables researchers to gain the benefits of both qualitative and quantitative approaches while lessening their weaknesses (Morgan, 2007; Tashakkori & Teddlie, 2003a). As explained in section 3.8.2.3, mixed-methods research fits into the pragmatist research paradigm. Therefore, a mixed-methods approach provides a variety of opportunities for the researcher to collect and analyse a wide range of qualitative and quantitative data (Creswell, 2013; Johnson & Onwuegbuzie, 2004). A comparison of different dimensions of mixed-methods against strictly qualitative and quantitative approaches is given in Table 3.5.

Table 3.5: Mixed-method Vs qualitative and quantitative approaches- Source: (Teddlie, 2009)

Dimension of contrast	Qualitative position	Mixed methods position	Quantitative position
Methods	Qualitative	Mixed methods	Quantitative methods
Researchers	QUALs	Mixed methodologists	QUANs
Paradigms (philosophical stance)	Constructivism (and variants)	Pragmatism; transformative perspective	Post positivism positivism
Research questions	Qualitative research questions	Mixed methods research questions	Quantitative research questions; research hypotheses
Form of data	Typically narrative	Narrative plus numeric	Typically numeric
Purpose of research	(Often exploratory) plus confirmatory	Confirmatory plus exploratory	(often confirmatory) plus exploratory
Role of theory; logic	Grounded theory; inductive logic	Both inductive and deductive logic; inductive-deductive research cycle	Rooted in conceptual framework or theory, hypothetical-deductive model
Typical studies or designs	Ethnographic research designs or others (e.g. case study)	Mixed methods designs, such as parallel and sequential	Correlational; survey; experimental; quasi-experimental
Sampling	Mostly purposive	Probability, purposive and mixed	Mostly probability
Data analysis	Thematic strategies: categorical and contextualising	Integration of thematic and statistical; data conversion	Statistical analysis; descriptive and inferential
Validity/trust-worthiness issues	Trustworthiness; credibility; transferability	Inference quality; inference transferability	Internal validity; external validity

3.8.4.2 Selection of a Research Approach

Having analysed the nature of the various research approaches, the current study combines both qualitative and quantitative approaches to address the research problem. Creswell (2013) and Bryman (2012) show that qualitative and quantitative approaches can be combined for the data collection, data analysis, and data interpretation stages of research. This hybrid process is normally referred to as “triangulation” by researchers.

Bryman (2012, p. 392) defines triangulation as "the use of more than one method or source of data in the study of a social phenomenon" so that findings may be cross-checked as explained by Webb, Campbell, and Schwartz (1966). Miles and Huberman (1994) outline triangulation in four different ways (see Figure 3.7).

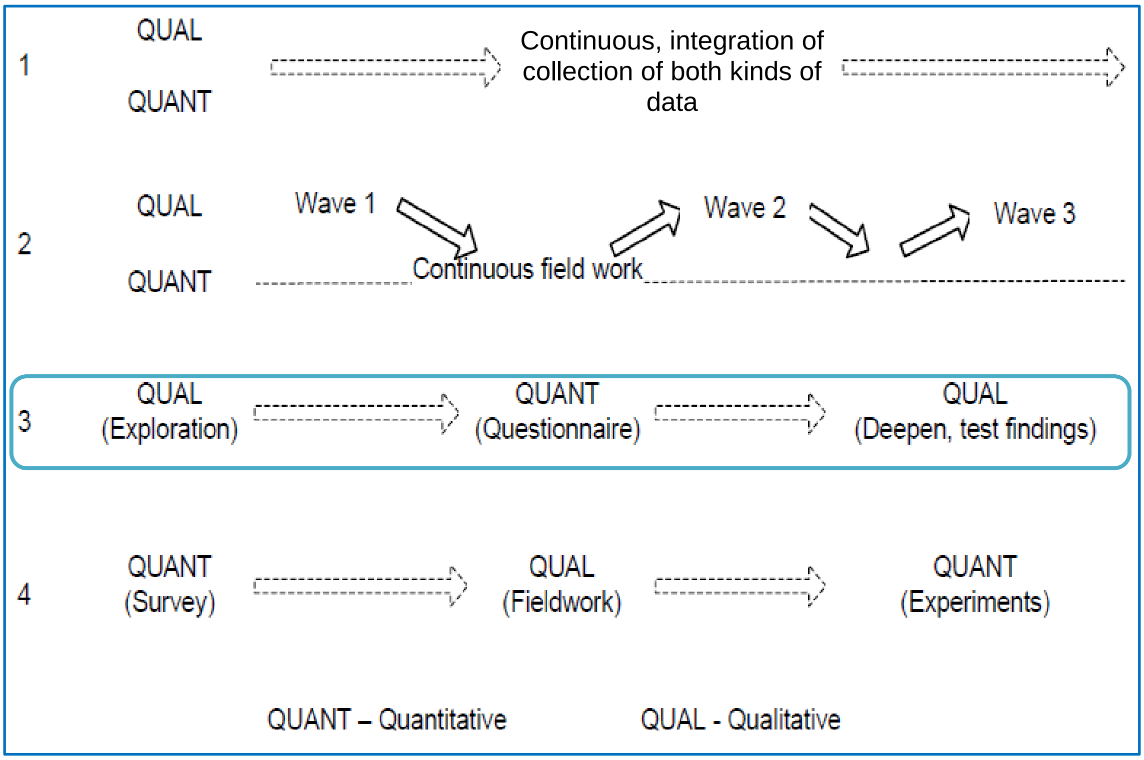


Figure 3.7: Linking qualitative and quantitative approaches

Source: (Miles & Huberman, 1994)

The first way is that both qualitative and quantitative data are collected concurrently and then both kinds of data are integrated. In the second way, multi wave qualitative data collection is conducted in parallel with continuous field work. The third way is to collect qualitative data followed by quantitative data collection. The last step of the third way is to verify the findings of preceding stages using a qualitative approach such as interviews. The last way described in Figure 3.7 is the reverse of the third way. That is, to start with a quantitative approach and carry out a qualitative approach. Finally the former two stages are validated through a quantitative approach.

As indicated in Figure 3.8, this study follows the third option shown in Figure 3.7. That is, an initial qualitative investigation on the nature of the New Zealand building materials supply chain was conducted using a qualitative approach (investigation of past literature and semi-structured interviews). This was followed by a quantitative data collection approach in the form of a New Zealand wide questionnaire survey. The constructs discovered from the first stages were quantified targeting a wide range of participants around New Zealand. A set of follow-up interviews (qualitative approach) were then conducted as a validation exercise of the research findings, which explained and revised the findings from former stages. This approach is known as a qualitative-quantitative cycle (Remler & Ryzin, 2011).

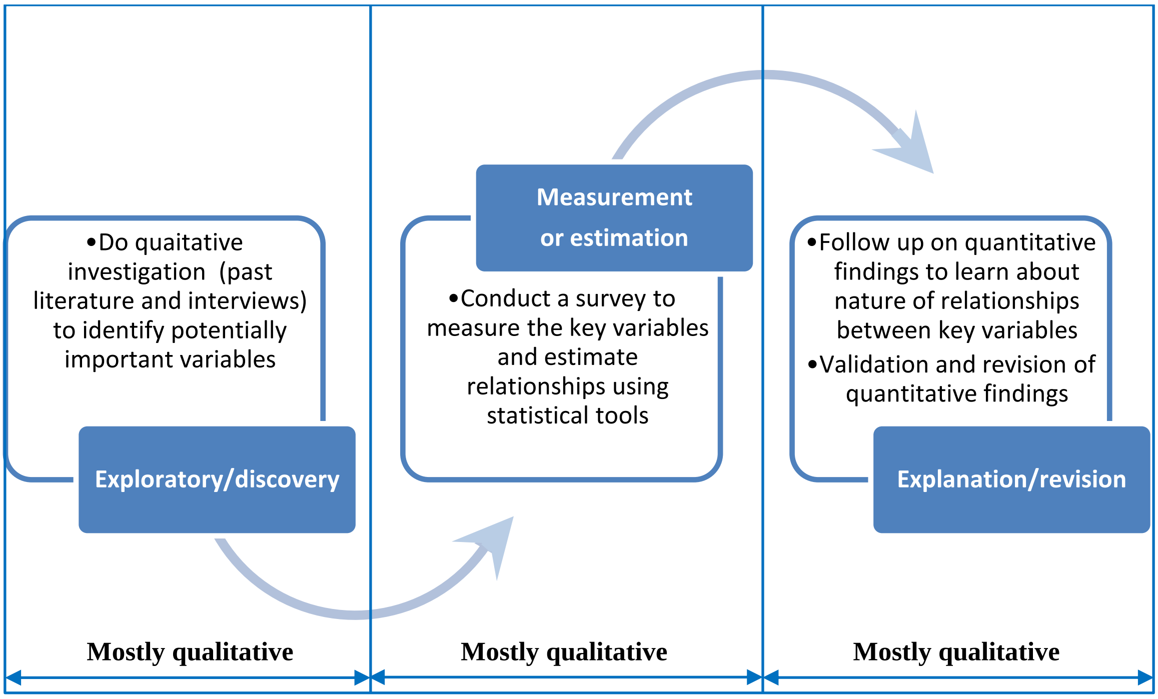


Figure 3.8: Qualitative-quantitative research cycle for the current study

Adapted from: (Remler & Ryzin, 2011)

3.8.4.3 Challenges of the Current Research Approach

Despite the great benefits of employing a mixed-methods approach for this study it is necessary to state the limitations and challenges associated with such an approach. Firstly, it is time consuming and requires significant resources as it contains both qualitative and quantitative approaches (Patton, 2002). This was particularly so in relation to conducting a wide range of personal interviews and a New Zealand-wide questionnaire survey. The integration of qualitative and quantitative approaches was challenging using different data collection and analysis methods in different phases of the research process (Bryman, 2012). Logistically, this study was extremely challenging and difficult as it employed a literature review, semi-structured interviews, a questionnaire survey (online and postal), and SME interviews, along with different data analyzing techniques throughout the research journey.

3.8.5 Research Strategies

According to Saunders et al., (2011) research strategies can be broadly categorised into experiment, survey, case study, action research, grounded theory, ethnography, and archival research. Same researchers further clarify that the selection of an applicable strategy is based on the research problem being investigated, the research philosophy, and the availability of resources within the given time frame.

However, Tashakkori and Creswell (2008) argue that the research problem, the researcher's personal experience, and the audience should all be considered as criteria for choosing a proper research strategy. In line with this, Yin (2003) demonstrated that the type of research question, the extent of control the researcher has over behavioral events, and the ability to focus on contemporary events, should all be considered in choosing a research strategy. These strategies are experiment, survey, archival analysis, history and case study (2003). Table 3.6 summarizes these strategies and discusses the applicable forms of research questions, the requirements of control over behavioural events, the degree of focus on contemporary events, and a short description of each.

This study belongs to a survey strategy and therefore it could use research questions such as who, what, where, how many, and how much (see the italic section in Table 3.6). A survey research strategy focuses on contemporary events and they are described as exploratory and descriptive research type with a wide range of data. Usually the data collection is not too expensive and data could be collected using both qualitative and quantitative approaches by employing questionnaires, structured observations, and structured interviews. The key limitations of a survey research strategy are the limited number of questions and the reduced trustworthiness and accuracy of the data.

Table 3.6: Research strategies and their applications - Adapted from: (Blaxter, Hughes, & Tight, 2010; Creswell, 2013; Leedy & Ormrod, 2001; Saunders et al., 2011; Williams, 2007; Yin, 2003)

Strategy	Form of research question	Requires control over behavioural events	Focuses on contemporary events	Description
Experiment (for exploratory and explanatory research)	How, why	Yes	Yes	▪ Natural sciences ▪ Exploratory and explanatory research
Survey (for descriptive, exploratory and explanatory research)	*Who, what, where, how many, how much*	*No*	*Yes*	▪ *Employed with exploratory and descriptive research* ▪ *A wide range of data* ▪ *Relatively cheap* ▪ *Both quantitative and qualitative approaches* ▪ *Questionnaires, structured observations, and structured interviews* ▪ *Limited number of questions* ▪ *Reduced trustworthiness, accuracy of data*
Archival analysis (for exploratory and explanatory research)	Who, what, where, how many, how much	No	Yes/No	▪ Employed with exploratory, descriptive and explanatory research ▪ Collection of data from administrative records and documents (recent and historical) ▪ Limited availability, accessibility, and preciseness of data ▪ Mostly secondary data
History	How, why	No	No	▪ Explores historical events
Case study (for descriptive, exploratory and explanatory research)	How, why	No	Yes	▪ Researcher explores an event or an activity ▪ Rich understanding of the research ▪ Interviews, participant observations, archival documents or records, and audio visual materials
Action (for explanatory research)	How, why	No	Yes	▪ Research-in-action ▪ Involvement of practitioners ▪ Iterative nature of the research process ▪ Implications beyond the immediate project ▪ Fact finding and analysis ▪ Action planning and action taking ▪ Contributes to theory development
Grounded theory (for exploratory and explanatory research)	How, why	No	Yes/No	▪ Researcher tries to derive a general, abstract theory of a process, action, or interaction ▪ Inductive approach ▪ Collects data to develop a theory (theory is grounded on data)
Ethnography (for descriptive and exploratory)	How, why	Yes/No	Yes	▪ Studying an entire group which shares a communal culture ▪ Observational data ▪ Inductive approach ▪ Flexible research process

3.8.5.1 Selection of Research Strategies for the Current Study

As observed from the list of research questions in section 3.8.3, the current research employs ‘what’, ‘how’, and ‘how much’ types of questions. For example, what are the key factors considered by manufacturers and suppliers in making their materials supply decisions? How does collaboration in the supply chain impact on improving materials supply chain practices? In terms of the research strategy, surveys have been employed in this research because they suit its descriptive, explanatory, and exploratory nature. Surveys are an effective strategy when there is a sample required to be chosen from a fixed population (Kelley, Clark, Brown, & Sitzia, 2003). A survey strategy is relatively inexpensive, which was important for this study as it had limited funding. This study employed two approaches of a survey strategy: semi-structured interviews and a nation-wide questionnaire survey.

When considering other research strategies (Table 3.6), since this research does not conduct any natural science related activities, an experimental strategy can be eliminated. Due to the unavailability and inaccessibility of recent and historical administrative records/documents on building materials procurement, an archival strategy was not applicable in this case. This study did not intend to explore any historical event, therefore a historical analytical strategy was also excluded. The use of single or multiple cases to address this research problem was inappropriate as this study requires data from a large sample size. Correspondingly, the use of action, grounded theory, and ethnography were also inappropriate for the nature of this study.

3.8.6 Research Techniques/Methods

The procedures adopted for data collection and data analysis are known as research techniques or methods (Crotty, 1998). These can be quantitative techniques or qualitative techniques depending on the type of data collection instruments, data analysis procedures employed and the type of data gathered (Saunders et al., 2007).

Mack et al. (2005) and Williams (2007) explain that quantitative data collection techniques generally employ questionnaires and graphs or statistical methods for data (numerical data) analysis procedures. Quantitative techniques are considered somewhat inflexible as all the participants are required to respond to similar sets of (usually closed) questions. Therefore, it can be argued that this rigidity could restrict participants from expressing their opinions beyond the given frame of questions (Oppermann, 2000).

As opposed to quantitative techniques, qualitative techniques usually use data collection (interviews) and analysis techniques that would generate textural data (Williams, 2007). Qualitative techniques have a significant flexibility as a researcher can closely interact with participants. Also in this case, the participants were given open-ended questions so that they could express their opinions, creating a rich context.

3.9 Research Design for the Current Study

The overall research design (see Figure 3.9) of this study is explained in line with the ‘research onion’ concept proposed by Saunders et al. (2007). The research philosophy belongs to the pragmatist paradigm as was discussed in section 3.8.3. This research uses both qualitative and quantitative approaches (see section 3.8.4.2). Surveys are employed as research strategies comprising both qualitative (interviews) and quantitative (questionnaire survey) methods. In terms of the research process, the study began with interviews which were then followed by questionnaire surveys to gather information from a wider spectrum of stakeholders in the BMSC. Having positioned the research design, subsequent sections of the chapter discuss the data collection process for this study.

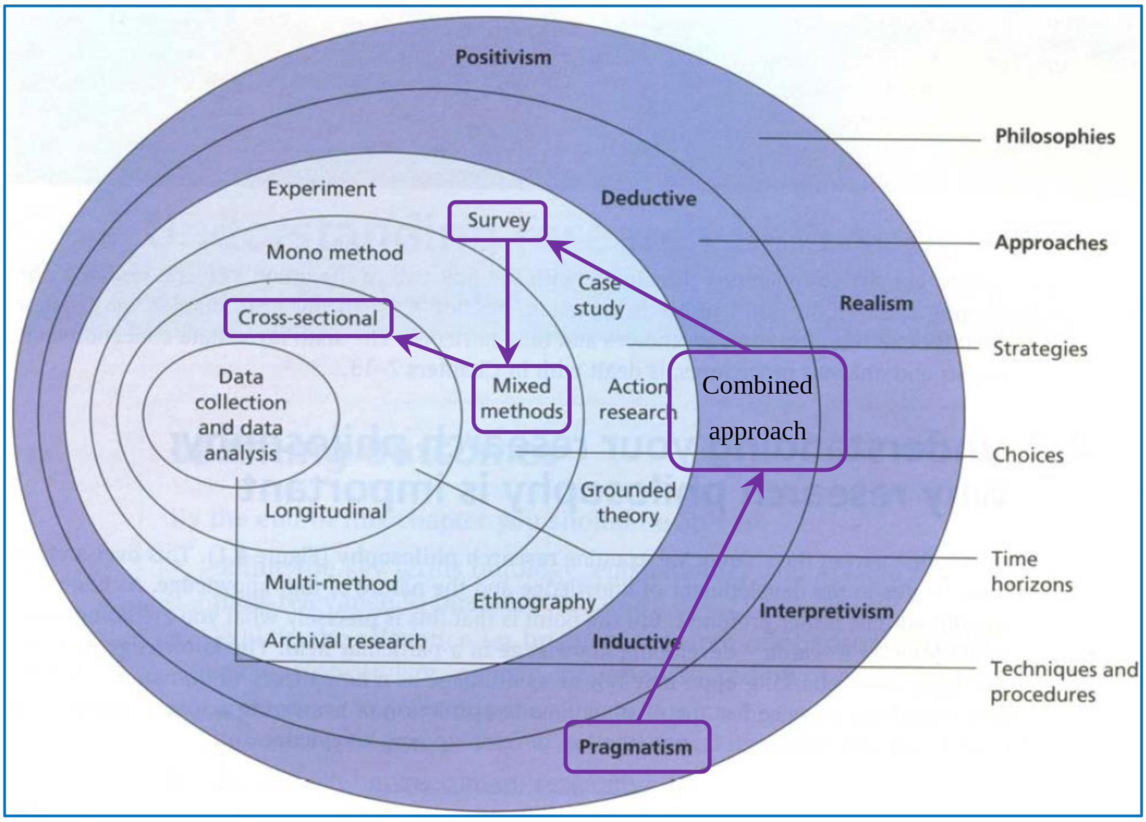


Figure 3.9: Research design for the current study in line with 'the Research Onion' concept

Adapted from: (Saunders et al., 2007)

3.9.1 Data Collection

As was previously explained, the current study uses mixed-methods research approach with both qualitative and quantitative data collection conducted in three phases. In addition the study used both qualitative and quantitative data analysis techniques. The first phase of the data collection process involves the review of the past literature on the research problem investigated, and conducting semi-structured interviews. This first phase was useful to identify the possible answers to some of the research questions. The semi-structured interviews were limited to the Auckland region due to the limitations of funding and time. Extensive and rich qualitative data were gathered (based on the research questions) from those interviews. The qualitative information gathered was then followed by a New Zealand wide questionnaire survey. The questionnaire survey aimed to measure the significance of variables derived from the interviews. This was the second phase of the data collection process. The final phase of data collection was aimed at validating and extending the findings from the questionnaire survey. The research validation exercise was conducted usingSMEs in the form of semi-structured interviews. These three phases of the data collection process are individually discussed in subsequent sections.

3.9.1.1 Phase 1 - Semi-structured Interviews

The aim of conducting interviews is to gather rich and experiential data on the research questions asked. Analysis of the responses will help to determine how and why participants think in the way they have responded. Punch (2005) argued that interviews provide an in-depth understanding of what people think about a particular research question. In addition, interviews could provide a relatively higher response rate (R. Kumar, 2005). Qualitative interviews can be unstructured, semi-structured, or structured, depending on the degree of question standardization (DiCicco-Bloom & Crabtree, 2006; Matthews & Ross, 2010). Table 3.7 shows the characteristics of these three types of interviews.

Table 3.7: Characteristics of different types of interviews - Adapted from: (Fellows & Liu, 2008; Kumar, 2005; Naoum, 2007; Sekaran, 2005)

Unstructured interviews	Semi-structured interviews	Structured interviews
No planned sequence of questions	Questions are structured to a certain extent	Standardised and pre-determined questions
Flexible	More formal compared with unstructured interviews	Higher reliability and repeatability
Preliminary issues can be identified	Flexible	Uniform information of findings
Difficult to analyse		Findings are describable and quantifiable
Need further investigation for clarification		Specific problems can be identified

Interview techniques have limitations: they are time-consuming; are expensive; have the possibility of bias in the researcher/interviewer; and depend on the quality of the interaction and the quality of the interviewer (Saunders et al., 2007; Sekaran, 2005).

This research used semi-structured face-to-face interviews because they allow the research findings to be expanded by modifying the research questions during interviews (Denscombe, 2003; Myers & Newman, 2007), while also maintaining the focus of the study. The foundation of the semi-structured interviews was formed based on the literature review conducted on the research questions established. This research administered 30 semi-structured interviews in phase 1 of the data collection process.

These interviews aimed to develop the questionnaire survey constructs in line with the literature findings (the second phase of the data collection process).

The time and place for the interviews were decided by prioritizing the convenience of the participants. The researcher personally guided participants through telephone conversations or by E-mail about the research project. All the necessary documents including the participant's information sheet, consent form, and indicative questions detailed in Appendix - 2 (C-G) were sent to participants one week prior to interviews, and written consents (Appendix - 2 (A)) were obtained from the participants before the interviews were conducted. Interviews were approximately 30 minutes long.

Fowler (2009, pp. 117-118) developed the following guidelines on the role of the researcher when conducting interviews, which was applied in this research.

1. To locate and enlist the cooperation of selected respondents

2. To train and motivate respondents to do a good job of being a respondent (for example, interviewers read the questions slowly to respondents, and in a nonverbal way, show their willingness to take the time to obtain thoughtful, accurate answers)

3. To ask questions, record answers, and probe incomplete answers to ensure that answers meet the question objectives

All interviews were audio recorded and notes were made where necessary. This enabled the researcher to easily transcribe the interviews. Also an audio recording of interviews provided a higher degree of reliability and validity of research findings, as direct quotes from interviews could be included when the research findings were reported. All the interviews were transcribed by the researcher using "express scribe' transcribing software.

3.9.1.2 Phase 2 - Questionnaire Survey

Questionnaires are appropriate data collection techniques in survey research strategy. They can be used to generate responses from a large number of participants using standardised questions (Saunders et al., 2007). In line with Saunders et al. (2007), questionnaires were used in the current study to extend knowledge gained from the first phase of data collection (literature review and semi-structured interviews).

A number of research studies conducted in the New Zealand construction industry have showed the appropriateness of questionnaires as data collection techniques. For instance, a study conducted to determine the nature and issues in New Zealand SCM practices used a postal survey among manufacturers (Basnet, Corner, Wisner, & Tan, 2003). In addition, Chilli Marketing (2010) conducted a questionnaire survey among subcontractors and contractors to examine payments issues in the New Zealand construction sector. Recently Ramachandra (2013) also used a questionnaire survey administered to consultants, contractors and subcontractors to extend knowledge of payment problems in the New Zealand construction industry. Moreover, Rotimi, Tookey, Rotimi, and Craig (2011) investigated the extent of snagging problems in the New Zealand residential construction industry through semi-structured questionnaires administered to new homeowners. These studies indicate that questionnaires would be appropriate for use in the current study.

Saunders et al. (2007) explain that questionnaires can be either self-administered or interviewer-administered. Self-administered questionnaires are further categorised into internet-administrated, postal and delivery and collection types, while interviewer-administered questionnaires are categorised as telephone or structured interview questionnaires. When the nature of the materials supply chain is explored, the questionnaire survey should be conducted across the supply chain in New Zealand. This shows the need for a large survey sample around the whole country. Therefore, this study chose a self-administered questionnaire as the medium of quantitative data collection as it was unfeasible to conduct an interviewer-administered questionnaire.

In order to address the research questions, it was necessary to engage building materials manufacturers/suppliers, building contractors, architects in the New Zealand residential construction sector, and new homeowners, in the survey. Based on the applicability of the research questions on these different groups of participants, it was decided to administer four versions of the questionnaires. For the manufacturers/suppliers, contractors, and architects, an online questionnaire was selected as these are contactable via e-mail or other online media. However, for the homeowners a postal survey was chosen as these participants were not reachable through online media. Table 3.8 presents the different attributes of these two (online and postal) selected questionnaire types in the current study.

Table 3.8: Main attributes of questionnaires used in the current study- Adapted from: (Saunders et al., 2007)

Attribute	Internet and internet mediated	Postal
Population's characteristics for suitability	Computer-literate individual who can be contacted by email internet or intranet	Literate individuals who can be contacted by post, selected by name, household, organization, etc.
Confidence that right person has responded	High if using email	Low
Likelihood of contamination or distortion of respondent's answer	Low	May be contaminated by consultation with others
Size or Sample	Large, can be geographically dispersed	
Likely response rate	Variable: 30% reasonable within organizations/via intranet, 11% or lower using internet	Variable, 30% reasonable
Feasible length of questionnaire	Conflicting advice; however, fewer 'screens' probably better.	6-8 A4 pages
Suitable types of question	Closed questions but not too complex; complicated sequencing fine; if using IT, must be of interest to respondent	Closed questions but not too complex; simple sequencing only; must be of interest to respondent
Time taken to complete collection	2-6 weeks from distribution (dependent on number of follow-ups)	4-8 weeks from posting (dependent on number of follow-ups)
Main financial resource implications	Web page design, although automated expert systems providers are reducing this dramatically	Outward and return postage, photocopying, clerical support, data entry
Data input	Usually automated	Closed questions can be designed so that responses may be entered using optical mark readers after questionnaire has been returned

It should be noted that internet administered or postal surveys are also considered as economic, fast, and anonymous, are private and cover a wide geographical area. In contrast they could also have a systematic bias, be low in in-depth information, and have a low response rate (Babbie, 2012; Bird, 2009). Having identified the limitations of survey methods, the current study attempted to minimise them in the stages of sampling, designing, and administering the questionnaire survey.

Designing the Questionnaire Survey

The questionnaire survey for the current study was designed based on the following criteria.

- The purpose of the study and the information needed to achieve the research's overarching aim
- The nature of the participants and the knowledge that they held pertinent to the questionnaire

- The required data (every question must have a purpose)
- The analysis procedures to provide outputs that relate to the project objectives
- The format of questions so that they are easy to understand and where all information obtained is of value

The main structures of the four versions of the questionnaire (see Appendix 3 (C-F)) are given in Table 3.10. It should be noted that section A was different to each participant group. Sections B to E had some common questions as well as different questions for each participant group. Chapter 5 discusses the applicability of each section and each question for each participant group.

Table 3.9: Structure of the questionnaire

<table>
<tr><th>Participant group</th><th>Section A</th><th>Section B</th><th>Section C</th><th>Section D</th><th>Section E</th></tr>
<tr><td>Manufacturers/ suppliers (Appendix 3 (A))</td><td>Building materials supply practices</td><td rowspan="4">Issues in the construction supply chain</td><td rowspan="4">Suggestions for improving the building materials supply chain</td><td rowspan="4">Collaboration in the building materials supply chain</td><td rowspan="4">Demographic data</td></tr>
<tr><td>Contractors (Appendix 3(B))</td><td>Building materials purchasing practices</td></tr>
<tr><td>Architects (Appendix 3(C))</td><td>Building materials selection practices</td></tr>
<tr><td>Homeowners (Appendix 3(D))</td><td>Building materials selection practices</td></tr>
</table>

Throughout the questionnaire, except for the demographic data, a five point Likert scale was employed to rate the given constructs under each section as shown in Table 3.10. A five point Likert scale was chosen as it allows participants to state their views across a reasonable scale (five points) rather than very tight (three points) or a very wide (nine points) scale of options. Therefore, a five point scale is the most preferred and popular Likert scale type (Saunders et al., 2007).

After the questionnaire was designed, it was revised by research supervisors and another associate professor from AUT who is an expert in the area of business research methods. Also the questionnaire was proof-read by a professional proof reader.

3.9.1.3 Phase 3 - SMEs' Interviews

This research examines the nature of the New Zealand building materials supply chain and suggests potential recommendations to improve the current supply chain. SME interviews were employed to validate and extend the research findings from phase 1 (semi-structured interviews) and phase 2 (questionnaire survey) and to check whether suggested solutions could be applied in practice. This is in line with Wass and Wells (1994), who recommend that semi-structured interviews would be applicable to validate questionnaire findings. On a similar note, King (1994) suggests that semi-structured interviews are the best way to validate research findings from a questionnaire survey.

A validation exercise of the current study was conducted with four SMEs. The SMEs were selected based on their expertise and experience in the New Zealand building materials supply chain. Further, the SMEs were defined as any personnel with management roles such as Chief Executive Officer, Chief Operating Officer, Managing Director, and General Manager (more information on the SME profile of participants is given in chapter 6).

A similar procedure as discussed in section 3.10.1.1 was followed to arrange the interviews. A structured questionnaire (see Appendix 4 (C-F)) was directed to all SMEs for their comments before interviews took placed. The questionnaires contained the outlines of key research findings and recommendations derived from the semi-structured interviews (phase 1), and questionnaire survey (phase 2). Information collected from this validation exercise further strengthened and improved the research findings from phase 1 and phase 2. This also helped to enhance the research triangulation with phase 1 (qualitative) and phase 2 (quantitative) approaches.

3.9.1.4 Sampling Approach

Understanding appropriate sampling techniques for any research enables the researcher to plan the data collection and analysis stages. Patton (2002) shows that predominantly, there are two sampling approaches; probabilistic and non-probabilistic sampling. Probabilistic sampling involves randomization to ensure that all elements in the population have some chance of being included in the sample. Moreover, the mathematical probability that any one element chosen can be calculated.

Nonprobability sampling selects population elements according to what specifically the researcher is looking for, and the availability of such population elements (Babbie, 2012; Bryman, 2012). However, it cannot be argued that nonprobability sampling is not representative of the population selected, and it is independent from the probability theory (Jackson & Trochim, 2002).

Babbie (2012), Gray (2009), and Neuman (2006) comment that the selection of an appropriate sampling strategy depends on the scope of the study and the research methods employed. In this context, the study reported here employed a nonprobability sampling technique. The first phase of this study employed snowball sampling for its semi-structured interviews. The second phase (questionnaire survey) of this study used purposive sampling. Again, for the third phase of the study (SME interviews), purposive sampling was used. The following paragraphs explain the specific sampling techniques used in each phase of this study.

Semi-Structured Interviews – Snowball Sampling

A snowball sampling strategy was used in the interviews to grow the number of interviews to 30, which is in line with Bryman (2012). Snowball sampling makes contact with a small group of participants in line with the data collection criteria of the study. These individual participants are then requested to identify any other prospective participants appropriate for the study (Kumar, 2005). This process continuous until the data saturation point is achieved. Therefore an initial number of interviewees were consulted, who then proposed other interviewees who had similar experience and characteristics, to participate in the research. At the beginning of the qualitative data collection there was no sampling frame to identify the research participants in the Auckland region, based on the experts in the subject area. New homeowners (houses built in 2011 or 2012) who had active roles in materials selection were selected for the semi-structured interviews. This shows that probability sampling was impossible and clarifies why a snowball sampling technique was employed instead (Noy, 2008).

As explained above, the sample size of a qualitative study should be selected in such a way that data saturation is achievable with the selected number of participants. Therefore, a sample size should not be too small or too large (Onwuegbuzie & Collins, 2007). The sample size for the current study was 30 (see chapter 4 for more details on the participants' profiles). This sample size (30) was considered adequate for the problem being investigated. The interviewees represent all of the major groupings of stakeholders in the BMSC. The sample size also sits within the range of samples normally employed in PhD interviews. Mason (2010) established that the mean sample size of 31, and median of 28 was normal in PhD studies undertaken in the UK and Ireland.

Questionnaire Survey – Purposive Sampling

The study reported here directs a particular group or population (homeowners, architects, building contractors, and building materials suppliers). Taylor-Powell and Hermann (2000) showed that a survey is most effective for the aforementioned situation. Therefore, the research participants identified to be appropriate to this study were purposively selected (Bird, 2009; Teddlie & Yu, 2007). The current study considered its purpose, budget, and timeframe for the purposive sampling technique.

The questionnaire sample sizes of this study were calculated considering the key players who belonged to the participant groups in the New Zealand residential building industry. Various trade associations and professional associations were considered as sources for selecting participants. The researcher ensured that recruited participants (firms) represented small, medium, and large companies with at least five years' experience in the New Zealand construction industry. These requirements were verified through their web sites. Cochran formulas for continuous data were used to calculate the sample sizes for each population group identified (Bartlett, Kotrlik, & Higgins, 2001).

$$\boldsymbol{n = (t^2 \times s^2)/d^2}$$

Equation 3.1: Minimum sample size (n)

$$N = n/1 + (\frac{n}{population})$$

Equation 3.2: Adjusted sample size (N)

Adapted from: (Bartlett et al., 2001)

Where:

t = 1.96 (value for selected alpha level of 0.025 in each tail t is 1.96 (the alpha level of 0.05 indicates the level of risk the researcher is willing to take, and that true margin of error may exceed the acceptable margin of error)).

s = 1.25 (estimate of standard deviation in the population. Estimate of variance deviation for 5 point scale calculated by using 5 (inclusive range of scale) divided by 5 (number of standard deviations that include almost all (approximately 98%) of the possible values in the range).

d = acceptable margin of error for mean being estimated = 0.03

N = sample size

The sampling method adopted to elucidate the sample size for each category of people is discussed below:

a) Manufacturers/suppliers

A total of 137 building materials manufacturers/suppliers including BMs were recruited in the sample. This sample was drawn from the Cement & Concrete Association of New Zealand (CCANZ), the Association of Wall and Ceiling Industries of New Zealand (AWCINZ), the Claddings Institute of New Zealand (CINZ), VicDir information system, and the Yellow Pages.

b) Contractors

A total of 158 residential building contractors were recruited in the sample. This sample was drawn from the 2011 Whats On report (top new house builders), the 2012 BRANZ study report (top builders by consents 2012), the Construction Strategy Group (CSG), the Building and Construction Industry Training Organisation (BCITO), VicDir information system, and the Yellow Pages.

c) Architects

According to equation 3.1 and 3.2, 185 participants were randomly selected out of 600 registered architects from the New Zealand Institute of Architects (NZIA).

d) Homeowners

According to equations 3.1 and 3.2, 144 participants around New Zealand were randomly selected out of 314 new homeowners obtained from the “Whats On” report 2011 (building consents). Table 3.9 summarises the selection of the questionnaire survey sample for this study.

Table 3.10: Survey sample

Participant group	Population source	Population identified	Medium of distribution	Number of questionnaires distributed
Manufacturers /suppliers	▪ CCANZ ▪ AWCINZ ▪ CINZ ▪ VicDir information system ▪ Yellow Pages (http://yellow.co.nz)	137	Directly administered to selected participants through survey monkey	137
Contractors	▪ WhatsOn report 2011(http://www.whatson.co.nz) ▪ BRANZ study report-new house owners' satisfaction survey 2012 ▪ CSG ▪ BCITO ▪ VicDir information system ▪ Yellow Pages (http://yellow.co.nz)	158	Directly administered to selected participants through survey monkey	158
Architects	NZIA	600	Directly administered to NZIA members through survey monkey	185
Homeowners	WhatsOn report-building consents 2011(http://www.whatson.co.nz/)	314	Directly administered to homeowners by post	144
Total		**1209**		**624**

SME Interviews – Purposive Sampling

Sugar and Schwen (1995) argue that SMEs should be chosen as individual experts in their field of activities. Therefore, the current study used a purposive sampling technique to select four SMEs: a senior executive of a leading building materials manufacturing and supply company, a senior management position of a residential construction company, a residential architect representing the New Zealand Institute of Architects (NZIA), and a senior executive of the Home Owners and Buyers Association of New Zealand (HOBANZ). These four participants are experienced building industry professionals with expertise and in-depth knowledge of the issues associated with building materials use in residential construction. Table 6.1 in Chapter 6 shows the demographic information of the SMEs.

3.9.2 Data Analysis

Data analysis refers to a body of methods that helps describe facts, search for patterns, develop explanations, and test hypotheses in collected data, which results in identification of recurrent behaviours and objects. Neuman (2003) identified that the process of data analysis comprises examining, sorting, categorizing, evaluating, comparing, synthesizing, and contemplating information in reviewing raw and recorded data. This chapter presents the data analysis process and techniques used to analyse the qualitative data collected from semi-structured interviews and SME interviews, and the quantitative data collected from the questionnaire survey.

3.9.2.1 Qualitative Data Analysis

The current study conducted 34 interviews (30 semi-structured interviews and 4 SME interviews) within the New Zealand residential building sector to explore the nature of the building materials supply chain. Interviewees were selected from various personnel linked in the supply chain. They were materials manufacturers, suppliers, contractors, architects, and homeowners. Analysis of the data from these interviews (interview transcripts) was used to identify key themes that emerged from participants. The current study employed content analysis to systematically identify the characteristics of the participants' views. The content analysis was conducted using NVivo 10 software.

The researcher considers free flowing text as qualitative data because of the exploratory and semi-structured nature of interviews. Code based analysis and word based analysis are two free text flowing data analysis methods introduced by Ryan and Bernard (2003), based on codes as units of analysis (code based), and words as units of analysis (word based).

Code Based Analysis

When texts are analysed based on codes, a link between theory and empirical data is created. This allows conclusions to be drawn with rigorous transparent analysis (Ryan & Bernard, 2003). Grounded theory, content analysis, and schema analysis are categorised under code based analysis. Grounded theory aims to generate or discover a theory (Glaser & Strauss, 2009), and develops analytical codes and categories from the data itself and not by pre-existing conceptualisations. Content analysis searches for the occurrence and frequency of specific words or phrases within texts and explains and justifies the reasons for their presence (Krippendorff, 2004). Schema analysts seek for metaphors of word repetitions and content shifts (Agar & Hobbs, 1985).

Generally, results generated from code based analysis are presented in frequency tables and cross tabulations and can result in poor data displays (Miles & Huberman, 1994). The key idea in this analytical method is that the researcher defines codes, or prior established codes are connected with qualitative data. In addition, pre-established codes force qualitative data to be categorised under pre-defined themes. As this could prejudice the data, it is considered a principle limitation of code based analysis (Jackson & Trochim, 2002).

Word Based Analysis

In word based analysis, the natural meanings rooted in free flowing text are reflected to make sense of the text (Carley & Palmquist, 1992). For example, key words in context, semantic networks, and cognitive maps. Word based analysis places emphasis on semantic or meaningful relationships (Colorado State University, 2006). Therefore, word based analysis takes into account the words formed by interview participants, and recognises the relationships in the form of maps within the particular transcript and within other transcripts (Carley, 1997). Therefore, it is clear that word based analysis permits different relationships to develop from interview transcripts themselves, rather than the researcher identifying relationships based on his/her views as in the case of code based analysis.

Code Based Analysis vs Word Based Analysis

This section explains the use of code based and word based analysis in the current research. It can be established that the researcher's prejudice regarding the qualitative data analysis is minimal in word based analysis compared to code based analysis. In addition, word based analysis facilitates opportunities to identify the relationships between concepts, which is not a feature of code based analysis. However, the underlying concepts should be primarily identified by the researcher. Therefore, a researcher's judgement could be influenced when building concepts from free flowing text (Ryan & Bernard, 2000b). Perhaps the key disadvantage of word based analysis is that the transparency of identifying concepts is fairly low.

The strengths and weaknesses of both code based and word based analysis have been discussed above. A combination of both word based analysis and code based analysis was used for this study to minimise the weakness of using just one method of qualitative data analysis. However, these analysis techniques represent relationships between concepts, and drawing conclusions from them is entirely up to the researcher. For this study, firstly a code based analysis was carried out on the interview transcripts to generate the main themes in the qualitative data, as this increases the transparency of identified main themes. Secondly, a word based analysis was carried out to find out how important was each theme generated from the code based analysis. Code based analysis was conducted as a content analysis while word based analysis was conducted in terms of how many times interview participants refereed to a particular theme. With this in mind, the next section presents the content analysis of the semi-structured interview transcripts.

Content Analysis

The definitions of content analysis came from (Berelson, 1952) and Holsti (1969) respectively (Bryman, 2008). Berelson (1952, p. 55) states "content analysis is a research technique for the objective, systematic and quantitative description of the manifest content of communication". Holsti (1969, p. 14) defined content analysis as "any technique for making inferences by objectively and systematically identifying specific characteristics of messages".

As can be seen from the definitions of content analysis, they contain ideas of quantification, inference, objectivity, and systematisation. It was encouraging to compare this argument with Franzosi (2004) and Krippendorff (2004) who provide similar definitions for content analysis. The next section compares content analysis in terms of word count and thematic analysis.

Categorisation of Content Analysis

Past literature shows that there are various ways of categorising content analysis. Table 3.11 shows a summary of how different authors have categorised content analysis. It describes the characteristics of both word count and thematic analysis. The table also provides the constraints of word count.

Table 3.11: Categorisation of content analysis

Types of content analysis	Description	Constrains
Word count (Krippendorff, 2004)	▪ Counting the frequency of words assuming that high frequency of word count signifies particular concerns	▪ Use of synonyms would underestimate particular concerns (Weber, 1990) ▪ Misleading of multiple meanings (Stemler, 2001)
Thematic analysis/conceptual analysis (Krippendorff, 2004)	▪ Scrutinising the text in order to discover the existence and frequency of a concept/theme (Colorado State University, 2006; Krippendorff, 2004) ▪ Major themes generated are positioned into codes (Colorado State University, 2006) ▪ The major themes in the text are categorised into codes (Franzosi, 2004) ▪ Similar perceptions under the same concepts are discovered (Swan, 1997) ▪ Occurrence of selected terms which could be implicitly or explicitly related to the themes within the text is identified (Colorado State University, 2006)	

The current study intends to explore the nature of the New Zealand residential building materials supply chain for its strengths and weaknesses. In addition, the study seeks to find possible improvements based on the suggestions provided by the interview participants (manufacturers, suppliers, contractors, architects, and homeowners). Thus the study integrates the insights of different groups of participants on the nature of the materials supply chain in order to accomplish better performance. With this in mind, pure word based analysis would be inappropriate to establish themes from the interview transcripts. Conceptual content analysis was selected to generate the main themes from the semi-structured interviews, and word count analysis was used to show the strengths of some of the themes generated, where appropriate.

Coding in Content Analysis

Stemler (2001) argues that coding and categorization in content analysis would make for expressive and rich results. This idea is in agreement with Ryan and Bernard (2000a) who stated that “coding is the heart and soul of whole text analysis”. Similarly Weber (1990, p. 37) stated that “category is a group of words with similar meanings or connotations”. Therefore, it is very important to focus on building and defining categories and codes in content analysis. Initially concepts should be identified through past literature analysis and the researcher’s experience in the subject area. These concepts should be used to develop categories and codes. This shows that coding is a process that should be done prior to data collection. However concepts, categories, and codes can be developed by text itself as well. That is to say coding can be done after the data collection. Therefore, coding is a process which could be identified before, during and after the qualitative data collection (Ryan & Bernard, 2000a, 2003).

Another perspective on data coding was proposed by Bernard (2000, p. 446) stating "coding is data reduction not proliferation". The number of codes should be decided and managed properly in order to generate meaningful results. Having an excessive number of codes would make the data analysis process over complicated, while having an insufficient number of codes would result in untrustworthy results (Palmquist, 2006). The development of categories and codes should be carried out by the words and phrases directly taken from the original text and this is referred to as in-vivo coding (Bernard, 2000). The next section describes the two main approaches of coding, inductive coding and deductive coding (Bernard, 2000; Krippendorff, 2004; Mayring, 2000), which are also known as emergent and a priori coding (Stemler, 2001).

Deductive Coding and Inductive Coding

In deductive coding, categories and codes are built based on a particular related theory and are linked with text (Bernard, 2000; Mayring, 2000; Stemler, 2001). The deductive approach is appropriate at the confirmatory phase of research (Bernard, 2000; Mayring, 2000). Therefore, data analysis is convenient due to the prearranged categories and codes. However, deductive coding has the weakness of avoiding concepts and categories which do not fit with pre-arranged categories. In inductive coding, categories and codes are generated from the text itself rather than based on theories. This technique suits the investigative phase of research (Bernard, 2000; Mayring, 2000) and has been used in grounded theory.

Coding Techniques Adopted in the Current Study

Considering both strengths and weaknesses of inductive and deductive coding, Miles and Huberman (1994) suggest coding the text using principles of both inductive and deductive methods. Consequently, some of the categories and codes should be based on past literature and other categories and codes can be established from the text itself. The coding of the current study was done using both deductive and inductive approaches to make the best use of both coding methods.

Software for Qualitative Data Analysis

There have been many computer software applications developed over recent years to facilitate qualitative data analysis. These include making notes, data display and building theories (Weitzman, 2003). Table 3.12 shows how different types of computer-assisted data analysis techniques support different types of researchers.

Table 3.12: Types of computer-assisted qualitative data analysis - Source: (Weitzman & Miles, 1995)

Type of researcher	Type of computer-assisted qualitative data analysis
Text retrievers	Search for words or phrases
Textbase managers	Sort and organise data
Code and retrieve	Support coding and reporting by codes
Code-based theory builders	Coding and the ability to build conceptual structures and test hypotheses
Conceptual network builders	Diagrams, concepts mapping, charts

However, Weitzman (2003) further says that computer aided software only assists the researcher's logical efforts rather than directly building theories by itself. This argument is consistent with Silverman (2005), who believed that computer software needs to be used wisely given that it has both strengths and weaknesses. As an advantage, with the aid of computer software, a large volume of data could be easily managed. In addition, a variety of options available for manipulating and displaying texts further strengthens the advantage of using computer software (Robson, 2002). Moreover, computer software packages offer a central location to store different types of qualitative data together (e.g. interview transcripts, category definitions, interpretations, comments, etc.) (Mayring, 2000; Robson, 2002). Therefore, the data analysis becomes more comprehensive, transparent and repeatable with a higher degree of reliability and validity (Mayring, 2000)

In contrast, the use of computer aided software can diminish the creativity of researchers. According to Weitzman (2003), the use of computer software for qualitative data analysis may not allow researchers to go through a proper learning process. In this circumstance the researcher has agreed with the inherent concepts of a computer software programme in order to analyse a large volume of data and to handle tedious tasks.

Selecting Appropriate Software

Nowadays, there are number of software programmes available for the analysis of qualitative data including ATLAS.ti, HyperRESEARCH, MAXQDA, NVivo, Decision explorer, and QSR N6. These software programmes are generally referred to as computer-assisted (or computer-aided) qualitative data analysis software (CAQDAS) (Bryman, 2008). Lewins and Silver (2006) and Saunders et al. (2007) suggested that the following aspects should be well thought out when choosing software for qualitative data analysis.

- The amount of data to be analysed
- Time available for the analysis
- Knowledge of the software
- Computer operating system and its capacity
- Data analysis approach (deductive or inductive)
- The adopted research methodology

Lewins and Silver (2006) also suggested that the selection of computer aided software for qualitative data analysis is subjective and is based on the above factors. As discussed previously, the researcher employed a software package to manage the qualitative data collected from the semi-structured interviews. QSR NVivo 10 was used as the qualitative data analysis software in this study, due to the satisfaction of the requirements in analysing semi-structured interviews. Selection of this software package was based on the availability, training and support received from the university, and on past literature. The following subsections explain the data analysis method that was carried out using NVivo 10.

QSR NVivo 10

NVivo is a software package designed by QSR international. NVivo functions in two different ways. Firstly, it provides for storage and for manipulation of texts. Secondly, it supports the creation and manipulation of codes (nodes in NVivo) for data management in qualitative data analysis, such as ideas management, organization, asking questions, generating graphical models, and reporting (Depoy & Gitlin, 2005; Stebbins, 2001), irrespective of the type of research methodology adopted (QSR International, 2013). The NVivo 10 programme was used in the current study for the following reasons:

- The number of semi-structured interviews (30) conducted, generating information that was too large and complex to manage manually (nearly 300 pages of interview transcripts)

- The rigorous and comprehensive data analysis tools inbuilt in NVivo 10 to manage, explore, and find patterns in qualitative data (QSR International, 2013).
- The facilitation of memos which help in tracking the analytical process with increased transparency and reliability for the research findings (QSR International, 2013).
- The provision of rapid accessibility to all the codes created allowing efficient revision work.
- Provision of retrieval of codes.

NVivo 10 offered easy access to all the project materials such as interview transcripts, audio files, references, and other documents through its workspace. Figure 3.10 displays the NVivo 10 workspace with its functions. As shown in Figure 3.10 above, within the NVivo workspace there are three main views. The navigation view (as shown in Figure 3.12) allows organising and accessing of project items. The list view displays the contents of folders selected in the navigation view and also allows the addition of new items, plus the opening/editing of existing items. The detail view displays the contents of opened items (e.g. documents).

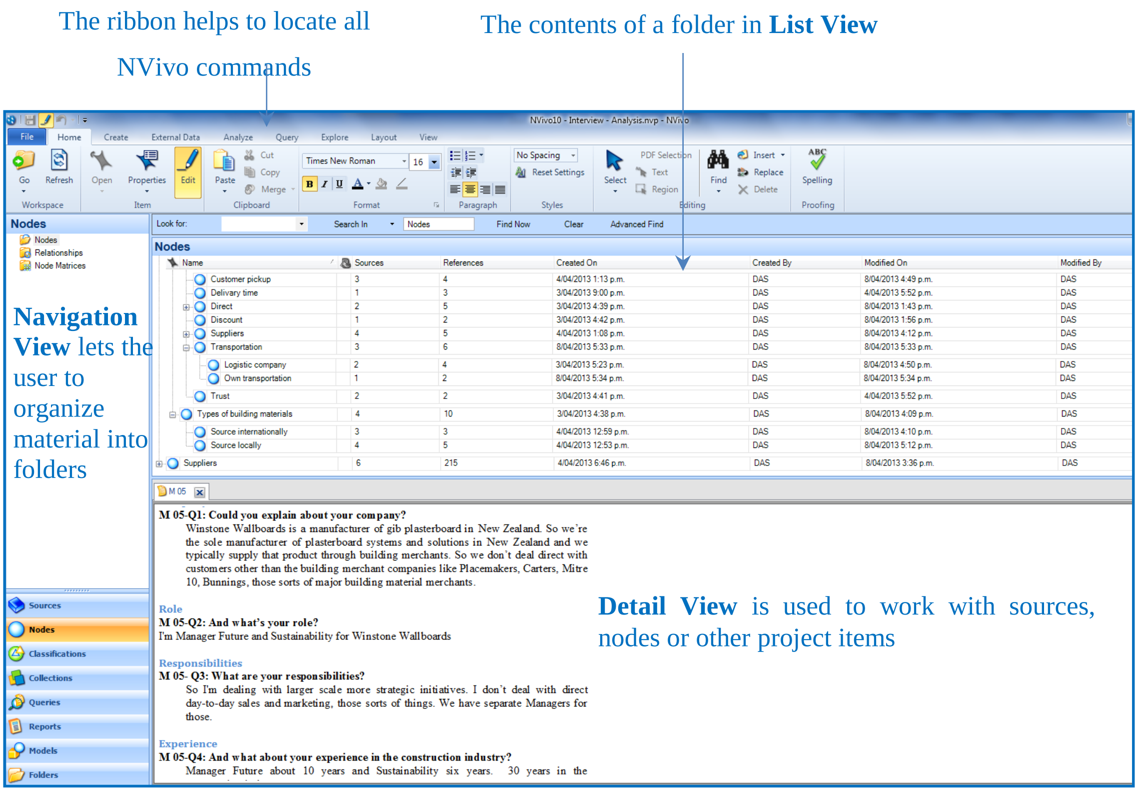


Figure 3.10: NVivo 10 workspace

The ribbon bar (as shown in Figure 3.11) in the workspace is designed for locating commands. Commands are grouped together under tabs, and each tab has a specific activity, for example creating a new project or exploring data with charts, maps, models, etc.

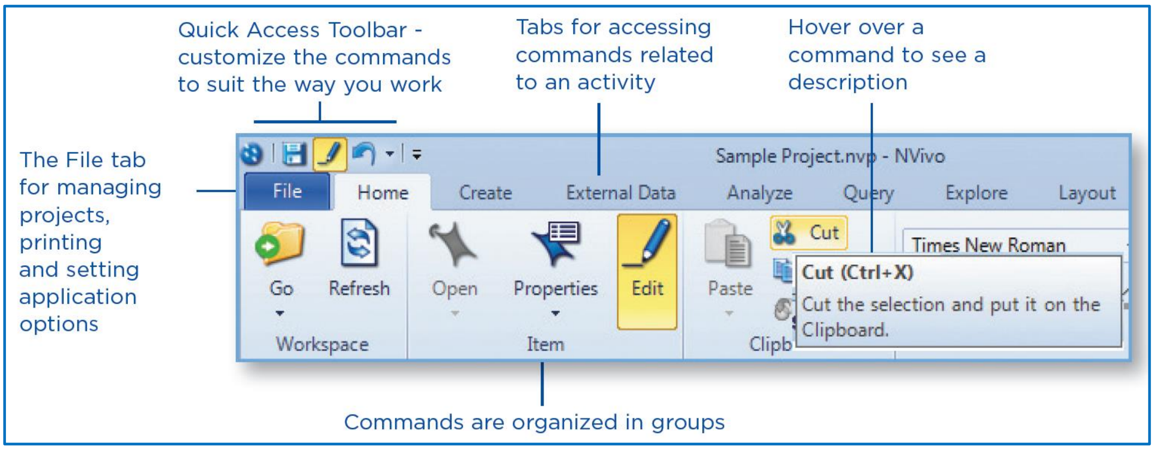


Figure 3.11:Reborn bar

Source: (QSR International, 2013)

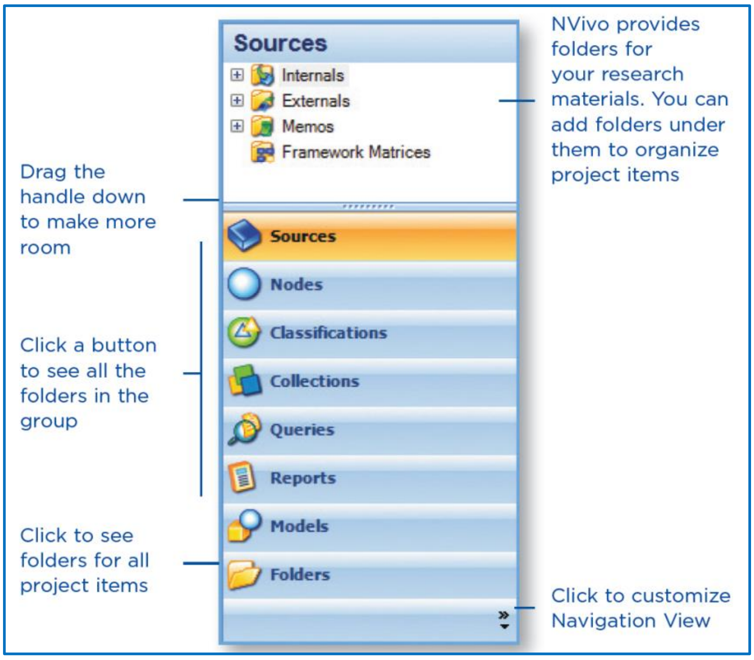


Figure 3.12: Navigation view

Source: (QSR International, 2013)

The following subsections describe the qualitative data analysis process adopted for the current study using the NVivo 10 software package.

Semi-Structured Interview Analysis Procedure in NVivo

NVivo is a popular tool for analysing textual interview transcripts (Depoy & Gitlin, 2005; Richards, 1999). The analysis of semi-structured interviews follows a process comprising numerous stages including data preparation, coding, searching, condensing, and connecting data. The next sections explain the sequence of steps involved in the analysis of textual information obtained from the semi-structured interviews, using the NVivo 10 software package.

Qualitative Data Preparation

Qualitative data preparation enriches the data analysis process in NVivo as it makes better openings to draw meaningful themes from the interview text (Depoy & Gitlin, 2005). Once all the interviews were transcribed, they were saved in MS Word format. As the conducted semi structured interviews represented five different parties (manufacturers, suppliers, contractors, architects, and new homeowners) across the building materials supply chain, transcripts were grouped separately. Transcribed documents were formatted to reflect the questions and answers separately in the order of the interview conducted. Each transcript was included in a specific code (e.g. M-01 for a manufacturer) to identify the type of interviewees who participated in the survey.

Various word process features were engaged in shaping data, expressing, emphasising and clarifying the responses statements, and in drawing attention to critical statements. Where applicable the texts in the transcripts were formatted as tables to break the text into meaningful units. The documents were structured using heading styles in order to organise the text. For example, headings were used to indicate the topics discussed and questions answered in semi-structured interviews. Thereafter, text lines were numbered across all the transcripts to specify the exact location of various features under consideration. They were saved with identical names in five different computer folders. This data preparation was the first step of the semi-structured interview analysis process, prior to exporting the interview transcripts into the NVivo software.

Working with NVivo

There were five different internal sources created for all the types of participants interviewed and their pre-formatted transcripts were imported separately. Qualitative data collection and data analysis occurred concurrently in the current study. Therefore, transcripts were introduced to the NVivo project gradually. Figure 3.13 shows the path taken to explore the building materials supply chain within the New Zealand construction materials supply chain.

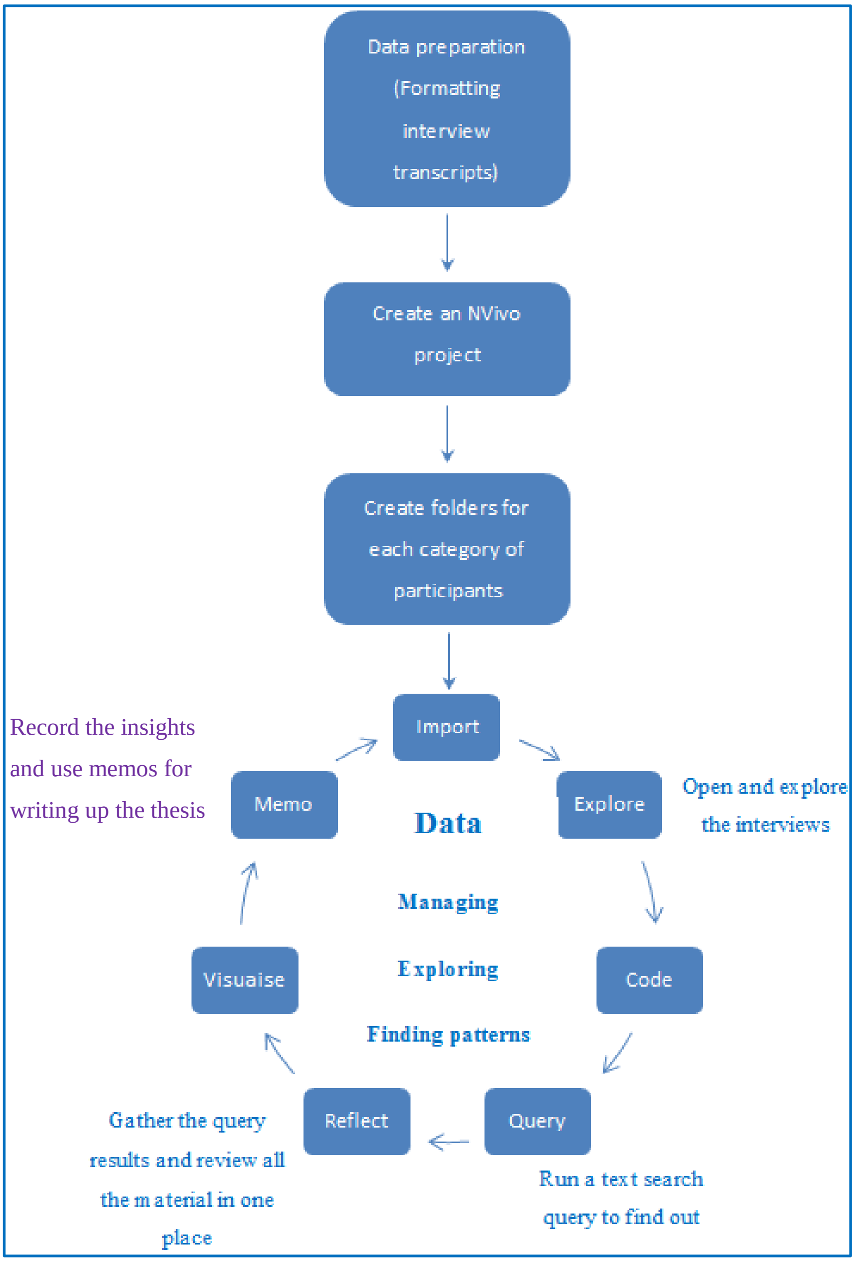


Figure 3.13: Path for exploring research with NVivo 10

Source: (QSR International, 2013; Stebbins, 2001)

The NVivo project is a database file which contains everything required for qualitative research study, comprising data, ideas, and the connections between them (QSR International, 2013). Therefore, semi-structured interview analysis comprises the exploration and coding of interview data; running text search querying to find out specific research aspects; gathering query results and reviewing all materials in one place; visualising results, and recording insights and using memos when drawing conclusions out of interview texts. The next sections explain how the semi-structured interview analysis was carried out with various techniques in the NVivo environment.

After transcripts were uploaded into discrete folders in NVivo, they were explored independently in order to reflect the ideas of participants on the research objectives and research questions. This reproduced the participants' perspectives on the same research frame. As the first step of generating themes on research objectives, transcripts were thoroughly examined. This process involved reading and reflecting on what participants have particularly commented on in the research. Thereafter, texts were fragmented into content categories connected with the concepts examined. These concepts were assigned to codes under different nodes created in NVivo. Creating nodes under identified themes was a parallel process, and themes were mostly further distributed over subthemes creating parent nodes and child nodes in the NVivo environment. Basically, this was the approach followed for coding. Figure 3.14 shows a screen shot of the interview data analysis at the coding stage.

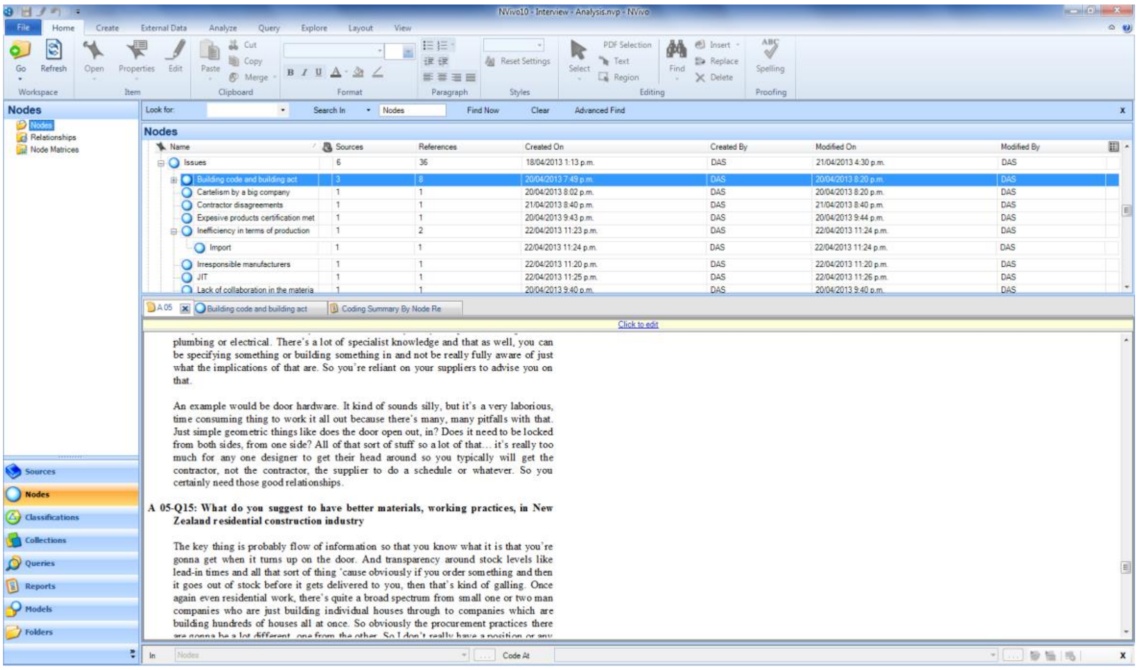


Figure 3.14: Semi-structured interview data coding

The researcher followed inductive and deductive coding approaches as indicated above. This means that when a concept was identified on the transcript, a code was assigned from the knowledge gained through past literature or assigned a new code based on what participants said. This was a continuous process followed until new themes were generated. In fact this continuous and repetitive process assisted the researcher to review the interview data and generate new themes from the interview transcripts. The key words used to represent themes (nodes in NVivo) were created from the original words and phrases mentioned by the interview participants.

The functionality of nodes was beneficial in bringing different participants' ideas together. For example, how similar and how different the perspectives of participants were, could be recognised using these nodes. NVivo interview analysis can also be enriched by using features such as memos, tracking, and modelling (Smyth, 2008). With this in mind, all the interview transcriptions were coded in five different node structures. Each node structure characterised the themes generated from the views of the participants, representing manufacturers, suppliers, contractors, architects, and home owners. Figure 3.15 shows a screen shot from NVivo, consisting of a portion of node structure created when analysing the qualitative data provided by architects involved in residential designs in New Zealand. The full coding summary for the study reported here is presented in Appendix 6 of this thesis.

Architects	6	254
Benifits from improving supply chain	2	4
Best materials	6	34
Accurate information	1	1
Collaboration with client	1	2
Fitting for purpose	2	2
Fitting with NZBC	1	8
Knowladge and experiance	3	5
Methods to avoid pitfalls	1	1
Safe to use	1	2
Well established materials	6	11

Figure 3.15: NVivo nodes

Therefore, it can be observed that NVivo provided added value to the semi-structured interviews in terms of dependability and robustness. This was helpful in strengthening the review and revision process (Seidel, 1998). In addition, NVivo provided improved interview data management in terms of identifying hidden data structures, patterns, and themes (Peters & Wester, 2007). NVivo strengthened the internal validity of the current study by its effective coding management system and excellent qualitative data management functionalities. However, the researcher believes because NVivo is a qualitative data analysis tool, there is a necessity to manually analyse the interview data by putting effort and thought into the interviews conducted.

Rigour of Semi-Structured Interview Analysis

The need for rigour in interview analysis is well established, signifying the importance of interpretation of transcribed interviews (Mays & Pope, 1995; Samkin & Schneider, 2008). With this in mind, a number of key criteria were considered to interpret the interview transcripts. They comprised identification, recognition, construction, deconstruction, reconstruction, and textualisation of themes and patterns within interview texts. These principles were evaluated through the recommendations provided by Love (1992) with modifications (as indicated by *italics*) as applicable to the current study. The following section shows how rigour was achieved in the semi-structured interviews.

1) Repetition within and across interviews: Ideas, beliefs, concerns, and issues that *the participants of the semi-structured interviews* discussed repeatedly throughout the interview and/or were brought up at least once in an interview, and were then again noted in other interviews, were considered significant.

2) Levels and nature of affect: This includes emotion that is evident through non-verbal cues such as a sudden rise in vocal volume, change in facial expression and other bodily movements. These were noted concomitantly with particular content, lending significance to that content or theme.

3) Historical explanations, descriptions, and interpretations. Stories of the past that explain and justify present behaviors and meanings are considered significant.

4) Explicit and implicit interpretations. These require connections between thoughts and activities and meanings ascribed to them whether they be obvious and direct or implied and metaphoric. These interpretations are considered significant.

5) Serendipity: Behaviours and expressions of the *participants* that are different from what was expected based upon the reading and experience *of the researcher*. These unexpected surprises are significant since they allow the research to recognize ideas which have not yet been published.

3.9.2.2 Quantitative Data Analysis

There are number of tools (software) that have been developed to enable fast and accurate quantitative data analysis. However software based analysis should be used with care, since these tools have both strong points and weaknesses (Lee & Fielding, 1991). Predominantly, computer based tools have the advantage of handling a large volume of data rapidly. Also, data manipulation and widespread data displaying behavior are facilitated by such computer software in analysing quantitative data (Graham, Cumsille, & Elek-Fisk, 2003). As a result, the entire data analysis process becomes comprehensive, transparent, and replicable, with a higher degree of reliability and validity.

SPSS is a very powerful computer aided software package in conducting social science related statistical data analysis and it is, perhaps, the most widely engaged computer aided tool for social science related quantitative data analysis (Bryman, 2008; George & Mallery, 2009; Sambasivan & Soon, 2007). This study adopted SPSS 20 (the latest SPSS version available at AUT University) for analyzing quantitative data with the intention of performing exploratory factor analyses, ANOVAs, and displaying the results in a variety of graphical formats.

Quantitative Data Editing, Cleaning, and Coding

The data gathered from the building materials manufacturers, suppliers, BMs, building contractors, and architects through the online survey administration tool "Survey Monkey", were transferred to SPSS. Similarly the data collected from the new home owners through the mail survey were entered onto SPSS. This process was followed by data editing, which aimed to check data omission, completeness, and consistency.

Data Editing

Data editing compromised merging all 4 SPSS files related to the 4 versions of the questionnaire survey. The process identifies the variable measures (scale, ordinal, or nominal), and assigned value labels to variables according to the Likert scale. Open-ended questions were moved from the data and appropriate variables were combined. Zikmund (2003) argued that data editing is a part of data processing and analysis. In addition, data editing enabled the identification of any errors in entering the mail survey responses.

Data Cleaning

It was necessary to clean the data before the statistical data analysis was conducted because cleaning enhances data accuracy. Mertlerand Vannatta (2005) suggested that this can be achieved through the identification of missing data and outliers as well as the fit of statistical assumptions (e.g. normality and linearity). The techniques recommended by Sekaran (2005) were applied in analysing the quantitative data to overcome blank responses. These techniques include assigning a mid-point number to an interval-scaled item, or programming the computer to neglect blank responses, or giving the mean value of all the responses for particular items during the analysis. Missing data screening, outliers, and a normality check were conducted at the beginning of the data analysis process. In order to make sure that the data was correctly recorded and the variables to be used in the analysis were normally distributed, a data screen exercise was conducted (Coakes & Steed, 2009). The following subsections describe the adopted initial quantitative data analysis procedure for the current study.

Missing Data

It was observed that some participants had not answered all the questions included in the questionnaire survey. Therefore, some gaps were identified in the SPSS data file and these are called missing values. Having missing values in the data file influences the data in a number of undesirable ways. Often missing values make the data file difficult to work with. SPSS enables researchers to deal with missing data in several ways. Graham et al. (2003) established that missing values in categorical data (e.g. demographic information) should be replaced with an additional numerical value which will identify the missing responses. Therefore, this study used number 99 for missing categorical values and they were assigned as “Not stated”. This eliminated the interference of missing categorical data in the analysis.

George (2003) explained that missing continuous data should be replaced with the mean value of all other subjects of a particular variable, given that the missing values are less than 15% of the total data of a variable. This is commonly known as mean substitution in SPSS (Coakes, 2013). Thus, replacing missing values with means would not bias results and the influence on the final outcome of the analysis is minimised. The current study employed mean substitutions for the missing values of continuous variables as the number of missing values was low.

Outliers

Outliers are the data responses that are very different from the majority of responses in a data set. As they can influence the results of the data analysis, outliers should be handled with care. Therefore an assessment of outliers is necessary to evaluate the distribution of the variables, because outliers can cause non-normality data and result in erroneous statistical tests (Hair, Black, Babin, Anderson, & Tatham, 2010; Tabachnick, Fidell, & Osterlind, 2001). Hair et al. (2010, p. 64) defined outliers as "observations with a unique combination of characteristics identifiable as distinctly different from the other observations". Coakes (2013) shows that outliers can be identified with boxplots of variables. Therefore, the current study checked the outliers of the data set with boxplots. If there are any outliers, they are displayed between one-and-a-half and three box lengths from the upper or lower edge of the box, in the box plot produced by the SPSS. Furthermore, outliers are indicated with circles in the SPSS boxplot output.

Normality Assessment

As the current quantitative data analysis was expected to be performed in terms of descriptive statistics, ANOVA, and factor analysis, evaluating the normality of the variable was essential (Field, 2013; Hair et al., 2010; Hashim & Ahmad, 2006; Kline, 2005; Tabachnick et al., 2001). Therefore, a normality check was carried out for those variables that were expected to be used in the analysis. With this in mind, the residuals (errors in predicting sample data) were plotted to visually represent and examine the normal probabilities. This examination signposted the normal distribution of data and confirmed the normality of the variables.

Skewness and Kurtosis were used to determine the actual eccentricity of the data from the normal distribution. Hair et al. (2010, p. 37) describe Skewness as the "measure of symmetry of a distribution; in most instances the comparison is made to a normal distribution," and Kurtosis as the "measure of the peakedness or flatness of distribution when compared with a normal distribution". Kline (2005) described the acceptable values of the absolute value of both the Kurtosis index and Skewness index in order to achieve a normality in the data distribution as shown in Table 3.13.

Table 3.13: Normality check with Kurtosis Index and Skewness Index- Source: Kline (2005)

<table>
<tr><th colspan="2">Kurtosis index</th><th>Skewness index</th></tr>
<tr><td>Absolute value of Kurtosis index > 10.0</td><td>Absolute value of Kurtosis index > 20.0</td><td rowspan="3">Acceptable absolute value of Skewness Index ≤ 3.0</td></tr>
<tr><td>Problem with normality</td><td>Significant problem with normality</td></tr>
<tr><td colspan="2">Acceptable absolute value of Kurtosis index ≤ 10.0</td></tr>
</table>

However, some statisticians explain that both Skewness and Kurtosis should be within the ± 1.000 range (George & Mallery, 2003; Leech, Barrett, & Morgan, 2008; Morgan, Griego, & Gloekner, 2001).Although George and Mallery (2009) argue that a value of ± 2.000 has been accepted in many cases for both Skewness and Kurtosis.

The SPSS 20 used in the current study indicated that both the Kurtosis Index and Skewness Index were in the range of acceptable values. Therefore, the survey instrument had univariate normality which dismisses the use of nonparametric statistics in the current study (George & Mallery, 2009). Normality checks were performed for all the variables used in the analysis of the questionnaire survey. An example of a normality check using the Kurtosis index and Skewness index is given in Table 3.14.

Table 3.14: Normality check – Manufacturers and suppliers' supply behaviour

Constructs	N	Skewness		Kurtosis	
	Statistic	Statistic	Std. Error	Statistic	Std. Error
Strong relationships with customers	36	0.321	0.393	-0.743	0.768
On time delivery services	36	-1.687	0.393	4.952	0.768
Availability of variety of products when they are needed	36	-0.457	0.393	-0.367	0.768
Customer satisfaction/understanding customer needs	36	-0.907	0.393	-0.253	0.768
Competitive prices	36	-0.619	0.393	-0.334	0.768
Product quality requirements	36	-0.270	0.393	-0.628	0.768
Collaboration and partnership in the materials supply chain	36	-0.441	0.393	0.961	0.768
Good logistics (transportation and warehousing)	36	-0.381	0.393	-0.839	0.768
Having a sophisticated computer system	36	-0.448	0.393	-0.543	0.768
Waste minimisation strategies	36	-0.308	0.393	-0.300	0.768
Streamlining payments and orders by customers	36	-0.791	0.393	0.795	0.768
Discounts	36	-0.505	0.393	-0.220	0.768
Advertising	36	-0.918	0.393	0.063	0.768
Strong relationships with customers	36	-0.813	0.393	-0.061	0.768
On time delivery services	36	-1.338	0.393	2.314	0.768
Availability of variety of products when they are needed	36	-0.553	0.393	-0.297	0.768
Customer satisfaction/understanding customer needs	36	-0.690	0.393	0.002	0.768

From the Table 3.14 it could be observed that Skewness and Kurtosis values are within the normal ranges 3 and 10 respectively which confirmed the normality of the research data. Furthermore, normal probability plots were visually assessed to show that there were no significant issues in the normality check. The visual assessment showed that all the values were assembled around the straight line and hence, no further data modifications were carried out prior to analysis (Tabachnick et al., 2001).

Data Coding

The process of converting the questionnaire data into meaningful categories is considered as data coding. In this study, coding allocated numbers to each type of response facilitated the transferring of questionnaire responses into SPSS (Malhotra, 2010). Pre-coding is an exercise done before a survey is administered, although coding can be done after questionnaire responses have been collected as well (DeVaus, 1995).

This study adopted a pre-coding approach after amendment of the survey instruments followed by the administration of the pilot surveys. As a result of this, the researcher was able to enter the data directly from the questionnaires into the SPSS database. The coding structure for the questionnaires was verified by an Associate Professor specialising in social research methodology at AUT University, New Zealand.

Figure 3.16 summarises the methods applied in the preparation of the questionnaire survey data before applying quantitative data analysis techniques.

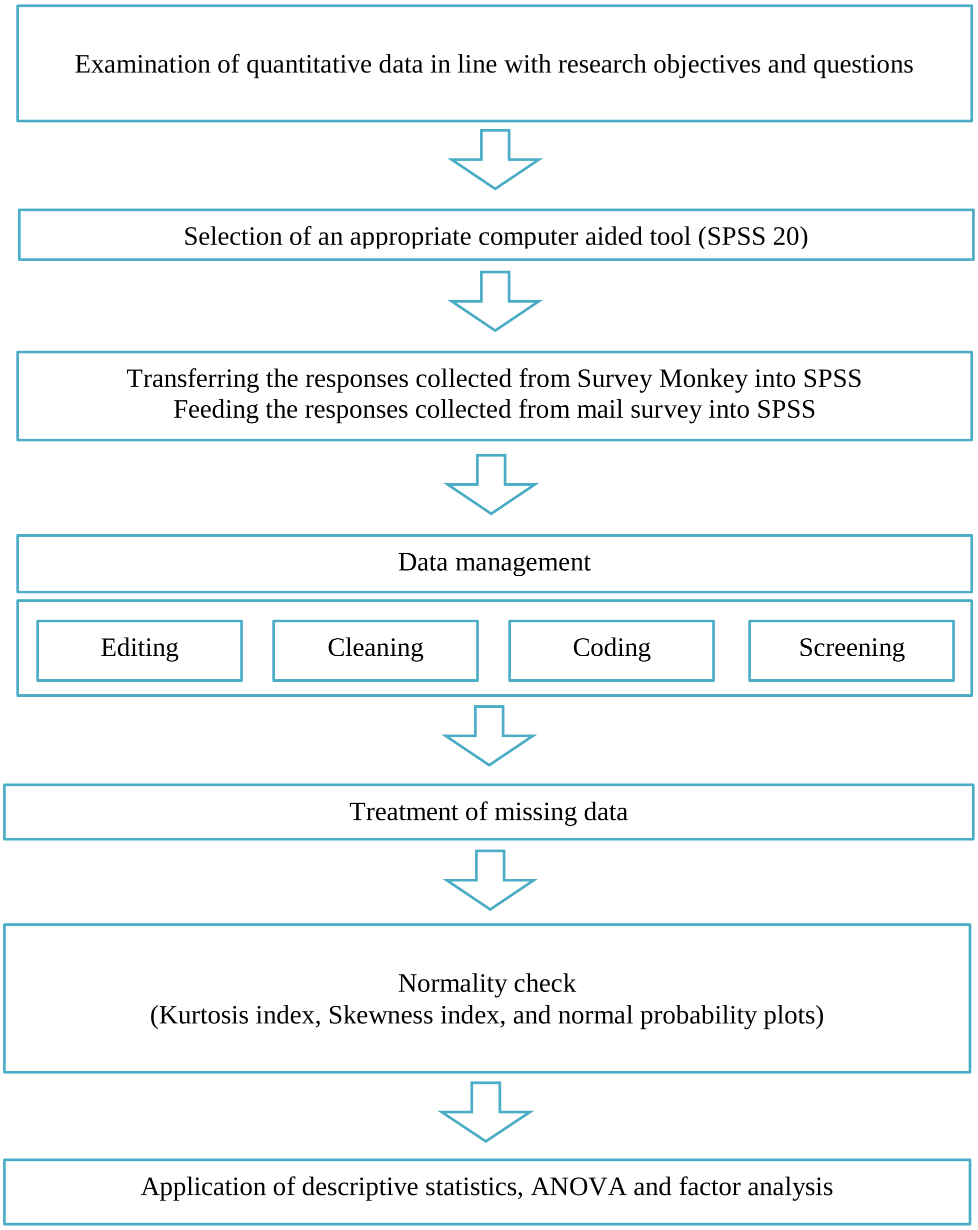


Figure 3.16: Basic steps involved in the analysis of the questionnaire survey

Quantitative Data Analysis Techniques

In general, descriptive statistics and inferential statistics are used to analyse quantitative data (Assaf, Al-Khalil, & Al-Hazmi, 1995). Descriptive statistics often describe or summarise the data while the use of inferential statistics involves making inferences on a population using an appropriate sample (New Zealand Government, 2011). Basically, descriptive statistics evaluates the mean, median, mode, variability, and standard deviation of a data set, while inferential statistics uses statistical tests to reduce data and test hypotheses (Tumi, Omran, & Pakir, 2009). In this way, the current study uses both descriptive statistics and inferential statistics (using SPSS 20) to test and analyse the data collected through the online and mail questionnaire surveys. The following sub-sections describe the descriptive and inferential statistics utilised in the current study.

Descriptive Statistics

In order to analyse the responses to categorical and rating questions in the questionnaire surveys, the current study engaged descriptive statistics in the form of mean, standard deviation, and frequency analysis.

Inferential Statistics

Inferential statistics make inferential statements on a population using a representative sample. This study applied a one way analysis of variance (ANOVA) and explorative factor analysis under the theme of inferential statistics. These inferential statistics techniques are described in the following subsections.

Comparisons of Means with ANOVA

The current study applied a one way ANOVA to test the statistical differences in the mean values of the different groups of respondents. The online survey and mail survey collected responses on the different themes regarding the New Zealand BMSC from building materials manufacturers and suppliers, contractors, architects, and homeowners. The ANOVA between groups of participants was performed to discover the mean differences of responses. However, it should be mentioned that the ANOVA assumes the normality and homogeneity of variances (Field, 2013) which have been verified in the current study (see Tables 6.1 and 6.2). This study applied the ANOVA to find the differences among the major groups of participants' responses to issues, suggestions for improvements, and collaboration in the BMSC in the New Zealand residential construction sector. The ANOVA involves testing the null hypothesis (H_0) as discussed by Gaur and Gaur (2006). The decision can be accepted or rejected by testing hypothesis which involves a probability value of 95%, giving confidence that the decision made is correct. Hence the significance (*p*) of less than .05 rejects the null hypothesis (H_0).

H_0: $\mu_1 = \mu_2 = \ldots\ldots \mu_k$; all population means are equal.

If the null hypothesis is rejected it shows that the population means for all groups are not equal. However there was no information given by the ANOVA in which group means differ. Hence a Post-Hoc test should be performed to find how the different groups responded to questions. Since the sample sizes of four different participants were significantly different from each other, Hochberg's GT2 Post-Hoc test was performed (Field, 2013) as a further analysis to elucidate which groups differ in their responses.

Exploratory Factor Analysis (EFA)

Exploratory factor analysis (EFA) was employed in this study as another inferential set of statistics. The use of EFA reduces data by identifying the most dominant factors from a larger set of variables. Therefore, it was expected to identify the key factors which describe collaboration in the BMSC using EFA. Green, Salkind, and Jones (2003) defined factor analysis as a technique that identifies variables with a statistical justification of variation and covariation between measures. This statement is in agreement with Hair, Anderson, Tathan, and Black (1995) who further said that factor analysis is a data reduction technique. In addition, factor analysis is an interdependence technique which supports examining the interdependent relationships among variables (Creswell, 2005; Kadir, Lee, Jaafar, Sapuan, & Ali, 2005). Moreover, Malhotra, Hall, Shaw, and Oppenheim (2005) state that factor analysis detects a limited number of significant variables from a large set of associated variables. The main steps involved in performing a factor analysis are described (in relation to this study) in the following sub-sections.

Stage 1: Problem Formulation

The first stage of factor analysis is the formulation of problems. This is basically the identification of variables in order to perform a factor analysis. Under the current study a factor analysis was performed to find the salient factors which describe collaboration in the BMSC. Fifteen statements relating to collaboration in the BMSC were included in the current study. The significance of these statements was determined using a 5-point Likert scale.

Performing a factor analysis necessitates having either interval or ratio scale data (Durdyev & Mbachu, 2011). The current study considered the Likert scale as interval data according to anecdotal evidence, even though there are arguments for and against the data type to which the Likert scale belongs (Achyar, 2008). For instance, Jacoby and Matell (2008) categorizes the Likert scale into an interval scale as it is widely used to measure attitudes and images. However, Hodge and Gillespie (2006) argue that Likert scales could be used with either interval data or ratio scale data which is really uncertain. The analysis of non-parametric procedures (e.g. frequencies, tabulation, chi-squared statistics, and Kruskall-Walls H tests) are highly supported when a Likert scale is used in the questions being analysed, due to its ordinal nature (Allen & Seaman, 2007). However a cross-examination of the applicability of data analysis methods related to the Likert scale is not important if the analysis supports answering the research questions (Clason & Dormody, 1994). This idea is further reinforced by Adams, Fagot, and Robinson (1965, p. 100) who said:

> "Nothing is wrong per se in applying any statistical operation to measurements of a given scale, but what may be wrong, depending on what is said about the results of these applications, is that statements about them will not be empirically meaningful, and this in turn means either that the statement is semantically meaningless or else that it is not scientifically significant."

In addition, performing a factor analysis requires an adequate sample size to be used. Gaur and Gaur (2008) suggested that the sample size should be at least four or five times as many observations as there are variables to be applied in the factor analysis. In this study there were 146 responses for the 15 statements considered in the EFA. Therefore sample adequacy was satisfactory for the current study.

Furthermore, testing of the null hypothesis that variables are uncorrelated in the population was also included as a part of conducting a factor analysis. Bartlett's test of sphericity was applied to test the null hypothesis. A large value obtained from the test statistics (e.g. Bartlett's test of sphericity) would favour the rejection of null hypothesis. In other words, the appropriateness of the factor analysis depends on the rejection of the null hypothesis. In addition to this, the Kaiser-Meyer-Olkin (KMO) statistic also indicates the adequacy of the sample size. When the KMO statistic is large (> 0.50), performing a factor analysis is allowed (Creswell, 2005; Standards New Zealand, 2005) because low KMO statistics values (< 0.50) indicate that the correlations between pairs of variables cannot be explained by other variables.

Stage 2: Factor Extraction Method

Principal components analysis (PCA) and principal axial factoring (PAF) are the two main approaches applied to abstract the primary factors for the factor analysis (Law Commission, 1999). In general, both analysis methods yield the same results, and depending on the mathematical nature of the analysis, the results could be varied. The

PAF method is often applicable in analysis where the research is designed based on a theoretical consideration (Field, 2013). Therefore, the current study applied the PAF method in extracting the most appropriate factors which describe the benefits of collaboration in the BMSC.

Stage 3: Determining the Number of Factors

The objective in this stage is to extract the key factors from the original numerous variables to review the information seen in the original materials. In order to accomplish that, Gaur and Gaur (2003) suggest two different approaches named eigenvalue and screen plot. The current study applied the eigenvalue approach to select the key factors to be included in the factor analysis. The variables with eigenvalue greater than 1.0 were engaged in the current study (Gaur & Gaur, 2006). An eigenvalue of less than one describes less variance than a single variable, and therefore should not be treated as a meaningful key factor for the study.

Stage 4: Rotation of Factors

Factor analysis results are presented in the form of a factor matrix (component matrix). Correlations among the factors and variables are exhibited in terms of coefficients and factor loadings in the factor matrix. When the factors and variables are closely related, coefficients which would interpret factors appear as large absolute values. Further, Cronbach’s alpha reliability coefficient was involved in the factor analysis to maintain the reliability and internal consistency between items. Bayley and Kennedy-Grant (2003) suggest that a Cronbach’s alpha reliability coefficient value greater than 0.70 represents an acceptable level of reliability in the items.

3.10 Credibility of the Research Findings

Credibility measures the trustworthiness of research findings (Guba & Lincoln, 1994). Having trustworthy information as research data is a very important aspect of successful research. Credibility of research is evaluated in terms of the validity, reliability, and generalizability of the research findings (Saunders et al., 2011). Subsequent sections explain how the current research attempted to gain a high degree of credibility for the research findings.

3.10.1 Validity

Validity of research findings can be assessed based on the accuracy of the instruments employed in the data collection, and the degree of achievability of the aim of that survey instrument (Amaratunga et al., 2002). Research validity has two main aspects: internal validity and external validity (Gill & Johnson, 1991; Yin, 1994). Internal validity ensures that a researcher is really examining what was meant to be examined, while external validity is the degree of generalizability of research findings (Amaratunga et al., 2002).

The internal validity of a survey instrument can be examined in terms of content validity, construct validity and criterion-related validity (Fink, 2009; Saunders et al., 2011).

Content validity refers to the degree of coverage of the research questions from the survey instrument. The current research established the research problem from a comprehensive literature review and the opinions of SMEs. The research questions were designed to address the research problem through a questionnaire survey and semi-structured interviews. It was ensured that the semi-structured interviews and questionnaires could answer in sufficient complexity all the research questions. This was verified by the help of research supervisors and an associate professor in business in the subject area of business research methods. Also the pilot survey contributed to improving the validity of the research findings.

Construct validity denotes how attitude and aptitude scales are measured by the questionnaire. Criterion related validity (that is predictive validity) measure the capability of questions in the questionnaire to make accurate predictions. Construct validity and criterion validity were not applicable in the current research.

Having multiple data collection methods to address the research problem also improved the reliability of the research findings (Denscombe, 2003; Saunders et al., 2011). With this in mind, this research employed semi-structured interviews for the initial data collection, followed by a questionnaire survey which was validated through the SME interviews. This triangulation method further assured the validity of the research findings.

3.10.2 Reliability

Consistency of research findings refers to reliability, which can be assessed through re-testing the test, maintaining internal consistency and having an alternative way of data collection (Saunders et al., 2011).

Re-testing requires conducting the data collection twice under similar conditions. However, for the current research, conducting 34 semi-structured interviews and a New Zealand wide questionnaire twice was not feasible within the given time frame and limited available research funding.

Internal consistency relates to the consistency of the responses across the questions in a survey. The current research tested Cronbach's α value in the quantitative analysis process to ensure that questionnaire responses were internally consistent (Bryman, 2012; Saunders et al., 2011). Generally a Cronbach'sα value of above 0.70 is an accepted test for scale reliability (Nunnally, 2010). Chapter 5 discusses further detailed information on the internal reliability of the questionnaire.

The reliability of the interviews conducted was based on the degree of question standardisation and accuracy of the responses provided by participants. Both semi-structured interviews and SME interviews were guided by indicative questions in the current study to ensure reliability. All the participants selected for interviews were well-experienced and well established in the New Zealand construction sector (see profiles of participants in chapters 4 and 5), and had high educational qualifications. Therefore, it can be argued that the research findings from the interviews are reliable. Also strategies such as guiding participants through participant information sheets prior to interviews, and transcribing interviews soon after the interview took place enhance the reliability of the interview findings.

It was found that 62% of the questionnaire participants had more than 20 years' experience in the construction industry (see chapter 5). In addition, 52% of the participants had a degree or postgraduate qualifications. These criteria further strengthened the reliability of the questionnaire findings.

3.10.3 Generalisability

The appropriate sample selection should guarantee the generalizability of the research findings. The current research initially approached 30 participants from Auckland (the main business city in New Zealand). These participants were selected using a snowball sampling method to ensure that small, medium, and large companies were represented in the sample. However, the interviews were limited to the Auckland region as it was not feasible to spread the interviewing process across New Zealand in the given time frame and budget.

For the questionnaire survey, responses were collected around the whole country. The survey had an overall 23.4% response rate. Again, the survey sample was carefully selected to represent small, medium, and large size companies. Therefore, it can be argued that the current research findings are generalizable in the New Zealand residential construction sector.

3.11 Ethical Considerations

Research ethics means the researcher’s correct behavior towards the subjects (e.g. participants) of the study (Saunders, Lewis, & Thornhill, 2009). Ethical considerations in research are important both to study and to practice making the right decisions. Ethical considerations should be maintained throughout the research process (establishing the research problem, designing the research, collecting data, analyzing data, and reporting data). Ethical approval (ethics application number 12/112) for the current research was granted by Auckland University of Technology Ethical Committee (AUTEC) before data collection commenced (Appendix 1). Subsequent sections discuss the general ethical issues considered in the current research throughout the research journey.

3.11.1 Researcher’s Experience or Expertise

A researcher’s experience and expertise in the research area is important to drive the research in an appropriate manner. The researcher should be skilful with “the ability to ask good questions, being a good listener, being adaptive and flexible, having a firm grasp of issues being studied and being unbiased by preconceived notions” (Ireland &

Hitt, 2005, p. 59).The researcher has a first class Bachelor's degree in Civil Engineering which includes a variety of core papers in the area of construction management. Also, he carried out his undergraduate research project in construction management, which is the area of this research. In addition, the researcher had hands-on experience in the Sri Lankan building construction industry for six months as an industrial trainee. He gained further experience as a contract lecturer in the construction management division, Department of Civil Engineering, Faculty of Engineering, University of Moratuwa, Sri Lanka, in the academic year 2009/2010.

3.11.2 Incorporation of the three principles of the Treaty of Waitangi

All researchers in New Zealand should respect and give consideration to the founding document of New Zealand, the Treaty of Waitangi, when conducting research. The current study incorporated the three principles of the Treaty of Waitangi: partnership, participation and protection.

3.11.2.1 The Principle of Partnership

The aim of the research was to identify system weaknesses limiting the performance of the residential construction sector in New Zealand, and potential ways to address these using interventions operating at the whole-of-supply chain level, including barriers to be overcome. Therefore, the study will be beneficial to both the researcher and the research participants. The mutual benefits as a consequence of this research thus can be shared between the participants and the researcher.

3.11.2.2 The Principle of Participation

The key role of participants in this research was via knowledge and information sharing. There were criteria for participants to be responsible, to be involved in the research, or to take part in the data analysis process. The participants were well guided through a participant information sheet, and written consents were obtained prior to participation. Additionally, the participants will have an opportunity to receive the research findings upon their request. Participation was entirely voluntary and participants had the right to withdraw at any time during the data collection process.

3.11.2.3 The Principle of Protection

In order to protect the privacy and confidentiality of participants, the identity of each respondent was not revealed in the findings of the study. Also, the participants' identity and information provided were not revealed to any other participant.

Consequently there are no issues which are directly impacting on the Treaty of Waitangi.

3.11.3 Privacy and Confidentiality

The participation in this research was voluntary, and the participants' privacy, confidentiality and anonymity were protected throughout the research process. The identity of any participants was not revealed to the other parties, and the actual names of the participants will not be indicated in the final report and/or publications emanating from the study. Any direct quotes will be presented as pseudonyms. Additionally, any identifiable personal information will be deleted to ensure the privacy and confidentiality of the research participants. The data collected was kept under lock and key under the supervisor's supervision. The data collected from the individual participants was analysed together and presented in the form of the overall findings of the research in a manner that did not reveal any individual's identity. These findings will be made available to the participants upon their request.

3.11.4 Social and Cultural Context of the Participants

The researcher has been living in New Zealand for the last 3 years, and was aware of the social and cultural sensitivities of the New Zealand community. Further, the researchers' supervisors have been living in New Zealand for more than 5 years and they were well familiar with the social and cultural context of the people in the New Zealand construction industry. Therefore, the researcher ensured that cultural diversity was respected during data collection. In addition, the research had no questions based on any race or ethnicity components.

3.11.5 Level of Discomfort or Embarrassment

Participants should not have experienced any physical or social discomfort or embarrassment or psychological implications. Participation was entirely voluntary and the participant could withdraw at any time during the process. Any participant could also refuse to answer any questions which they were not comfortable with, or terminate the interview at any time during the process. Therefore, there were no discomforts (physical, psychological or social) as a result of this research project.

3.11.6 The Researcher's Professional, Social, Financial, or Cultural Relationships

There were no potential conflicts of interest anticipated as there was no relationship between the researcher and the potential participants. The participants were New Zealand construction industry professionals and the researcher was associated with AUT University. The purpose of the research was purely academic, that is, to increase knowledge and to gain a PhD qualification. Even though the researcher was funded by the School of Engineering, AUT, the research had not been commissioned by AUT University. The researcher does not have any obligations towards AUT University.

3.12 Research Scope and Limitations

The research methodology employed in this study has limitations. Firstly, the initial semi-structured interviews were limited to only the Auckland region and only six participants represented the key participant groups defined (altogether 30 participants represented five participants in each group). This was a limitation as the next phase of the data collection was based on the findings of the semi-structured interviews.

The study followed a mixed method sequential procedure. Therefore, there may be an issue: the direct effect of one method upon the other method. This is because the issues under investigation are being exposed to more than one data collection method. For instance, respondents' responses to the questionnaire survey questions could be influenced by earlier participants in the semi-structured interviews and the findings from my literature review. The extent to which such influential issues impacted on the current study and the study's outcome is difficult to determine. Hence, it is important to note that the study's results should not be treated as a methodological effects free outcome.

Also, the overall response rate received for the questionnaire was 23.4%. Therefore, the research findings may be subject to the accuracy and the trustworthiness of the information provided by research participants during the data collection process.

3.13 Summary

This chapter has outlined and justified the overall research methodology applied in the current study. The chapter established the research philosophical position and explained and justified the research approaches employed, research strategies, data collection, and data analysis techniques. Also the credibility of the research findings were shown where applicable in the research process. The chapter concluded with a discussion of ethical considerations in research and research limitations.

Subsequent chapters of the thesis will discuss the results of both qualitative and quantitative approaches.

CHAPTER FOUR

Semi-Structured Exploratory Interviews: Report of Findings

4.0 Introduction

This chapter presents the results of the semi-structured exploratory interviews with building materials manufacturers, building materials suppliers, contractors, architects, and homeowners in the New Zealand residential construction industry. A particular focus was given to identifying the nature of the New Zealand BMSC during the interview series. This comprises materials supply behaviour from manufacturers and suppliers, materials buying behaviour from contractors, and materials selection behaviour from architects and homeowners. Interviews were guided by the indicative questions prepared and based on the research findings obtained from the literature review conducted so far, and which were in accordance with the research objectives.

This chapter is basically divided into six sections, and begins with demographic information of participants and a presentation of the structure of the interviews. Thereafter the chapter presents the views of the five main groups of interviewees. The participants' views are organized under key themes (see section 4.1.2) in line with the research objectives identified. The chapter emphasizes the key points emanating from the interviews which helped to prepare the questionnaire survey that is discussed in chapter 5.

4.1 The Semi-Structured Interviews

Individual semi-structured interviews were conducted among building materials manufacturers, suppliers, residential contractors, architects, and homeowners in the Auckland region. Altogether 30 participants (six from each group) were interviewed representing small, medium, and large sized companies. A brief introduction and self-discloser was made to participants at the beginning of the interview process. Sometimes, participants too revealed more of themselves with background information of their business during the interview. This created an ice-breaker to open up and develop the interview and to explore the nature of the building materials supply chain under the main themes considered. The following sub-section describes the profiles of the participants.

4.1.1 Demographic Data of Participants

Due to privacy requirements, detailed information of the participants is withheld and they are identified by codes (e.g. M-01 to M-06 for manufacturers). Tables 4.1 to 4.5 display summaries of the participants' profiles indicated with their role, responsibilities, and experience in the construction industry, and building materials related information.

Table 4.1: Demographic data - Manufacturers

ID	Types of materials manufacturer	Role	Responsibilities	Experience
M-01	▪ Concrete ▪ Aggregates ▪ Steel and cement products	Manager of depot	▪ Supervising 23 staff ▪ Thirteen truck drivers through dispatch staff taking concrete bookings from various contractors and resellers ▪ Dispatch trucks with concrete manufactured by the company to various sites	19 years
M-02	▪ Mag concrete products ▪ Tile and water proofing products	Procurement manager	▪ Looking after inventory, logistics and procurement	20 years
M-03	▪ Plaster ▪ Cladding ▪ Aerated concrete panels ▪ Polystyrene ▪ Permapanel ▪ Woodtex ▪ Floor levelling compounds ▪ Tile adhesives ▪ Waterproofing membranes	Technical consultant	▪ Handling problems ▪ Giving advice to applicators ▪ Giving advice to architects of large projects	35 years
M-04	▪ Garden ornaments	Owner	▪ Responsible for all operations	15 years
M-05	▪ GIB plasterboard	Manager Future and Sustainability	▪ Larger scale, strategic initiatives	30 years
M-06	▪ Galvanised sheet metal ▪ Louver vents	National Sales Manager	▪ Sales and trading throughout New Zealand	25 years

Table 4.2: Demographic data - Suppliers

ID	Types of materials supply	Role	Responsibilities	Experience
S-01	All materials related to buildings	General Manager of Operations and Supply Trade	▪ Operation of company branches and management of franchise system (standards, inventory, logistics, and estimations) ▪ Compliance, governance, business planning and performance management of branches	10 years
S-02	Cement based products for repair	Auckland Sales Manager	▪ Sales ▪ Promoting the products within the Auckland region to the architectural and engineering community	10 years
S-03	All materials related to buildings	Category manager, building products	Everything	12years
S-04	All materials related to buildings	National Procurement Manager	Procurement and supply chain and brought-in goods for resale	18years
S-05	▪ Aggregates ▪ Base fills ▪ Drainage materials	Transport Manager	Organizing and supplying materials	20years
S-06	▪ Bricks ▪ Stone products ▪ Paving products	Owner	Responsible for all operations	18years

Table 4.3: Demographic data - Contractors

ID	Types of materials purchase	Role	Responsibilities	Experience
C-01	▪ All materials related to house construction	Performance Improvement Manager	▪ Overseeing procurement for the group nationally ▪ Managing and negotiating deals	23 years
C-02	▪ All materials related to house construction	General Manager	▪ Managing 8 independent spec builders	42years
C-03	▪ Race course ▪ Crush metal ▪ Chip seal ▪ Hot mix ▪ Pipes ▪ Ready mixed concrete	Owner	▪ Everything	40years
C-04	▪ Drainage pipes ▪ Manholes ▪ Aggregates ▪ Pipes for water mains ▪ Fittings ▪ Concrete for slabs ▪ Footpaths and curbing	Commercial Director	▪ Financial management of the company ▪ Securing of work procurement ▪ Tendering and negotiating contracts ▪ Running the company's financial statements on a monthly basis	24years

C-05	▪ All materials related to house construction	Sales Manager	▪ Ongoing training for consultants ▪ Understanding people's budgets	35years
C-06	▪ All materials related to house construction	Estimator	▪ Pricing, orders and liaising with all the subcontractors	7years

Table 4.4: Demographic data - Architects

ID	Types of architectural work	Role	Responsibilities	Experience in the construction industry
A-01	Highly crafted residential work and some community projects (art galleries).	Principal architect	Designing and observing work on sites	20 years
A-02	High end residential architectural practice	Director	Everything	15 years
A- 03	Residential homes	Director		5 years
A-04	Residential and commercial work (medical centres and accommodation for resorts) in New Zealand and Fiji	Principal architect	Client liaison and initial concept sketch planning and design. Supervising the architects doing the contract documents.	32 years Overseas experience (Fiji)
A-05	Small scale architectural building designs	Private single architect	Designing houses	35 years Overseas experience (Fiji, Thailand, Columbia, and Mexico)
A-06	Residential and commercial designs with long term established contractors	Business owner	Designing houses and managing staff	40 years

Table 4.5: Demographic data - Homeowners

ID	Occupation	Highest educational qualifications
H-01	University lecturer	Postgraduate degree
H-02	Retired university associate professor	Postgraduate degree
H-03	Computer analyst	Bachelor's degree
H-04	Teacher trainer	Postgraduate degree
H-05	Businessman	Bachelor's degree
H-06	Medical laboratory scientist	Bachelor's degree

It can be noted from these demographic tables that all participants had good levels of in their fields, and their roles and responsibilities indicate their suitability for participation in this study, as well as indicating the validity of the research findings.

4.1.2 Key Themes

This section presents the main themes included in the semi-structured interviews for the different participant groups. All indicative questions for semi-structured interviews can be found in Appendix 2 (C-G). The themes are in line with the research questions and objectives of the study previously outlined in chapter 1. The themes covered in the interview are summarised in Table 4.6.

Table 4.6: Main themes included in the semi-structured interview series

Main Theme	Manufacturers	Suppliers	Contractors	Architects	Homeowners
01	Demographic data	Demographic data	Demographic data	Demographic data	Demographic data
02	Ways of supplying building materials	Materials sourcing considerations	Building materials purchasing process	House designing process	Significance of the materials selection
03	Transportation of building materials	Transportation of building materials	Ways of purchasing building materials	Key considerations in selecting building materials	Key considerations in selecting building materials
04	People involved in the building materials supply process	Building materials supply process	People involved in the building materials supply process	Issues in the BMSC	Issues in the BMSC
05	Key considerations in supplying building materials	Key considerations in supplying building materials	Key considerations in purchasing building materials	Suggestions for issues raised	Suggestions for issues raised
06	Issues in the BMSC	Issues in the BMSC	Issues in the BMSC	Collaboration in the BMSC	Collaboration in the BMSC
07	Suggestions for issues raised	Suggestions for issues raised	Suggestions for issues raised		
08	Collaboration in the BMSC	Collaboration in the BMSC	Collaboration in the BMSC		

The next sections present the research findings of the semi-structured interviews in accordance with the main themes shown in Table 4.6 for each stakeholder group.

4.2 Presentation of the Manufacturer's Views

This section describes the perspectives of building materials manufacturers on the main themes identified from the semi-structured interviews. It includes how manufacturers supply building materials and how they transport them, who the people involved in the supplying process are, what the key considerations in supplying materials are, BMSC issues, suggestions for improving the BMSC, and BMSC collaboration from the manufacturers' perspective.

4.2.1 Ways of Supplying Building Materials

Respondents were asked to list and describe the various ways of supplying building materials and to justify their preferences. This theme in the questionnaire aimed to identify the building materials supply behaviour from the manufacturers' points of view. The interviewees commented that generally, building materials are supplied to builders' merchants, to other building materials suppliers, to building contractors, and sometimes combinations of all of the above. Each method was justified by the participants with their advantages and disadvantages depending on different situations. Table 4.7 compares the participants' opinions on the various methods engaged in supplying building materials.

Table 4.7: Ways of supplying building materials

Building materials supplying method	Justification	Examples from transcripts
To BMs/other suppliers	Requirement of being licensed and trained applicators for particular products.	"*We sell a cladding system for a building, and the only people that can put that system on are people that we've actually licensed and accredited (M-03)*".
	Manufactures are directly paid when materials are supplied to other suppliers or BMs.	"*With a re-seller generally you know you're gonna get paid straight away for it (M-01)*".
	Supplying building materials directly to the contractors could be a risk.	"*With some of the other bigger companies, you might have heard of Mainzeal and the like that have gone under. And then sometimes you struggle to get money out of companies like that (M-01)*".
	Intermediate suppliers or BMs are discounted by manufacturers for direct payments given.	"*I basically gave them about 10% to 12% discount, for paying me on a fortnightly basis. Because for me it was worth it to have all my money in all the time, never had to wait* (M-02)".
Directly to customers (cash sales)	When the materials are directly sold to customers manufacturers make greater profits.	*"Well obviously we make more money when we sell it direct (M-06)".*
	However, due to the limitation of manufacturer's geographical location this method was considered inefficient.	*"But it's not as efficient. The guys have to be able to, when you're doing a construction job, it's never perfect science, so the guys order 10 window flashings, and they need one. Well if they're in New Plymouth, they're not gonna ring us up and have us courier down one flashing; they have a shop that they go into (M-05)".*

	Direct customer sales generally happen for low volume purchases.	*"We do have cash sales, but then people come in - but generally speaking, the plasterers would ring us up and order, you know, a truckload of material because for a house lot, it's sometimes, could be, 15 ton for a house, you know, so it's gotta be one load and that's trucked out and taken to site (M-04)".*
Combination of all methods	Geographic location of the store is important. Otherwise customers have to purchase materials from a BM/supplier rather than from the manufacturer.	"*Well if they're in New Plymouth, they're not gonna ring us up and have us courier down one flashing; they have a shop that they go into, so in some ways, a combination of both actually works out really, really well (M-03*". "*See, for example, we've got a job in Gisborne at the moment, we have one applicator in Gisborne, we will actually truck the stuff direct to Gisborne from here, the reason being there's no rail to Gisborne any more, that's been out for a while, and the trucking's way too expensive. So we share the cost of the delivery and he buys from us direct. So, theoretically, if he bought it from Hastings, which is closer, we would discount the material 25% to the people in Hastings, they would make 25% on it, but because we sell it to him direct, the 25% can help with the... so a combination of both is definitely advantageous to us as a manufacturer. And for the applicators too, service is what it's all about isn't it, really? (M-03?*"

4.2.2 Transportation of Building Materials

Participants were asked to discuss how they transport building materials to clients. Some participants commented that they have their own transport and could therefore avoid payments to logistic subcontractors. One participant said:

> "We've always had our vehicles and serviced our own vehicles and done all our own repairs and had our own drivers on wages. So we're not paying sub-contractors on a contract basis or anything like that (M-01)".

However, a majority of the participants acknowledged the need for a logistic, company for the transportation of building materials. All the manufacturers interviewed considered the service delivery component as a basis of delivering value to their customers. Most of the participants used a separate logistics company as a subcontractor. This was clearly seen from the comment given by interviewee M-05.

> "The order will be assembled, probably overnight, and a logistics company will deliver the product directly from our factory to the contractor's site the next day".

In addition, customer confidence in a manufacturer's delivery service was considered extremely significant. This was emphasised from interviewee M-05 who said:

> "...and that ability to place an order today knowing that they're going to get that delivered to their site tomorrow is hugely, hugely valuable to the customer".

In addition, participants acknowledged that having a separate logistics company reduces expenditure on a manufacturer's logistics. For example, interviewee M-02 said:

> "We supply all over New Zealand and for us to have trucks going all over to different places would be a very big expenditure. So we prefer that we manufacture and get the transport companies to supply the products for us."

Most of the participants had used a separate logistics company as a subcontractor. Participants believed that with a separate logistic company, they could accomplish the goal of delivering a good service to their customers.

4.2.3 Parties involved in the Building Materials Supply Process

It is necessary to identify the parties involved in building materials supply practices and their roles as it provides opportunities to solve the associated materials supply chain issues. In this way, the appropriate personnel can be addressed for identifying issues leading to suggestions on where exactly to improve the supply chain. Therefore, the participants in the semi-structured interviews were asked to discuss the key persons involved in the materials supply chain. In order to do this, it is necessary to describe the process of ordering construction materials. According to the interview participants, the first part of the materials purchasing process is the placement of the order. These are placed through merchants who are actually purchasing on behalf of their clients. BMs approach manufacturers' contact centres and place their orders. The contact centres comprise a team who take these orders, process them, and feed them into the order assembly process. Materials orders are delivered though a separate logistics company in most cases (5 out of 6 participants). Interviewee M-05 summarised the materials purchasing process stating:

> "Well, the first part of that process is the placement of the order, so there will be the contractor contacting their building material merchant; then they're just ringing up and saying, I want this plasterboard; put it on my account; get it delivered to this address on such and such a day."

Figure 4.1 demonstrates a summary of the manufacturers' views on the key people involved in supplying building materials.

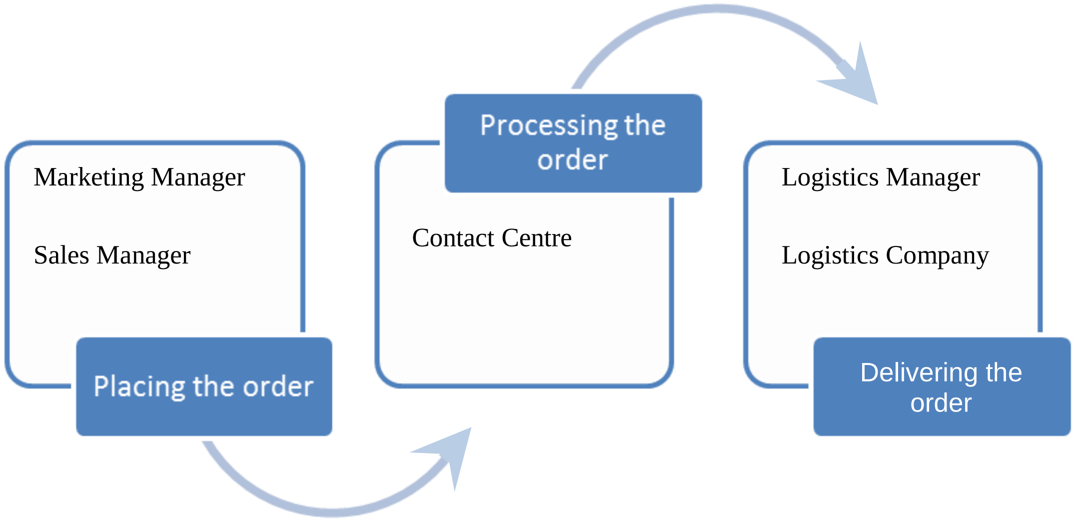


Figure 4.1: Key people involved in supplying building materials

It was found that people involved in manufacturing in the materials supply chain can be placed in three stages: of placing, processing, and delivering an order. In the stage of placing an order, the marketing manager, sales manager, sales reps, BMs, and call centre crew are considered the main people involved in materials supply decisions. In the stage of processing the order, contact centre staffs are the key persons; and lastly in the stage of delivering the order, the logistics manager and logistics company employees are considered the key people involved in materials supply decisions.

4.2.4 Key Considerations in Supplying Building Materials

This section was designed to discover the participants' views on key factors considered in supplying building materials. In general, all the participants agreed that the three most important criteria are product quality, delivery service, and product price, in no particular order. Further, the participants refused to rank the factors they mentioned. Moreover, the significance of the criteria considered varied greatly depending on the situation. Details of the responses are shown in Table 4.8.

Table 4.8: Key considerations in supplying building materials

Key considerations	Summary of participant comments
Good communication	Good communication makes strong relationships with suppliers/BMs and contractors.
Waste minimisation	Waste minimisation optimises the usage of materials.
Customer satisfaction/ having better informed customers and	This is a mix of how well customers have experienced the business in terms of payment; how well customers have been able to utilize

customer relationships	the product in the construction site and how accessible and helpful manufacturers were in that specification process. For example, some manufacturers run workshops for their suppliers.
Advertising	Solution strategies to create pull for materials.
Quality of materials	Quality is important to maintain competitive materials prices.
Technical service	Advising engineers and architects on materials issues.
Delivery service	Delivering maximum value in full, on time, in spec.
Materials specifications	Manufacturing of materials according to specifications results in better quality materials
Availability of whole range of different materials	As most of the houses in New Zealand are customised, supplying a wide range of materials is necessary
Strong relationships with original customers	Supplying materials to original customers promptly assists manufacturers to stay in the building materials supply chain.
Price	
Materials standards	Meeting the materials standards requirements is mandatory as manufacturers are not allowed to sell their products otherwise. This is an alternative way of controlling the quality of materials.
Trust with customers	Strong trust is necessary to avoid call-back costs.

The above key factors were analysed using the results obtained from the NVivo coding summary report. It can be seen that participants discussed these key considerations in 49 instances (NVivo coding report shows that there are 49 references in this section and in total there are 184 references in the whole manufacturers' coding summary report). Therefore out of 49 instances each key consideration in Table 4.8 was analysed and the results are given in Figure 4.2.

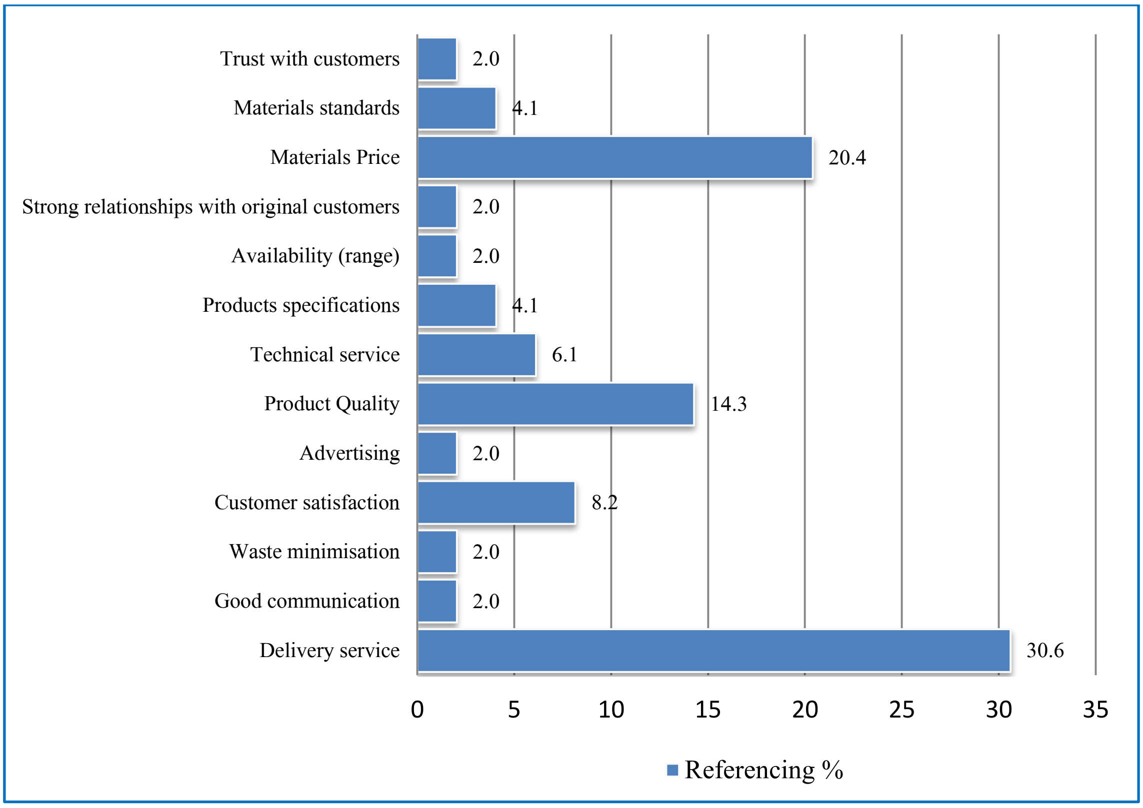


Figure 4.2: Key criteria in supplying building materials

Figure 4.2 displays the significance of the key factors explained by manufacturers during the semi-structured interview series. It can be seen that during the discussion of the materials supply key criteria, 30.6% of references were in the discussion on materials delivery service. Therefore, during the semi-structured interviews, participants gave the highest priority to delivery service over all other considerations. The participants believed materials price was the second most significant criterion, with 20.4% referencing it during the discussion. The third significant criterion was product quality, with 14.3% referencing it. Therefore, materials delivery service, materials price and product quality were treated as the most significant factors in supplying building materials, according to the six building materials manufacturers interviewed. The following sections describe the identified key considerations separately.

4.2.4.1 Delivery Service

Most of the participants agreed that good service is basically delivering the materials that the customer wants to their site in a given timeframe and in a friendly manner. Most of the participants stressed that delivery time is an important part of delivery service. For example, interviewee M-01 stated:

> "Our delivery drivers do a good job and they don't annoy the customers and make a nuisance of themselves, and we try and get their product to them when they need it".

Further, participants elaborated that having a good delivery service contributes in maintaining slightly higher materials prices compared to the general market price. For example, according to interviewee M-03:

> "But our concrete generally is a little bit more expensive, but it's because it's a good quality product and service is something that we're hot on. So we think that for good service and a good quality product people are willing to pay a little bit extra."

Participants agreed that having higher degrees of service with slightly higher prices is something their customers are satisfied with. In interviewing manufacturers, the overall indication was that a higher degree of service, despite the somewhat higher price, increased demand for their materials.

4.2.4.2 Materials Prices

Interview participants (manufacturers) believed that because the construction industry is an extremely competitive one, price is definitely important among all other criteria when supplying building materials. For example, interviewee M-04 stated:

> "For the price, because buying cement, it's got to be cheaper than the local one otherwise no-one's gonna buy it".

Therefore most of the interviewees stated the significance of maintaining competitive materials prices. However, price was not considered as the sole determinant in supplying building materials by most of the participants because supplying cheaper materials with lower quality would create risks for the manufacturer during the defects liability period (rectification provisions). For example, interviewee M-05 stressed:

> "If someone wants a cheaper price they could probably go to any of our competitors and get it. But they prefer to do business with us for other reasons. Things can go horribly wrong. The biggest call-back in the building industry is interiors. Problems with surface finish and all those sorts of things".

Most of the participants highlighted the advisability for customers to shift away from the concept of lowest cost or first price, because a low price often comes with lower levels of service and that is not good for the industry.

4.2.4.3 Quality of Materials

Among all the participants interviewed, all agreed that product quality is one of the main concerns regarding materials supply in the construction industry. Further, the participants stated that product quality is always related to product price. The key is to maintain a balance between materials quality and competitive prices. This fact was clearly shown by interviewee M-03 who said:

> "Quality is definitely something that we have a lot to do with, and price is as well. We have a big advantage on most of our opposition in that we make all our own materials in-house, so we can be competitive in price, and we are, right? But then again, I think we're way ahead of everybody else as far as products go".

Most of the participants related product quality to maintaining New Zealand materials standards. Members of the interview group believed that sustaining materials quality means meeting those standards. As customers rely on the manufacturers to provide the right quality product which complies with materials standards, quality was also considered as a key to building trust with customers.

4.2.5 BMSC Issues – Manufacturers' Views

The interviewees were asked to list and describe the existing key issues experienced in supplying building materials. This question aimed to identify the issues in the New Zealand building materials supply chain from the manufacturers' perspective. The next sections summarise the interviewees' responses in no particular order and was created with the aid of the NVivo qualitative analysis results.

4.2.5.1 New Zealand Standards

This issue was pointed out by participant M-03 who was very dissatisfied at all with BRANZ's appraisal system. For example, the interviewee said:

> "It's actually a private company, it's money-making and nobody fails a BRANZ appraisal. You pay $120,000 to appraise a product, it takes about five months and then you are on a par with everybody, but the products are so different".

Further, some of the participants commented that the use of Australian standards for some materials has caused enormous issues in New Zealand. This aspect was supported by interviewee M-01 who said:

> "I mean, we still have an Australian standard in New Zealand for brick, and thank goodness for Christchurch, because people have suddenly woken up to realise that bricks are not quite what everybody thought they were, they fall off, they leak, they're not waterproof, they don't have flashings, they're [the product of] a system that in the 1930s we accepted an Australian standard".

Similarly, participant M-03said:

> "You can't tell me that Australia has the same climate as we do. You know, I mean, we have a very wet, damp, humid climate, so dry cavity is the only way to go, whereas all the brick houses you see around here are all wet cavity. They allow the water in; they allow it to drain out the bottom. Totally inappropriate for New Zealand. Concrete tiles, scary, you know? Do you know how much a concrete tile roof weighs? 30 tons. So you put 30 tons on the roof of your house and wait for an earthquake. Unbelievable. But anyway, that's the sort of frustrations that we have is that, I mean New Zealanders have grown up with this brick and tile mentality. Totally wrong."

Since Australian and New Zealand weather conditions are totally different, following Australian standards for some building materials in New Zealand is an important issue.

4.2.5.2 Payment Problems

The interviewees strongly indicated that getting paid for their work is one of the major current issues in the materials supply chain. Interviewee M-03 stated:

> "The biggest bugbear in the construction industry is getting paid for your work."

However, participants agreed that the big companies generally pay on time and the payment problem generally lies with small to medium sized companies. Even though payment problems occur in the industry, manufacturers still have to supply materials to maintain sales. This point was very clear from the statement received from participant M-01, who said:

> "See for example, if one of our big contractors who does maybe $50,000 or $60,000 worth of materials a month, says, "I can't pay you", what do you do? I mean, if you stop supplying him, your sales go down by 60 grand, he goes to someone else, you know".

Therefore, obtaining payment and maintaining cash flows were considered as two of the most important issues among the participants interviewed. Their comments therefore confirmed that payment problems are still prevalent in the New Zealand construction industry.

4.2.5.3 Inappropriate Materials Selection

The participants pointed out that some of the architects try to increase the cost of construction as they can claim higher fees for more expensive buildings. The participants further stated that modern architects tend to specify expensive foreign materials rather than comparatively less expensive products available locally. This view was supported by the following comments.

> "I would say one house over in Mt Eden, it's probably half a million dollars more expensive than using New Zealand products, and there are three or four manufacturers in New Zealand, or three or four companies like us in New Zealand that could supply the materials; the architect makes about 4%, so what's 4% of 500,000, that's about 40 grand, 50 grand, so him doing that, I mean how do you beat that? I mean, the architect convinces the owner, or the owner signs a contract with the architect to design the building, so the architect really can go out of his way to make the building more expensive so that he makes more money. That's wrong (M-03)".

> "I'll give you an example, they have acrylic plasters, I lived in Europe for about 10 years and I could take my shirt off at 6 o'clock in the morning and have no shirt on the whole day, never got sunburnt. They bring acrylics from Germany and they put

> them on outside buildings in New Zealand, and I don't particularly think the climate suits, anything that's made for Europe's not necessarily appropriate for New Zealand, you know?(M-02)".

A lot of New Zealand manufacturers appear to be frustrated about this issue. Based on the views of the participants, it seems that many architects prefer to recommend popular materials from Europe even though they are not suitable for New Zealand conditions.

4.2.5.4 Other Issues

This section presents other issues that emerged from the interviewees. Interviewees expressed the view that people in the building industry are not keen to use new products introduced by manufacturers. Because of this the need for strong quality reports on newly introduced products was stressed by some participants. For example, participant M-04 pointed out:

> "Well all you can do is you can give them a report of the quality so the quality's okay; that type of thing".

Another main concern highlighted from the manufacturers' perspective was that maintaining a competitive price for good quality materials is a huge problem. Further, participant M-05 commented that enabling people to understand what best value is, was an important issue. Therefore, the desirability of purchasing on the basis of best value as opposed to lowest price was evident during the interview series among manufacturers.

One of the concrete manufacturers interviewed said that having the right staff at the right place is a concern in the New Zealand building materials supply chain. The participant expressed:

> "For example, we've had loader drivers that have put the wrong colour oxide in customer's deliveries and they wanted a brown coloured concrete and when it got to site it was black and now brown. So you know, train them to make sure the staffs know what they're doing and they're competent at it, it's probably a big thing".

This manufacturer's argument was that because the construction industry is unique, there is a significant learning cost associated within the supply chain. Participant M-06 explained that, the physical transportation of products is a major problem due to their shape and nature. The basic reason for this is the customised nature of the product requirements, noting:

> "Our flashings are made out of galvanised steel. They're 2.4 metres long and they are in varying shapes, profile because they're pressed to meet the customer's

> requirements. So it's difficult transporting that product: (a) its expensive, (b) it is subject to damage; and to get any correction in that is very expensive".

Similarly, manufacturer M-05 said that the biggest problem affecting the whole supply chain is the bespoke nature of the customers' requirements. For example, manufacturer M-05 pointed out:

> "I think the, at a sort of larger level design, the fact that every building is very different and it's very hard to get modular coordination and standardised dimensions of things. It complicates our industry immensely".

Some of the other issues acknowledged by the interview participants are shown in Table 4.9 along with a summary of their views.

Table 4.9: Other issues

Issues	Summary of participant comments
"Cartelism" by big construction companies	Most of the participants complained that a few big companies in New Zealand buy up all the competition and therefore materials prices and competition are completely controlled.
Demand variability	The highly cyclical nature of the industry creates uncertainties for manufacturers and some are not able to face these variable demands. Participant M-05highlighted *"We can't gear up for the highs or the lows".* Further, participants commented that the solution is to bring in more skilled workers and build volume at required rates.
Exchange rate	Participants who import raw materials from overseas faced problems caused by fluctuations in the exchange rate between the New Zealand and US currencies. Interviewee M-05 stressed that *"The fact that it's pretty hard to predict where the US dollar's gonna be; where the New Zealand dollar's gonna be, 'cause we're buying materials internationally and also competing with imported product that's bought on a US dollar basis. That's pretty important to us."*
Geographic spread	Because manufacturers supply customers all over New Zealand, this creates extra costs.
Less competition	Some participants expressed the opinion that for some materials, competition between manufacturers is insufficient. Interviewee M-04 commented that more competition would be good sometimes, by lowering prices and providing more choices for customers.
Traffic congestion	Participant M-01 reported that heavy traffic in Auckland could affect their delivery schedules. He said:*"Definitely traffic's a bit of an issue. We have to factor that into our delivery times and our booking times because of the Auckland traffic, especially around before school and after school. Yeah it can be quite heavy".*
Site safety	A few participants commented that increasingly, safety on construction sites is a really significant issue. For example, participant M-05 said that, *"In our case we have sheets as big as this table and if you've gotta carry those three storeys up or higher, how do you do that? And if they're going into a multi-storey building how do you crane them in? It's okay if there is a crane on site but what if there's not, how do you actually physically get the product in and you get it in safely? At the moment if people are passing plasterboard up from one floor to another they've actually gotta be harnessed in and roped back to the structure so that they can't fall from the building".*

4.2.6 Suggestions for Improving the BMSC - the Manufacturers' Views

As interviewees were requested to raise issues in the building materials supply chain, they were also asked to comment and discuss the possible remedies for the issues raised. It was interesting to see that not all the manufacturers were keen to answer this question. In general the participants' point of view was that these issues are common everywhere and due to the nature of the construction industry. However there were some key suggestions that came from the interviewees based on the issues around payment problems, a better materials evaluation system, and demand variability. The following subsections explain the key suggestions provided by these participants on the issues raised during the series of interviews.

4.2.6.1 Company Credit - Worthiness

Participants emphatically agreed that money is the biggest article in the building industry. Therefore the need for a government body to develop a system by which people could get financial satisfaction more quickly was stressed. For example, interviewee M-03 said:

> "If it was more detrimental for a company not to pay its bills, then the building industry would transform overnight, people would make money, prices would come down".

Interviewees expressed the view that getting their bills paid would definitely result in lower materials prices.

4.2.6.2 Accurate Forecasting

As many participants explained that demand variability is one of the major issues in the materials supply chain, the solution they suggested was more accurate forecasting. For example, according to interviewee M-01:

> "We have GPS's in all our trucks and it tracks them to and from the job and keeps a record of that data. And then it will forecast how long it's gonna take for our truck to get to the site at a given time of the day. And as long as we stick with those forecasts we generally get the materials to the site on time."

Therefore, the use of technology assisted in making accurate forecasts in terms of delivery service, and helped to more evenly regulate variability in demand.

4.2.6.3 Materials Evaluation Systems

Some of the participants highlighted that improvements in the materials supply chain should emphasise better quality materials. This idea was clearly stated by interviewee M-04, who argued:

> "There should be a New Zealand standard, yeah, and it should be government controlled and not private. It's a bit like giving the AA the ability to give people driver's licences, it should never have been privatised, and it should always have been a police thing. It should be government and not private. 'Cause then it becomes a money-making thing. BRANZ is just a money-making organisation".

Therefore participants stressed the need for a government controlled body which evaluates materials on the basis of New Zealand climatic conditions, not Australian climatic conditions.

4.2.7 BMSC Collaboration - the Manufacturers' Views

Participants were asked to discuss the importance of collaboration in the construction materials supply chain. Among the six participants who took part in the interviews, five agreed that the concept of collaboration within the industry is hugely important and that they believed that there are direct benefits for suppliers, contractors, architects, and home owners working together in the building materials supply chain. In contrast to this finding however, participant M-03was uncertain that the directly benefited from collaborative materials supply chain practices, saying:

> "On the surface it appears to be upfront but it's not, everybody backstabs everybody just to make a sale. It's true, you know, we're a very competitive, the building industry is strictly a competitive contract business, tendering, price. Unfortunately it has to be, it's a shame, but that's the way it is. We are, in our particular industry, we're very competitive, there's four or five major players, and everybody competes with everybody else, to be honest".

However the participant commented that a more collaborative materials supply chain would certainly make the construction industry more professional. Figure 4.3 summarises the participants' comments on this theme.

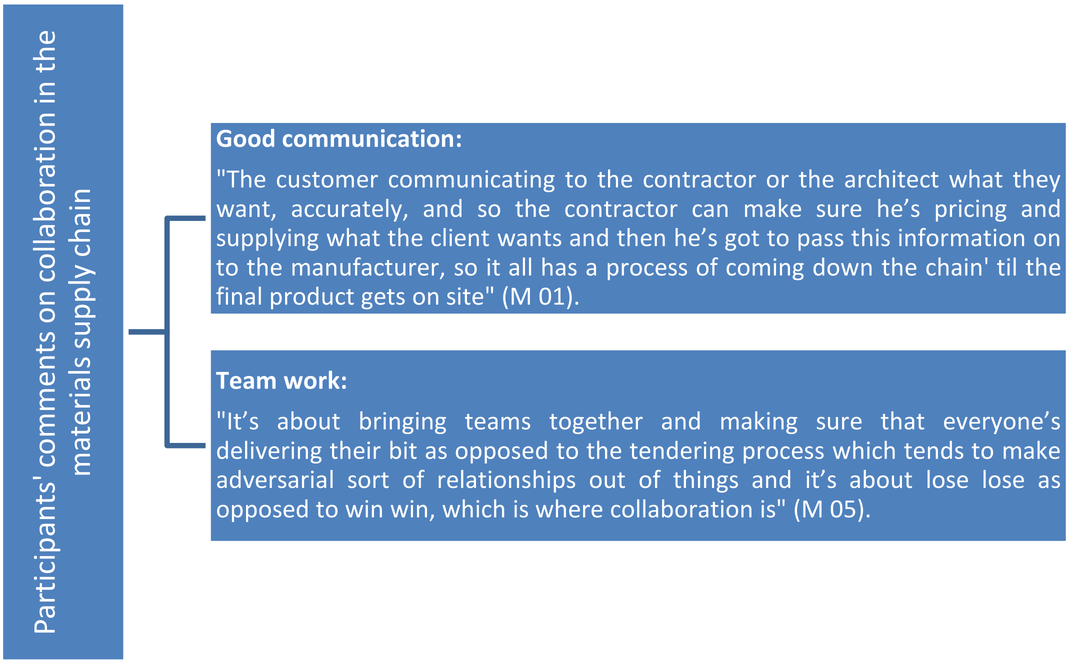


Figure 4.3: Collaboration in the BMSC - Views of manufacturers

Therefore, interviewees who agreed that collaboration is important further emphasised that good communication and team work are the basis for greater collaboration.

4.3 Presentation of Suppliers' Views

This section describes the perspectives of building materials suppliers (including BMs) on the main themes identified from the semi-structured interview process. The section discusses building materials sourcing considerations, how suppliers supply materials, how they transport materials, the materials supplying process, key considerations in the supply process, BMSC issues, suggestions for improving the BMSC, and BMSC collaboration from the suppliers' perspective.

4.3.1 Building Materials Sourcing Considerations

The interviewees were asked to comment on and rationalise building materials sourcing strategies. This particular theme was included in the semi-structured interview questions in order to get some insights into suppliers' building materials purchasing decisions. Firstly, interviewees commented that generally building materials are purchased locally due to the cost-effectiveness and efficiency of the delivery service. Such materials decisions depend on a number of other decisions (e.g. availability). Therefore some suppliers source materials internationally to meet various requirements that are not available locally. Secondly, the interviewees were asked to discuss building materials sourcing concerns. In general interviewees showed that it is necessary to source through the lens of the builders. Figure 4.4 is a summary of what participants considered as the main sourcing criteria, with some examples from interview transcripts, as appropriate.

Sourcing Criteria

- What is the right answer for the builder?
  "I mean if you think about the total bill cost there's lots of stuff in the Productivity Commission's Report on affordability and yaadi-yaadi-yaadi. But a drill that breaks down or the battery doesn't last, that can be down time for the builder on site, so anything that contributes to their down time you want to try and avoid, so the right answer for the builder". (S-04)
- What is the appropriate quality?
- Longitivity of the manufacturer/supplier
- Warranty and technical support
  "Houses tend to last more than a few days, so you want to make sure that if there is a problem the people you are sourcing from are going to be there to stand behind it. Listen, the customer's got a problem and they will investigate what the problem is, I don't have to because it's their product I'm promoting". (S-02)
- Efficency of the manufacturer's/supplier's supply chain
  "If you're able to get something delivered direct to site as opposed to through the store, we'll go for that every time". (S-03)
- Price
- Logistics (transportation of products)
  "By the time you've moved it from Papakura to here, add the transport and everything, and leasing the yard, so it bumps the price up, right? it's quicker to come down to Albany, and pick up a load and take it up there, than drive an hour and a half return up to, up north, or two hours return down to Papakura, or an hour and a half to Three Kings". (S-06)

Figure 4.4: Building materials sourcing criteria

4.3.2 Ways of Supplying Building Materials

Respondents were asked to list and describe the ways of supplying building materials and justify their preferences. This theme aimed to identify the building materials supply behaviour from the suppliers' points of view. The interviewees commented that generally building materials are supplied to building contractors or sub-contractors directly, as well as through builders' merchants. Both methods were justified by the participants, depending on different situations. Table 4.10 compares the participants' opinions on direct and indirect materials supply behaviours.

Table 4.10: Ways of supplying building materials

Building materials supplying method	Justification	Examples from transcripts
Directly to contractors and subcontractors	More revenue compared to supplying through BMs, which usually involves discounts	*"Predominantly directly. A small percentage through merchants, but predominantly we sell direct to builders and bricklayers and the public building their own homes or renovating their own homes".* (S-04)
	The knowledge involved in supplying products	*"Our products need a little bit of knowledge involved. Two reasons, one is you need the knowledge to sell the products for what they are, otherwise if you were dealing with merchants the skill-set of the people selling it quite often is very wide, but not concentrated on one product, unless they're that sort of biased. It's very simple to sell a sheet of ****** because they're all the same colour".*(S-06) *"But for our products, we have a large colour range and the installation and knowledge of variation in batching and things like that are too hard to sell through merchants that aren't experienced in what they're doing. They turn their staff over a lot too, so you'd spend all your time training them".* (S-03) *"We supply to applicators who are registered and approved to be able to apply the products on a construction site. So our direct clients are our plasterers and applicators, and then they contract to the construction companies".* (S-02)
	Low profit margins in the industry	*"There are not huge margins in our industry. It's a low margin industry. So sharing a bit of the pie is not possible".* (S-01)
	Fewer people involved	*"If you could manufacture a product and deliver it to site it's the ultimate, isn't it? Otherwise you've got people involved in the chain all the way through".*(S-02)
Through BMs	Guaranteed payments	*"As opposed to doing it yourself, you're at risk of them not paying you".* (S-05)

4.3.3 Transportation of Building Materials

Participants were asked to discuss the delivery of delivering building materials to clients. As they explained, logistics companies are responsible for supplying freight services to customers. Upon a request being received from a customer, the supplier informs the logistics company which organises the appropriate vehicles and delivery to the customer as informed by the supplier. Another reason for engaging a third party for materials delivery is cost effectiveness. For example, interviewee S-02 said:

> "The insurance that goes with the cost of having a driver, because we don't need that facility all the time, it's a lot cheaper for us just to use a third party such as PBT, when it is needed".

In addition to that, the geographical spread of the BMs and building contractors also influenced their use of logistics companies with their higher scope of delivery. Supplier S-03 stressed:

> "Reason being is the geographic spread of building merchants and builders. So there wouldn't be many suppliers that would have their own trucking fleet, normally they would just contract that out".

The suppliers' preference was to use third party logistics or third party freight providers as opposed to having their own transportation means, because freight delivery is considered an integral part of the supply chain. Their perspectives on transporting building materials corroborated the findings (under the same theme) from manufacturers.

4.3.4 Building Materials Supply Process

The interviewees were asked to describe the process of supplying building materials including the main parties involved in the supply process. Typically the process of supplying materials commences with a customer's request through telephone calls, the web, or sales reps. Based on the client's requirements the purchase order is billed and priced. Subsequently, the supplier's quotation is presented to the customers (e.g. a builder) and upon their agreement the supplier will schedule the delivery through a logistic company. Scheduling is based on the phase of the build. Once an order is converted to a bill of materials, the remainder of the process is undertaken by inventory controllers, telesales and logistics companies to manage the end-to-end processing.

4.3.5 Key Considerations in Supplying Building Materials

This section was designed to understand the suppliers' views on the key factors considered when supplying building materials. Suppliers were asked to discuss the key criteria when they supply such materials. In general all the participants agreed that the top three criteria were product quality, delivery service, and materials price, in no particular order. Further, the significance of the criteria considered varied greatly, depending on the situation. Details of their responses are shown in Table 4.11.

Table 4.11: Key considerations in supplying building materials

Key considerations	Summary of participants' comments
Alignment and dialogue	Clear communications with builders or BMs would open more opportunities to provide better service.
Availblity of materials	Having the product available when it is needed is a simplistic approach to make the supply chain work.
Collaboration in the supply chain	Working together ensures the lowest supply chain cost and supply chain time.
Compliance requirements	Products should be approved and verified by a third party (e.g. BRANZ) in order to meet industry standards.
Delivery service	On time delivery with good service ensures customer satisfaction.
Educating customers on products	Identifying and making sure that the customers understand what they are getting for their purpose; suppliers should deliver a product that fits the purpose.
Least waste	Waste minimisation is an optimisation strategy in the supply chain.
Market conditions	Materials are supplied by suppliers based on the specifications on the construction drawings. In this regard a lot is determined by the market rather than the products that suppliers would like to sell to customers. Therefore, suppliers often follow, rather than lead, the market conditions.
Minimisation of supply chain time	Shortest possible time of delivery.
Price of materials	Competitive prices with good quality are a challenge. Price is an important factor because low profit margins affect long term stability in the business.
Products specifications	It is very important to make sure the specifications are correct at the beginning of the process. Correct specification is a point of quality control.
Quality of materials	Basically quality is a key because good quality does not create any issues for anybody in the supply chain. Therefore, customers should be prepared to pay for a very good quality product that fits the purpose.
Site constraints	Understanding site peculiarities is important in supplying building materials. Often suppliers (or logistics companies) visit the site to determine what sort of vehicles to use for delivery.
Specifications	It is necessary to make sure that specifications are correct at the beginning of the supply process.
Understanding customer needs	Accurate interpretation of unclear and dismally vague descriptions of what customers think they want, is a challenge.

The above considerations were analysed using the results gained from the NVivo coding summary report. It was determined that participants discussed these key considerations in 41 instances (NVivo coding report shows that there were 41 references in this section, and in total there were 215 references in the whole suppliers' coding summary report). Therefore, out of 41 instances each key consideration in Table 4.11 was analysed and the results are shown in Figure 4.5.

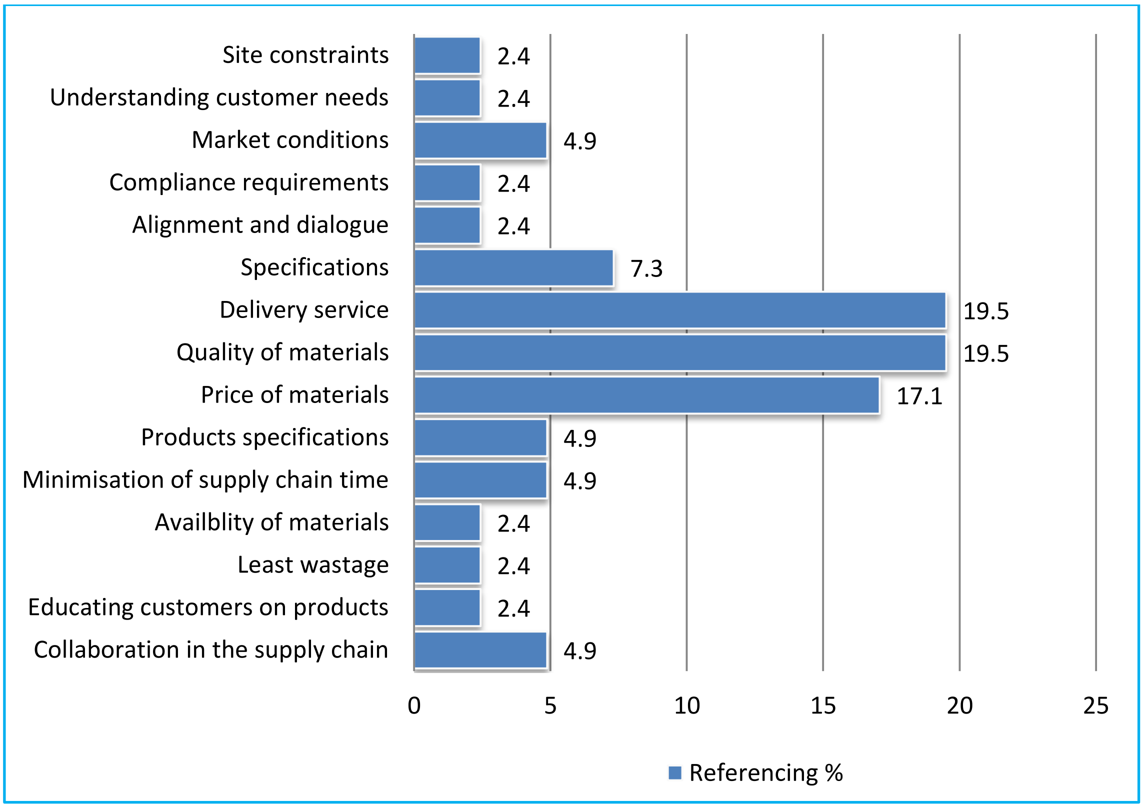


Figure 4.5: Key criteria in supplying building materials

The NVivo analysis results yielded the three most important considerations in supplying building materials among the interview samples were: quality of materials (referencing percentage of 19.5), delivery service (referencing percentage of 19.5), and price (referencing percentage of 17.1) of materials. The next three sections describe the three key criteria identified above, with selected participants' comments where appropriate.

4.3.5.1 Quality of Materials

During the series of interviews, all the participants (suppliers) stressed that providing quality materials is the key to remain competitive in the industry. According to the interviewees, offering good quality building materials for a competitive price is a challenge in the New Zealand construction industry as it is comparatively small in size, but large in terms of competitiveness. Supporting this, participant S-02 pointed out:

> "Price is always a concern in the New Zealand construction industry, well, global construction industry - but we do play at the top end and therefore we are probably recognized as the more expensive supplier in our particular field. But we offer a quality of product that's quite superior to even the next closest opposition; we're many times above them as far as quality and durability, so while

> we try to maintain the best price possible we're still more expensive, but very rarely has it been a negative for us because of what our product can achieve".

The interviewee believed that maintaining good quality of materials results in higher prices and ultimately buyers have to bear it. Conversely, paying more for good quality materials will probably reduce house maintenance costs. For homeowners another interviewee, S-06, argued:

> "As far as I'm concerned if the customer's getting a really good product for a good price, they should be prepared to pay for it. If they want crap they can buy crap".

Hence, the interviews demonstrated that providing good quality building materials (under the theme of key considerations in supply decisions) was one of the most important considerations.

4.3.5.2 Delivery Service

As in materials quality, providing a good delivery service was given an equivalent importance among the building materials suppliers. The participants considered freight delivery to be an integral part of the service they provide. Creating customer satisfaction by providing on time delivery with good service is therefore an important part of the supply chain. Participant S-06 commented:

> "Well, the delivering on time comes standard with us. That's just what we do. That's just the nature of our business is, we are quite organized in getting stuff there and looking after people well".

Having a good materials delivery service is therefore seen as essential for keeping customers in the long term.

4.3.5.3 Price of Materials

The third important consideration (2nd rank in Figure 4.5 above) in supplying building materials was price. Materials prices are a very important factor throughout the supply chain, because profit maximisation is the main goal of any business, even though there are other goals to be pursued. Further, enhancing profits helps to ensure better quality materials with good delivery service. This was supported by Participant S-04 who stated:

> "I perceive price is the key thing 'cause that's where I make my money. And the other things, if you get the right price you can deliver a good product and have the good service."

This was also supported by participant S-01 who stated:

> "Price is the hard one in that there are opposition companies that suffer a little bit on quality; they suffer a little bit on service, so their answer to that is price."

Therefore, the semi-structured interviews with materials suppliers found that competitive prices are a key consideration in supplying materials but this does not necessarily mean the cheapest price; other factors such as quality of materials and delivery service are also important considerations.

4.3.6 BMSC Issues - the Suppliers' Views

Under this particular theme, participants were asked to discuss the current issues in the New Zealand BMSC, in order to identify these issues from the suppliers' perspective. Based on the NVivo interview analysis coding summary, the next sections summarise different issues identified by the participants in no particular order.

4.3.6.1 The Bespoke Nature of Houses

The bespoke nature of New Zealand houses was reported as a major issue. Participants explained that having very customised houses creates the need to purchase specific sizes, colours, shapes, and various other one-off requirements. As a result, a significant amount of materials could be wasted and this was a considered as an issue by some of the participants. For example, interviewee S-01 said:

> "So if you go back to the integration we just talked about, and the bespoke nature of our builds, I mean *** ***, *** ***, most panel manufacturers manufacture bloody sheets to 2400. A new trend is let's do a 2700 high ceiling stud, so what are you going to do with that 300mm?…So I think the bespoke nature and the wastage that comes off, I mean I don't know what the number is, but six or seven bins might come off a site; well that's hopeless and it doesn't need to be that way, you know, through tighter integration and increased standardisation you'll drop that wastage big time."

This issue also creates less efficiency in the BMSC as the whole construction process tends to become more complicated. This was corroborated by participant S-03 who said:

> "I'll probably go back to that thing around the bespoke nature of homes. I mean if we had more modular, more standard residential configurations, you would have a

> far more efficient material supply chain in New Zealand, but everybody wants a different sized-window, or they want a window with double-glazing with krypton. Something like that."

Throughout the interview series the participants frequently expressed the view that the bespoke nature of houses is an issue as it increases construction costs and reduces efficiency in the BMSC, while creating a significant amount of waste materials.

4.3.6.2 Industry Size

Another issue acknowledged by the interviewees was the small capacity and size of the market compared to overseas. Since the New Zealand market is small compared to many other parts of the world (Europe, North America, etc.), the demand as a total is not large. Consequently material prices and construction costs are relatively high in New Zealand.

4.3.6.3 Building Code Complexity

Some of the participants pointed out that the complexity in the current building code creates issues about what is allowable and which system needs to go with another system to give the best outcome. Also it was identified that homeowners' knowledge of building materials and products is limited. For example, participant S-01 stated:

> "Yeah, I mean certainly I'd buy the first one and that goes back to lack of understanding. So you know there's a lot of Chinese taps that come into the country and then when the washer goes we can't have a washer to fix it. You know the average home owner doesn't understand that sort of thing."

The current building code is seen as complex and time consuming. The interviewees felt that many homeowners do not understand materials, their specifications, and the requirements of building a home under the modern building code.

4.3.6.4 Inferior Products

The interviewees commented that the introduction of new materials in the building industry is one of the major issues in the supply chain and has caused other problems such as leaky buildings. For example, participant S-06 commented:

> "Well in general of course, as we know, there's been a lot of inferior products delivered and it's caused a lot of problems in the building industry. That's why we have leaky home problems and issues."

Therefore inferior products which are attractive but low in quality can result in leaky buildings and similar types of building performance issues.

4.3.6.5 Profit Margins

The participants stressed that the New Zealand construction industry is a low profit margin one and maintaining competitive prices challenges the materials suppliers. Participant S-04 commented:

> "Well I mean price is of course to the people is an important factor and to us because if you don't make money you don't have a business. So that's what's been wrong with our industry for a long time, there's been no money made in it for many years hence major changes. And even though we've been through some building booms there was still really no money made. There was but not what it should have been."

The interviewees felt that their only option was maintaining a viable price, as demand is so comparatively low.

4.3.6.6 Materials Standards

The participants expressed the view that the regulatory framework around materials standards is insignificant in the New Zealand construction industry. Participant S-01 said:

> "So when you bring food into New Zealand and I look at this, I'm very familiar with the food safety standards authority, you can't be an importer and distribute stuff unless there's certain criterion you meet. Yet I could actually go and import a container of steel and start shipping it around, or import a container of plasterboard or something and do it."

The interviewees also said that although there are regimes to oversee materials standards, in reality they are ineffective, and the need for mandating only proper quality materials in the supply chain was commented on repeatedly during the interviews.

4.3.6.7 Other Issues

This section presents some other issues raised by participants. The participants stated that demand forecastability is problematic. Participant S-02 said:

> "Specifically for us being a European or a German [product] supplier we need to ensure that we have products that arrive in a timely fashion from Europe. …so we need to have appropriate forecasting in place to ensure that we've got a continuous supply of product. That's probably the main challenge."

Other participants also agreed that planning and forecasting become very difficult as demand varied in the short term. Linking to demand forcastability, the lack of such forecasting facilities again makes supply planning more challenging, because suppliers have to base it on historical information rather than factual and guaranteed forecasts. In addition, supplying building materials according to the demand (demand variability) was mentioned as a problem facing supplier S-05 who stated:

> "My biggest problem is getting enough of it to service the customer. And that's generally because the closest quarry is two hours' turnaround so I might get a customer ring up, some customers ring up and say, "I want 100 metres of GAP40 tomorrow". So tonight and tomorrow morning, you make sure you got enough coming in just to cover that job. Then you get other customers just rock in there and hit you for 100m, you didn't know it was going out, you're not equipped for it, and you're not prepared for it. That's a challenge."

The suppliers who import and export materials commented that the currency exchange rate also acts as a challenge in supplying materials. The participants said that imported products (e.g.Chinese products) also acted as a price challenge for local suppliers to remain competitive in the market. However, they said that ensuring materials are available at the time they are needed and at a competitive price would eliminate such challenges from imported building materials.

In addition to the issues discussed above, the low level of sophistication of owner-operated suppliers with their very short term focus, materials unavailability, and safety and security on building sites, were also stated by the interviewees to be BMSC issues.

4.3.7 Suggestions for Improving the BMSC - the Suppliers' Views

Subsequently, participants were requested to suggest prospective solutions to overcome the issues revealed. This section discusses the participants' suggestions on overcoming these issues. The interviewees expressed the view that as building materials suppliers, studying, learning and understanding what people want in building materials is an important aspect of improving New Zealand building materials supply chain practices. The need for tighter integration in the BMSC was also suggested by the participants. Further, pre-ordering is one practice suggested by some of the participants that would overcome many materials delivery issues. Another way to grow the materials supply industry is providing materials that have good aesthetic values. This would increase customers' satisfaction and as a result, materials demand would increase.

One of the common ideas that emerged in the series of interviews was that the bespoke nature of New Zealand houses causes many problems in terms of increased costs. Therefore, a lot of suppliers commented that house standardisation would greatly help to generally bring down costs in the residential construction industry. As homeowners are the last node in the materials supply chain, some of the participants felt that homeowners should be more actively involved in choosing the appropriate materials for their houses. Participant S-01 stressed the idea that if homeowners were educated in selecting the right materials it would eliminate a lot of problems and reduce costs. Participant S-01 said:

> "And I was at one place in the middle of last year, out by the coast - it was right on the coast - and there was not even galvanised… you know, the bloody joist hangers were all rusty and shitty; they weren't the right ones you should have used. Now they were probably fine inland, but you go, well, that was a new place, that shouldn't have happened. A builder wouldn't have done that. There's no question in my mind that the home owner put that deck on. So I think the education and consequences are two things I think we've got to think about".

One of the other suggestions from participants was the necessity for good forecasting of product stock levels and product lines in order to make sure that shipping and delivery happens on time, and that suppliers have sufficient stocks. Lastly, the participants emphasised the need for better transport infrastructure in New Zealand in order to improve the logistical aspects of the BMSC.

4.3.8 BMSC Collaboration – the Suppliers' Views

Generally the participants agreed that greater collaboration in the materials supply chain would have positive impacts. The participants believed that collaboration is working together to create better built houses that ensure quality construction in New Zealand. In addition, collaboration is a kind of communicating with building contractors to make sure that the right products are delivered at the right time. Interviewee S-05 expressed it this way:

"Collaboration makes sure that the material that they want, or think they want, or what is prescribed in their drawings, is available.

Figure 4.6 summarises the opinions of interviewees (suppliers) on greater collaboration in the materials supply chain.

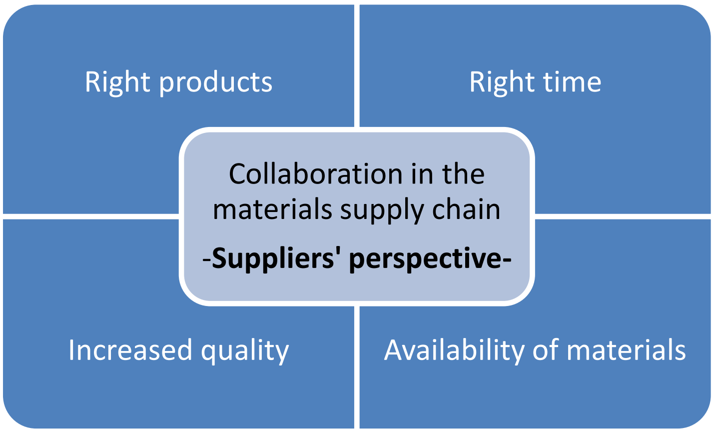


Figure 4.6: Collaboration in the BMSC - Suppliers' views

Therefore materials suppliers believe that collaboration assists in finding right materials in terms of right quality, availability, and right delivery time.

4.4 Presentation of the Contractors' Views

This section presents the residential contractors' responses to the interview questions and covers the following themes: the significance of the materials purchasing process; ways of purchasing materials; the different parties involved in the purchasing process; key materials purchasing considerations; BMSC issues; suggestions for improving the BMSC; and BMSC collaboration from the contractors' perspective.

4.4.1 Significance of the Materials Purchasing Process

Under this theme the participants were requested to comment on the significance of the materials purchasing function. The participants stressed that the materials purchasing process is critical in the sense that having the right product options (quality and durability) at the right price for the right service is a key aspect of the business, and determines the level of profit at the end of the project. For example, participant C-02 said:

> "It is absolutely critical because if you buy wrongly then your build cost goes up and you don't make any money."

Also participants stressed that the construction industry is totally distinct from other industries in the sense that a builder has to sell a house before materials are purchased (the tendering process). Therefore the only way to increase profits from the contract is to purchase the materials more cheaply than is initially specified. Therefore the participants believed that buying cheaper materials decides the profitability of a contract.

Secondly, the interviewees were asked to explain the process of purchasing building materials, in order to better understand buying behavior in the New Zealand residential construction industry.

The participants explained that a house construction project may begin upon an enquiry from a client which is generally in terms of the tender documents. Contractors then go through the project details (scope) and price the project, which is then tendered or negotiated. If the contractor is successful, the next step is working through suppliers in terms of purchasing. Generally contractors seem to already have approved suppliers and sub-contractors. At the time of tendering, the enquiry will go out to the supplier to price materials. Consequently, suppliers will price the work (a "quotation") to the contractors - there are usually three to four quotations for each type of product. Once the quotations are evaluated, the contractor selects the supplier based on various criteria such as materials prices, quality, availability, delivery service, etc. Then, when the contractor wins the project, a quotation is formally accepted. Afterwards, purchase orders will be prepared and then that is passed on to the construction management team in the form of a cost management plan (quotations, workings and necessary information).

4.4.2 Ways of Purchasing Building Materials

The interviewees were requested to describe their ways of purchasing building materials and to justify their practices. For example, some contractors purchase directly through manufacturers, while others purchase through suppliers or BMs, or by a combination of different methods. Further, most contractors prefer to purchase materials locally. Table 4.12 shows a summary of the participants' views on ways of purchasing building materials.

Table 4.12: Ways of purchasing building materials

Ways of purchasing materials	ID	Participants' comments	Description
Directly from manufacturers	C-03	"Mostly manufacturers. We purchase wholesale, we don't purchase retail".	▪ Depending on the relationship and the ability to add value ▪ Better price by avoiding middle persons ▪ Resource based products ▪ Finding best manufacturer is worthwhile rather than paying more for intermediate BMs
	C-04	"Well, all our purchases, we deal directly with the manufacturer; we don't go through agents, ... If we can't deal directly with the manufacturer we don't buy that product, we will go somewhere else"	
	C-02	"Some articles get sold and there's three sticky fingers touch the article before it ends up being sold, so it starts off at a $1 and then someone puts 20 cents on it, then the next sticky finger puts another 22 cents on it; the third sticky finger puts 33 cents on it, and you end up paying $1.72 for a product that you should be able to buy directly from the manufacturer for $1. So that's 72% you've just saved yourself by working hard. It's a matter of working hard".	
	C-05	"Directly from the manufacturers in most cases 'cause we don't want to pay a middle-man."	
	C-01	"...with a building merchant, they facilitate all the bits and pieces, so they add value to that relationship".	
Combination of manufacturers, suppliers, and BMs	C-02	"A bit of everything. We would buy through building merchants. We buy some through suppliers, like tapware we buy through suppliers; it's all over the place, not one thing we do. It's wherever we can buy the product that we want".	▪ Added value to the relationship ▪ All the materials can be purchased under a single supplier ▪ Materials availability ▪ Consumable items are purchased through BMs
	C-05	"In terms of purchasing from a building supplier generally that's mostly what we'd call consumable items. So it's smaller products which you just need on an ad hoc basis, so the likes of nails and bolts and fastenings, glues are what we would purchase from what you'd call a building supplier, the likes of *** or *** or all those types of places".	
	C-06	"It's a combination of it. But most of it is through the merchants and subcontractors. And only one we probably buy direct is the bricks and stuff like that. But otherwise most of it's through the merchants".	
	C-04	"So normally if we have to source something from overseas it takes anywhere between eight to 12 weeks to land in the country and a lot of our contracts are finished in eight to 12 weeks. So it makes sense for us to purchase locally wherever possible".	
	C-01	"No, we use local businesses all the time if we can; like we use Stevenson's Quarry, 'cause that's local; we use the local ready mix company. Yeah we use the local people but they have to meet our price. If we can buy it cheaper elsewhere then we go back to those local and say, "Look, this is the price you've gotta supply; this product at this price for this particular job, otherwise we'll have to buy it from so and so".	
	C-03	"Because they all live in the area, and why wouldn't you look after your local people? Why send money out?"	
	C-06	"So if there's something wrong with the product it's a lot easier to go to a local supplier and get them to rectify any issues that we have. It's also easier for us to manage in terms of our programme".	

In addition all the participants positively commented that purchasing locally is the most preferable option, as long as materials are locally available.

4.4.3 Parties in the Purchasing Process

Participants were asked to describe the parties involved in purchasing building materials, and a general view of the different parties involved in making materials purchasing decisions in different stages of a house construction project was obtained. Generally there were three positions identified: contract estimator, project manager and contract administrator, and accounts administrator; all of whom are involved in purchasing decisions.

4.4.4 Key Purchasing Considerations

This section was designed to discover the participants' views on the key factors considered in purchasing building materials. The interviewees were asked to discuss the key criteria in making building materials purchasing decisions. Their responses are summarised in Table 4.13.

Table 4.13: Key considerations in purchasing building materials

Key considerations	Summary of participants' comments
Understanding of current building materials	Keeping up to date with training on materials so that procurement is on the best product that contractors can obtain.
Materials quality testing regimes	Materials quality testing system which runs alongside each project.
Price	Securing a project is evaluated based on price. That price-driven focus is initiated by the clients and goes right through the business.
Quality	Making sure that materials are good quality products that are not going to fail in the near future, and they will last the time of the warranties.
Integrity in the supply chain	Working as a team to complete house construction projects successfully.
Materials specifications	Sourcing the right materials in terms of specifications (what homeowner wants), and products are installed and completed in accordance with them.
Information sharing with branches of the same company	Large companies tend to share information on materials and material sources among different branches.
Strong supplier relationships with a pool of standard suppliers	Having a set of reputable suppliers as a starting point, who back up their product with service and are accountable for their products.
Availability of a variety of products	Client's requirements are generally very broad and therefore having a variety of products is important when selecting building materials suppliers.
Supplier service	Materials delivery service. Supplier's ability to provide a good back-up service (durability and warranty).
Customer feedback	Homeowner's opinions on materials used and onsite meetings on

	homeowner satisfaction regarding materials used.
Researching for the best supplier	Proper research regarding materials in terms of specifications, quality, availability, and price, prior to selecting the best supplier.
On time payments to suppliers	Paying suppliers' bills on time keeps the relationship strong and leads to better offers from suppliers
Having a sophisticated software system	A sophisticated software system should allow estimating materials requirements to very effectively produce a purchase order (which states what material is required and when it is needed).

The above key criteria were analysed using the results obtained from the NVivo coding summary report. It can be seen that participants discussed these key considerations in 100 instances (the NVivo coding report showed there were 100 references in this section, and in total there were 229 references in the whole contractors' coding summary report). Therefore, out of the 100 instances each key consideration in Table 4.13 was analysed and the results are given in Figure 4.7, which shows the significance of key factors discussed by contractors during the semi-structured interview series.

It can be seen that during the discussion of materials purchasing key criteria, 25% of references were on discussion of materials prices. Therefore during the semi-structured interviews participants gave the highest priority to materials prices over all the other considerations. The participants believed materials quality was the second significant criterion with 16% referencing during the discussion. The third significant criterion was having strong supplier relationships with a pool of selected suppliers (15% referencing), while the fourth significant criterion given was supplier service (11% of referencing).

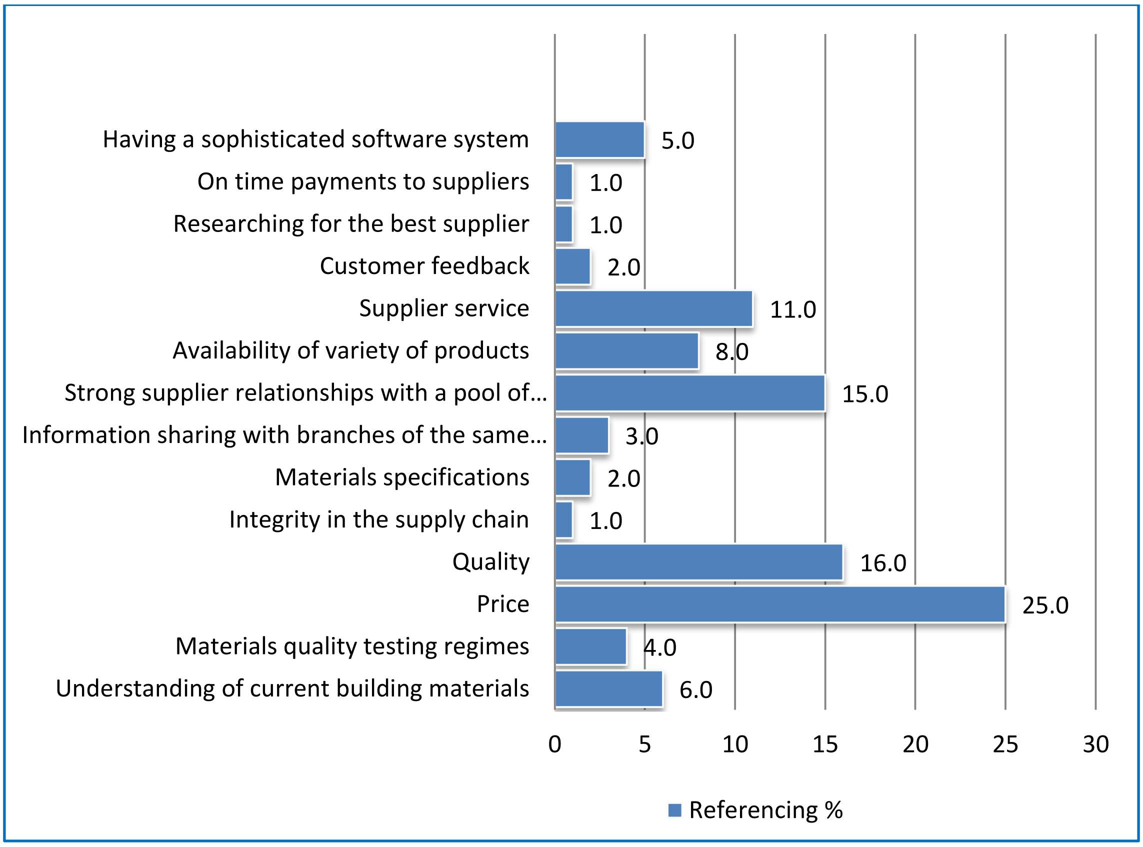


Figure 4.7: Key criteria in supplying building materials

It was found that materials price, quality of materials, strong supplier relationships, and supplier service, were treated as the most significant factors in purchasing building materials according to the six residential building contractors interviewed. The following sections describe separately the four most important considerations identified.

4.4.4.1 Materials Prices

Unlike the other groups interviewed, it was interesting to notice that the building contractors emphasised the significance of the price of materials throughout the interview process. The participants pointed out that construction is very different from other industries, as the output is sold before actual construction is commenced, through the tendering process. Therefore contractors tend to purchase materials for lower prices than those used in the tendering process. For example interviewee C-03 said:

> "And that's how you run a business. If you own a shoe company you've already bought your shoes; you know how much you've paid for them, you put them on the market with a margin. So the construction is totally different; tendering is totally different. It's the opposite. You see, you have to have an opposite business plan; you've gotta buy right".

Some participants highlighted that the price driven nature of the industry forces them to stick with the lowest price concept. Interviewee C-04 twice commented:

> "When we try and secure a project we are evaluated on price as the number one priority ourselves. And so for us to win a project we've gotta make sure that we have the lowest price and that means that we select everything on the priority of being the lowest price first. That price-driven focus is driven by the clients and goes right through the business".

> "Because effectively everyone that we ask to price, we are generally satisfied with the quality. So when I say quality, the products that they supply are in accordance with the specifications and the standards that we have to build with".

Therefore participants agreed that they were satisfied with the quality of building materials available in New Zealand and accordingly, materials purchasing decisions are based heavily on materials price.

4.4.4.2 Quality of Materials

As the second most important criterion in choosing building materials, quality was identified by the participants. This was primarily because their reputation is based on the quality of houses they build. Participant C-05 stated:

> "For us it's about making sure that we have the best products we can in our homes so that this company is known for good quality products that are not gonna fail in the near future; and they will last the time of the warranties."

The interviewees felt that good quality materials should be selected along with good prices; that is, prices that are as low as possible. Sharing information was considered an effective way of sourcing the best quality materials. For example, participant C-02 said:

> "So the quality is, if we see a bad product coming into the market our managers talk to one another and they say, "That's no good, don't use it." So we've got the advantage of that."

Even though many of the interviewees argued that the price of materials is the most important consideration in choosing building materials, some expressed the view that choosing quality materials and maintaining their reputation was their uppermost consideration.

4.4.4.3 Strong Supplier Relationships

The interviewees clearly showed the significance of supplier relationships in making materials purchasing decisions. They agreed that having long term relationships with recognised suppliers could greatly support their materials purchasing decisions. For example, participant C-01 explained:

> "From our point of view, if the relationships are working well we just keep working on them and if there's little things that need fixing like tending to, you work with them in partnership. So we've had long term relationships with you know *** *** been a 2003, so what's that? Ten year relationship.***the same. There's a number of relationships that are 10 year plus. So we don't just chop and change".

This shows the importance of the continuity of supplier relationships. That's the importance of having strong supplier relationships is that it makes for better prices with good quality materials, according to interviewee C-03:

> "You actually get better deals if people know that you're gonna come back and do repeat business; you will get much better deals. You might not to start off with, but in the passage of time if you use the same companies you'll get the best possible deal out of them".

Also, some participants stated that strong relationships guarantee supplier service, as the suppliers prefer not to lose future business. This was indicated from participant C-04:

> "And we find that because of those relationships that we have that if one thing goes wrong on a job, that there's a joint effort with the supplier to fix the problem and they don't walk away from it because they don't wanna lose that ongoing business. So relationships are important and that's one of the things we maintain to make sure that we get what we want".

Regarding homeowner satisfaction on the type of building materials used, having a variety of materials available certainly appears to satisfy homeowners according to the interviewees. The participants highlighted this by using the example of how a broad colour range can help to meet homeowners' wishes. Therefore having a group of established materials suppliers assists in ensuring customer satisfaction as they can offer a wider range of products.

4.4.4.4 Suppliers' Service

One of the significant key considerations appearing in the semi-structured interviews with contractors was regarding the delivery service provided by suppliers. Basically what participants required was on-time materials delivery. According to the semi-structured interview results, it was seen that the building contractors signified the materials delivery service as a key criterion which affects their purchasing decisions.

4.4.5 BMSC Issue - the Contractors' Views

The participants were asked to explain the key issues regarding the New Zealand building materials supply chain. The interviewees showed that the bespoke nature of houses was an issue. Because of each homeowner's very different and unique materials and design requirements, house construction costs are increased, something which does not occur in a standardised house. Participant C-02 pointed this out by saying:

> "This is what's wrong with the New Zealand market; everybody wants a house that looks different".

Many of the participants stressed that because of some big building contractors' dominance position in the industry, small and medium sized contractors suffer. Interviewees further showed that this dominating behaviour has created a significant problem for small and medium contractors in terms of competitiveness. For example, interviewee C-03 said:

> "I think the Commerce Commission needs to look at this large organisation quite seriously, 'cause they own too many subsidiaries. Not as under their name, that they've gathered them in. So that then makes it more difficult to compete with those companies, they don't seem to have the same flexibility on price; 'cause this big company wants to dominate the industry".

Another issue reported by the participants was that of cheap imported materials. For instance, interviewee C-03 stated:

> "…the other thing is, I'm concerned about cheap imports coming in from China which are poor quality and people are buying houses with poor quality stuff in. Not ours, but other; it's so easy to buy a house with poor quality. And come a couple of years and you're gonna have failures."

Having a limited number of materials for certain products (because of economies of scale) was mentioned by some participants as an issue in the BMSC. As a consequence, there is decreased competition amongst suppliers, which raises materials prices. The participant C-04 said:

> "For example, concrete drainage pipes, there's only two suppliers in Auckland. It probably couldn't support another supplier but the economies of their production are such that it all adds into the price for products".

As contractors are extremely concerned about materials prices, they also argued that the small volume of construction in New Zealand also drives materials prices up. For example participant C-02 said that:

> "I think there's a perception that building materials are expensive in New Zealand and they probably are; but then you've gotta look at the scale of building. No one does any volume. If you don't do volume, price is an issue."

Also high traffic congestion in Auckland was reported by the participants as a further issue, as delays in the transportation of building materials added to their costs.

Participants were satisfied with the quality of materials and their availability; the only major challenge they highlighted was the price. Participant C-06 stated:

> "Yeah, keeping the price down, really. Because the price has been stable for quite a bit of time, but now it's like getting busy, so keeping the prices down. That is the biggest challenge."

The reason for high materials prices was, according to the participants, manufacturers' and suppliers' overheads and labour costs. Consequently BMs also increased materials costs and had an effect on the whole supply chain.

4.4.5.1 Other Issues

The other issues stated by interviewees are summarised in Table 4.14 with appropriate comments made by them.

Table 4.14: Challenges in the BMSC - Contractors' views

Issue	Description	Participants' comments
Cash flow management	Timing of supply and deliveries to manage cash flow is crucial. Participants described that they aim to have the product JIT on site, so that it is not sitting there exposed to theft and deterioration.	*"So obviously if we place orders for products we're on a typically a 30 day payment. So if a product arrives on the 30th day of the month and we haven't installed that product till the 1st of the month, we've gotta pay for that product before we get paid for it ourselves (C-04)".*
Finding the right product	Due to availability of variety of products, finding the right product in the purchase order was considered a challenge.	*"I guess for me it's probably just making sure that when we order something, that it is the right product; 'cause you can imagine within each company their product list of items is massive; thousands of items, SCU numbers. So its making sure we have the right SCU number so when we order it off our purchase orders, it is correct (C-03)".*
Geographical spread and volume	Because New Zealand construction industry is small and spread out, transport costs seem to be very high.	*"They don't have the volume that other countries have, or even states - Australian states have got more than we've got as one whole country, but they've got a massive big city of the same amount of people as New Zealand but we're spread so geographically. That's certainly one of the challenges for the New Zealand*

		products supply (C-01)". *"Just the volume and the transport challenges, so for instance, getting bricks to far north or wherever it is, is part of the challenge of doing business in New Zealand (C-01)".*
Spikes in demand	Managing of peaks and troughs in terms of materials supply.	*"So there's spikes in demand for product, for example, pipe demand for this last six months which is the earthworks sort of season because of the amount of subdivisions going on is that the two pipe suppliers can't keep up (C-06)".*
Small scale industry	Due to the small size of the construction industry, materials seem to be expensive and therefore construction costs are high.	*"Yes that's right. I think New Zealand's got a problem because of scale, we don't build enough houses therefore we can't do things on scale. Residential building is a cottage industry and anyone that tries to take it out of a cottage industry will lose money (C-02)".*

4.4.6 Suggestions for Improving the BMSC - the Contractors' View

The interviewees were asked to suggest any solutions to previously identified issues in the BMSC. Having a wider knowledge of all aspects of the construction industry was suggested by some of the participants as a way to improve the BMSC. As an example, interviewee C-03 said:

> "So you have your knowledge of electrical, plumbing, drainage, construction of how a home goes together, all the products we use; you have to have a lot more knowledge now because people are asking questions. Land; understanding development of land, resource consents, building consents, Geotech reports, surveys. We have to have some knowledge of all of these different events that go on through the process of the construction."

In terms of materials management and logistical support, some participants expressed the view that having sophisticated and integrated computer systems would probably improve the efficiency of the BMSC. The significance of homeowner feedback was also commented on by participants as a way of improving the current BMSC. This was clearly shown by the comment received from participant C-01:

> "One of the key things we do is we have a customer survey; ask our customers who we've built with, for direct feedback across the whole parts of our business, to see how we can improve. So at no time do we think we've got it sorted, there's always learners".

Another suggestion provided by participant C-05 was that finding exactly what a homeowner is looking for would eliminate a lot of issues related to materials.

> "So for instance, if there was a playroom for the kids you might suggest tough line *** board for us, it's gonna take knocks. So our job is to ask really good questions

> and find out what the customer's needs, challenges, concerns are about building; and then help provide those solutions. So they don't necessarily know the products they want; they just have this need or this want, and as a consequence I suggest the products; so that's our job to help deliver that."

Some participants pointed out that the use of modern technology (smart phones, computers, web based communications, etc) is still incomplete. The increased use of modern electronic equipment and technology in the BMSC was stressed by the interviewees in order to make the decision process quicker and smarter. For example, participant C-03 said:

> "Yeah we're dealing with tradesmen, that sometimes they don't even have computers. So obviously your tradesmen, we take on within this company; they've gotta have computers, they've gotta have emails; they've obviously gotta be up to date with technology, iPhones, Smartphones, to collect data during the day; make sure that they can be getting back to us if there's something wrong".

A lot of the participants observed that one of the major issues in the New Zealand building industry is the bespoke nature of houses. Therefore as a suggestion to overcome this, participants indicated the need for the greater use of house standardisation in order to bring down the cost of building materials.

4.4.7 BMSC Collaboration - the Contractors' Views

Interviewees were asked to discuss the significance of collaboration in the construction industry in order to improve the BMSC. It was seen throughout the discussions that generally contractors who build houses for external clients seemed to believe that collaboration among different parties in the BMSC was important, whereas contractors who build houses for sale believed that collaboration was less important. Participants who felt collaboration is important said that homeowners come to them to find a solution, to manage the design, to manage the construction of the house, to bring in subcontractors, to deal with suppliers and to deal with council, etc.

Collaboration in terms of selecting building materials by homeowners happens at an early stage of construction:

> "They do at the very initial stage sort of because they also wanna know the building for them, what products we use. And actually some of the product is driven by them. If you have external cladding as weatherboard, they wanna know what sort of cladding it is; weatherboard or what comes with it, what the warranty is and what their maintenance is gonna be, all that(interviewee C-06)."

Therefore the contractor's responsibility is to have strong relationships to deal with any challenges that might occur. The participants' perception was that collaborative practice is a value that they offer in their business. Some of the participants commented that collaboration is vertical integration and this makes savings for the client (homeowner) through economies of scale. However, one participant (C-04) also pointed out that there could be potential inefficiencies in vertical integration and it also lessens competition. For example:

> "A lot of companies rely on effectively their construction business as a means to an end. So they're effectively just a purchaser of all the products of that company supply chain. You know where I'm going to, but yeah it just makes it difficult sometimes to compete with more vertically integrated companies I guess."

In contrast, some believed that collaboration reduces the time taken for information transmission across the supply chain. In line with this, interviewee C-05 commented:

> "Oh it's so important because we're needed on a particular day, because we have tradesmen waiting onsite to install that product. If we've got a delay, that costs us money; we'll be charged money that comes off our profit. The rep that works for that particular company, it's so important to us; we will ring him and they say it's gonna be onsite tomorrow, we jack up our labourer and the gang to be there to install it; that is onsite".

The interviewees who believed that collaboration is not important said that the choice of materials that is used was their choice, not the designer's choice. For example, interviewee C-02 pointed out:

> "We would sit down with designers and say, okay let's look at this design. We do a floor plan, this one wouldn't do; put some architecture on it; the architecture needs bricks so we'll use bricks; the architecture needs timber weatherboards, we put timber weatherboards on. But the collaboration ends about there. We tell suppliers what we want, so collaboration is rare for us."

Further, these participants said that there needs to be separation, because as long as the client's focus is on price then collaboration very quickly leads to collusion and there is no focus on competitive pricing.

4.5 Presentation of the Architect's Views

This section presents the research findings gained from the six architects interviewed. The section covers the house designing process, key considerations in selecting building materials, BMSC issues, suggestions for improving the BMSC, and BMSC collaboration from the architects' perspective.

4.5.1 Design Process

The interviewees were asked to explain the residential house designing process. This was intended to identify how building materials selection is undertaken by architects. Interviewees were requested to stress how materials selection is placed among the major steps involved in designing a house. According to the participants' comments, initially an architect meets the client to find out what the homeowner wants, what the site is, where their site is, and the homeowner's preferences. Based on these factors a brief is established and an initial concept is developed. Subsequently the detailed concept, proposals, developing designs, and cost estimations are carried out. During the briefing process, there is usually discussion about the source of materials (e.g. an overview of the exterior cladding and the interior may be involved in terms of the material selection). Once the design has been agreed, an architect does a working drawing set that the builder will use, and the council will give the building consent for. Figure 4.8 displays the three main steps involved in a residential house designing process, established from the participants.

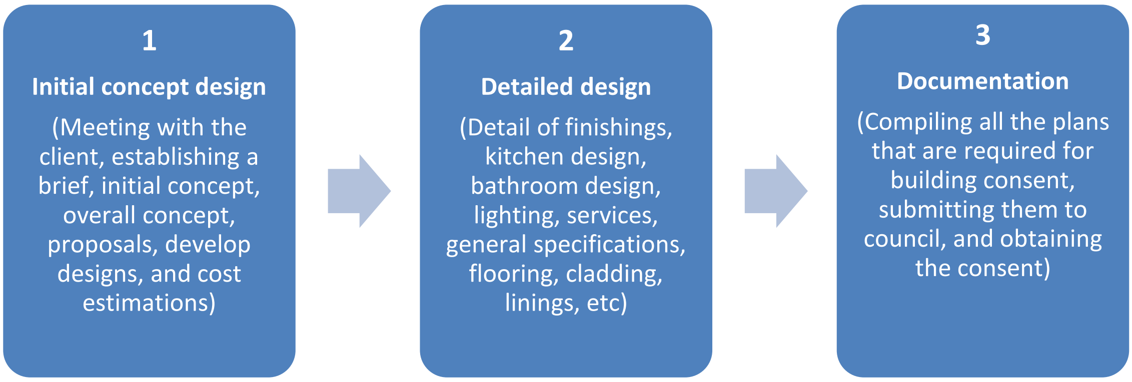


Figure 4.8: Residential house construction process and building materials selection

The interviewees commented that the selection of materials is hugely important in the house designing process. For example, participant A-04 pointed out:

> "Selecting materials means making decisions about the material's usage and how they might or may not perform when it's aligned to the client's brief, in terms of the geometry of the building, and where it's positioned and its exposure to weather, its environment and whether it's a harsh environment or sheltered, or very exposed. So it's very important."

Participant A-06 also contributed to the discussion on the significance of materials selection in terms of finding the "right materials for the right price":

> "So materials are hugely important. Right now if you do a plaster house you can't sell it; no one wants to buy it, so if you use plaster you would kill the sale, so it's pretty serious. That's generated by our little bit of lack of knowledge out there and a little bit of fear. Price is massively important. If you can't get the price thing part working, you don't do it. But then if someone wants a plaster house you think twice about doing it too, because it puts everybody at risk. That's just one example and there are lots and lots of products on the market that are not up to the promise."

This interview section demonstrated that materials are important in the designing process because of the aesthetics of the design concept, their appropriateness for the specific conditions of the site, and weather tightness and durability.

4.5.2 Key Considerations in Selecting Building Materials

Participants were asked to list and discuss the key considerations in selecting building materials, based on their experience. This section was designed to understand the architects' views on the key factors considered in selecting building materials. Details of the responses are shown in Table 4.15.

Table 4.15: Considerations in selecting building materials

Key considerations	Summary of participant comments
Accurate information	Obtaining samples of products and accurate information about them.
Homeowner's requirements	Homeowner's requirements (e.g. material that needs maintenance regularly or low maintenance). Wooden house, concrete house, what sort of people are going live there? What sort of colours, etc. Selecting materials which can be afforded by homeowner.
Fitting the purpose	Based on different properties of materials, some materials are suitable to put in certain places and not others.
Fitting with New Zealand Building Code (NZBC)	Meeting NZBC requirements
Knowledge and experience	Using knowledge and experience in finding materials in terms of quality, price, and durability. This will help clients to understand the benefits, pros and cons of using different materials in terms of the; performance versus the cost (for instance, wool insulation is a lot more expensive than fibreglass insulation. Wool is also more environmentally friendly, and has humidity regulating qualities).
Safety	Identifying which materials are safe to use.
Well established materials	Use of previously used materials that have been proven in use in the industry for at least ten years.
Being updated	Materials selection decisions should be made based on the trade literature provided by materials suppliers.
Good communication	Constant communication with the materials suppliers. Communication should be based on documents and should be unambiguous.
Drawing specifications	Specifying materials information clearly on the drawings.
Materials supplier relationships	Having relationships with many material suppliers. Knowing what the latest/newest materials are and seeing and feeling the materials samples.
Trustworthy information	Having legitimate and trustworthy information about materials.
Collaboration with other architects	Information sharing with other architects (e.g asking about pitfalls of unknown materials).
Costs and benefits of	Finding the costs and benefits (appearance, durability, etc) of materials

materials	from samples.
Information availability on Web	Online specification information on the internet for free.
Site conditions	The context that the building is in and the appropriateness of materials for the site.
Timeframe	Completing tasks in a timely fashion.
Sustainability	Energy efficiency and construction efficiency.
Warranties and guaranties	Any warranties, guarantees and testing that have been done on those products.
Availability of materials	Materials should be available in the market.

The above key factors were analysed using the results obtained from the NVivo coding summary report. It can be seen that the participants discussed these key considerations in 109 instances, (the NVivo coding report shows 109 references in this section and in total there are 254 references in the whole architects' coding summary report). Therefore, out of the 109 instances, each key consideration in Table 4.15 was analysed and the results are displayed in Figure 4.9.

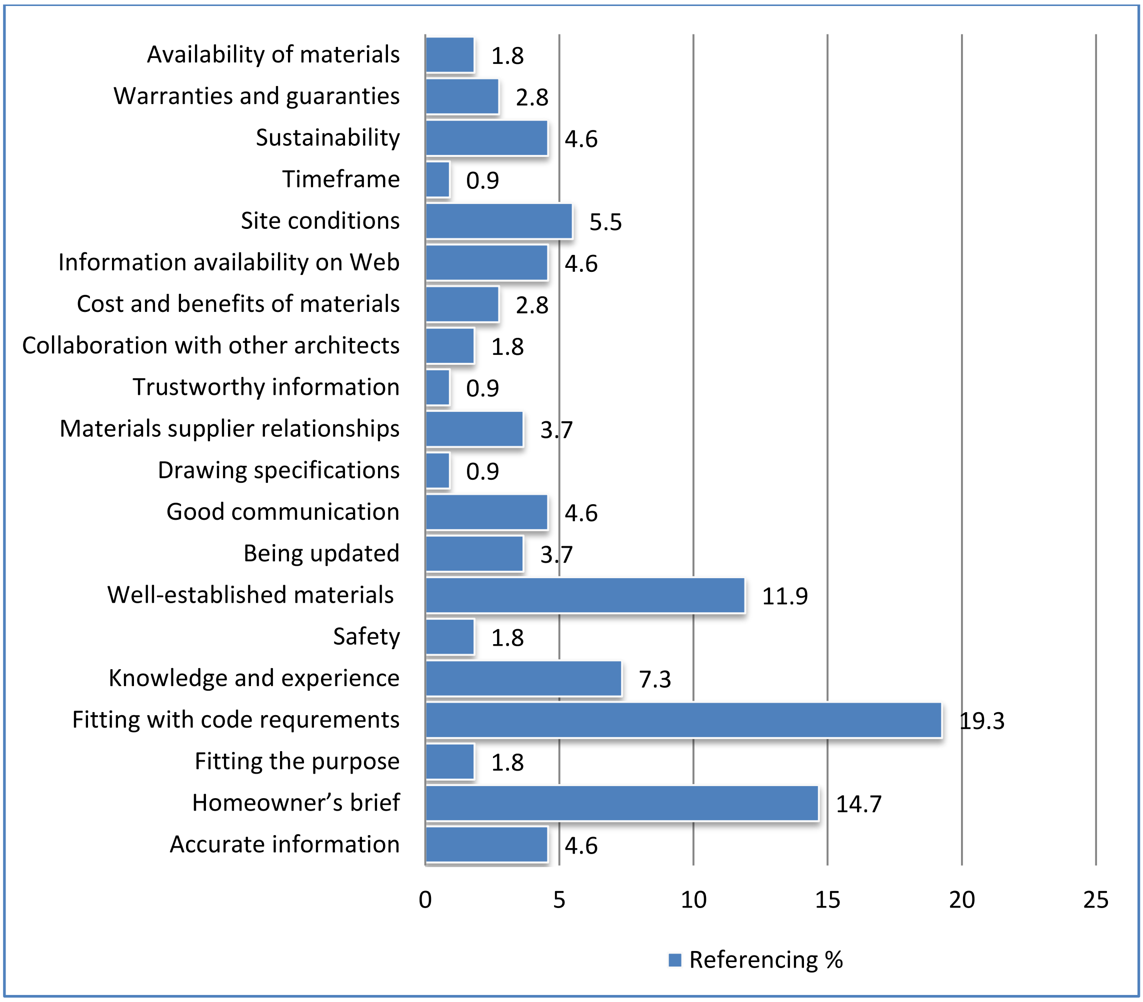


Figure 4.9: Key considerations in selecting building materials

According to the referencing percentages analysis graph, it can be seen that the three most important considerations in selecting building materials by architects: are fitting with code requirements, homeowners' requirements, and relying on established products in the BMSC. The next subsections describe these three most important criteria and are illustrated by comments from the participants.

4.5.2.1 Fitting with Code Requirements

The interviewees actively expressed the view that the first consideration in materials selection decisions is building code compliance. Participants discussed the various types of specifications available; for example, BRANZ materials specifications, wood and timber treatment standards (NZSQ604), the NZBC, etc. The participants stated that meeting the code requirements is very important in building a long-lasting home. For example, interviewee A-01 said:

> "You could say 18mm plywood for a floor, and if you haven't got the specification that actually says to New Zealand standard whatever it is, for the glue component in the plywood or something, then you might find that a builder will source some plywood that somebody up north found or wasn't actually made in New Zealand or wasn't made to any kind of standard at all, and the whole thing goes into a house and it ends up delaminating. So I think standards are reasonably important and they do exist".

Basically, satisfying all the code requirements means obtaining the best materials suitable for the design, materials treatment levels, moisture levels, finishing, etc.

4.5.2.2 Homeowner's Brief

The architects reported that satisfying the homeowner's needs was the second most important factor for them when choosing building materials. This includes the brief that the homeowner gives and their available budget. The participants mentioned that the client's budget plays a huge part in choosing the right materials, colours, and aesthetic values of the completed house after construction (e.g. wide pan steel roof or a wooden shingle or concrete tiles, etc). Interviewee A-01 illustrated the importance of the homeowner's brief and budget by stating:

> "First of all, what they want; what their site is, where their site is, what they like. That's partly stylistically what they like as well as what they like in terms of the house might work, whether they like, an open plan sort of a house, or whether they like smaller rooms that are all just you know, they're all put together, but more

> private. So those kinds of things. So you have to get your brief together and you also have to get an idea of a budget as well".

The homeowner's brief was seen as a critical consideration because it takes in so many factors in terms of building materials, their usage, their performance in terms of the building's geometry, its position, exposure to weather, its environment, and so on. In addition, the homeowner's brief covers aesthetic wishes and considerations.

4.5.2.3 Using Well-established Materials

Interestingly, the participants expressed the view that when selecting materials they always rely on well-established and previously used materials and products. The participants also confirmed that they usually avoid newly introduced materials. Interviewee A-01 stated:

> "The newest sorts of materials we ever use really are kind of Perspex and things like that, which are actually 40 years old or more; 50 years old. So we don't use that many new materials, no."

It was implied from the interviews that interviewees tended to select fairly traditional materials such as cedar weatherboards or concrete, or brick or stone or concrete block. As the participants said, those sorts of materials have been used in New Zealand for the last 100 years and their quality and durability are guaranteed.

4.5.3 BMSC Issues - the Architects' Views

The interviewees were asked to describe the existing issues related to the materials supply chain in the New Zealand residential construction industry. The issues around the building code and Building Act 2004 were pointed out by the participants. The complexity of the building code, and constant changes to it, as well as excess documentation, were the key issues they related. For example, in the tendering situation, where a builder wants to do an alternative solution to what an architect has specified, at that point it is a matter of negotiation. An issue arises from the way that the current building code is designed. The participants stated that the Building Act is set up in such a way that a building may be compliant with the documentation rather than with the building code.

In addition, participants mentioned that due to constant changes in the building code, technical details also change and therefore become an issue for architects. Consequently the whole supply chain is affected in terms of the flow of information and flow of materials. The participants also mentioned that cartelism by big companies has isolated with small companies in the construction industry, and hence materials prices are not sufficiently subject to competition. For example, participant A-05 said:

> "And some people would say oh well, there's a kind of a monopoly or a duopoly on a lot of materials and so we're paying more than we absolutely need to."

The lack of connectivity between the contractor and architects was reported by interviewees, and can result in having different materials compared to what was specified in the drawings. Further, the participants said that contractors tend to think independently rather than collaborating with architects, and from time to time purchase completely inappropriate materials. This sometimes results in rejection by council inspectors and a delay in construction work. For example, participant A-06 said:

> "So what we're annoyed with is the fact that having done all that work and satisfied ourselves that there's a safe environment for the client and for ourselves, the council have signed it off and forced us into signing it off to spend all that extra time doing that, and then they let the builder go and buy from the local hardware merchant some other bloody product that nobody knows whether it's any good. They don't even know it isn't the right product. And that's the problem; that is a big problem in the building industry is that the builders still think they don't have to follow the plans and that's actually happening and it's something that we don't even get to find out about until it's all done. And most of the time we don't even find out. It's a certainty that when it goes wrong, which it does, then you get around there and the council's just rejected the job".

Another interviewee, A-03, added that product certification by BRANZ is very expensive and that is detrimental to the industry. The participant further said that this incurs an extra cost for the manufacturers and suppliers which is then passed on to their customers.

Inefficiency in the production process was identified in the New Zealand BMSC by participant A-06:

> "We're only doing at the best an eight hour shift every five days a week - well that's not very efficient. When you see what happens in America where they've got 360 days that machine was just going 24 hours. Trucks never stop. Nothing stops. And then they have a shut down and they do maintenance. Open up again, churn another 300 days or whatever. They just churn it out and therefore price drops. Can't happen here."

Participant A-01 stressed the delays that can occur because of the JIT delivery system is another issue in the supply chain. A-01 said:

> "Then the next thing that happened is that when you have a whole mid floor done with I-beams and you have to have certain other types of beams to go with it to do different jobs on each beams, what would happen is that they didn't have that in stock down there in Tauranga, or they had it in stock but because they didn't know what length they had to cut anything and then because they hadn't cut it they hadn't treated it, you get your floor up here and you've got this hard out worker and he's put it all up, and oh there's a couple of beams missing, and you finally find out its because you ordered it just in time and couldn't supply the treated piece, so we've sent it to the treatment and that's a two week delay - job stops. You can't prop the part, you can't keep going so you stop and go to another job you see."

Lack of communication and lack of collaboration between parties throughout the supply chain was identified as significant by all interviewees. Similarly, they reported that poor information transmission between manufacturers and contractors can lead to materials failures.

The "leaky building" crisis (badly constructed buildings that were built from inappropriate materials) was another issue which was mentioned by participant A-01. This interviewee said that these inferior materials should be completely removed from the construction industry.

Participant A-01 also mentioned that the lack of choice regarding timber varieties is additional issue:

> "I'm trying to say simply, the fact that we are only basically planting, growing and harvesting pine trees which I regard as a pretty low grade kind of tree really; and there actually probably 15 other species that would work just as well if we were to put the same amount of time and energy and basically kind of cull out the low grade stuff. Like macrocarpa would be particularly good and there are all sorts of gums and totara and other trees that I believe we should be pushing."

In contrast, architect A-05 explained that having many choices could be an issue as some materials are available only for a short term and their durability cannot be guaranteed. This participant said:

> "Well for me the issue is too much choice. Like for example bathroom fittings. It's just ridiculous how much choice there is and most of these things are just imported, they're here for a very short time, until they've sold out and then that particular model is not available anymore."

Lack of standard performance evaluation methods for some materials was indicated as another issue by participant A-03. The interviewee stated that the benefits of some materials over others are unknown as there is no independent party to perform an evaluation. For example, regarding insulation, A-03 compared wool and Pink Batts by stating:

> "There's no sort of independent, or third party body that can validate whether indeed wool has better moisture regulating properties than Pink Batts. It's something that the wool people sell, but there's no evidence. You can't compare it, the performance of that product, directly to the performance of Pink Batts. There's no kind of standard performance evaluation".

Finally, the availability of materials that have not been tested for New Zealand UV conditions was considered an issue by participants, and the need for evaluation of these materials in such conditions was stressed. For example, interviewee A-02 commented:

> "Well particularly in New Zealand conditions. You know, like a lot of these things are tested - sure they say they're tested in Arizona somewhere, that's fine. They don't have the UV conditions that we do here".

Participant A-02 also argued that in New Zealand, building materials generally cost three times more than anywhere else. The participant said:

> "There are all these different technical types of materials used for different circumstances and it's quite difficult keeping on top of what is the latest product; what is the latest science behind it; how should it be detailed in a building; is the company gonna be around in 20 years' time or in 10 years' time? Or they stand behind their product in terms of its durability; in terms of its warranty; if it's not around then its warranty is no good to us".

Since the New Zealand construction industry has a proliferation of companies selling a variety of building materials, as opposed to having established companies with reputable, tried, and tested products, finding the most suitable material is a challenge.

4.5.4 Suggestions for Improving the BMSC - the Architects' Views

The participants were asked to discuss possible solutions to improve the current building materials supply chain practices and were reminded about the current issues in the BMSC discussed in the previous section of the interviews.

In order to avoid using inferior materials the participants said that homeowners and architects should be able to touch, feel, and look at products. Seeing materials which are already in an actual building before selection was seen as the best way of doing this.

Homeowners' lack of knowledge of building materials was identified as a critical aspect by the interviewees. Participant A-06 said:

> "The homeowner now can blindly stumble into any house and be pretty protected, which is stupid I think. I think the homeowner should be a little bit more careful and be a little bit more responsible for buying something that's dumb."

In addition the interviewees emphasised that homeowners should be educated on the life cycle cost of materials rather than the upfront capital cost. Participant A03 explained on this:

> "There are a couple of ways you can assess cost … if there was a way for that to be easy for us to talk about to people and say, "Look the upfront cost of this is $20 a square meter, but actually the total, over the cost of say 15 years, … is going to be $35 a square meter; compared with this which is gonna be $25 a square meter although the upfront cost of this is gonna be $20 a square meter…"

The need for having detailed information on building materials availability on the web (e.g. EBOSS) was highlighted by participant A-05. The interviewee said the free flow of information is the key criterion to improve the materials supply chain.

The necessary amendments required to the building code in order to compare performance based nature of materials as opposed to specification based, were suggested by participant A-02.

All participants stated that there is a need for some kind of central body that is responsible for the analysis of building materials. Further, the information produced by this independent body should be performance based and easily accessible by architects. For example, participant A-03 said:

> "I think it would be useful to have some standard means of evaluating different types of products, both in terms of performance and price and durability and warranty, and all of those things. So that the choice between products is more empirical rather than based on anecdotal or salesman evidence."

Further the current building materials testing bodies were criticised by participants as being time consuming and excessively expensive.

Interviewee A-06 pointed out that increased materials supply availability would make the materials supply chain more efficient and eventually lead to lower materials prices.

> "If we did want a better New Zealand supply, what we should be doing is cranking up the plants and exporting, so that we've actually got enough product going through the plants to be efficient…"

The need for exploring the nature of supply chains in other countries and researching new building materials was suggested as a means of improving the New Zealand BMSC by interviewee A-06, who said:

> "And also maybe look at the rest of the world, go to America occasionally, go to Aussie, pick up ideas, bring it back, tailor it, put it into our market. They've stopped doing that but that's a level of research."

Also manufacturers' and suppliers' transparency around stock levels (e.g. lead-in times) needed to be improved, according to the participants. For example, participant A-05 said:

> "Because obviously if you order something and then it goes out of stock before it gets delivered to you, then that's kind of galling".

Therefore architects suggested that maintaining transparency around stock levels could overcome unnecessary delays and other related issues.

4.5.5 BMSC Collaboration – the Architects' Views

The interviewees were asked to discuss the significance of collaboration in improving the BMSC. They agreed that collaboration is slowly being practiced in the building industry although they accepted that greater collaboration would improve the BMSC in many ways. For example, participant A-06 stated:

> "Yeah, it's really important and actually I have to say its working, we're getting it. Anybody you ring up - say you can't find it on the web and you still need to know - say your typical little thing would be here's a whole set of weatherboards and you find they've told you everything about it except what the treatment is. So you can get on the phone and there's no argument. They don't moan. A few years ago they used to, 'Why do you need to know that?' Now it's quite supportive".

Sharing knowledge and experience more often with other architects and other parties in the supply chain would help support each other to overcome supply chain issues. For example, participant A-06 mentioned:

> "We never used to talk to them but now we realise we need a bit of sort of support for what went wrong for him so we don't all go and fall in the same hole."

Another participant, A-05, stated that collaboratively working with building contractors increases cost effectiveness and helps build good relationships with contractors. Interestingly, participant A-06 showed that publications produced by different parties in the MSC are a means of collaboration in the form of sharing information among the various parties in the supply chain. This participant stated:

> "You know, monthlies and bi-annuals or whatever, comes from the Concrete Association. The Building Industry Authority produces a book. The Master Builders produce a book. The Construction Industry produces a book. They've all got quite a lot of really quite good articles in them, so that's quite an easy way to find stuff out - quite interesting and actually quite technically advanced I would say. There's a lot of stuff in there that is quite helpful. They all run a kind of legal, little legal

> thing, about what you can do and what you can't do and what you should do, so that's quite helpful in terms of the industry."

Participant A-02 showed the significance of collaboration in terms of meeting and negotiating various detailed requirements of specific building systems:

> "There's also a big push towards building systems, structured systems, and water-proofing systems; so that's important for us to be able to talk to specific people about how they see their systems coming in place and meeting other systems, and how those junctions can be negotiated in detail."

The interviewees expressed the view that collaboration is about being involved in a project. For example, by staying connected with the builders, if there are things that are going to change in a project, the reasons and whether or not they are in line with the design intent in terms of appearance, longevity etc., all need to be communicated. Therefore collaboration is being able to influence and to direct things in a collaborative manner which benefits all stakeholders in the supply chain.

4.6 Presentation of Homeowners' Views

Six interviews were conducted with selected new homeowners who had been actively participating in their house construction projects. The interviews explored the nature of the BMSC in terms of what homeowners think, under the main themes stated in section 4.1.2. Participants expressed the points that materials were important in terms of what they reflect, living style, and their message to others. It was seen throughout the discussions that homeowners actively contributed in choosing interior and exterior materials. The following sub-section describes the views of homeowners regarding the interview questions.

4.6.1 Key Considerations in Selecting Building Materials

This section was designed to discover the participants' views on key factors considered in selecting building materials when they began the construction process. The interviewees were asked to discuss the key criteria in choosing building materials and the details of their responses are outlined in Table 4.16.

Table 4.16: Considerations in selecting building materials

Key considerations	Summary of participants' comments
Being prepared to confront, disagree, negotiate, and appreciate.	When the materials are selected homeowners should express their views and ask questions about what they do not know. This will help secure the most suitable materials.
Recommendations by architect	Having a good architect definitely assists the homeowner to select the best materials in terms of budget, appearance, and quality.
Knowledge of materials from others (e.g. friends)	Discussions with friends who have already completed their houses can enhance homeowners' knowledge of materials.
Budget	The portion of the homeowner's budget that can be allocated for materials.
Fitting with the environment and site's location	Materials that are chosen should blend with the environment in terms of colours, designs, shapes, etc.
Aesthetic values	Visual impression of the building materials.
Maintenance level	The level of maintenance of a house is affected by the type of materials used. Therefore, materials should be chosen in accordance with maintenance affordability.
Life style	Number of people that are expected to stay in the home and their living styles, emotional backgrounds, what they like, what they dislike, etc.
Quality and durability of materials	Selecting long lasting materials with good performance.
Current fashions and trends	Modern designs, colours, and shapes of building materials.
Local industry supportiveness	Purchasing New Zealand made building materials.
Functionality and feeling of materials	Insulation, ventilation, reflection index, etc of building materials.
Specifications	Information on what building materials are made of.
Manufacturer's reputation	Industry reputation of material sources.
Builder's recommendation	Contractor's recommendations on selecting building materials.
Availability of variety of materials	Availability of a wide range (sizes, colours, shapes, etc) of materials.
Materials information availability on Web	Online detailed information availability as material library databases.
Weather conditions	Whether the materials are suited for the climatic conditions in New Zealand.

The above key factors were analysed using the results obtained from the NVivo coding summary report.

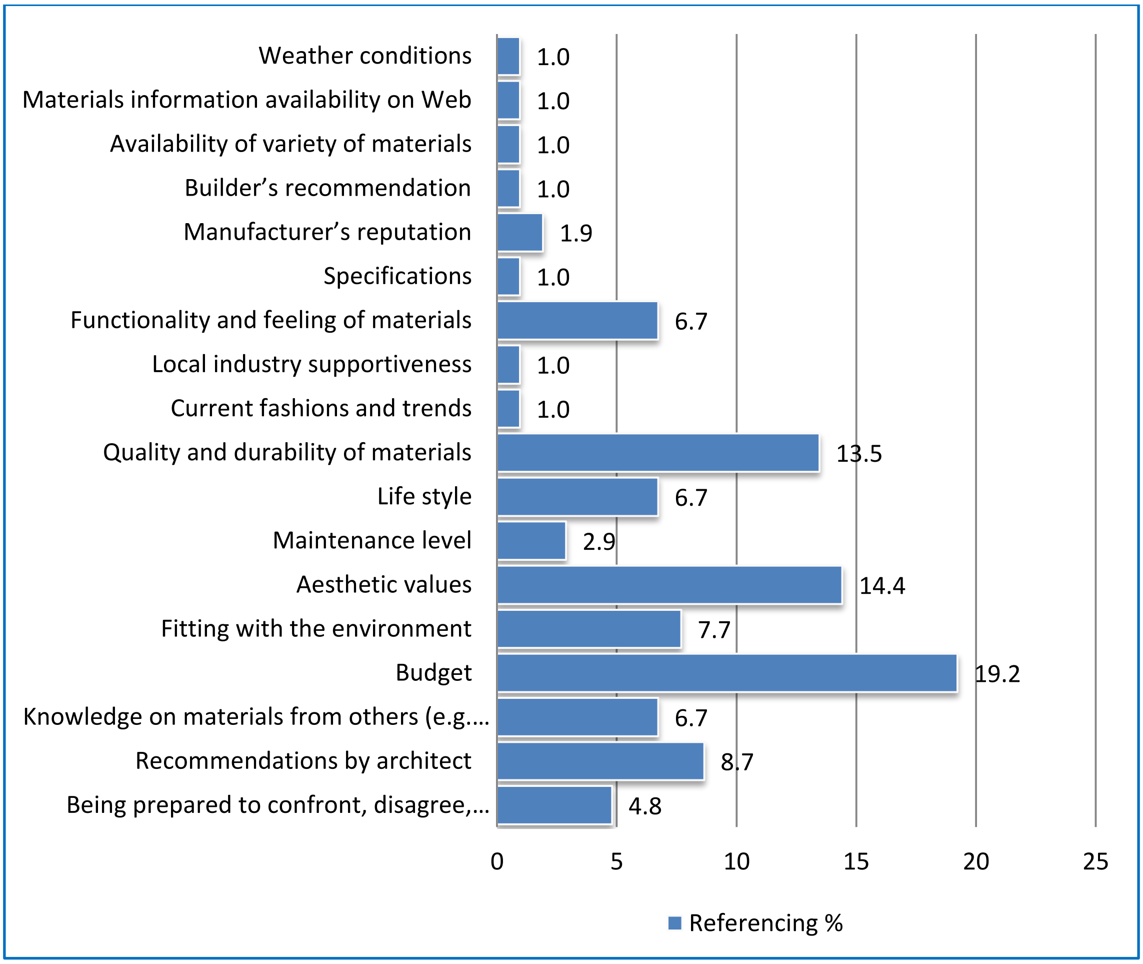


Figure 4.10: Key considerations in selecting building materials

It can be seen that the participants discussed these key considerations in 104 instances (the NVivo coding report shows that there were 104 references in this section and in total there were 185 references in the whole homeowners' coding summary report). Out of these 104 instances each key consideration in Table 4.16 was analysed and the results are given in Figure 4.10.The NVivo analysis showed that the three most important considerations in choosing building materials among the interview sample were: the homeowner's budget (referencing percentage of 19.2), the aesthetic value of building materials (referencing percentage of 14.4), and the quality and durability of materials (referencing percentage of 13.5). Subsequent subsections of the thesis describe the three key criteria identified above with selected participants' comments where appropriate.

4.6.1.1 Homeowner's Budget

As can be seen from Figure 4.10 above, 19.2% of references discussed the significance of the homeowner's budget when building materials are selected. It was observed throughout interviews that participants considered how much money they could allocate on building materials before any other decisions were made. For example, interviewee H-01 stressed that identification of affordability is critical:

> "There's always a product that you like, like when you go to an interior designer they like the colour kind of decorative stuff. They say you could do this, or this …and then you say but we're filtering it through contract price all the time, 'cause otherwise everything blows out, and you've got to stay in a budget".

Therefore, the participants stated that they critically considered the price of materials when budgeting. However it was observed from the interviewees that even though the price of materials was very important, they did not always choose on price; rather, they chose reasonable prices along with other considerations (e.g. appearance and quality).

4.6.1.2 Aesthetics

The interviewees considered the appearance of building materials as the second most significant criteria when selecting building materials. Interviewee H-06 said:

> Everything's filtered through price, so its aesthetic divided by price."

The participants were aware that changing the materials could considerably change the look of a house. For example, participant H-03 stated that:

> "We want the house to look nice so we've gone for more expensive materials that will look better; so to get a house it's the quality that we like and the look that we like. Inevitably you have to select the materials to give you the look that you want".

Interestingly, all the participants commented that the aesthetic values of building materials were a very important criterion when selecting appropriate building materials.

4.6.1.3 Quality and Durability

The third significant criterion when choosing building materials by homeowners was their quality and durability. Interviewee H-05 illustrated this by stating:

> "It costs a lot more to do it in cedar than it would in another wood, and paint it, but I knew that it... it's got a history of lasting for a long time. So yeah it did have some bearing actually".

The participants were well aware that having quality building materials would reduce their life cycle cost. It was observed from the interviews that the participants looked for certified and sustainable materials.

4.6.2 BMSC Issues - the Homeowners' Views

The interviewees were asked to discuss the issues they faced when building materials were chosen. Also they were asked to discuss issues in the BMSC in general. Interviewee H-02 stated that building materials in New Zealand are substantially more expensive than those equivalent materials in most other countries. The interviewee expressed the justification for this as:

> "In New Zealand I think everything tends to be more sort of custom-made and also the stockists have to hold so much more stock that they need higher margins".

Homeowner H-06 showed a similar opinion as H-02. The interviewee said that as New Zealand is a small country, having a wide range to satisfy homeowners' wishes for customised materials greatly increases materials prices. This interviewee further stressed the need for house standardisation to bring materials prices down:

> "In other countries they tend to have a lot more companies like Fletcher Building that do standardized things, where they're going to do 200 houses like this and therefore they tend to get large runs and use standardized products; and because they're using standardized products the price comes right down".

Participant H-04 pointed out that the main issue in the New Zealand BMSC is that each party is disconnected. In other words, the collaboration between the supply side and the purchasing side is insufficient. As a result, homeowners face difficulties in selecting building materials. Participant H-05 provided an example of this:

> "…up the stairwell there was a large glass panel divided up into six, and the architect specified that that panel was divided off; it had some coloured glass in there. The contract for the windows went to an aluminium joinery firm and they said, well, we can put the coloured glass in provided we can get it from a glass supplier. The glass supplier doesn't stock coloured glass so we basically had to go and search for somebody else".

Interviewee H-01 reported that some building materials are not readily available in the New Zealand building industry. The reason given was insufficient demand, highlighting once again both the small size of the New Zealand industry and the bespoke nature of houses. Interviewee H-01 said:

> "Quite often you get difficulties in terms of what you specified is perfectly reasonable and used to be available, but right now nobody is actually stocking it because there isn't sufficient demand for it. So quite often you can end up with searching out for things and not being able to find what you want and having to compromise."

Participant H-03 mentioned that a wide variety of certain products can create difficulties in collecting information on quality and price. One participant stated:

> "…I think I could probably come up with a thousand different taps, and obviously that makes it very difficult in terms of selecting the product and it also makes it very difficult because you have to collect all the information".

The lack of specifications for building materials on the internet was considered an issue by participant H-02. This interviewee said:

> "Well, I think one of the difficulties…is to get things like specifications of products and colour ranges that you can download over the internet, because you know if you looking at the product, a lot of people, they seem to keep the information that they've got quite private on the internet…quite often you'd have to take a trip out to their premises and then you find that no there's nothing in their range that you're interested in, and you could have immediately told that over the internet without necessarily going there."

Therefore the need for a web-based centralised building materials specification system was emphasised, so that homeowners can access all information regarding building materials without needing to visit supply sources.

4.6.3 Suggestions for Improving the BMSC – the Homeowners' Views

The homeowners were requested to provide suggestions to overcome the issues stated in the previous section. Participant H-02 suggested having a central system whereby the general public can access materials specifications for free. This would help homeowners to make provisional decisions in choosing building materials. This interviewee said:

> "If there was some sort of central area where if you're looking for a product you can look up under 'category' and you'd have links to everybody's websites and you'd have the sort of information that you need in order to make a decision on that product."

Further, homeowner H-03 recommended that materials suppliers should provide detailed information on the price and quality of their materials. This would assist homeowners to compare the available products in the market and select the best options. This interviewee stated:

> "And one of the things that's quite often missing is the indication to what the relative quality and price of things are…It's like when I'm looking at taps; you know, talking to people they say, "Well, this $250 tap has got exactly the same internal workings as that $2000 tap." So the only thing you get is the difference in looks".

Another interviewee, H-04, suggested that wise choices regarding materials should be made at the beginning of construction. Further, the interviewee said homeowners should research on the types of materials, based on the life cycle costs and within their budget. For example, this homeowner stated:

> "Not just going for the cheapest job because the cheapest job isn't always the best job. I think you pay in other ways…"

Homeowner H-06 recommended forming strong relationships with the architect and builder as this could assist homeowners to secure the best materials. This interviewee said:

> "But I think you really, you know, you have to rely upon the expertise of your architect a lot because they've got a lot more experience. But also I think you have to rely upon the expertise of the builders as well because quite often they can say, "Well no, but the way the architect is doing it is wrong; you should use this product and do it this way because it's cheaper and better." And I don't think architects are ever gonna have as much experience as the builders who actually have to build the house".

Therefore, having an experienced architect and builder would also increase opportunities for homeowners to see samples of building materials and previously built houses, which they can use when making materials selection decisions.

4.6.4 BMSC Collaboration - the Homeowner's Views

The homeowner interviewees were asked to comment on the significance of collaboration in the building supply chain that they experienced. Good communication between the parties and making good relationships between each other in the supply chain were identified as the keys to collaboration. Further, participants explained that collaboration among the homeowners, architects, contractors, suppliers, and manufacturers is important to achieve the aim of building the right house with the right materials for the right cost. Homeowners explained that the collaboration between homeowner, architect, and contractor seems distinct from that of contractor, supplier, and manufacturer. Participants also highlighted that collaboration helps to resolve complications that can arise when selecting building materials. This fact was shown from the following comments.

> "We had the colour of the aluminium joinery, the garage door in the roof; they needed to be coordinated, they were all in sort of a metallic silver colour but initially they were all in different colours. So obviously it wasn't until the builder

> became involved and everybody had to say, 'well, can you do this particular powder coating so that we can get a uniform colour throughout? (H-02)'"

Interviewee H-01 explained how they were informed by their contractor regarding construction progress and types of materials used.

> "They work on Friday and you usually get a photograph, a photo on a website with each major stage (H-01)."

It was seen that the homeowners had very good interactions with their architects, contractors and suppliers in choosing the materials they wanted.

4.7 Chapter Summary

The chapter has presented the results of the semi-structured interviews carried out with manufacturers, suppliers, contractors, architects, and homeowners in the New Zealand residential construction industry. The findings from each group (out of a total of six groups) were presented separately and organised by the main themes included in the interviews. In other words, the opinions of the interviewees have been presented in line with the key themes covered by the research. The interviewees' opinions were sought to extend the research data collection in terms of a questionnaire survey. In chapter 5 the researcher will discuss the findings of the questionnaire survey which was formed, based on the semi-structured interview results discussed in this chapter.

CHAPTER FIVE

Questionnaire Surveys: Report of Findings

5.0 Introduction

This chapter presents the findings of four versions of the questionnaire survey administered across the New Zealand BMSC. The questionnaire survey was undertaken to achieve the following key questions (as given in Table 5.1) in order to meet the overarching aim of the current study.

Table 5.1: The research objectives and questions addressed in the questionnaire survey

Research objectives	Research questions
1. To review the nature of the building materials supply chain in the New Zealand residential construction sector	1. What are the current issues in the materials supply chain?
2. To identify building materials supply, purchasing, and selection behaviours of supply chain stakeholders (materials suppliers, building contractors, architects, and homeowners)	2. How do materials suppliers supply building materials? 3. What are the key criteria considered by building materials suppliers in making their materials supply decisions? 4. How do contractors purchase building materials? 5. What are the key criteria considered by residential building contractors in making their materials purchasing decisions? 6. What are the key criteria considered by architects in making their materials selection decisions? 7. What are the key criteria considered by homeowners in making their materials selection decisions?
3. To integrate buyer and supplier behaviours to improve the building materials supply chain	8. What are the key benefits of collaboration in the materials supply chain?
4. To suggest an improved framework in the current building materials supply chain practices for selecting the appropriate building materials	9. What are the key criteria that would improve the current building materials supply practices?

Figure 5.1 shows how each of these nine survey questions relate to the survey participants. Questions 1, 8, and 9 are common to all the participants, while questions 2 and 3 are related to manufacturers/suppliers; questions 4 and 5 are related to contractors; questions 6 is related to architects; and question 7 is related to homeowners.

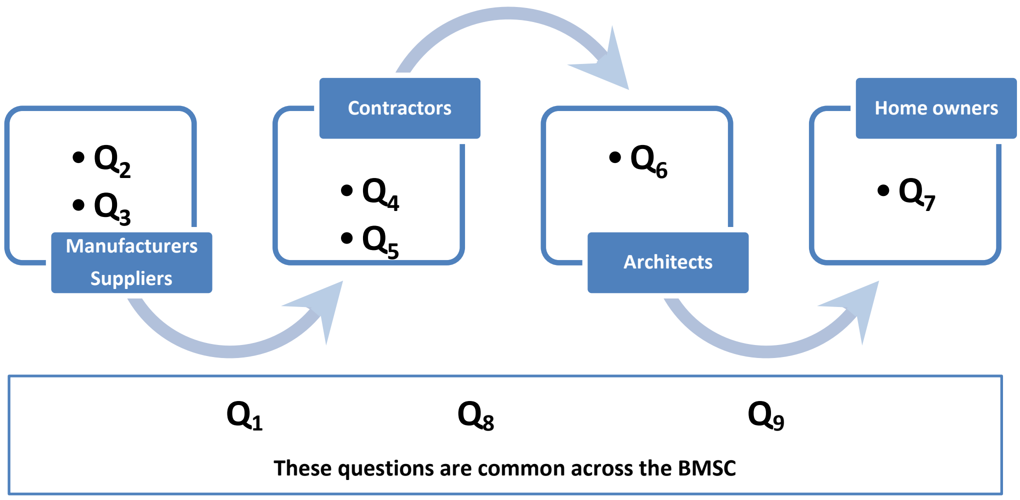


Figure 5.1: Structure of the questionnaire survey

The survey results are presented under eight main themes identified in line with the research objectives described in chapter one. Firstly the process followed in administering the questionnaire survey is presented. Secondly the survey response rate is discussed. Thirdly a profile of the survey participants (demographics) is explained. This is followed by the five sub-themes in the subsequent five sections which include analyses of: materials supply and purchasing practices, building materials supply, purchasing and selection criteria, collaboration in the BMSC, issues in the BMSC, and suggestions to improve the BMSC.

5.1 Questionnaire Administration

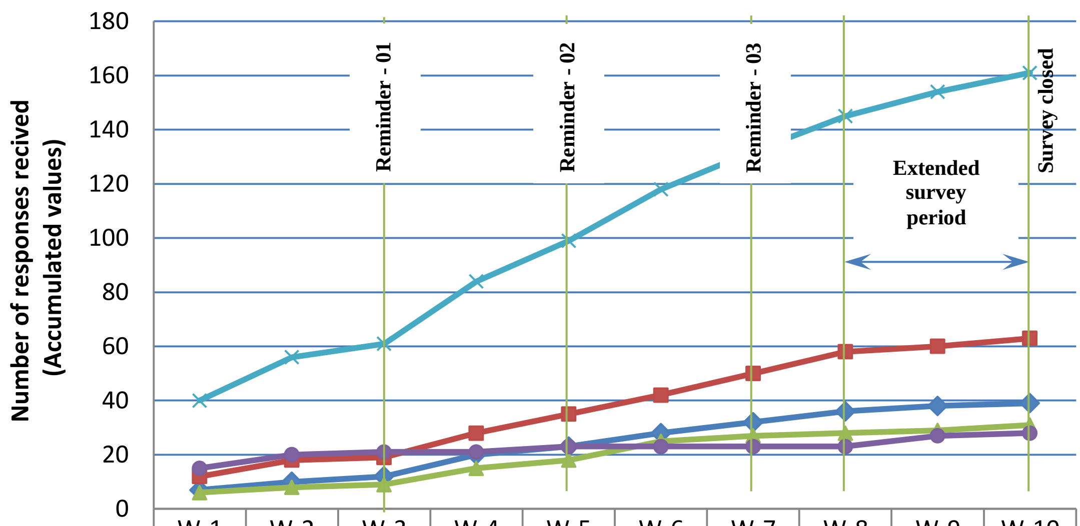
It was decided that questionnaires designed for manufacturers/suppliers, contractors, and architects should be administered via an online survey tool, "SurveyMonkey" (www.surveymonkey.net). SurveyMonkey was used mainly because of its designing functions and very convenient administration capabilities. Also it facilitates automatic data transmission into SPSS which saves time and enhances the survey accuracy. However, the questionnaire designed for homeowners was administered by post, as homeowners' contact details were available in the form of their physical addresses, with pre-paid return envelopes. All four versions of the survey ensured the anonymity of the participants, as recommended by Williams (2003).

5.1.1 Pilot Survey

Conducting a pilot survey is essential to improve participants' response rate. A pilot survey aids in the identification of poorly worded questions and the questionnaire can be amended accordingly before it is administered (Fellows & Liu, 2008). Thus pilot testing should enhance the content validity and reliability of the data (Saunders et al., 2007). All four versions of the questionnaire were pilot tested by 20 respondents who participated in phase 1 of the current study (semi-structured interview participants). Therefore, the requirement of having at least 10 participants in the pilot survey was satisfied in the current study (Fink, 2009). The pilot survey aimed to estimate the time taken to complete the survey, and to check the accessibility, functionality, and understandability of the survey. A number of changes were made to reflect the clarity and wording of questions, based on the recommendations made by the 20 participants.

5.1.2 Invitation to Participate

Three separate survey links were sent out to manufacturers/suppliers, contractors and architects along with a brief e-mail message outlining the current study and participant information sheet which was actually the first page of the survey. All three versions of the questionnaire are attached in Appendices 3 (A-C). The questionnaire for homeowners was posted by mail with an attached participants' information sheet (Appendix 3 (D)). All four versions of the questionnaire were launched at the same time and Figure 5.2 displays the nature of the received responses over the 10 week time span. The first reminder for the online survey was sent out in the third week, after receiving 61 responses. The second and third follow-up rounds increased the total to 145 responses.



	W-1	W-2	W-3	W-4	W-5	W-6	W-7	W-8	W-9	W-10
M & S	7	10	12	20	23	28	32	36	38	39
A	12	18	19	28	35	42	50	58	60	63
C	6	8	9	15	18	25	27	28	29	31
H	15	20	21	21	23	23	23	23	27	28
Total	40	56	61	84	99	118	132	145	154	161

M & S=Manufacturers and Suppliers **A**=Architects **C**=Contractors **H**=Homeowners

Figure 5.2: Administration of questionnaire survey

The first three reminders discovered that: some of the targeted participants were temporarily unavailable; some participants had not received the questionnaire; and some had declined to respond to the survey. With these in mind, the survey administration time period was extended for a further two weeks to increase the number of responses. Additional telephone follow-ups were conducted to contact non-respondents, targeting those who were temporarily unavailable. This brought 161 responses or 146 completed and usable responses, in total at the end of the tenth week, closing the survey.

5.2 Response Rate

Table 5.2 shows the breakdown of the number of responses received for each category of the survey participants. Additionally it shows the types of industry bodies involved in this research who provided assistance in accessing survey participants. Three versions of the online questionnaire were sent through the Web-based survey administered tool SurveyMonkey among manufacturers, suppliers/BMs, and contractors. However, homeowners received the questionnaires by post.

As shown in Table 5.2, a total of 161 responses were received (146 responses were useful for data analysis) from the 624 questionnaires sent out. Fifteen questionnaires were rejected because the participants did not answer at least a minimum of 25% of the survey questions. The overall response rate was calculated as a percentage of the total number of completed and usable questionnaires received, over the total number of total online and postal questionnaires sent out. This gave an overall response rate of 23.4%, which was a satisfactory response rate (Saunders et al., 2007). The breakdown of the responses shows that 24.65% of participants are manufacturers and suppliers, 19.18% are contractors, 40.41% are architects, and 10.79% of participants are homeowners.

Table 5.2: Survey distribution and response rate

Participant group	Medium of distribution	Number of questionnaires distributed	Number of participants responding	Number of usable questionnaires	Response rate (%)
Manufacturers /suppliers	Direct administration to selected participants	137	39	36	28.45
Contractors	Direct administration to selected participants	158	31	28	19.62
Architects	Direct administration to NZIA members	185	63	59	31.89
Homeowners	Direct administration to selected participants	144	28	23	15.97
Total		**624**	**161**	**146**	**23.39**

The researcher was aware that the response rate could possibly be low, in comparison to past literature and from anecdotal evidence. For example, Saunders et al. (2007) stated that generally 11% is a reasonable rate for an online survey. In addition Bassioni, Hassan, and Price (2008) stated that a minimum response rate of 10% should be obtained to minimize sample biases. It should be noted that the overall response rate in the current research was 23.4%. Fowler (1988) and Grady and Wallston (1988) claim that the research findings from questionnaires with a low response rate could still be valid if there are no systematic differences between responders and non-responders. Further, Fowler (1988) reports that the non-response bias is the most important factor in assessing the effect of a response rate on the validity of research findings.

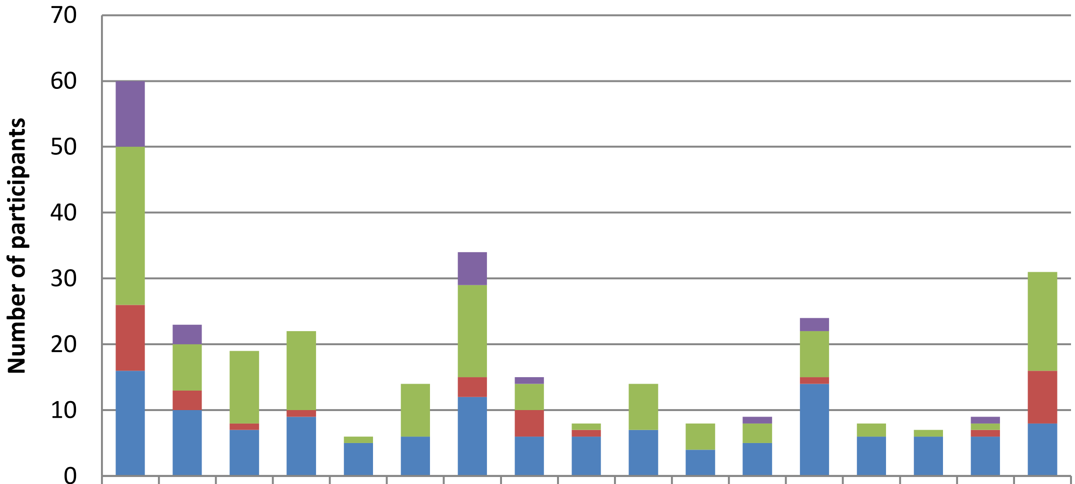
It is therefore widely recommended that researchers investigate non-response bias in order to ensure the validity of their research findings (Gehlbach, 1993; Parashos, Morgan, & Messer, 2005). Non-response bias can be verified by the independent samples t-test suggested by Armstrong and Overton (1977). This study verified the non-response bias by separating the total number of responses (161/146) into 3 groups and conducting an independent samples t-test between the first one third of the responses and the last one third of the responses. The results of the independent samples t-test showed that there were no significant differences between responders and non-responders in general. The statistical analysis was performed both between groups of participants and the total sample as a single group. Therefore, the survey offered an adequate sample and response rate for the statistical analysis required in the current research.

5.3 Demographics

The last section of the questionnaire survey covered the profiles of the survey participants which collected salient demographic information depending on the type of participant group. Survey participants were asked to indicate the geographical region they belong to, highest educational qualifications obtained, years of experience in the construction industry, number of employees in their organisations, and types of building materials supplied. The following sections present the analysis of the demographic information of the survey participants.

5.3.1 Geographical Region

The survey aimed to collect a representative number of responses across New Zealand. Therefore, participants were asked to indicate the geographical region(s) that they work in. Figure 5.3 shows that responses represented all regions in New Zealand. However, the majority of participants are based in Auckland, Wellington, and Canterbury (the most populated regions in New Zealand), where numerous residential construction projects were taking place. However, there is no evidence within parts of the survey that participants' regional groupings had any influence on their responses to the questionnaire.



	Auckland	Waikato	Northland	Bay of Plenty	Gisborne	Hawkes Bay	Wellington	Otago	Taranaki	Manawatu-Wanganui	Tasman	Nelson	Canterbury	Southland	West Coast	Marlborough	Region not stated
H	10	3	0	0	0	0	5	1	0	0	0	1	2	0	0	1	0
A	24	7	11	12	1	8	14	4	1	7	4	3	7	2	1	1	15
C	10	3	1	1	0	0	3	4	1	0	0	0	1	0	0	1	8
M&S	16	10	7	9	5	6	12	6	6	7	4	5	14	6	6	6	8

H=Homeowners **A**=Architects **C**=Contractors **M & S**=Manufacturers and Suppliers

Figure 5.3: Geographical location

5.3.2 Educational Qualifications

The reliability and accuracy of the survey results are based on the educational qualifications of participants. Respondents were asked to indicate the highest educational qualifications they have attained. A summary of the results are shown in Figure 5.4 (A) and (B). It can be seen from Figure 5.4 (A) that one third of the manufacturers and suppliers who participated have certificate level qualifications. The majority (57.14%) of contractors who responded have certificate and postgraduate degrees. Architects had the highest educational qualifications among the 4 groups of participants; 54.24% of them have degree level qualifications, while the majority of homeowners (69.59%) have certificates and diplomas. Figure 5.4 (B) shows that 30.82% of the respondents have degree level qualifications. Therefore it can be argued that the research participants have a good level of relevant academic experience which shows the high degree of reliability of the information collected from the questionnaire survey.

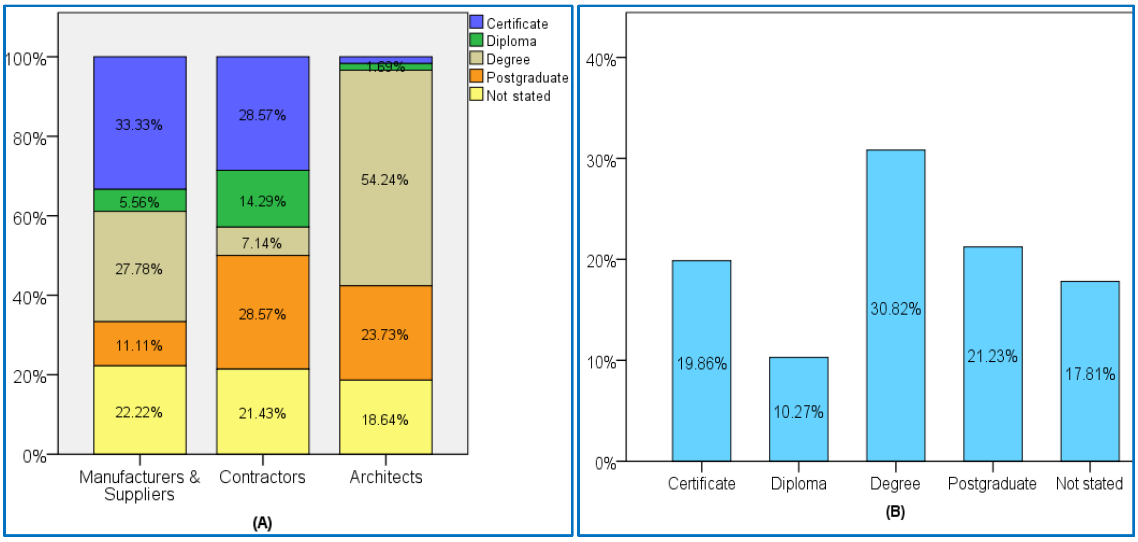


Figure 5.4: Survey participants' highest educational qualifications

5.3.3 Experience in the Construction Industry

Data presented in Figure 5.5 shows the distribution of the participants' experience in the construction industry. Figure 5.5 shows that 41.67% of the manufacturers and suppliers had more than 25 years' experience. Further, 28.57% of contractors reported 21-25 years of experience and another 28.57% of them had more than 25 years' experience in the construction industry.

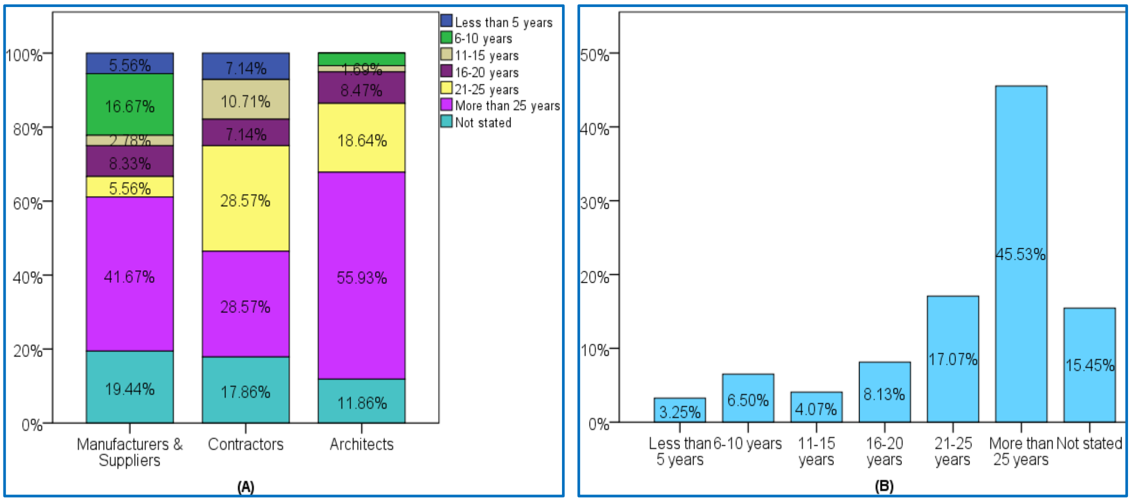


Figure 5.5: Experience in the construction industry

Architects indicated that 55.93% of them had more than 25 years of construction related experience. In total, 45.53% of participants had more than 25 years' experience, and only 3.25% of the respondents had less than 5 years' experience in the construction industry, as indicated in Figure 5.5 (B). The implications of this are that the respondents have enough construction related experience to appropriately answer the questionnaire survey.

5.3.4 Employees in the Business

Participants were required to indicate the number of employees in their businesses. The question was aimed to ascertain the participants' company size and how they are distributed among the different groups of participants. As shown in Figure 5.6 (A), 36.11% of manufacturers and suppliers who participated in the survey had more than 30 employees. Contractors who participated in the survey showed a different distribution. For example 21.43% of them had 1-5 employees while another 21.43% had more than 30 employees. Architects who participated in the survey worked for mainly small companies with 1-5 employees (59.23%). Overall 34.96% of the respondents in total had 1-5 employees, and 17.07% of them had more than 30 employees, as indicated in Figure 5.6 (B).

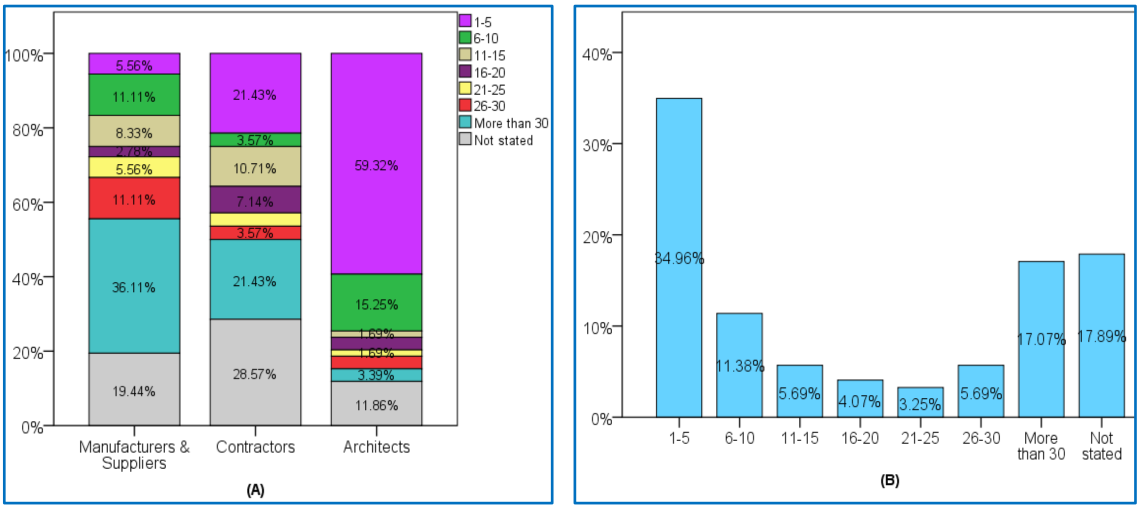


Figure 5.6: Number of employees in the businesses

5.3.5 Key Materials from Manufacturers and Suppliers

Building materials manufacturers and suppliers were required to indicate the types of building materials that they trade in. The question aimed to elucidate the key building materials that participants are involved with. Figure 5.7 shows that the participants demonstrated a good distribution of the variety of materials that are considered in the building materials supply chain in the New Zealand residential construction sector.

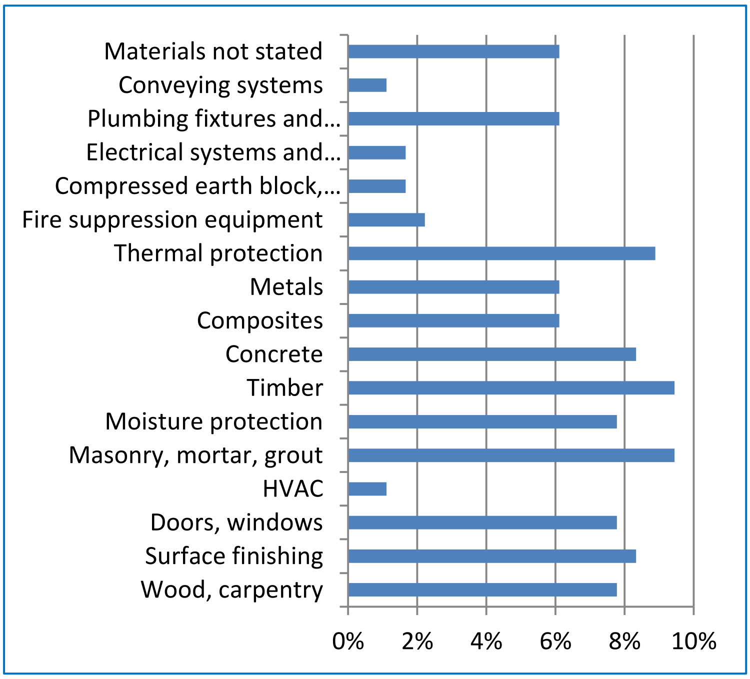


Figure 5.7: Types of building materials supplied

5.4 Materials Supply and Purchasing Practices

Manufacturers and suppliers were asked to indicate who they supply building materials to. Similarly, building contractors were also asked to indicate who they purchase building materials from. Suppliers were given the options of supplying to: other suppliers; BMs; and contractors and sub-contractors. Contractors were given the options of purchasing from: manufacturers; BMs; and suppliers. It should be noted that participants were given the opportunity to select more than one option.

The survey analysis results (see Figure 5.8) show that the most common way of supplying materials is directly to contractors (55% of the total responses), followed by BMs (32% of the total responses). The least common option was supplying to other suppliers, which received only 13% of the responses.

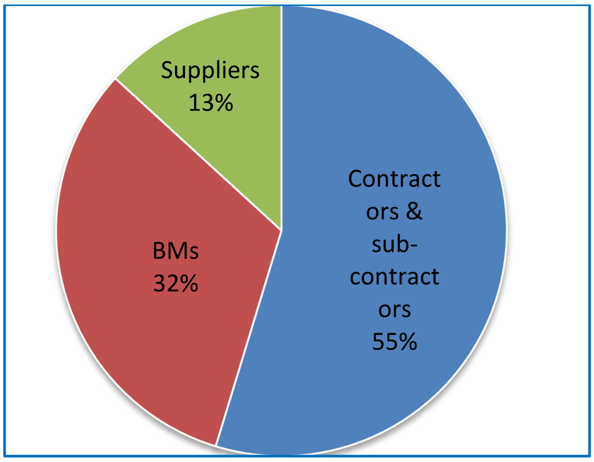


Figure 5.8: Who do manufacturers and suppliers supply building materials to?

Also the survey analysis results (see Figure 5.9) show that the two common ways of purchasing materials is from BMs (37% of the total responses) and suppliers (36% of the total responses). The least common way of purchasing materials was chosen as purchasing directly from materials manufacturers, which had 28% of responses.

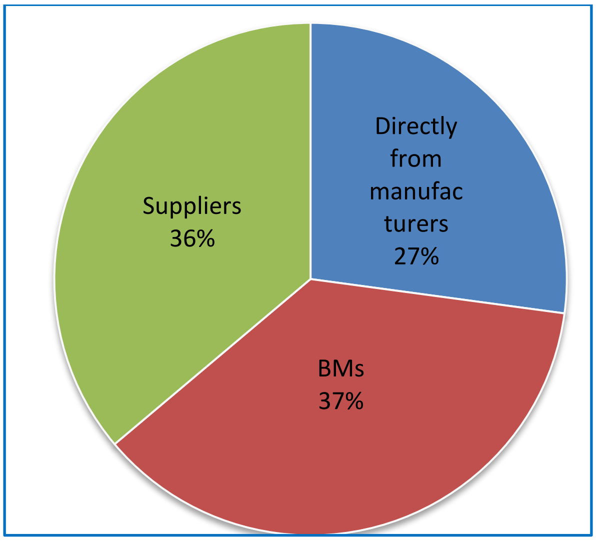


Figure 5.9: Who do contractors purchase building materials from?

5.5 Criteria for Materials Related Decisions - Descriptive Statistics

This analysis aims to identify the most important criteria for supplying, purchasing, and choosing building materials as applicable to the research participants. Of the given criteria derived from the semi-structured interview analysis results, the participants selected the significance of each criterion in making their decisions. A list of criteria was presented to the respondents. Response options were ranged on a Likert scale of 1 to 5, with 1 representing the lowest score (unimportant) and 5 the highest score (very important). Participants were also given the opportunity to indicate other criteria, outside of the list provided to them, according to their understanding of the issue.

The mean scores of each criterion were obtained from the descriptive statistical analysis conducted in SPSS, and each criterion perceived for all participants were ranked in descending order according to the mean score values. Criteria with mean values of 3.5 and above (that is statistically significant) were considered the most important criteria. Where two or more metrics have the same mean, the one with the lowest standard deviation was assigned the highest importance ranking (Sharpe, Veaux, & Velleman, 2010).

According to Field (2005), the standard error is the standard deviation of sample means and is a measure of how representative a sample is likely to be to the population. If the standard error associated with the mean is relatively close to zero it suggests that the sample chosen in this research is an accurate reflection of the population. Furthermore, standard deviations of less than 1.0 also indicate that there is little variability in the data, and there is a high degree of consistency in participants' responses. A summary of the analysis results for each group of participants including the associated mean values, standard deviations and standard errors, are reported in the following subsections.

5.5.1 Key Supplying Criteria

This section of the analysis aims to identify the most important criteria for supplying building materials by manufacturers and suppliers from the 13 given criteria. A summary of the results with means for each criterion, including the associated standard deviation and standard error, is shown in Table 5.3.

Table 5.3: Descriptive statistics - Criteria for supplying building materials

Rank	Criteria	N	Minimum	Maximum	Mean (M)	Std. Error	Std. Deviation (SD)
01	**Strong relationships with customers**	36	4	5	4.70	0.074	0.446
02	**On time delivery services**	36	3	5	4.58	0.089	0.536
03	**Availability of variety of products when they are needed**	36	2	5	4.48	0.106	0.638
04	**Customer satisfaction/understanding**	36	3	5	4.44	0.099	0.595

	customer needs						
05	**Competitive prices**	36	3	5	4.44	0.114	0.684
06	**Product quality requirements**	36	2	5	4.39	0.119	0.715
07	**Collaboration and partnership in the materials supply chain**	36	3	5	4.33	0.103	0.617
08	**Good logistics (transportation and warehousing)**	36	3	5	4.21	0.118	0.707
09	**Having a sophisticated computer system**	36	2	5	4.06	0.138	0.826
10	**Waste minimisation strategies**	36	2	5	3.79	0.163	0.979
11	Streamlining payments and orders by customers	36	1	5	3.47	0.158	0.946
12	Discounts	36	2	5	3.36	0.157	0.944
13	Advertising	36	1	5	2.76	0.215	1.288

The statistically significant (M ≥ 3.5) criteria are shown in bold. Therefore the 10 most statistically significant criteria were considered important in the decisions concerning building materials supply practices.

5.5.2 Key Purchasing Criteria

This part of the data analysis aims to identify the most important criteria for making materials purchasing decisions by building contractors. A list of 14 criteria was presented to the building contractors. A summary of the analysis results is presented in Table 5.4.

Table 5.4: Descriptive statistics - Criteria for purchasing building materials

Rank	Criteria	N	Minimum	Maximum	Mean (M)	Std. Error	Std. Deviation (SD)
01	**Materials quality and satisfactory outcome**	28	3	5	4.70	0.100	0.532
02	**Price**	28	3	5	4.52	0.108	0.569
03	**Own level of efficiency**	28	3	5	4.46	0.128	0.679
04	**Materials specifications**	28	3	5	4.37	0.105	0.554
05	**Degree of negotiation**	28	2	5	4.23	0.157	0.830
06	**Repetitive business**	28	2	5	4.23	0.139	0.736
07	**Supplier's service**	28	2	5	4.22	0.139	0.737
08	**Past experience**	28	2	5	4.19	0.136	0.722
09	**Collaboratively working with the supply chain**	28	1	5	4.15	0.197	1.043
10	**Credit periods**	28	2	5	3.74	0.203	1.075
11	Relationship with other contractors/subcontractors	28	1	5	3.48	0.164	1.132
12	Good feedback from suppliers	28	2	5	3.42	0.169	0.895
13	Having sophisticated software system	28	1	5	3.26	0.216	1.142
14	Exchange rate	28	1	5	2.46	0.220	1.162

The statistically significant criteria (M ≥ 3.5) are shown in bold in Table 5.4. Therefore the 10 most statistically significant criteria were considered important in the decisions concerning building materials purchasing practices. Participants also indicated the following criteria which were outside of the list provided to them, as being important considerations too.

- Relationship between supplier and importer/manufacturer critically important for reliable supply.
- Supplier’s ability to deal with faulty product quickly and easily.
- Appearance
- Company sustainability
- Health & Safety Systems
- Quality Systems
- Environmental Management Systems

5.5.3 Key Selection Criteria - Architects

This section of the analysis aims to identify the most important criteria in making materials selection decisions by architects from a list of 12 criteria that they were provided. The participants were also given the opportunity to indicate other criteria that they considered important apart from the 12 criteria. Table 5.5 summarises the responses and gives the results of the statistical analysis.

Table 5.5: Descriptive statistics - Criteria for selecting building materials by architects

Rank	Criteria	N	Minimum	Maximum	Mean (M)	Std. Error	Std. Deviation (SD)
01	**The material is fit for purpose**	59	4	5	4.86	0.045	0.345
02	**Accurate information**	59	3	5	4.75	0.071	0.544
03	**Quality and satisfactory outcome**	59	3	5	4.69	0.065	0.500
04	**Materials specifications**	59	2	5	4.32	0.107	0.819
05	**Homeowner’s brief**	59	3	5	4.19	0.092	0.706
06	**Knowledge and experience**	59	3	5	4.17	0.094	0.722
07	**Good communication with suppliers**	59	2	5	3.98	0.107	0.820
08	**Architectural concepts**	59	1	5	3.81	0.129	0.991
09	**Site conditions**	59	2	5	3.81	0.112	0.860
10	Relationships with suppliers/manufacturers	59	1	5	3.39	0.128	0.983
11	Relationships with other architects	59	1	5	3.05	0.129	0.990
12	New products in the market	59	1	5	2.91	0.135	1.039

The statistically significant criteria (M ≥ 3.5) are shown in bold in Table 5.5. Therefore the nine most statistically significant criteria were considered important in the decisions concerning the building materials selecting process. Participants also indicated the following criteria outside of the list provided to them as being important considerations too.

- Sound and applicable knowledge by supplier / representative.
- Warranty conditions
- Durability
- Maintenance requirements (NB: this is something that the BCA needs to consider for residential projects under the Building Act 2004)
- Product is available - not on indent
- Product doesn't change between time when specified and time construction starts
- Sustainability - How sustainable is the product? Does it have a low carbon emission profile? Is there a net carbon store in the materials like solid wood?
- Appearance, durability, initial cost, life cycle cost, sustainability, embodied energy (all very important)

5.5.4 Key Selection Criteria - Homeowners

This section of the analysis aims to identify the most important criteria in materials selection decisions by homeowners from the given 15 listed criteria. A summary of the analysis results is reported in Table 5.6.

Table 5.6: Descriptive statistics - Criteria for selecting building materials by homeowners

Rank	Criteria	N	Minimum	Maximum	Mean (M)	Std. Error	Std. Deviation (SD)
01	**Quality and satisfactory outcome**	23	4	5	4.78	0.088	0.422
02	**Functionality, properties, specifications, and the feel of materials**	23	3	5	4.55	0.121	0.582
03	**Appearance**	23	3	5	4.39	0.122	0.583
04	**Maintenance**	23	3	5	4.30	0.147	0.703
05	**Homeowner's requirements**	23	3	5	4.30	0.147	0.703
06	**Material supplier's reputation**	23	3	5	4.00	0.154	0.739
07	**Relationship with contractor**	23	1	5	3.91	0.226	1.083
08	**Relationship with architect**	23	1	5	3.50	0.279	1.340
09	Materials information availability on the Web	23	2	5	3.48	0.207	0.994
10	Support local industry by choosing local products	23	2	5	3.35	0.173	0.832
11	Relationships with materials suppliers and manufacturers	23	1	5	3.13	0.211	1.014
12	Opinions from others (e.g. friends)	23	1	5	2.91	0.208	0.996
13	Where they come from	23	1	5	2.82	0.223	1.072
14	Fashion and trends	23	1	5	2.57	0.216	1.037
15	Availability of bigger showroom	23	1	4	2.48	0.198	0.947

The statistically significant criteria ($M \geq 3.5$) are shown in bold in Table 5.6. Therefore the eight most statistically significant criteria were considered important in the decisions concerning the building materials selecting process. Participants also indicated the following criteria outside of the list provided to them as being important considerations too.

- Both price and replacement if required
- Product availability / timeframe / ability of contractors to install given product

5.6 Issues in the BMSC

This section of the questionnaire covered the issues in the BMSC in New Zealand. This set of questions was included in all four versions of the questionnaire survey to obtain the different participants' views on issues in the BMSC. Participants were given issues identified from the semi-structured interviews with a scale of 1 (is not a serious issue) to 5 (is a serious issue), to indicate the intensity of listed issues. In addition, participants were given the option to indicate any other issues apart from the listed items. Depending on the type of participants the listed issues were different. Some of the listed issues were only applicable to particular participant groups while there were some common listed issues across all the participants. Table 5.7 shows the listed issues and types of participants who selected to indicate those issues.

Table 5.7: Issues listed

No	Issues listed	Groups of participants answered
01	Price of materials	Answered by all 4 groups of participants N = 146
02	Inferior products	
03	Poor collaboration across the supply chain	
04	Fewer choices	
05	Wastage (bespoke nature of houses)	
06	Fragmented industry	
07	Poor IT infrastructure	Answered by manufacturers/suppliers, contractors, and architects N = 123
08	High transport costs	Answered by manufacturers/suppliers and contractors N = 64
09	Road traffic	
10	Constant flux in the building code	Answered by contractors and architects N = 87
11	Complexity in the building code	
12	Homeowners' lack of understanding about materials	Answered by manufacturers/suppliers and architects N = 95
13	Site safety	
14	There are no real NZ standards for materials	
15	High labour costs	Answered by manufacturers/suppliers only N = 36
16	Expensive products' certification methods	
17	Materials substitution (non-adherence to materials specified)	Answered by architects and homeowners only N = 82
18	Delivery issues	Answered by contractors only N = 28
19	No supplier quality assurance	
20	Complicated consenting process and	Answered by architects only

	documentation process	N = 59
21	Poor contractor service	
22	Unreliable suppliers/manufacturers	

The significance of these issues were tested using descriptive statistics (mean and standard deviations) based on the type of participant group. According to the mean values obtained from descriptive statistics, the statistically significant issues ($M \geq 3.5$) are shown in bold text.

5.6.1 Manufacturers' and Suppliers' Views

Table 5.8 shows the descriptive statistics on the issues in the BMSC based on manufacturers' and suppliers' answers. There were eight statistically significant issues ($M \geq 3.5$) and are shown in bold.

Table 5.8: Issues - Manufacturers and suppliers

Rank	Issues	N	Mean (M)	Std. Error	Std. Deviation (SD)
01	**Price of materials**	36	3.97	0.146	0.878
02	**Inferior products**	36	3.80	0.171	1.025
03	**Site safety**	36	3.80	0.161	0.968
04	**High transport costs**	36	3.73	0.159	0.954
05	**Poor collaboration across the supply chain**	36	3.67	0.180	1.078
06	**Expensive products' certification methods**	36	3.63	0.141	0.845
07	**Homeowner's lack of understanding about materials**	36	3.63	0.167	1.000
08	**High labour costs**	36	3.60	0.162	0.974
09	Fragmented industry	36	3.40	0.152	0.913
10	IT infrastructure	36	3.40	0.117	0.701
11	Wastage (bespoke nature of houses)	36	3.36	0.147	.880
12	There are no real NZ standards for materials	36	3.28	0.186	1.119
13	Fewer choices	36	3.27	0.173	1.040
14	Road traffic	36	2.75	0.147	0.882

Participants also indicated the following issues outside of the list provided to them as also being important considerations.

- Lack of a focus on collaboration between developer/owner, architect/designer, engineering, construction, supply chain and manufacturer: This leads to enormous waste (time, energy, materials), and a fragmented response to the demand or need to

simplify complex processes. Waste of materials and the impact on cost is huge (for every 5 houses we built, one goes in the skip).
- Lack of interest across the whole chain in terms of embedded carbon.
- Regulatory changes (foundations, working at heights, Department of Labour (DOL), consents, engineering have driven up costs hugely).
- You have ignored labour inflation at sub-trade level: drain layers, plasterers, painters, bricklayers etc.

5.6.2 Contractors' Views

Table 5.9 displays the descriptive statistics on the issues in the BMSC based on contractors' answers. There were nine statistically significant (M ≥ 3.5) issues that can be identified and are shown in bold.

Table 5.9: Issues - Contractors

Rank	Issues	N	Mean (M)	Std. Error	Std. Deviation (SD)
01	**Price of materials**	28	4.33	0.111	0.588
02	**No supplier quality assurance**	28	4.22	0.126	0.664
03	**Poor collaboration across the supply chain**	28	4.08	0.185	0.978
04	**High transport costs**	28	3.88	0.180	0.955
05	**Delivery issues**	28	3.83	0.168	0.889
06	**Complexity in the building code**	28	3.83	0.151	0.801
07	**Wastage (bespoke nature of houses)**	28	3.80	0.167	0.886
08	**Constant flux in the building code**	28	3.79	0.170	0.902
09	**Inferior products**	28	3.74	0.180	0.951
10	IT infrastructure	28	3.30	0.227	1.200
11	Fragmented industry	28	3.30	0.189	0.998
12	Road traffic	28	3.25	0.201	1.063
13	Fewer choices	28	3.09	0.162	0.857

Participants also indicated the following issues outside of the list provided to them as also being important considerations.

- The consent process and existence of unqualified, lacking-in-building-knowledge inspectors is a major obstacle to licensed building practitioners (LBP).

5.6.3 Architects' Views

Table 5.10 shows the descriptive statistics on the issues in the BMSC based on architects' responses. There were nine statistically significant (M ≥ 3.5) issues that can be identified and are shown in bold text.

Table 5.10: Issues - Architects

Rank	Issues	N	Mean (M)	Std. Error	Std. Deviation (SD)
01	**Materials substitution (non-adherence to materials specified)**	59	4.09	0.090	0.691
02	**Price of materials**	59	4.06	0.098	0.752
03	**Complexity in the building code**	59	3.88	0.125	0.958
04	**Complicated consenting process**	59	3.84	0.133	1.023
05	**Constant flux in the building code**	59	3.80	0.126	0.965
06	**Poor contractor service**	59	3.77	0.114	0.875
07	**Inferior products**	59	3.71	0.108	0.830
08	**Wastage (bespoke nature of houses)**	59	3.68	0.158	0.987
09	**Poor collaboration across the supply chain**	59	3.54	0.115	0.885
10	Fewer choices	59	3.41	0.121	0.927
12	Unreliable suppliers/manufacturers	59	3.33	0.117	0.898
13	Fragmented industry	59	3.24	0.127	0.974
14	Site safety	59	3.17	0.135	1.039
15	Homeowners' lack of understanding about materials	59	3.16	0.114	0.878
16	There are no real NZ standards for materials	59	3.11	0.141	1.086
17	IT infrastructure	59	2.96	0.105	0.809

5.6.4 Homeowners' Views

Table 5.11 shows the descriptive statistics on the issues in the BMSC based on homeowners' responses. There were six statistically significant (M ≥ 3.5) issues that were identified and are shown in bold texts.

Table 5.11: Issues - Homeowners

Rank	Issues	N	Mean (M)	Std. Error	Std. Deviation (SD)
01	**Inferior products**	23	4.30	0.171	0.822
02	**Poor collaboration across the supply chain**	23	4.09	0.177	0.848
03	**Price of materials**	23	4.09	0.165	0.793
04	**Wastage (Bespoke nature of houses)**	23	3.70	0.247	1.185
05	**Materials substitution (non-adherence to materials specified)**	23	3.55	0.186	0.891
06	**Fewer choices**	23	3.52	0.165	0.790
07	Fragmented industry	23	3.09	0.177	0.848

The participants also indicated the following issues outside of the list provided to them as also being important considerations.

- The quality of received products does not reflect the supplier's statement or satisfaction - especially in the timber product industry.

5.6.5 Comparison of Participants' Views

A one-way ANOVA was performed to identify the perceptions of the different groups of participants regarding the issues (answered by more than one group) in the BMSC. The SPSS generated four different tables of statistics to explain the views of the participants. Table 1 in Appendix 5 gives the descriptive statistics. Mean values greater than 3.5 ($M \geq 3.5$) are considered as significant issues. Table 2 in Appendix 5 gives the one-way ANOVA test results. The results of ANOVA at the 0.05 level of significance show that there were no significant differences between the opinions of the participants. When the sig. value (p) is less than 0.05, it is considered that there is a statistically significant difference between the opinions of groups. Table 3 in Appendix 5 gives Hochberg's GT2 post-hoc test results. From the results obtained in Tables 1 and 2 in Appendix 5, it can be seen whether there are significant differences between the groups as a whole or not. Therefore Table 3 in Appendix 5 shows multiple comparisons showing which groups differed from each other at the 0.05 level of significance level. Table 4 in Appendix 5 gives Homogeneous Subsets and groups participants with the same opinion together.

Comparisons were made between the groups to determine how critical the listed issues for different groups of participants were. In other words, the ANOVA identified that participants' perceptions as similar or different on the issues given. The statistically significant issues (according to Table 1 in Appendix 5) are discussed in following paragraphs.

There was no statistically significant difference between the groups on the issue of price of materials ($F = 1.282$, $df = 3$, $p = 0.283$), inferior products ($F = 2.575$, $df = 3$, $p = 0.056$), high transport costs ($F = 0.347$, $df = 1$, $p = 0.558$), constant flux in the building code ($F = 3.821$, $df = 1$, $p = 0.054$), and complexity in the building code ($F = 0.000$, $df = 1$, $p = 0.984$), as shown in Table 2 of Appendix 5. Therefore all the participants who responded to the aforementioned issues were of the opinion that those issues are statistically significant ($M \geq 3.5$).

There was no statistically significant difference between the groups on the issue of wastage/bespoke nature of houses ($F = 1.770$, $df = 2$, $p = 0.177$), as shown in Table 2 of Appendix 5. However, the contractors (M = 3.80) and homeowners (M = 3.70) thought that wastage is a statistically significant issue (M > 3.5), whereas the manufacturers and suppliers thought it is not (M < 3.5).

As can be seen in Table 2 of Appendix 5, there is a statistically significant difference between the participant groups regarding the issue of materials substitution (non-adherence to materials specified) ($F = 3.329$, $df = 3$, $p = 0.021$). According to Table 1 of Appendix 5, the homeowners (M = 3.55) thought materials substitution (non-adherence to materials specified) was less serious than architects (M = 4.09). However both sets of participants thought that the price of materials was a critical issue (M ≥ 3.5).

As shown in Table 2 of Appendix 5, there was a statistically significant difference between the groups of participants on the issue of materials substitution (non-adherence to materials specified) ($F = 3.153$, $df = 3$, $p = 0.027$). According to Table 1 of Appendix 5, the architects (M = 3.54) thought poor communication was less serious than the manufacturers and suppliers (M = 3.67), contractors (M = 4.08), or homeowners (M = 4.09). Further, there were no statistically significant differences between the opinions of the groups.

5.6.6 Statistically Significant Issues

Based on the descriptive analysis and the ANOVA conducted on the given issues of the BMSC, 14 statistically significant issues (average M ≥ 3.5) were identified and listed in Table 5.12.

Table 5.12: Statistically significant issues identified

No	Issues listed	Groups of participants answered
01	Price of materials	Answered by all 4 groups of participants N = 146
02	Inferior products	
03	Poor collaboration across the supply chain	
04	Wastage (bespoke nature of houses)	
05	High transport costs	Answered by manufacturers/suppliers and contractors N = 64
06	Constant flux in the building code	Answered by contractors and architects N = 87
07	Complexity in the building code	
08	High labour costs	Answered by manufacturers/suppliers only N = 36
09	Expensive products' certification methods	
10	Materials substitution (non-adherence to materials specified)	Answered by architects and homeowners only N = 82

11	No supplier quality assurance	Answered by contractors only N = 28
12	Delivery issues	
13	Complicated consenting process	Answered by architects only N = 59
14	Poor contractor service	

5.7 Benefits of Collaboration in the BMSC

This section of the questionnaire covered participants' views on the benefits of collaboration in the BMSC. Collaboration in the materials supply chain was given for the participants as the working practice whereby building materials manufacturers, suppliers, building contractors, architects and home owners work together to successfully complete a house construction project. Firstly, participants were asked to indicate (with a scale of 1 = unimportant to 5 = very important) how important collaboration is to achieve better materials supply chain practices.

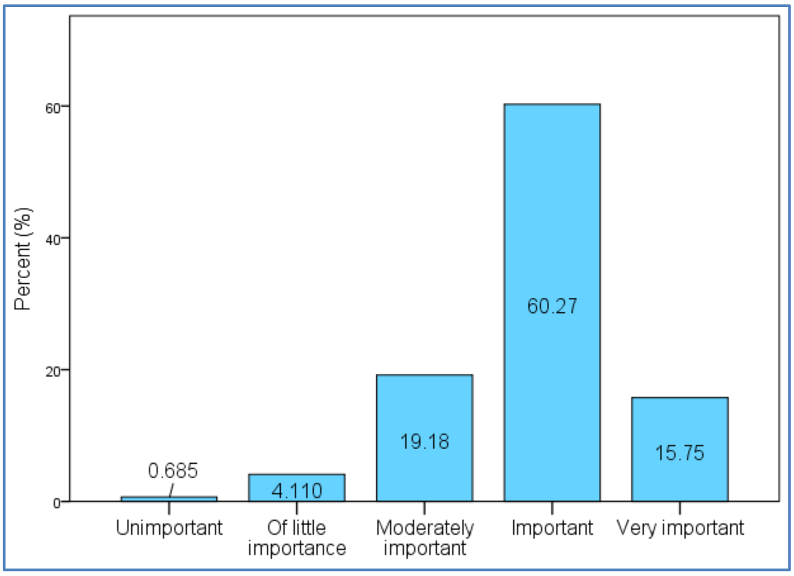


Figure 5.10: Significance of collaboration - All participant groups

The data presented in Figure 5.10 shows that out of 146 participants, 88 (60.27%) indicated that collaboration is important. Twenty three (15.75%) mentioned that collaboration is very important, and 28 (19.18%) stated that collaboration is moderately important. Moreover, Figure 5.11 displays the different participant groups' views on the significance of collaboration in achieving better materials supply chain practices. It can be clearly seen that all the participants agreed that collaboration is important.

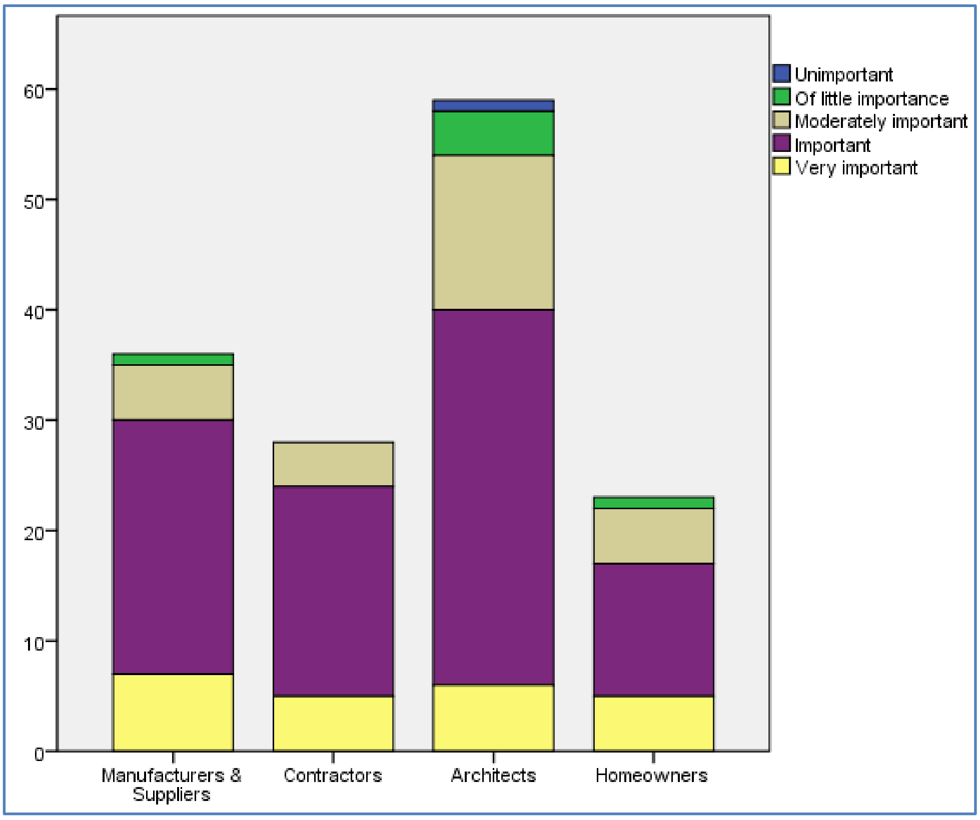


Figure 5.11: Significance of collaboration - Different participant groups

Secondly, participants were given 15 statements on the benefits of collaboration, developed from the semi-structured interviews with a Likert scale of 1 (unimportant) to 5 (very important), to indicate the significance of given statements. This set of questions was included in all four versions of the questionnaire survey with the intention of obtaining different participants' views on collaboration. Further, participants were given the option to write down any other views than the listed items. Table 5.13 shows the given statements.

Table 5.13: Given statements on collaboration

No	Statements given	Groups of participants answered
01	Collaboration brings better understanding about the information flow	Answered by all 4 groups of participants N = 146
02	Collaboration brings better understanding about the materials flow	
03	Collaboration ensures cost effectiveness	
04	Collaboration ensures diversity of products and methodologies	
05	Collaboration ensures materials availability	
06	Collaboration ensures right delivery time	
07	Collaboration ensures the various building materials related requirements of different supply chain parties	
08	Collaboration helps to solve issues in the materials supply chain	
09	Collaboration increases trust between different parties in the supply chain	
10	Collaboration increases understanding of total supply chain goals	

11	Collaboration is bringing teams together and making sure that everyone is delivering their bit (as opposed to the tendering process).
12	Collaboration makes negotiation better
13	Collaboration makes strong relationships in the materials supply chain
14	Collaboration requires a partnership approach
15	Collaboration spreads specialized knowledge across the materials supply chain

The importance of these statements in relation to collaboration was tested using descriptive statistics (mean and standard deviations). According to the mean values obtained from the descriptive statistics, the listed statements were ranked and significant statements ($M \geq 3.5$) related to each group of participants were then identified. Thereafter, the significant statements were combined so that highly inter-correlated statements were clustered into a limited number of independent factors that describe the importance of collaboration in the BMSC.

5.7.1 Manufacturers' and Suppliers' Views

Table 5.14 shows the descriptive statistics on the statements related to collaboration, based on manufacturers' and suppliers' responses. It can be seen that all 15 statements were recognised as significant ($M \geq 3.5$).

Table 5.14: Collaboration – Manufacturers and suppliers

Rank	Statements	N	Mean (M)	Std. Error	Std. Deviation (SD)
01	Collaboration is bringing teams together and making sure that everyone's delivering their bit as opposed to the tendering process	36	4.18	0.098	0.588
02	Collaboration ensures the various building materials related requirements of different supply chain parties	36	4.04	0.109	0.654
03	Collaboration requires a partnership approach	36	4.00	0.126	0.756
04	Collaboration brings better understanding about the materials flow	36	3.96	0.093	0.560
05	Collaboration brings better data flow	36	3.96	0.109	0.654
06	Collaboration increases the trust between different parties in the materials supply chain	36	3.86	0.118	0.706
07	Collaboration increases understanding of total supply chain goals	36	3.86	0.142	0.852
08	Collaboration makes strong relationships in the	36	3.82	0.120	0.719

	materials supply chain				
09	Collaboration spreads specialized knowledge across the materials supply chain	36	3.82	0.113	0.678
10	Collaboration helps to solve issues in the materials supply chain	36	3.71	0.137	0.823
11	Collaboration ensures diversity of products and methodologies	36	3.68	0.132	0.795
12	Collaboration ensures cost effectiveness	36	3.68	0.144	0.864
13	Collaboration ensures materials availability	36	3.61	0.156	0.936
14	Collaboration makes negotiation better	36	3.57	0.156	0.939
15	Collaboration ensures right delivery time	36	3.56	0.145	0.873

5.7.2 Contractors' Views

Table 5.15 shows the descriptive statistics on the statements related to collaboration, based on the contractors' responses. It can be seen that all 15 statements were recognised as significant ($M \geq 3.5$).

Table 5.15: Collaboration - Contractors

Rank	Statements	N	Mean (M)	Std. Error	Std. Deviation (SD)
01	Collaboration ensures the various building materials related requirements of different supply chain parties	28	4.38	0.096	0.507
02	Collaboration requires a partnership approach	28	4.29	0.117	0.617
03	Collaboration is bringing teams together and making sure that everyone's delivering their bit as opposed to the tendering process	28	4.15	0.106	0.563
04	Collaboration increases the trust between different parties in the materials supply chain	28	4.14	0.093	0.493
05	Collaboration increases understanding of total supply chain goals	28	4.14	0.093	0.493
06	Collaboration makes strong relationships in the materials supply chain	28	4.14	0.106	0.563
07	Collaboration makes negotiation better	28	4.05	0.131	0.693
08	Collaboration helps to solve issues in the materials supply chain	28	4.00	0.103	0.544
09	Collaboration brings better understanding about the materials flow	28	4.00	0.073	0.385
10	Collaboration brings better data flow	28	4.00	0.103	0.544
11	Collaboration ensures right delivery times	28	3.95	0.120	0.637

12	Collaboration spreads specialized knowledge across the materials supply chain	28	3.90	0.114	0.603
13	Collaboration ensures materials availability	28	3.90	0.153	0.812
14	Collaboration ensures cost effectiveness	28	3.81	0.132	0.700
15	Collaboration ensures diversity of products and methodologies	28	3.62	0.096	0.507

Participants indicated the following comments outside of the list provided to them as also being important considerations.

- It is assumed that the collaboration is between positive, holistic thinking, flexible parties. Collaboration does not always work if one party has only their own self interests.
- For budget driven housing we (the group home builder) are best left to it. We can deliver on cost and time better if left to it.

5.7.3 Architects' Views

Table 5.16 shows the descriptive statistics on the statements related to collaboration, based on the responses of the architects who participated. It can be seen that 10 statements were recognised as significant ($M \geq 3.5$) and are shown in bold.

Table 5.16: Collaboration - Architects

Rank	Statements	N	Mean (M)	Std. Error	Std. Deviation (SD)
01	**Collaboration ensures the various building materials related requirements of different supply chain parties**	59	3.86	0.092	0.709
02	**Collaboration increases understanding of total supply chain goals**	59	3.86	0.095	0.733
03	**Collaboration brings better data flow**	59	3.81	0.088	0.676
04	**Collaboration makes negotiation better**	59	3.68	0.104	0.797
05	**Collaboration is bringing teams together and making sure that everyone's delivering their bit as opposed to the tendering process**	59	3.63	0.118	0.905
06	**Collaboration requires a partnership approach**	59	3.63	0.115	0.886
07	**Collaboration ensures right delivery time**	59	3.54	0.116	0.892
08	**Collaboration spreads specialized knowledge across the materials supply chain**	59	3.54	0.116	0.892
09	**Collaboration brings better understanding about the material flow**	59	3.51	0.108	0.833
10	**Collaboration ensures cost effectiveness**	59	3.50	0.119	0.914
11	Collaboration makes strong relationships in the materials supply chain	59	3.49	0.106	0.812
12	Collaboration increases the trust between different parties in the materials supply chain	59	3.49	0.114	0.873

13	Collaboration ensures materials availability	59	3.45	0.126	0.969
14	Collaboration ensures diversity of products and methodologies	59	3.36	0.099	0.762
15	Collaboration helps to solve issues in the materials supply chain	59	3.34	0.120	0.921

Participants indicated the following comments outside of the list provided to them as also being important considerations.

- At the end there needs to be one party to make decisions and many of the problems I encounter are from builders convincing client that they know best and messing jobs up. Design by committee does not work. Having all the facts of quality, price and supply as well as ease of construction is important but often those involved are not all working to the same goal.

5.7.4 Homeowners' Views

Table 5.17 shows the descriptive statistics on the statements related to collaboration based on the architect participants' responses. It can be seen that 14 statements were recognised as statistically significant (M ≥ 3.5) out of the 15 given, and are shown in bold.

Table 5.17: Collaboration - Homeowners

Rank	Statements	N	Mean (M)	Std. Error	Std. Deviation (SD)
01	**Collaboration ensures the various building materials related requirements of different supply chain parties**	23	4.32	0.132	0.631
02	**Collaboration is bringing teams together and making sure that everyone's delivering their bit as opposed to the tendering process**	23	4.14	0.130	0.625
03	**Collaboration ensures right delivery time**	23	4.05	0.194	0.928
04	**Collaboration requires a partnership approach**	23	3.95	0.172	0.824
05	**Collaboration helps to solve issues in the materials supply chain**	23	3.90	0.177	0.848
06	**Collaboration spreads specialized knowledge across the materials supply chain**	23	3.90	0.177	0.848
07	**Collaboration increases understanding of total supply chain goals**	23	3.86	0.211	1.013
08	**Collaboration brings better understanding about the material flow**	23	3.86	0.170	0.814
09	**Collaboration increases the trust between different parties in the materials supply chain**	23	3.86	0.202	0.967
10	**Collaboration brings better data flow**	23	3.77	0.166	0.794
11	**Collaboration ensures cost effectiveness**	23	3.76	0.208	0.996
12	**Collaboration makes strong relationships in the materials supply chain**	23	3.68	0.171	0.819
13	**Collaboration ensures materials availability**	23	3.66	0.207	0.956

14	**Collaboration ensures diversity of products and methodologies**	23	3.62	0.222	1.065
15	Collaboration makes negotiation better	23	3.48	0.223	1.071

Participants indicated the following comments outside of the list provided to them as also being important considerations.

- Collaboration should be founded on the needs of the owner, not the needs of the contractor.

5.7.5 Comparison of Participants' Views

A one-way ANOVA was performed to identify the perceptions of the different groups of participants about collaboration in the BMSC. The SPSS generated 4 different tables of statistics to explain the views of the various participants. Table 5 of Appendix 5 gives the descriptive statistics. Mean values greater than 3.5 ($M \geq 3.5$) are considered as significant statements. Table 6 of Appendix 5 gives the one-way ANOVA test results. The results of ANOVA at the 0.05 level of significance show that there were no significant differences between the opinions of the participants. When the sig. value (p) is less than 0.05, it is considered that there is a statistically significant difference between the opinions of the groups. Table 7 of Appendix 5 gives Hochberg's GT2 post-hoc test results. From the results obtained in Tables 5 and 6 of Appendix 5, it can be seen whether there are significant differences between the groups as a whole or not. Therefore, Table 7 of Appendix 5 displays multiple comparisons showing which groups differed from each other at the 0.05 significance level. Table 8 of Appendix 5 gives homogeneous subsets and groups participants with the same opinion together.

Comparisons were made between the groups to determine how significant the listed statements for different groups of participants were. In other words, the ANOVA identified that the participants' perceptions are similar or different to the given statements on collaboration. All of the given statements above (see Table 5.17) are discussed in the following paragraphs.

According to the data presented in Table 6 of Appendix 5, there is no statistically significant difference between the groups about the statements listed below:

- Collaboration increases understanding of total supply chain goals ($F = 1.011$, $df = 3$, $p = 0.390$)

- Collaboration brings better data flow ($F = 0.909$, $df = 3$, $p = 0.439$)
- Collaboration ensures cost effectiveness ($F = 1.016$, $df = 3$, $p = 0.388$)
- Collaboration spreads specialized knowledge across the materials supply chain ($F = 2.186$, $df = 3$, $p = 0.092$)

However, according to Table 5 of Appendix 5, all the participants thought the above statements were significant ($M \geq 3.5$).

There are no statistically significant differences between the groups who responded to the statement “collaboration ensures diversity of products and methodologies” ($F = 1.483$, $df = 3$, $p = 0.221$), as shown in Table 6 of Appendix 5. However, the architects ($M = 3.36$), and homeowners ($M = 3.48$), thought this is not a significant criterion ($M < 3.5$), whereas the manufacturers and suppliers ($M = 3.68$), and contractors ($M = 3.62$), thought this is a significant criterion ($M \geq 3.5$).

There is no statistically significant difference between the participant groups on the statement “collaboration ensures materials availability” ($F = 1.442$, $df = 3$, $p = 0.223$) as shown in Table 6 of Appendix 5. However, the architects ($M = 3.45$) thought this is not a significant criterion ($M < 3.5$), whereas the manufacturers and suppliers ($M = 3.61$), contractors ($M = 3.95$), and homeowners ($M = 3.62$), thought this is a significant criterion ($M \geq 3.5$).

As can be seen in Table 6 of Appendix 5, there is a statistically significant difference the between groups concerning the statement “collaboration brings better understanding about the materials flow” ($F = 4.705$, $df = 3$, $p = 0.004$). According to Table 5 of Appendix 5, the contractors ($M = 4.00$) believed this criterion is more significant than the other participants (manufacturers and suppliers ($M = 3.96$), architects ($M = 3.51$), and homeowners ($M = 3.86$)). Hochberg’s GT2 post-hoc test (Table 7 of Appendix 5) revealed that the manufacturers and suppliers’ opinions were statistically significant compared to the architects ($p = 0.016$), and the contractors’ opinion was statistically significant compared to the architects’ ($p = 0.017$). Further, there were no statistically significant differences between the opinions of the other groups. Moreover, Table 8 of Appendix 5 identified two subsets of opinions (subset 1 = manufactures and suppliers, homeowners, and architects; subset 2 = contractors, homeowners, and manufacturers and suppliers).

As can be found in Table 6 of Appendix 5, there is a statistically significant difference between the groups of participants regarding the statement "collaboration ensures right delivery time" ($F = 3.711$, $df = 3$, $p = 0.013$). However, according to Table 7.46, all participants thought this is a significant ($M \geq 3.5$) criterion. Hochberg's GT2 post-hoc test (Table 7 of Appendix 5) revealed that the architects' opinion was statistically significant compared to the homeowners' ($p = 0.016$), and the contractors' opinion was statistically significant compared to the architects' ($p = 0.042$). There were no statistically significant differences between the opinions of the other groups. Table 8 of Appendix 5 identified two subsets of opinions (subset 1 = manufacturers and suppliers, contractors, and architects; subset 2 = contractors, homeowners, and manufacturers and suppliers).

As can be seen in Table 6 of Appendix 05, there is a statistically significant difference between the participant groups regarding the statement "collaboration helps to solve issues in the materials supply chain" ($F = 5.229$, $df = 3$, $p = 0.002$). However, according to Table 5 of Appendix 5, the architects ($M = 3.34$) thought this is not significant criterion ($M < 3.5$) whereas manufacturers and suppliers ($M = 3.71$), contractors ($M = 4.00$), and homeowners ($M = 3.90$) thought this is a significant criterion ($M \geq 3.5$), Hochberg's GT2 post-hoc test (Table 7 of Appendix 5) revealed that the architects' opinion was statistically significant compared to the contractors' ($p = 0.004$), and the homeowners' opinion was statistically significant compared to the architects ($p = 0.037$). Further there were no statistically significant differences between the opinions of the other groups. Table 8 of Appendix 5 identified two subsets of opinions (subset 1 = manufactures and suppliers, and architects; subset 2 = contractors, homeowners, and manufacturers and suppliers).

As can be seen in Table 6 of Appendix 5, there is a statistically significant difference between the groups concerning the statement "collaboration increases the trust between different parties in the materials supply chain" ($F = 4.813$, $df = 3$, $p = 0.003$). However, according to Table 5 of Appendix 5, the architects ($M = 3.49$) thought this is not significant criterion ($M < 3.5$), whereas manufacturers and suppliers ($M = 3.86$), contractors ($M = 4.14$), and homeowners ($M = 3.86$) thought this is a significant criterion ($M \geq 3.5$). Hochberg's GT2 post-hoc test (Table 7 of Appendix 5) revealed that the architects' opinion was statistically significant compared to the contractors' ($p = 0.003$). There were no statistically significant differences between the opinions of the other groups. Table 8 of Appendix 5 identified two subsets of opinions (subset 1 =

manufacturers and suppliers, architects, and homeowners; subset 2 = contractors, homeowners, and manufacturers and suppliers).

As can be found in Table 6 of Appendix 5, there is a statistically significant difference between the groups regarding the statement "Collaboration ensures the various building materials related requirements of different supply chain parties" (F = 5.409, df = 3, p = 0.001). However, according to Table 5 of Appendix 5, all participants thought this is a significant (M ≥ 3.5) criterion. Hochberg's GT2 post-hoc test (Table 7 of Appendix 5) revealed that the architects' opinion was statistically significant compared to the contractors' (p = 0.004), and the homeowners' opinion was statistically significant compared to the architects' (p = 0.026). There were no statistically significant differences between the opinions of the other groups. Table 8 of Appendix 5 identified two subsets of opinions (subset 1 = manufacturers and suppliers, and architects; subset 2 = contractors, homeowners, and manufacturers and suppliers).

As shown in Table 6 of Appendix 5, there is a statistically significant difference between the groups of participants regarding the statement "collaboration is bringing teams together and making sure that everyone's delivering their bit as opposed to the tendering process" (F = 5.971, df = 3, p = 0.001). However, according to Table 5 of Appendix 5, all participants thought this is a significant (M ≥ 3.5) criterion. Hochberg's GT2 post-hoc test (Table 7 of Appendix 5) revealed that the architects' opinion was statistically significant compared to the manufacturers' and suppliers' (p = 0.004); the contractors' opinion was statistically significant compared to the architects' (p = 0.016); and the homeowners' opinion was statistically significant compared to the architects'.

As can be seen in Table 6 of Appendix 5, there is a statistically significant difference between the groups who participated regarding the statement "collaboration requires a partnership approach" (F = 4.590, df = 3, p = 0.004). However according to Table 5 of Appendix 5, all the participants thought this is a significant (M ≥ 3.5) criterion. Hochberg's GT2 post-hoc test (Table 7 of Appendix 5) revealed that the architects' opinion was statistically significant compared to the contractors' (p = 0.003).

As shown in Table 6 of Appendix 5, there is a statistically significant difference between the groups concerning the statement "collaboration makes negotiation better" (F = 3.809, df = 3, p = 0.012). However according to Table 5 of Appendix 5, the homeowners (M = 3.27) thought this is not a significant criterion (M < 3.5), whereas the manufacturers and suppliers (M = 3.57), contractors (M = 4.05), and architects (M =

3.68) thought this is a significant criterion (M ≥ 3.5). Hochberg's GT2 post-hoc test (Table 7 of Appendix 5) revealed that the homeowners' opinion was statistically significant compared with the contractors' (p = 0.007).

Table 6 of Appendix 5 demonstrates there is a statistically significant difference between the participant groups regarding the statement "collaboration makes strong relationships in the materials supply chain" (F = 5.099, df = 3, p = 0.002). However, according to Table 5 of Appendix 5, all participants thought this is a significant (M ≥ 3.5) criterion. Hochberg's GT2 post-hoc test (Table 7 of Appendix 5) revealed that the architects' opinion was statistically significant compared to the contractors' (p = 0.001).

5.7.6 Statistically Significant Statements

Based on the descriptive analysis and the ANOVA conducted, all 15 given statements on collaboration in the BMSC (M ≥ 3.5) were identified as important and are listed in Table 5.18.

Table 5.18: Significant statements - Collaboration

Rank	Significant statements identified	Average mean values for all participants (M)
01	Collaboration ensures the various building materials related requirements of different supply chain parties	4.07
02	Collaboration is bringing teams together and making sure that everyone's delivering their bit as opposed to the tendering process	3.95
03	Collaboration increases understanding of total supply chain goals	3.91
04	Collaboration requires a partnership approach	3.89
05	Collaboration brings better data flow	3.88
06	Collaboration brings better understanding about the materials flow	3.77
07	Collaboration increases trust between the different parties in the materials supply chain	3.76
08	Collaboration spreads specialized knowledge across the materials supply chain	3.74
09	Collaboration makes strong relationships in the materials supply chain	3.73
10	Collaboration ensures right delivery time	3.67
11	Collaboration makes negotiation better	3.66
12	Collaboration helps to solve issues in the materials supply chain	3.65
13	Collaboration ensures cost effectiveness	3.64
14	Collaboration ensures materials availability	3.60
15	Collaboration ensures diversity of products and methodologies	3.51

5.7.7 Factor Analysis – Collaboration

It was observed that statements in regards to collaboration are interrelated, each correlating with the other. These statements describe the key functions and characteristics of collaboration in the BMSC. Therefore, the need for understanding these interrelationships was noted. A principal axis factor analysis was conducted on the 15 statements with oblique rotation (direct oblimin). This permitted clustering the statements that are highly inter-correlated into a smaller number of independent factors which describe the importance of collaboration. The appropriateness (sample adequacy and rejection of null hypothesis) of conducting a factor analysis was validated through Bartlett's test of sphericity and the Kaiser-Meyer-Olkin (KMO) statistic. As was described in section 6.4.2.2, it is necessary for testing the null hypothesis variables are uncorrelated in the population size (J. Stevens, 2002) with the 0.05 level of significance. Sample adequacy was verified using KMO statistics.

Table 5.19: Appropriateness of factor analysis

KMO and Bartlett's test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.877
Bartlett's Test of Sphericity	Approx. Chi-Square	1336.278
	df	105
	Sig.	0.000

The SPSS results on KMO and Bartlett's test are given in Table 5.19 above. KMO = 0.877 and all KMO values for individual items were greater than 0.801, which is well above the acceptable limit of 0.5 and showed that the sample size is adequate for the factor analysis (Field, 2013). As shown in Table 5.19, a significant Barlett's test statistic value of 1336.278 ($p < .05$) shows that the null hypothesis can be rejected and the variables are uncorrelated (Field, 2013). The suitability of conducting a factor analysis is therefore verified.

An initial analysis was run to obtain eigenvalues for each factor in the data. Three factors had eigenvalues over Kaiser's criterion of 1, and in combination explained 64.625% of the variance. Figure 5.12 displays the screen plot of the eigenvalues with 3 inflexions that justify retaining three factors.

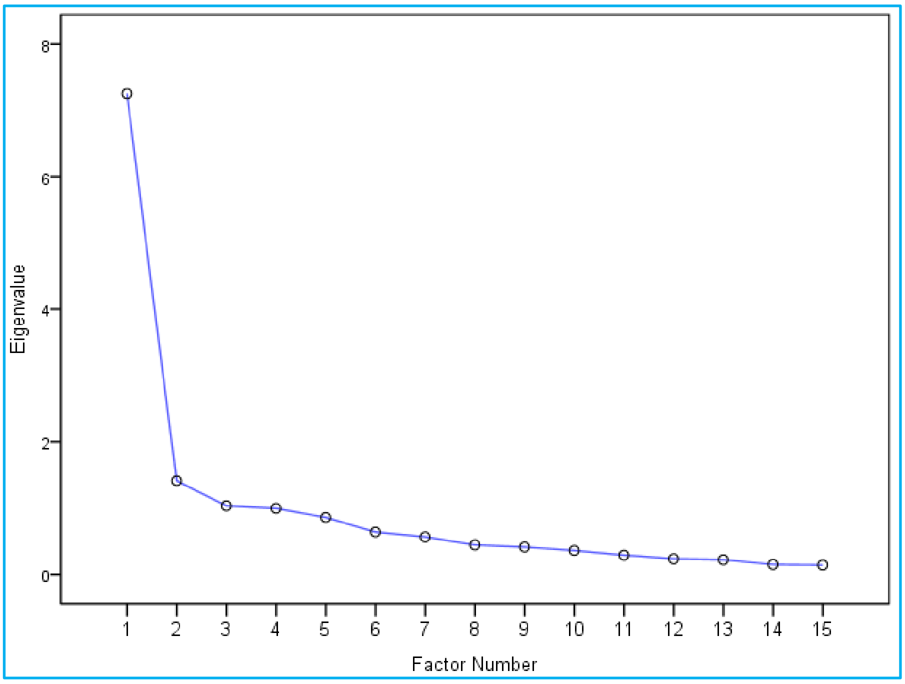


Figure 5.12: Eigenvalues - Factor analysis

Using the PAF method, all 15 statements related to collaboration were able to be clustered into 3 main factors (collaboration ensures the right building materials, other benefits, and collaboration builds better teamwork). The results of the factor analysis, factor loadings after rotation and Cronbach's α coefficients, are presented in Table 5.20. The items that cluster on the same factors suggest that factor 1 represents flow of information flow, factor 2 represents benefits, and factor 3 teamwork.

Table 5.20: Collaboration - Factor Analysis

Constructs	Rotated factors loadings			Reliability measure
	01	02	03	
Collaboration ensures the right building materials (48.33% of variance)				
Collaboration increases understanding of total supply chain		0.690		α = 0.943
Collaboration brings better data flow		0.928		α = 0.942
Collaboration brings better understanding about the materials flow		0.727		α = 0.940
Other benefits (9.40% of variance)				
Collaboration ensures cost effectiveness	0.360			α = 0.941
Collaboration ensures diversity of products and methodologies	0.310			α = 0.943
Collaboration ensures materials availability	0.891			α = 0.939
Collaboration ensures right delivery time	1.009			α = 0.940
Collaboration helps to solve issues in the materials supply chain	0.677			α = 0.939
Collaboration builds better teamwork (6.89% of variance)				

Collaboration increases the trust between different parties in the supply chain	0.311	α = 0.939
Collaboration ensures the various building materials related requirements of different supply chain parties	0.295	α = 0.943
Collaboration is bringing teams together and making sure that everyone's delivering their bit as opposed to the tendering process	0.338	α = 0.940
Collaboration requires a partnership approach	0.703	α = 0.941
Collaboration makes negotiation better	0.901	α = 0.941
Collaboration makes strong relationships in the materials supply chain	0.554	α = 0.938
Collaboration spreads specialized knowledge across the materials supply chain	0.402	α = 0.939

Generally a Cronbach's α value of above 0.70 is an accepted test for scale reliability (Nunnally, 2010). Therefore, all three factors extracted show higher reliabilities (all Cronbach's $\alpha > 0.93$).

5.8 Suggestions for Improving the BMSC

This section of the questionnaire covered the participants' suggestions to improve the BMSC. This set of questions was included in all four versions of the questionnaire survey, with the intention of obtaining the different participants' views on their suggestions. Participants were given possible suggestions identified from the semi-structured interviews with a scale of 1 (unimportant) to 5 (very important) to indicate the significance of the given possible suggestions. In addition, participants were given the option to write down any other recommendations apart from the listed items. However, depending on the type of participants, the listed suggestions were different, although there were some common suggestions across all the participants. Table 5.21 shows the given suggestions and the types of participants who selected to respond to those suggestions.

Table 5.21: Suggestions given

No	Suggestions given	Groups of participants answered
01	Waste minimization	Answered by all participants N = 146
02	Technical advancement	
03	Central materials specification system on Web	
04	Customer opinions and surveys	
05	Good communication	
06	Homeowner education on materials	
07	More fashionable materials	
08	More research	
09	NZ standards system for materials, controlled by	Answered by manufacturers/suppliers,

	the government	contractors, and architects N = 123
10	More competition in the materials supply chain	
11	Independent qualification for materials testing	
12	Better infrastructure	Answered by manufacturers/suppliers and contractors N = 64
13	An improved system to control payment problems	Answered by manufacturers/suppliers only N = 36
14	Transparency around stock levels	Answered by homeowners only N = 23
15	Workshops with suppliers and manufacturers	Answered by contractors only N = 28
16	Building consents should not allow contractors to change the materials specified by architects	Answered by architects only N = 59
17	Enhanced building inspector and builder relationship	

The significance of these issues were tested using descriptive statistics (mean and standard deviations) based on the types of participants. According to the mean values obtained from the descriptive statistics, the listed suggestions were ranked and the statistically significant suggestions ($M \geq 3.5$) related to each group of participants were then identified and are shown in bold.

5.8.1 The Manufacturers' and Suppliers' Views

Table 5.22 displays the descriptive statistics on the suggestions to improve the BMSC based on the contractors' responses. There were six statistically significant recommendations that can be identified ($M \geq 3.5$).

Table 5.22: Suggestions - Manufacturers and suppliers

Rank	Suggestions	N	Mean (M)	Std. Error	Std. Deviation (SD)
01	**Good communication**	36	4.24	0.110	0.661
02	**An improved system to control payment problems**	36	4.03	0.135	0.810
03	**Independent qualification for materials testing**	36	4.00	0.132	0.793
04	**Technical advancement**	36	3.90	0.115	0.691
05	**Waste minimization (increased house standardisation and integration in the supply chain)**	36	3.83	0.138	0.830
06	**Better infrastructure**	36	3.72	0.132	0.789
07	Central materials specification system on Web	36	3.41	0.171	1.029
08	Customer opinions and surveys	36	3.38	0.184	1.106
09	NZ standards system for materials,	36	3.34	0.170	1.022

	controlled by the government				
10	Homeowner education on materials	36	3.34	0.175	1.050
11	More research	36	3.21	0.146	0.874
12	More competition in the materials supply chain	36	2.90	0.171	1.024
13	More fashionable materials	36	2.67	0.149	0.894

5.8.2 The Contractors' Views

Table 5.23 shows the descriptive statistics on the suggestions to improve the BMSC based on the contractors' responses. There were seven statistically significant recommendations that can be identified ($M \geq 3.5$) and are shown in bold.

Table 5.23: Suggestions - Contractors

Rank	Suggestions	N	Mean (M)	Std. Error	Std. Deviation (SD)
01	**Good communication**	28	4.24	0.102	0.538
02	**Waste minimization (increased house standardisation and integration in the supply chain)**	28	4.05	0.131	0.693
03	**Technical advancement**	28	4.05	0.131	0.693
04	**Better infrastructure**	28	3.90	0.145	0.765
05	**Independent qualification for materials testing**	28	3.90	0.135	0.715
06	**More research**	28	3.71	0.127	0.675
07	**Workshops with suppliers and manufacturers**	28	3.60	0.140	0.740
08	More competition in the materials supply chain	28	3.45	0.109	0.576
09	Homeowner education on materials	28	3.38	0.158	0.838
10	NZ standards system for materials controlled by the government	28	3.33	0.181	0.956
11	Central materials specification system on Web	28	3.30	0.163	0.865
12	Customer opinions and surveys	28	3.29	0.127	0.675
13	More fashionable materials	28	3.10	0.162	0.857

In addition one participant gave the following comment:

> "…to have clients with more knowledge is a two-edged sword. I am not sure we should be reliant on established suppliers. The industry is controlled by two major players. More competition would give us lower prices. Government does control the testing of products now through BRANZ."

5.8.3 The Architects' Views

Table 5.24 shows the descriptive statistics on the suggestions to improve the BMSC based on the architects responses. There are nine statistically significant recommendations that can be identified ($M \geq 3.5$) and are shown in bold.

Table 5.24: Suggestions - Architects

Rank	Suggestions	N	Mean (M)	Std. Error	Std. Deviation (SD)
01	**Technical advancement**	59	4.00	0.073	0.557
02	**More competition in the materials supply chain**	59	3.93	0.088	0.680
03	**Good communication**	59	3.90	0.093	0.715
04	**Central materials specification system on Web**	59	3.86	0.095	0.733
05	**Independent qualification for materials testing**	59	3.83	0.116	0.889
06	**More research**	59	3.74	0.097	0.744
07	**Waste minimization (increased house standardisation and integration in the supply chain)**	59	3.72	0.090	0.694
08	**Building consent should not allow contractors to change the materials specified by architects**	59	3.62	0.139	1.066
09	**Enhanced building inspector and builder relationship**	59	3.55	0.116	0.894
10	NZ standards system for materials controlled by the government	59	3.29	0.122	0.934
11	Homeowner education on materials	59	2.93	0.098	0.752
12	Customer opinions and surveys	59	2.57	0.100	0.769
13	More fashionable materials	59	2.36	0.093	0.715

Participants also offered the following suggestions outside of the list provided to them as being important considerations.

- Substitution of products assists competitive building but it should require the designer's approval. Change of detailing is more of a problem as builders do not often fully understand the consequences, and site inspectors from council are not fully conversant with the particular building, and so tend to accept the apparent minor change to details. Also councils are now often insisting on certain detail from the acceptable, and not accepting alternative that may be better.
- Transparency around costs.
- Central and local government should not be dictating materials to be specified or for that matter used. These large companies have the government right where they want them.
- Generic description should suffice, e.g prefin metal roofing or plaster board - not *** *** or *** *** - the contractor should be able to make that choice - but most importantly though - in conjunction with the architect/engineer.

- Education throughout the industry to bring skill levels up above bare minimum.

5.8.4 The Homeowners' Views

Table 5.25 displays the descriptive statistics on the suggestions for improving the BMSC based on the homeowners' responses. There were five statistically significant suggestions that can be identified ($M \geq 3.5$) and are shown in bold.

Table 5.25: Suggestions - Homeowners

Rank	Suggestions	N	Mean (M)	Std. Error	Std. Deviation (SD)
01	**Good communication**	23	4.09	0.165	0.793
02	**Waste minimization**	23	4.00	0.189	0.905
03	**Technical advancement**	23	3.85	0.144	0.692
04	**Central materials specification system on Web**	23	3.82	0.195	0.936
05	**Homeowner education on materials**	23	3.68	0.212	1.017
06	Customer opinions and surveys	23	3.45	0.206	0.988
07	More research	23	3.41	0.185	0.887
08	Transparency around stock levels	23	2.91	0.234	1.124
09	More fashionable materials	23	2.59	0.224	1.073

5.8.5 Comparison of the Participants' Views

A one-way ANOVA was performed to clarify the perceptions of the different groups of participants about the suggestions proposed (and responded by more than one group). The SPSS generated four different tables of statistics to explain the views of the participants. Table 9 of Appendix 5 gives the descriptive statistics. Mean values greater than 3.5 ($M \geq 3.5$) are considered significant suggestions. Table 10 of Appendix 5 gives the one-way ANOVA test results. The results of ANOVA at 0.05 level of significance show that there were no significant differences between the opinions of the participants. When the sig. value (p) is less than 0.05, it is considered that there is a statistically significant difference between the opinions of groups. Table 11 of Appendix 5 gives Hochberg's GT2 post-hoc test results. From the results shown in Tables 9 and 10 of Appendix 5, it can be seen whether or not there are significant differences between the groups as a whole. Therefore, Table 11 of Appendix 5 does multiple comparisons showing which groups differed from each other at 0.05 significance level. Table 12 of

Appendix 5 gives Homogeneous Subsets and basically groups participants with the same opinion together.

Comparisons were made between the groups to determine how significant the listed suggestions for different groups of participants were. In other words, the ANOVA identified that the participants' perceptions were similar or different on the given suggestions to improve the BMSC. The statistically significant suggestions (see Table 9 of Appendix 5) are discussed in the following paragraphs.

According to the data presented in Table 10 of Appendix 5, there was no statistically significant difference between the groups with regard to the suggestions of good communication (F = 2.455, df = 3, p = 0.066), technical advancement (F = 0.596, df = 3, p = 0.619), independent qualification for materials testing (F = 0.433, df = 3, p = 0.730), waste minimization (increased house standardization and integration in the supply chain) (F = 1.530, df = 3, p = 0.209), better infrastructure (F = 0.903, df = 2, p = 0.408), and a central materials specification system on the Web (F = 2.099, df = 3, p = 0.103). However all the participants believed that the aforementioned suggestions were statistically significant ($M \geq 3.5$).

As can be seen in Table 10 of Appendix 05, there was a statistically significant difference between the groups of participants regarding the suggestions for more research (F = 4.032, df = 3, p = 0.09). According to Table 9 of Appendix 5, the manufacturers and suppliers (M = 3.21), and homeowners (M = 3.41), thought more research is not a significant suggestion to improve the BMSC; whereas the contractors (M = 3.71), and architects (M = 3.74), thought more research was a significant suggestion. Hochberg's GT2 post-hoc test (Table 11 of Appendix 5) revealed that the manufacturers' and suppliers' opinions were statistically significant (p = 0.011) compared to the architects. Further, there were no statistically significant differences between the opinions of other groups. Moreover, Table 12 of Appendix 5 identified two subsets of opinions (subset 1 = manufacturers and suppliers, homeowners, and contractors; subset 2 = homeowners, contractors, and architects).

As can be seen in Table 10 of Appendix 5, there was a statistically significant difference between the groups regarding the suggestion of more competition in the BMSC (F = 19.864, df = 2, p = 0.000). According to Table 9 of Appendix 5, the manufacturers and suppliers (M = 2.90), thought more competition in the MSC was a less significant suggestion, compared to contractors (M = 3.67), and architects (M = 3.93).

As can be seen in Table 10 of Appendix 5, there was a statistically significant difference between the groups of participants with regard to the suggestion that homeowners need more education on materials (F = 4.673, df = 3, p = 0.004). According to Table 9 of Appendix 5, the architects (M = 2.93) thought that homeowners' education on materials is a less significant suggestion compared to the manufacturers and suppliers (M = 3.34), contractors (M = 3.38), and homeowners (M = 3.68). Hochberg's GT2 post-hoc test (Table 11 of Appendix 5) revealed that the architects' opinion was statistically more significant (p = 0.005) than the homeowners'. Further, there were no statistically significant differences between the opinions of the other groups. Moreover, Table 12 of Appendix 5 identified two subsets of opinions (subset 1 = architects, homeowners, manufacturers and suppliers; subset 2 = contractors, homeowners, and manufacturers and suppliers).

5.8.6 Significant Suggestions Identified to Improve the BMSC

Based on the descriptive analysis and the ANOVA conducted on the given suggestions to improve the BMSC, 12 statistically significant suggestions (M ≥ 3.5) were identified and are listed in Table 5.26.

Table 5.26: Statistically significant suggestions identified

No	Suggestions given	Groups of participants answered
01	Waste minimization	Answered by all participants N = 146
02	Technical advancement	
03	Central materials specification system on Web	
04	Increased communication	
05	Homeowner education on materials	
06	More research	
07	More competition in the materials supply chain	Answered by manufacturers/suppliers, contractors, and architects N = 123
08	Independent qualification for materials testing	
09	Better infrastructure	Answered by manufacturers/suppliers and contractors N = 64
10	An improved system to control payment problems	Answered by manufacturers/suppliers only N = 36
11	Building consents should not allow contractors to change the materials specified by architects	Answered by architects only N = 59
12	Enhanced building inspector and builder relationship	

5.9 Summary

This chapter reported the findings from the analysis of the four versions of the questionnaire survey. The chapter initially surveyed the administration process followed by the demographic data of the survey participants. This was followed by the manufacturers' and suppliers' materials supply behaviours, the contractors' materials purchasing behavior, and the architects and homeowners' materials selecting behavior. These all were identified and discussed, using descriptive statistics. An ANOVA was performed to examine the differences in perceptions between the different participant groups regarding the issues in the BMSC, collaboration in the BMSC, and suggestions for possible improvements in the BMSC. These findings were verified and extended using SMEs. The following chapter presents the views of the SMEs on these findings.

CHAPTER SIX

Validation of Key Research Findings

6.0 Introduction

This chapter presents the results of the research validation interviews conducted through SMEs in the New Zealand residential construction sector. The research validation was a follow-on exercise to a set of semi-structured interviews and an online survey administered within the New Zealand residential construction sector. The data from semi-structured interviews and the online survey were analysed and the results were presented to the SMEs for their verification and additional input. The chapter begins with a brief description of the research validation process, with profiles of the SMEs interviewed. Then it goes on to present the SMEs' views under seven themes, in line with the research objectives outlined in chapter one of this thesis.

6.1 The Research Validation Process

A research validation exercise ensures the credibility of research findings (Patton, 2002) and enhances the understanding and explanation of the research findings (Cronbach, 1990). In order to refine and expand the research findings, the researcher compiled a summary of key research findings that emanated from the earlier stages of qualitative and quantitative data collection. These summaries were then validated and extended using the SMEs. As explained, this research validation exercise was conducted through the SMEs selected from the residential construction sector in New Zealand. It also completes the research triangulation by verifying the qualitative data gathered from the semi-structured interviews and the quantitative data gathered from an online questionnaire survey. The SME interviews followed a similar procedure with the semi-structured interviews at the beginning of the field study. The SME interviews were conducted face to face in line with the interview guidelines attached in Appendix 4 (C-F). The SMEs provided their views and further contributed to the research findings in order to enhance the quality of the overall research contributions.

6.1.1 Profile of Participants

The demographic information of the SMEs participated in this study is shown in Table 6.1 in terms of the type of organisation they represented, their roles, and experience/knowledge of the construction industry.

Table 6.1: Demographic data - SMEs

Participant ID	Type of Organisation Represented	Role	Experience/knowledge of the construction industry
SME-01	Building materials manufacturer and supplier	National sales executive	25 years
SME-02	Residential building contractor	Senior manager	35 years
SME-03	NZIA	House designing architect	32 years
SME-04	HOBANZ	Senior executive	30 years

SME-01 is a manager of one of the leading building materials manufacturing and supply organisations in New Zealand, and has a very good understanding of the supply behavior of suppliers/manufacturers as well as other issues pertaining to residential construction work.

SME-02 holds a senior management position in a residential building construction company. This residential construction company is one of the largest builders in the New Zealand residential construction sector, recognised by Curtis (2012). Therefore SME-02 has a very good understanding of the New Zealand building industry.

SME-03 ia a principal architect and a member of the NZIA. The participant has significant work experience in pre-purchase inspection, site assessment studies, design feasibility studies, construction documentation, site master planning, schematic design, presentation drawings and models, development/ resource consent applications, building consent applications, contract administration, and site inspections during construction, in New Zealand as well as in Fiji. The research findings that emanated from participating architects were presented to this participant for verification and additional input.

SME-04 holds a senior management position in HOBANZ. The participant has vast experience as well as a family background in the construction industry. The principal aim of HOBANZ, which SME-04 represents, is to be a trusted source of information and guidance for current and future homeowners in all areas associated with buying, selling, maintaining and owning homes.

6.2 Findings from the Research Validation

The findings from the research validation exercise are presented in the following themes. The SMEs' agreements and disagreements on the various issues discussed will be emphasized, with relevant quotes as appropriate. It should be noted that the themes were presented to applicable SMEs only.

- Issues in the BMSC - Presented to All SMEs
- Building materials supply criteria – Presented to SME-01
- Building materials purchasing criteria - Presented to SME-02
- Building materials selection criteria by architects - Presented to SME-03
- Building materials selection criteria by homeowners - Presented to SME-04
- Collaboration in the BMSC - Presented to All SMEs
- Suggestions for improving the BMSC - Presented to All SMEs

6.2.1 Issues in the BMSC

The current research identified issues (see Table 6.2) in the New Zealand BMSC. All four SMEs were asked to provide their insights on the issues identified. It should be mentioned that the issues presented were not common to all SMEs. Table 6.2 shows the applicability of various issues to all four SMEs.

Table 6.2: Issues in the BMSC

No	Key issues	Applicable participant/s
01	High building materials prices	All SMEs
02	Cheap products with lower quality are available in the market. This could create leaky home issues/ similarly costly issues.	

03	Poor communication (collaboration) in the supply chain that significantly increases the time taken to find the right product.	
04	Materials wastage. Possibly due to because of the lack of collaboration in the supply chain and bespoke nature of houses. Having very customised houses also requires purchasing specific sizes, colours, shapes, and various other very-customised requirements. This creates less efficiency in the building materials supply chain, as the supplying process becomes more complicated.	SME-01, SME-02, and SME-04 only
05	High transport costs.	SME-01and SME-02 only
06	Constant flux in the building code: The materials that are available in the codes, and what is permitted to be used are constantly changing.	SME-02 and SME-03 only
07	Complexity in the building code: Complexity in the current building code creates the issues of understanding what is right and not right, and which system needs to go with another system to give the best outcome.	
08	High labour costs.	SME-01 only
09	Expensive products certification methods	
10	Materials substitution (non-adherence to materials specified): where the architect specifies a particular material but the contractor wants to change to different materials which look the same but their performance could be different.	SME-03, and SME-04 only
11	No supplier quality assurance.	SME-02 only
12	Delivery issues	
13	Complicated consenting process involved with getting approval for the materials chosen for a house.	SME-03 only
14	Poor contractor service A lot of products fail because they are not properly assembled. The reason is the poor information transmission between manufacturer/supplier and assembler.	

The following sub-sections describe, compare, and contrast all these issues, based on the comments received from all four SMEs. The discussion follows the order of the issues/themes listed in Table 6.2.

1) High materials prices

SME-01 explained that the issue of high material price is always a relative case (e.g. New Zealand building materials are more expensive than in some countries but may be cheaper than in some other countries). Also, SME-01 said that high building materials prices represents higher labour costs, types of construction, the way buildings are erected, earthquake proofing, standards of construction, the European market, shipping, etc. Therefore SME-01 disagreed with the above statement (high materials prices). In contrast, SME-02 agreed that materials are expensive in New Zealand but justified them by saying that the local construction industry is small and thereby materials demand is low. Whereas in countries like the USA and Australia, materials are relatively inexpensive because their construction markets are larger and have greater turnover. However, SME-03 showed a different viewpoint from both SME-01 and SME-02. SME-03 said that the high cost of materials sometimes occurs due to the unavailability of certain materials:

> "You've gotta watch that, but sometimes there is that you don't have the availability of other materials if that's what there is. It might have a premium price on it so may not have the choices."

SME-04 agreed that building materials are expensive in New Zealand. This participant considered this as a volume issue and said:

> "But it is very disappointing to see; we have one Canadian company that's set up here in New Zealand and now they bring in all of their hardware from Canada. So freight, insurance and duty paid, landed in New Zealand they can land it for at least two-thirds if not half the price that they're paying for the products here in New Zealand. So there's some serious questions that have to be asked about the supply chain in terms of all of the successive mark-ups and any duties that are imposed on certain products to get a real understanding of it."

SME-04 further stated that timber prices are higher in New Zealand because it grows timber mainly for export, compared to Australia, the USA, or Canada. The influence of the bigger players in terms of the monopolistic situation in the market was pointed out by this participant. From SME-04's viewpoint corporate collusion and market protection, rather than the size of the New Zealand market, make building materials very expensive. Therefore purchasing or selling good quality materials for competitive prices is a challenge. From the manufacturers/suppliers perspective, it is challenging to establish a value against price because of the competing materials. The SMEs expressed the view that customers should consider associated values when they purchase building materials. For example, technical support, background support, logistic supply, etc. Therefore, good quality materials are often perceived to be associated with higher prices.

2) Cheap products with lower quality

Both SME-01 and SME-02 acknowledged that the use of some new materials has been a problem for the industry. However these participants further said that the way that building materials are being used by builders could create leaky home issues or similar costly problems. In SME-01's own words:

"…there is nothing wrong with having a plaster external house so long as you have a cavity drain on the inside. Now, if you don't do that, then if water gets in through cracks or whatever, then it needs to get to out and if it doesn't get out then it pools and creates damage to timber; that's a construction system, it's not to do with the materials that were supplied."

SME-03 expressed the view that new products/inferior products should be used by New Zealand architects very cautiously. In SME-03's own words:

"If it's vital for their design and the aesthetic to go into new territory with new materials, that would risk the performance of the house. Then don't do it because it depends how much stress you can live with - not knowing whether it will fail – 'cause ultimately you're the specifier so you'll be in the line-up if there's a case for indemnity."

SME-04 agreed with the inferior products issue. This participant explained that there are some inferior products that are cheap but fail every time, for example liquid applied waterproof membranes or other products such as torch-on waterproofing membranes which are designed to be durable, but researchers have found that over time they start to take up moisture and can increase in volume to almost three times their own weight. Therefore although products are cheaper and are seemingly a more cost effective solution, homeowners may not get the protection they should, from a weather tightness perspective.

3) Poor communication

All four participants accepted that the level of communication in the current materials supply chain is poor. From the contractors' perspective, good communication with suppliers ensures the right materials in purchase orders, SME-02 said.

"Yeah, it is communicating the right product especially from QS, but when it comes down to the right weatherboard, which profile it is. Is it 180, is it 150, there's a whole lot of factors in that communication through the purchase order, and the information has to be on that purchase order. If you can't identify it then take a photo and say, "This is what I want." So communication is absolutely number one."

SME-03 emphasised that poor collaboration exists in onsite activities where manufacturers/suppliers' specifications/guidelines are not properly followed by the contractors. SME-04 expressed a similar view point which showed that products installation is the biggest issue in the residential sector, as communication between contractors and manufacturers/suppliers is poor.

"What we have seen is dumb installation. So the builders are just lazy, incompetent, and they have been not following the instructions. So you have to drill then nail and

> they come along and they use a nail gun and they blow the back of the board out because the nail gun explodes the back of the board and then exposes the untreated or the unsealed part of the board; it takes up moisture; then it fails. It's not the board, it's the bloody builder. So we need to scotch a lot of the rumours, and also some products need a little bit more intensive labour to install but you get the right result in terms of their finish. And builders are just lazy."

SME-04 also stated that there is a lot of misinformation and self-interest in the residential construction sector. Sometimes it is very difficult to get what homeowners want or need responded to by contractors and architects.

> "So they're not pulling back and they're not listening necessarily to the customers. And so when really well-informed owners are coming onto the scene they are finding it very tough to get their wants or needs responded to by the builders and architects. And it's all again this misinformation and self-interest in many cases. We find it staggering sometimes when owners go along and say, "I want this." And the architect or the builder's saying, "No." And you're going, "Hang on a minute who's paying the bills? If you've got a good technical reason tell us, we want to know." But we never find any good technical reason. And then of course you dig a little bit further beneath the surface and you find that the architect's on nine points, he needs 10 points to get his free holiday in Fiji. That's sick, the industry is very sick in that regard (SME-04)."

4) Materials wastage

SME-01 reported that there is a significant amount of waste generated due to the highly customized nature of houses. Therefore, this participant suggested more mass produced construction.

> "…if you compare the housing development for instance in NZ compared with say what you see in Canada, you have completely different styles; in Canada you will get whole housing areas which are all of a similar sort of standardised or if you go to *** you will see samples of that sort of thinking, but a lot of other areas, they are all individual houses all with their individual builder and architect so the cost and waste of that is going to be considerably higher."

SME-02 also shared a similar view that design and build (i.e. a bespoke house) is quite expensive compared to having standardised houses where any materials left over go onto the next project, and therefore reduces wastage. SME-04 argued that bespoke building focuses on minimizing labour effort and so there is little effort put into maximizing materials efficiency.

5) High transport costs

Both SME-01 and SME-02 verified that high transport costs are an unavoidable part of being in a country with a small population which is geographically spread out. For example, SME-01 said:

> "The cost of shipping a pallet of product is always going to be higher than shipping a truckload of the same product. It's just in the US for instance, they would ship truckloads of product to distribution centres, and of course obviously when you're shipping truckloads compared with a pallet you're going to get a lot lower costs. So, it is just a dynamics of the population base."

SME-01 and SME-02 further said that trans-shipping between the North and South Islands is a major cost for the building industry because of the bulky nature of its products.

6) Constant flux in the building code

Both SME-02 and SME-03 did not agree that constant change in the building code is a significant issue. They pointed out that both architects and contractors have to cope with the constantly changing nature of the building code.

7) Complexity in the building code

Both SME-02 and SME-03 disagreed that the current building code is complex. These participants said that the building code used to be complex because there were five or six different councils all with different ideas on the code. However, currently there is one code with one set of standards. Therefore the current building code is clear in what is acceptable and what is not. Both SEM-02 and SME-03 accepted that complying with the building code is time-consuming, however.

8) High labour costs

SME-01 acknowledged that high labour costs in New Zealand contribute to high materials costs compared to other countries (e.g. Australia, the UK, and the USA). Therefore hiring the right staff for the right positions is a challenge, as explained by SME-01:

> "One of the problems of the building industry that has to supply right through is that people are trying to help the cost down so you're trying to minimise the wage costs; you try to make a job as straightforward as possible so that you can get your labour costs down. Now, one criticism that it would have of the merchants is that

> the larger, what you might call big boss merchants, have huge churn of staff and we just don't get product knowledge built up in their stores and it's not retained because they are paying minimum wages and they're getting people who are there for a short possible time before they move on."

9) Expensive product certification methods

SME-01 agreed that BRANZ produced certification methods are very expensive and time consuming.

10) No supplier quality assurance

SME-02 reported that quality assurance from some suppliers/manufacturers can be an issue. The participant stressed that it is important to have warranties/guarantees on materials as a means of quality assurance.

11) Delivery issues

SME-02 accepted that sometimes materials delivery issues such as late deliveries or early deliveries can cause problems such as construction delays, storage problems, and cash flow maintenance problems.

12) Excess documentation process involved with the building consent

SME-03 strongly agreed that much of the paperwork related to materials approval is unnecessary. The participant further suggested that all the documents involved with getting approval for the materials chosen for a house should be digitised.

> "This all should be digitised. There's a waste of paper. I put in a building consent for a very small building residence - timber frame, just corrugated steel roof, standard details - and there was a ream of paper for the documentation. It's wasteful. It's unnecessary and I wish the councils would get onto this (SME-03)."

13) Poor contractor service

SME-03 agreed that poor service from contractors could be an issue. This participant said that a lot of contractors usually practice their past working experience rather than following an architect's actual drawings. The participant said:

> "They've done a thousand slabs before, so he's not going to look at my drawings, he's going to do what he knows how to do, and it's always passed in the past so done. What they do is they leave stuff out, you know, like they might leave some batten out so they undersupply in batten, or they might not put the brick mould around the top, it's not in the thing."

Such bad workmanship by some contractors can create serious problems for the homeowner, SME-03 reported. Therefore, this participant said that it is always better for the architect to be involved in the contract administration process to avoid any poor service received from contractors.

SME-03 explained that the architect should generally specify products that can be checked onsite by the supplier. For example, if there is a plaster proprietary system, the supplier should have its own in house checking system that is then issued as a producer statement for the code compliance certificate, and that should be signed off. The manufacturer should specify it before the documents are finished and submitted with the building consent. This would provide a good level of control over this issue.

14) Other Issues

SME-04 provided some additional comments on the current issues in the BMSC. The lifecycle cost of the building materials is more important than anything else, this participant pointed out. SME-04 stressed that a lot of decisions with new home builds are really made by group housing operators, not by homeowners. The key issue highlighted was that homeowners are under the control of contractors when building materials related choices are made.

SME-04 further shared his views on the current issues in the supply chain related to building materials. SME-04 said some building contractors and architects sometimes want to specify products for their own incentives. This SME said:

> "Contractors don't apply sufficient degrees of caution to the build proposition in terms of the selection of materials. They'll choose what they know and not necessarily what is best for the homeowner in terms of the performance of the home in the long term. So a classic example is again that Flashman Flashing System, an integrated flashing system around doors and windows which is bulletproof. I would never build a house without one of those systems installed, given our experience over the years. And yet the builders says, "Oh no, no, I'll just cut up the plastic or the aluminium flashings and I'll fit them myself." But they get twisted and they bend and they leak."

It was explained that some of the traditional building contractors have an adverse impact on the quality of the build because they stay with what they know and do not make a well-reasoned decision about assessing new products. These contractors appear not to think about how new materials might aid the owner in terms of the long term performance of the home.

Another issue reported by SME-04 was the insufficient support received from the industry by homeowners. Primarily this is due to the inaccessibility of information, as well as misleading information about certain building materials. SME-04 said:

> "And it's a shame that the industry doesn't have like a global standard which not only appraises the products but also looks at the long-term durability of those products and that's what's kind of missing. And then enabling or empowering the owners to make a very prudent decision about the choices that they have."

Moreover this participant said that some architects and contractors get secret rebates and commissions, which influences their decisions on the specification of certain materials. Therefore, having access to product information on materials available in New Zealand would support homeowners to make the right decisions on building materials.

6.2.2 Building Materials Supply Criteria

The current research had identified that building materials manufacturers/suppliers consider ten main criteria (see Table 6.3) when they make materials supply decisions. SME-01 commented on each criterion which are shown in Table 6.3.

Table 6.3: Criteria in supplying building materials - SME-01

Rank	Criteria	SME-01 comment in brief
01	Having strong relationships with customers: This would allow manufacturers/suppliers to maintain themselves in the supply chain.	*"That's the key. That is the most important thing, I think, in terms of a customer."*
02	On time delivery (shortest possible time of delivery), delivery with a good service to ensure that the customer is satisfied.	*"That's important. Yes."*
03	Having available, and supplying a wide range of materials as most houses are customised in New Zealand.	*" Yes that would certainly"*
04	Customer satisfaction/understanding customer needs (this is a mix of how well customers have experienced the business in terms of payment; how well customers have been able to utilize the product on the construction site and how accessible and helpful manufacturers were in that specification process).	*"Avoiding misunderstanding is very important"*
05	Offering a competitive price with good quality. Price is an important factor because low profit margins do not ensure the long-term stability of the business.	*"Yes. Price is becoming even more important."*

06	Product quality requirements.	*"Under government regulation your products have to meet certain quality standards."*
07	Collaboration and partnership in the materials supply chain to ensure the lowest supply chain cost and supply chain time.	*"I don't think that's quite as important, particularly if you are supplying through merchants. Because it breaks that supply chain to the end customer."*
08	Having a good logistics system (transportation and warehousing).	*"Yes, that is important."*
09	Having a sophisticated computer system to estimate materials requirements (demand) very efficiently.	*"That is actually quite important because the expectation, if you like of No. 2 – on time delivery, is dependent upon being able to estimate that, so there is a relationship between 2 and 11."*
10	Use of waste minimisation strategies.	*"Yeah, that's around the sort of cost containment within logistics, so everybody is trying to reduce the impact of damage and wastage through damage, but as a part of that there is also the cost of materials that are associated with that, and how do you control that. So for instance, with our products, to reduce damage we would wooden crate the products – very expensive; obviously you've got the wood and then you've got the labour to make up the crates. At the other end, what do you do with that waste material? The merchants don't want it and it's too expensive for us to go and pick up, and you don't know when you're going to be picking it up so it's really difficult. The whole problem of freight protection is quite complex."*

It should be emphasized that SME-01 pointed out that collaboration (criterion No 7) in the supply chain is dependent on end-users. Participants said that, when manufacturers/suppliers deal with BMs, collaboration with other supply chain nodes is not important. The remainder of the criteria presented was completely acknowledged by SME-01. In addition SME-01 stated that building materials supply decisions are driven by what is required by the building regulations, and by what manufacturers perceive to be market needs.

6.2.3 Building Materials Purchasing Criteria

The research findings in relation to the building contractors' materials purchasing decisions were presented to SME-02. The current research had identified that building contractors consider ten major criteria (see Table 6.4) when they make materials purchasing decisions. SME-02 was requested to briefly comment on each criterion.

Table 6.4: Criteria in purchasing building materials - SME-02

Rank	Criteria	SME-02's comment in brief
01	Making sure that materials are good quality products that are not going to fail in the near future, and they will last the time of the warranties.	*"Yeah, this is most important."*
02	Price of materials: Securing a project is evaluated based on price. That price driven focus is required by the clients and goes right through the business.	*"Yeah."*
03	Being more organized. for example, there can be a quality management system which runs alongside each project and that controls materials quality and testing.	*"As soon as contractors get the contract they need to be doing purchase orders and organizing their subcontractors and suppliers straight away so that they know the job is gonna happen at a certain time and that contractors get the right material on the right job."*
04	Sourcing the right materials in terms of specifications (what the homeowner wants), and the products are installed and completed in accordance with them.	*"Yeah, this is important."*
05	Degree of negotiation with suppliers.	*"Yeah there's a lot of that that goes on more in the QS department. So they'll have a quote but they'll do a negotiation with them. They might say there's a price rise but we'll say, "No we don't accept that." Contractors have got locked in prices for a certain amount of time so that's important."*
06	Repetitive business: This would yield the best possible deal.	*"Yeah."*
07	Supplier's service	*"Yeah."*
08	Ability to forecast future supplier performance as a result of past performance.	*"Yeah."*
09	Past experience and knowledge.	*"Yeah."*
10	Collaboratively working with the supply chain	*"Oh really important because you're dealing with a client that wants a particular thing in their house, so I would go to suppliers and say, "Okay, what sort of product; how can this be, what's the details of it?" It's so important that contractors understand the product, understand the price, understand how it's gonna work and then the client makes a decision whether he/she wants to go ahead."*

Therefore, all ten criteria presented to SME-02 were confirmed as important criteria when purchasing building materials.

6.2.4 Building Materials Selection Criteria by Architects

The current research identified that the architects consider nine main criteria when they make materials selection decisions on behalf of their clients. SME-03 was requested to comment on each criterion and these are tabulated in Table 6.5.

Table 6.5: Criteria in selecting building materials by architects - SME-03

Rank	Criteria	SME-03's comments in brief
01	The material is fit for purpose based on its properties.	*"Yeah. Always." "Because we do bespoke or one-off design for each client, it should be related to the site always. So if it's on a high cliff where there's a lot of wind pressure and suction on one side and sand blown debris off the cliffs which accumulates in gutters or materials, you'd need to know about that, as opposed to a building that's situated in a bush site area that has different issues - less wind but debris and other issues of not so much drying out and sunlight etc."*
02	Architects should be able to find accurate information about materials (e.g. availability of a sample, testing reports, materials availability, etc.) Most up-to-date information about materials in the industry (e.g. what materials have failed, what are the best-performing materials, etc.).	*"Yes, important that we learn from failures." "Yep, always new materials. Yes. We need the backup info for them to rely on them. I think on 15, with the research and new materials, architects should tread very cautiously. If it's vital for their design and the aesthetic to go into new territory with new materials that would risk the performance of the house then don't do it, because it depends how much stress you can live with - not knowing whether it will fail – 'cause ultimately you're the specifier so you'll be in the lineup if there's a case for indemnity."*
03	Quality and satisfactory outcome of materials suppliers' responsibility for a replacement if required. Having low quality building materials increases the life cycle cost of the materials.	*"Yes. And again, you have to check the credentials of the supplier - how financially able are they to withstand any claims? That's one of the big things."*
04	Materials specifications (NZBC requirements, drawing specifications)	*"Yeah, the plans, but the actual detail of the connections you mean provided by the suppliers as DWGs and CAD drawings to be used. That's good; very helpful. Cause you don't want to invent your own details. That's where architects have been sued time and again in terms of leaky house buildings where they have created their own details and fail. So you need industry standard drawing specification for each product that is tested."*
05	Homeowner's brief (e.g. budget, living style, likes, dislikes, etc.).	*"That's pretty important. That comes up at the top. It overlies all of these things. It's not the first thing but it's certainly to be read in conjunction with all of these, 'cause without the owner's budget being met none of this happens."*
06	Architect's knowledge and experience.	*"We tend to be creatures of habit and to use materials and methods we have tried before."*
07	Good communication with suppliers so that clear information about materials can be obtained (e.g. materials testing reports, specifications, quality, suitability, etc.).	*"Yeah. So that's important. That comes up near the top as well. All of these are pretty important. It's hard to know which one is the most important. They all rank quite high."*
08	Architectural concepts (e.g. wood house or a concrete house, or a glassy house).	*"That's again a design aesthetic issue, part of the client brief. The client will always comment on whether they want a solid made concrete building and masonry in situ or whatever, or a lightweight timber frame. Again, that can relate to the site conditions. Sometimes if there's a geological risk of soil and substrate movement then you would use a building that was more flexible perhaps. I've had people now that don't want buildings that are earthquake prone after Christchurch and they've said no concrete tiles cause they all fall in and*

		collapse and shatter themselves to bits. No concrete blocks. No brick veneer - that falls off - and timber framing. No concrete slabs."
09	Site conditions.	*"Site conditions, yes."*

SME-03 agreed that all nine criteria are important in selecting the right building materials. SME-03 was of the opinion that some of the criteria are closely related, for example SME-03 suggested that criteria 5 (homeowner's brief) and 8 (architectural concepts) are related.

6.2.5 Building Materials Selection Criteria by Homeowners

The current research identified that homeowners consider eight main criteria (see Table 6.6) when they make materials selection decisions. Participant SME-04 commented on each criterion and their comments are presented in Table 6.6.

Table 6.6: Criteria in selecting building materials by homeowners- SME-04

Rank	Criteria	SME-04's comment in brief
01	Quality and satisfactory outcome of materials (suppliers' responsibility for a replacement if required): Having low quality building materials increases the life cycle cost of the materials.	*"Yeah I think what I have to be very careful of is actually imposing our organization's thoughts on what the order should be. But we find that many owners seeking to build homes or renovate or extend aren't necessarily participating in the process of material selection and they're not generally aware of the different qualities of the different products. But the quality generally seems to fall down the ranking somewhat and cost seems to be the number one driver."*
02	Functionality, properties, and the feel of materials (e.g. insulation, ventilation, reflection index, etc.).	*"I think for internal finishing it's a very important thing. People are very focused on the functionality, feel and quality, it's more the look, and it's the bling rather than the substance of the products. So they are focused on that."* *"The external envelope, we see people not necessarily making wise decisions about the quality of the products and they're going with the aesthetics more than quality. And sometimes that's fine because you can get some aesthetically pleasing exterior componentry which is still of high quality."* *"But we don't see that owners are that discerning when it comes to exterior envelope."*
03	Aesthetic value: Visual impression of the building materials is important as it affects the appearance of the house.	*"Agree. This is the area where homeowner has flexibility in choice. Their focus again is just on how good it looks rather than perhaps how good it performs."*
04	The level of maintenance affordability of the house: The level of maintenance of the house is affected by the type of materials used. Therefore, materials should	*"In our experience it simply hasn't been a focus of owners in the past. We try and encourage people to consider the lifecycle costs of materials. A good example is the aluminum weatherboard system there as opposed to a timber weatherboard system. The aluminum weatherboard is far more durable, thermally very stable and it doesn't require*

	be carefully chosen in accordance with maintenance affordability.	*painting and its 50 year life. And so it is slightly more expensive and the people, they find it very difficult to discern between that and say going along with the timber product which will require painting every five to seven years.”* *“So they’re gonna be up for a 10 or $12,000 paint job adjusted for inflation throughout the years. Say every six years on average.”* *“And so when we are able to equip the owners with that information they make a prudent choice in terms of the whole of life costs of the materials and opt for the far more stable and no painting required aluminium product.”*
05	Homeowner’s requirements (Budget, number of people that are expected to stay in the home and their living styles, emotional backgrounds, what they like, what they dislike, etc.)	*“Budget needs to have some flexibility to allow for additional costs and to take advantage of potential savings.”* *“It’s not good to personalize a house too much if it limits the value when it comes time to sell it.”*
06	Materials supplier’s reputation in the industry.	*“Yes so there is quite a bit of that. We see that in so far as, for example, the **** products where a lot of owners have misunderstood the problems and they think that the **** products are actually failing in of themselves, when in actual fact we have never seen the product really failing in of itself, it’s always been an installation problem.”* *“So the reputation albeit unfair, does have an impact on the **** products. And the irony is that they’ll go to perhaps another fiber cement board cladding system which is made by a competitive company that has equally the same sorts of problems but it hasn’t featured so heavily in the media.”*
07	Homeowner’s relationship with contractor: Homeowners collaborate with building contractor when they make material selection decisions.	*“Very important to have a good working relationship, but owner needs to recognize that all time on consultation, and any changes, all have a cost.”* *“Yeah there’s a lot of contest there. We see a lot of perverse behaviour on the part of building contractors and architects who sometimes want to specify products for which they’ll get a kick-back for.”*
08	Homeowner’s relationship with architect: Homeowners collaborate with architect when they make material selection decisions.	*“Owners need to make decisions based on cost. Architects aren’t good at this. It seems generally architects want to build something flash that enhances their reputation, but using owner’s money to do this. Owners often get duped in this process I feel.”*

The participant SME-04 was in agreement that all eight criteria are important for homeowners to select the right building materials. Also SME-04 suggested that the priority of choosing building materials should be given to ease of installation, quality of products, warranties, and lifecycle costs in terms of maintenance.

SME-04 further said that homeowners need to be careful of what promises are being made around warranties:

> "They need to come to the realization that most of the warranties aren't really worth the paper they're written on. So they need to make sure that: (a) the products are good, and (b) that they actually have skilled installers installing the product, and that there's some independent oversight of the overall build so that they're not being duped."

In addition, SME-04 emphasised that quality, performance, installation and then cost obviously become factors in selecting the right building materials. However, the lifecycle cost overshadows everything else, not only for the homeowner but also for when it comes to selling the property, as sometimes, consideration of lifecycle cost would add an extra value. In SME-04's own words:

> "We would encourage all owners to factor that into their decision making process. And it might not necessarily be for themselves because they might say, "Well we're gonna sell this home in two, three, four, five years." But we're saying, "Actually it looks really good on paper but when you actually come to sell the property as well so you can enhance its value."

6.2.6 Collaboration in the BMSC

The current research identified 15 main constructs under three main themes (see Table 6.7) that describe the benefits of collaboration in the New Zealand building materials supply chain. The following subsection explains SMEs' views on the three main themes regarding the benefits of collaboration.

Table 6.7: Benefits of collaboration in the BMSC

Collaboration ensures the right building materials
Collaboration ensures the various building materials related requirements of different supply chain parties
Collaboration brings better understanding about the information flow
Collaboration brings better understanding about the materials flow
Collaboration builds better teamwork
Collaboration increases trust between different parties in the supply chain
Collaboration increases understanding of total supply chain goals
Collaboration is bringing teams together and making sure that everyone is delivering their bit (as opposed to the tendering process).
Collaboration requires a partnership approach
Collaboration makes negotiation better
Collaboration makes strong relationships in the materials supply chain
Collaboration spreads specialized knowledge across the materials supply chain
Other benefits
Collaboration ensures cost effectiveness
Collaboration ensures diversity of products and methodologies
Collaboration ensures materials availability
Collaboration ensures right delivery time
Collaboration helps to solve issues in the materials supply chain

6.2.6.1 Ensures the Right Building Materials

The SMEs commented that increased information flow and increased materials flow due to greater collaboration would help in understanding the various building materials related requirements of different supply chain parties. (for example, understanding warranties, prices, delivery on time, pre-ordering requirements, etc). Also the SMEs said that modern technologies (smartphones, computers, the Web) could substantially help to increase collaborative practices in the construction industry.

6.2.6.2 Better Teamwork

All SMEs agreed that collaboration in the supply chain is the combined teamwork of all the parties involved in construction. Collaboration occurs through exchanges of knowledge and enquiries among the various parties associated in the supply chain. Teamwork originates from the trust between these different companies. Working together as a team is greatly increased by good communication, which ensures that all the parties connected in the supply chain work effectively together.

6.2.6.3 Other Benefits

The SMEs explained that collaboration assists in building cost effectiveness but it does not ensure that cost effectiveness because of various other factors. Also, collaboration improves knowledge because good communication across the supply chain ensures understanding of the existing difficulties related to purchasing and supplying materials. However SME-04, who represented homeowners, was not satisfied with the current collaborative practices in the residential building sector. This participant said:

> "So it's really interesting, some of the architects that we deal with they go, 'Oh we hate it when you guys are involved because we have to work hard.' And we go, 'Well yeah damn right, because you're earning your money because we've got owners here who are well informed, they have access to information and you cannot bluff them.'"

Therefore SME-04 argued that despite the great benefits of collaborative practice in the materials supply chain, sometimes homeowners need to take charge of the decision making process in order to gain those benefits for themselves.

6.2.7 Suggestions for Improving the BMSC

The current research identified the following suggestions (see Table 6.8) to improve the New Zealand building materials supply chain from the manufacturers'/suppliers', contractors', architects', and homeowners' points of view. These suggestions were presented to SMEs and their comments are reported in Table 6.8.

Table 6.8: Suggestions for improving the BMSC

No	Suggestions	Applicable SME/s
01	Waste minimization strategies (e.g. house standardisation, increased integration in the supply chain). For example, lack of focus on collaboration between developer/owner, architect/designer, contractor, and supplier/manufacturer could lead to enormous waste (time, energy, materials).	All SMEs
02	Technical advancement: use of modern electronic equipment and technology in the supply chain to make the decision process much quicker and smarter.	
03	There should be a central materials specification system with available sources, relative quality, and price, on the Web. This system should be able to evaluate different types of products, in terms of performance, price, durability, and warranty. So that the choice between products is empirical rather than based on anecdotal or sales staff evidence. This would help homeowners make provisional decisions on materials.	
04	Increased communication in the supply chain would increase the efficiency of the information flow across it. This will more efficiently enable finding the right materials.	
05	Homeowners should be educated on selecting right materials. This would eliminate having unsuitable materials in houses which result in excessive house maintenance costs.	
06	More research on building materials supply chain practices.	
07	More competition in the materials supply chain.	SME-01, SME-02, and SME-03 only
08	There should be an independent qualification for materials testing. This would be a central body that is responsible for the analysis of materials and then architects are able to find information on those materials easily and quickly. This central body should assist architects to obtain real life samples of those materials' cost information (which would come from the suppliers).	
09	Having better infrastructure in New Zealand would improve the logistical aspects of the building materials supply chain.	SME-01and SME-02 only
10	An improved system to control payment problems	SME-01 only
12	Building consents should not allow contractors to change the materials specified by architects	SME-03 only
12	Enhanced building inspector and builder relationship	

The following sub-sections describe, compare, and contrast all these suggestions, based on the comments received from all four SMEs. The discussion follows the order of the issues/themes listed in Table 6.8.

1) Waste minimization strategies

SME-01 and SME-02 represented manufacturers/suppliers and contractors respectively and expressed the viewpoint that waste minimization strategies through house standardisation is necessary. SME-02 said that when houses are designed by an individual architect, the wastage is often huge due to the over-customized nature of those houses. In contrast, SME-03 who represented architects disagreed that waste minimization would occur because of house standardisation. According to SME-03, satisfying homeowners' customized requirements is more important than house standardisation. SME-04 provided a similar argument:

> "I think there is a high degree of standardization around sizes, whether it be bath, showers, hand basins, refrigerators, other fixed appliances. Other than that you can anticipate that certain materials will have to be trimmed to size in the building process and it's the very nature, that's why they're equipped with saws and trimming devices. So there is some inherent waste with that process when you are dealing with sizes which mean that you have to specifically trim down boards."

This participant further argued that it is the contractors' responsibility to adopt waste minimisation strategies. Therefore, the suggestion of having standardised houses was validated by SME-01 and SME-02, but rejected by SME-03 and SME-04.

2) Technical advancement

All SMEs agreed with this suggestion. The New Zealand building materials manufacturing and supply sector does need to constantly invest in new equipment as suggested by SME-01. SME-02 said that building contractors should use modern communication equipment to efficiently communicate with suppliers and clients. From SME-03's view, all the information related to building materials should be available online so that it would be very easy to effectively communicate with suppliers and homeowners. The same idea was suggested by SME-04 who said that contractors should use modern electronic devices to keep homeowners up-to-date about construction progress and issues.

3) A central materials specification system

SME-01 accepted the need for a centralized materials specification system. However, this participant stressed that it required legislation to ensure that materials were not illegally copied by others. SME 01 said:

> "…if we put up specifications for how our products are manufactured, then it would be very easy for somebody else to copy. Like we have had a problem here in NZ where our products have been copied and then shipped overseas to be made overseas and they've come back from China exactly the same, to the millimetre in terms of the measurements etc."

SME-02, SME-03, and SME-04 also agreed with this suggestion of having a materials database in terms of their performance and all other necessary information. The SMEs said that it is very important to the decision making process to have an empirical and independent source of information. The participant SMEs further said that this would enable feedback about the failure of materials.

4) Increased communication

All SMEs strongly agreed that increased and effective communication is greatly required in the construction industry. The participants further stated that modern communication media and devices should be used further in the construction industry to increase the degree of communication with the different parties in the supply chain. Such increased effective communication would help support faster and smarter decisions with regards to materials.

5) Homeowners should be educated on selecting right materials

Participant SME-04 pointed out that homeowners should be more careful and more responsible when they choose building materials. Homeowners should be educated so that they consider the life cycle costs and the upfront capital cost of materials rather than just choosing the cheapest options. Therefore educating homeowners in terms of lifecycle costs and total costs over a certain number of years, as well as the upfront capital cost were supported by SME-04. All SMEs interviewed said that it is hard to help homeowners realise the best value versus the lowest price. SME-01 explained the need for the suppliers' marketing departments to ensure that customers understand the difference between the best value and lowest price. Therefore, the customers should be informed on the risk of having lowest price materials versus the overall costs (life cycle costs) of construction.

SME-04 showed the need for homeowners to have better organizational and research skills when they choose building materials. However, this participant further stressed that homeowners do not have access to independent and reliable information on building materials, and this is a big problem for New Zealand homeowners. SME-04 said:

> "So it's very difficult for owners to go out and do research. I think it goes beyond just having good personal organizational skills. They have to be a detective and have good research skills, because they have to go after the information and it's sort of not in one single place. So yeah it's just hard; the industry doesn't support it; most of the sites, like you look at the Future Proof Building site, it's just full of vested interests; they're just selling products; it looks rosy, it looks like it has a veneer of looking to the sustainability and to the long-term durability as products, but it is all commercial; it is all self-interest."

6) More research

All SMEs agreed that more research should be conducting continuously on building materials, and that this would help the supply chain decision making process. Currently there is little research conducted both on building materials and their purchasing and supply behaviors in New Zealand. Therefore there is scope to conduct more research to support the various aspects in supply chain behaviours and issues.

7) More competition in the materials supply chain

All SMEs agreed that cartelism occurs in the New Zealand construction industry and the competition is effectively controlled by them. As a few big companies drive the building materials costs down, many homeowners are happy to deal with them, believing a cost effective build will result. However, it seems that the overall quality and durability of buildings are often poor, as explained by SME-04:

> "A good example is a whole range of shower boxes imported by one group housing company that didn't have proper safety glass in it. So not only are they bringing in cheap products to increase their margins, they're also exposing homeowners to significant risk of personal injury as a result."

Consequently, homeowners, small and medium size builders, and manufacturers/suppliers are all affected. Homeowners have to bear the very high lifecycle construction cost. The construction costs of small and medium size builders appears to be very high; and small and medium sized building materials manufacturers/suppliers are also challenged by price collusion. Therefore the desirability of increased competition in the construction industry was greatly accepted by all SMEs. Further, the participants said that greater competition could bring about better customer service, better understanding regarding the strengths and weaknesses of different parties in the supply chain, efficient practices in the supply chain, creative ideas, and lower prices for building materials.

8) There should be an independent qualification for materials testing

SME-01, SME-02, and SME-03 all agreed on the need for having an independent and affordable standardised system for testing building materials. This system should be able to evaluate the performance, price, and durability of building materials. For example, SME-01 said:

> Now it is by law required that it has to have a certain degree of, for instance on metal, of galvanising; it's got to be certain thicknesses - well who knows what's coming in from China? Nobody asks. There are no certificates provided. Yeah, we've got, you know, because we're using locally manufactured products that we require and have the ability to get testing done… but for somebody bringing something in from overseas, who would know?

The participants felt this evaluation could provide assurance on building materials to the entire supply chain. Also the participants agreed that the existing materials evaluation system (BRANZ's appraisals), is very expensive and time consuming.

9) Better infrastructure

SME-01 and SME-02 agreed that better infrastructure systems will certainly improve the materials supply practices in terms of delivery time. For example, SME-01 said:

> "I mean certainly improvements in the logistics supply chain is going to be better for everybody; for instance, if you improve the ability to get products to the South Island for instance, you know, improve shipping services to provide alternatives to using Cook Strait ferries because that's extremely expensive for trucking, so that would help."

10) An improved system to control payment problems

SME-01 and SME-02 agreed that there are issues associated with payments and construction. Also the participants said that there are still major construction companies that are sitting on retention payments, looking for every reason not to pay their subcontractors and suppliers. Therefore the participant strongly supported the necessity for a system to resolve this issue. In line with the previous suggestion, SME-01 stated that there should be a system to identify which companies were more likely not to pay their bills. This would help manufacturers/suppliers/subcontractors to avoid those builders, and would gradually have a positive impact throughout the whole supply chain.

11) Building consents should not allow contractors to change the materials specified by architects

SME-03 disagreed with this idea, saying that it should be not possible to substitute materials in approved documents for a building consent.

12) Increased building inspector and builder relationship

SME-03 elaborated on the issues between building inspectors and builders that could result in the poor performance of New Zealand houses. The participant explained that weak relationships between building inspectors and builders have caused inappropriate building practices in some houses in New Zealand. SME-04 further said that, building inspectors should improve relationships with builders so that building materials in houses satisfy the necessary quality and specification requirements.

13) Performance warranties on building materials

As an additional comment on this section of the interviews, SME-04 said that there is a need for performance warranties on building materials. The participant said that many products are installed and the product itself might be warranted, but the installation is not. That is an indictment on the industry, because insurers will not cover installers because they frequently install items incorrectly. Therefore it is should be a requirement to have performance warranties which include proper installation.

6.3 Summary

This chapter has presented the results of the SME interviews conducted to validate the current research findings. The key research findings regarding the current issues in the BMSC, manufacturers'/suppliers' materials supply behavior, contractors' materials purchasing behavior, architects' and homeowners' materials selection behaviours, benefits of collaboration in the BMSC, and possible suggestions to improve the current BMSC, were presented to the SMEs. Numerous constructs under each of the aforementioned themes were either validated or rejected, based on the views received from the SMEs. These SME interviews provided invaluable insights into the validity of the current research findings on the New Zealand residential construction supply chain.

The research findings obtained from the literature review, semi-structured interviews, the questionnaire survey, and the SME interviews will be synthesized and the overall research output will be discussed in chapter 7. This will be followed by the overall conclusions to the research in chapter 8.

CHAPTER SEVEN

Synthesis of Research Findings and General Discussion

7.0 Introduction

This chapter synthesises the research findings from the semi-structured interviews, questionnaire survey and SME interviews. The synthesis is presented so that it answers the research questions and delivers the research objectives that will be presented in the next chapter. The chapter follows the order of research questions listed in Table 7.1. The chapter is subdivided as per the developed research questions. Both qualitative (semi-structured interviews and SME interviews) and quantitative information (questionnaire survey results) are integrated and are discussed generally when addressing the research questions. References are also made within the chapter to the key literature reviewed around the subject matter. Therefore this chapter provides a triangulated output of the current research study.

Table 7.1: Research questions and objectives

Research objectives	Research questions
1) To review the nature of the building materials supply chain in the New Zealand residential construction sector	1) How does the New Zealand residential construction sector operate? 2) What are the current issues in the materials supply chain?
2) To identify building materials supply, purchasing, and selection behaviours of supply chain stakeholders (materials suppliers, building contractors, architects, and homeowners)	3) Who are the people involved in the building materials supply process? 4) How do materials suppliers transport building materials? 5) How do materials suppliers supply building materials? 6) What are the key criteria considered by building materials suppliers in making their materials supply decisions? 7) Who are the people involved in the building materials purchasing process? 8) How do contractors purchase building materials?

	9) What are the key criteria considered by residential building contractors in making their materials purchasing decisions? 10) What are the key criteria considered by architects in making their materials selection decisions? 11) What are the key criteria considered by homeowners in making their materials selection decisions?
3) To integrate buyer and supplier behaviours to improve the building materials supply chain	12) What are the key benefits of collaboration in the materials supply chain? 13) How can buyer and supplier behaviours be integrated to improve the materials supply chain?
4) To suggest an improved framework for current building materials supply chain practices for selecting appropriate building materials	14) What would be the possible mechanism to improve the current building materials supply chain?

7.1 The Nature of the BMSC in the New Zealand Residential Construction Sector

This section discusses the nature of New Zealand's residential BMSC (addressing research objective 1) in terms of its operational behavior and current issues in the supply chain.

7.1.1 The Operational Behavior of the New Zealand Residential BMSC

The review of literature (section 2.3 of chapter 2) related to the New Zealand construction industry revealed that the New Zealand residential construction sector is dominated by a large number of small to medium sized organisations and only a very few large organisations. This includes few volume builders (out of 14,845 builders in 2010, there were only 597 builders with more than 5 employees). On the suppliers' side, there are few large volume suppliers/BMs: as Page (2008) noted, there are only four main BMs who provide reasonable competition. Many local suppliers are subjected to international market conditions as they always import materials from overseas. The New Zealand residential construction sector is characterised by a fragmented nature that leads to management issues in the supply chain, decreased innovation, low productivity, increasing building costs, poorly informed homeowners, inappropriate procurement strategies, complicated and lengthy consenting procedures, lower building quality, demand volatility, inefficient information transmission, and skill issues (these issues are covered extensively in section 7.1.2).

The New Zealand Productivity Commission (2012) reports the residential sector in New Zealand contributes 24,000 new homes and renovates 32,000 homes annually. According to Page (2013a), BRANZ has estimated that the total number of new dwelling units demand in Auckland will be about 10,500 per annum by 2021. Significant new housing growth will also be seen in Canterbury in the near future. However, New Zealand house costs have increased by 727% (11.1% per annum on average) from 1969 to 1989, and 128% (4.2% per annum on average) from 1989 to 2010 (CHRANZ, 2011). According to Page (2008) land (40%), materials (30%), and labour (20%) are the key inputs of new housing. Generally, materials represent more than 50% of the total house construction cost (New Zealand Productivity Commission, 2012). New Zealand houses are generally made of timber with different wall and roof cladding types. There are seven key building materials in house construction: concrete (flooring), timber (framing), interior wall linings, wooden window frames, aluminum window frames, roofing tiles, and iron roofs, on the basis of their importance and cost contribution in house construction (NZBE, 2010). All building materials and products used in New Zealand are subjected to BRANZ appraisal, which is an independent assessment of construction building products and materials.

The New Zealand construction industry usually follows the traditional procurement method as shown by Hinton (2011) and Wilkinson and Scofield (2010). Therefore a house construction project may begin upon an enquiry from a client, which is generally in terms of the tender documents. Generally contractors seem to already have approved suppliers, and mainly purchase materials through BMs. They have strong relationships with selected BMs and suppliers and purchase materials from those selected sources. Generally, consumable items are purchased through BMs and resource-based products are purchased directly from manufacturers. Materials manufacturers/suppliers usually employ separate logistics companies which organise the appropriate vehicles for materials delivery.

7.1.2 The Current Issues in the BMSC

The research identified the current issues in the New Zealand residential BMSC from building materials manufacturers/suppliers, contractors, architects and homeowners (sections 4.2.5, 4.3.6, 4.4.5, 4.5.3, 4.2.6 of chapter 4, section 5.6 of chapter 5, section 6.2.1 of chapter 6). The key issues identified are high materials prices, inferior products, poor collaboration in the supply chain, materials wastage, high transport costs, unreliable suppliers/manufacturers, constant flux and complexity in the building code, insufficient site safety provisions, high labour costs, expensive products certification methods, materials substitution (non-adherence to materials specified), damaged materials, delivery issues, no supplier quality assurance, materials under-supply, excessive documentation processes involved with getting approval for the materials chosen for a house, poor contractor service, and materials assembling issues. These key issues are described in the following subsections.

1) High materials prices

Building materials are expensive in New Zealand compared to Australia and other countries (BIFNZ, 2013). Kenley (2003) showed that for ten common building materials, the price is 55% more expensive in New Zealand than in Australia, after exchange rate adjustments are made. Over the past five years, building material costs have increased by nearly 12% in New Zealand (CCANZ, 2013). High building materials prices include factors such as: higher labour costs, types of construction, the way buildings are erected, earthquake proofing, standards of construction, the European market, transport costs (e.g. heavy traffic in Auckland), low demand, geographical isolation, etc.

The New Zealand construction industry is small and therefore its demand for building materials is low. It is difficult to achieve economies of scale in a small marketplace, compared to countries like the USA and Australia, because their construction industries are larger and have greater turnovers. Further, the New Zealand BMSC comprises very few materials manufacturers and BMs. Therefore the influence of the bigger players in the market creates collusion. This also contributes to the high cost of building materials. CCANZ (2013) have also identified the following environment factors as determinants of the high cost of materials in New Zealand. They are cold temperatures, strong winds, high precipitation levels, and seismic activities, all of which require a comparatively large amount of very strong materials. Within the current study, the questionnaire survey results (p = 0.283, M > 3.5) have indicated that the high cost of materials is statistically significant. The SMEs interviewed also confirmed that building material costs are an issue that needs to be addressed by the supply chain.

2) Inferior products

According to SMEs there are cheap, lower quality building products in the New Zealand market which are potential causes of quality failure in residential buildings. Hinton (2011) has shown that using alternative but inferior products is a common practice in the New Zealand construction industry. During the research validation exercise, the SME representing architects said that new products/inferior products should not be specified by architects. From the questionnaire survey it was found, without a statistically significant difference between the participants, that inferior products are a statistically significant issue (p = 0.056, M > 3.5).

3) Poor collaboration in the supply chain

Lack of collaboration and communication between parties all the way through the supply chain from manufacturers to vendors to architects to clients, was a critical issue that emerged from the current study. For example, at the first stage of the study (semi-structured interviews) the architects interviewed explained that insufficient communication between the contractor and architects often results in the use of unsuitable materials that are not specified in the project documentation drawings. Homeowners also showed that this lack of collaboration creates difficulties for when attempting to select the right building materials. According to the questionnaire survey results, this was a statistically significant (p = 0.056, M > 3.5) issue for all the participants. During the research validation exercise all SMEs agreed with this. SME-03, an architect, said that poor collaboration can be observed onsite when manufacturers/suppliers' specifications/guidelines are not properly adhered to by the contractors. This was further confirmed by SME-04 who stated that because collaboration between contractors and materials suppliers is poor, product installation is the biggest issue in the residential sector, as communication between contractors and manufacturers/suppliers is poor.

The literature review revealed that the majority of construction projects in New Zealand use the traditional procurement method (Hinton, 2011), without exception, in the residential sector. The use of traditional procurement makes for poor collaboration in the supply chain as the objectives and goals of the different parties are contradictory (Love et al., 2008). This causes project overruns (time and cost), defects, and disputes between project parties, and general poor performance. Subsequently this leads to considerable waste of time, energy, and materials, and a fragmented response to demand.

4) Materials wastage

New Zealand houses are highly customised with very few standardised houses compared to other countries. Such houses require the purchase of specific sizes, shapes, and various other unique requirements for materials their construction. As a result materials wastage is considerable. The current research also identified that the lack of coordination between the supply chain parties can cause a significant waste of building materials. According to Parsanejad et al. (2010), lack of coordination between the purchasing and construction sections often results in poor estimation of the quantity of materials needed, while lack of coordination between the design and materials production sections causes insufficient production of materials. CCG (2008) supported this argument by explaining that waste elimination is one of the purposes of project team collaboration. The questionnaire survey revealed that the contractors (M = 3.80), and homeowners (M = 3.70), thought that this is a statistically significant issue, but for the manufacturers and suppliers it was not statistically significant (M = 3.36). However, all the SMEs confirmed that materials wastage is a critical issue and that it is a direct result of the bespoke nature of New Zealand houses and a lack of collaboration in the supply chain.

5) High transport costs

This issue is more related to manufacturers/suppliers and contractors. The New Zealand construction industry is geographically spread out. Therefore materials transport costs are high, and this adds extra costs to materials prices. Consequently a substantial amount of the purchase cost is comprised of transportation costs. The questionnaire survey found that both the manufacturers/suppliers and contractors indicated that this was statistically significant (p = 0.558, M > 3.5). During the research validation process this issue was confirmed by SME-01 and SME-02, and they further said that as the New Zealand construction industry is small, transport costs are inevitably high when delivering small quantities of materials. According to BIFNZ (2013), many manufacturers/suppliers operate as regionally based small-scale businesses to minimise the high transport costs in New Zealand. CCANZ (2013) stated that low truck axle loading limits (9-12% more weight can be carried in trucks in NSW), imposed by the New Zealand Transport Agency (NZTA) is another reason why materials transport costs are high.

6) High labour costs

This issue is of more concern for building materials manufacturers/suppliers. Skilled labour shortages, especially compared to other industries is another issue in the New Zealand construction industry. The questionnaire survey found that this issue is statistically significant (M = 3.6) and it was confirmed by SME-01. During the literature review it was identified that this issue was also noted by CHRANZ (2011). Therefore, as Ying et al. (2013) argue, there is an imperative need to work on the skilled labour shortage in the New Zealand construction industry.

7) Expensive products certification methods

Some of the small scales building materials manufacturers/suppliers are unsatisfied with BRANZ appraisal/certification for building materials. They consider that materials certification through BRANZ is costly. The questionnaire survey showed that this was a statically significant issue (M = 3.63). Also, SME-01 confirmed that BRANZ appraisal is expensive for small scale manufacturers/suppliers.

8) Materials substitution (non-adherence to materials specified)

Materials substitution is a common practice in the New Zealand construction industry. Sometimes an architect specifies a particular material, however contractors may change it to a different material which looks the same but the performance could be different. This issue may affect code compliance, and causes extra work for the architect and others. The questionnaire survey indicated that this is a statistically significant issue for both architects (M = 4.09) and homeowners (M = 3.55). The research validation exercise also further confirmed this. Moreover, BIFNZ (2013) explained that the high degree of materials substitution (e.g. bathroom and plumbing materials) is one of the current characteristics of the residential construction sector.

9) Materials delivery issues

Sometimes materials delivery issues, such as late or early deliveries, can cause difficulties such as construction delays, storage problems, and cash flow maintenance problems. In addition the research found that delivering damaged materials or delivering insufficient materials could create issues for contractors; for example, damaged materials would need to be sent back to the supplier for a credit refund. As this process can cause delays in construction, it could add to the overall project cost. The questionnaire survey indicated materials delivery issues is a statistically significant issue (M = 3.83) for contractors, and it was further confirmed by SME-02 during the validation exercise. The literature review identified expediting (simple status reporting, reactive expediting or proactive expediting) as an extremely important materials management function which ensures on time materials delivery. This was also suggested by Bell and Stukhart (1986). The function of ensuring material delivery can be carried out by an external "expediter" or within the procurement department. The main functions of the expeditor are predicting accurate vendor delivery dates. Expediting information makes the contractor and supplier more mobilised in response to problems or delays (CII, 1988b).

10) No supplier quality assurance

The current research identified that the quality assurance of building materials from some suppliers/manufacturers can be an issue in the BMSC. Therefore, it is important to ensure warranties/guarantees on materials as a means of quality assurance. As was found in the questionnaire survey, the lack of supplier quality assurance is a statistically significant issue (M = 4.22) from the contractors' point of view, and was also validated by SME-02. The literature also states that quality assurance processes in the New Zealand construction industry are insufficient (CHRANZ, 2011). During the SME interviews an additional issue was added around warrenties. It was found that for many products installed in buildings, although the products may be warranted, their installation may not be. Therefore it is necessary to have performance warranties conditional on proper installation. Also, many products have 10 year warranties (as required in the Building Act) by manufacturers to meet the 15 years' minimum durability period. Some of these materials fail after 10 years' time, however. Therefore this study found that longer warranties may become necessary under the Building Act.

11) Poor contractor service

A lot of materials fail in New Zealand houses because they are not properly installed. This causes quality failure. The key reason for this is that information transmission between the manufacturer/supplier and assembler is poor. That is, some contractors do not follow installation instructions properly because some products need intensive labour to install. The questionnaire survey showed that this was statistically significant (M = 3.77). During the research validation excercise, SME-03 suggested that architects should generally specify products that can be physically seen in store. The manufacturer should specify materials and products before the documents are finalised and submitted with the building consent. In SME-03's opinion, this would provide a good level of control over this issue.

12) Substantial documentation process involved with obtaining approval for the materials chosen for a house

The study revealed that the documentation related to materials approval is unnecessary, time consuming and complicated. Previous research conducted by BCPP (2013) explains that the New Zealand construction industry follows a complex consenting process which is both time consuming and expensive. The questionnaire survey showed that this is a statistically significant issue for architects (M = 3.84). Consequently, the current study found that the digitalization of documents involved with obtaining approval for materials may be necessary. As a result the materials approval process would be more efficient and simple according to SME-03 during the research validation interviews. The literature also suggests New Zealand councils should make changes to the consenting process so that it is simple, fast, and inexpensive (New Zealand Productivity Commission, 2012; Page, 2013b). The current research suggests digitalizing all documents related to the consenting process.

7.2 Building Materials Supply, Purchasing, and Selection Behaviours of Supply Chain Stakeholders

This general section discusses the building materials supply behaviour of manufacturers/suppliers, the building materials purchasing behavior of building contractors, and the building materials selection behaviours of architects and homeowners (addressing research objective 2 with its applicable research questions).

7.2.1 Key People Involved in the Building Materials Supply Process

From the results (section 4.2.3 of chapter 4) obtained from the semi-structured interview analysis, the process of supplying materials typically commences with a customer's request through telephone calls, the web, or Sales Reps. Based on the customer's requirements, a purchase order is billed and priced. Subsequently, the supplier's quotation is presented to the customers and upon their agreement the supplier will schedule the delivery through a logistics company or by using the supplier's own transport modes. Scheduling is based on the phase of the build. Once an order is converted to a bill of materials, the remainder of the process is undertaken by inventory controllers, telesales personnel and logistic companies to manage the end-to-end processing.

The research identified that there are three main stages involved in the building materials supply process. The first stage is placing the materials order. The Marketing Managers, Sales Managers, Sales Reps, and call centre crew are considered the main people involved in making materials supply decisions at this stage. Secondly, in the stage of processing the order, contact centre staff, and lastly in the stage of delivering the order, the Logistics Manager and logistic company employees are considered the key people involved in materials supply decisions.

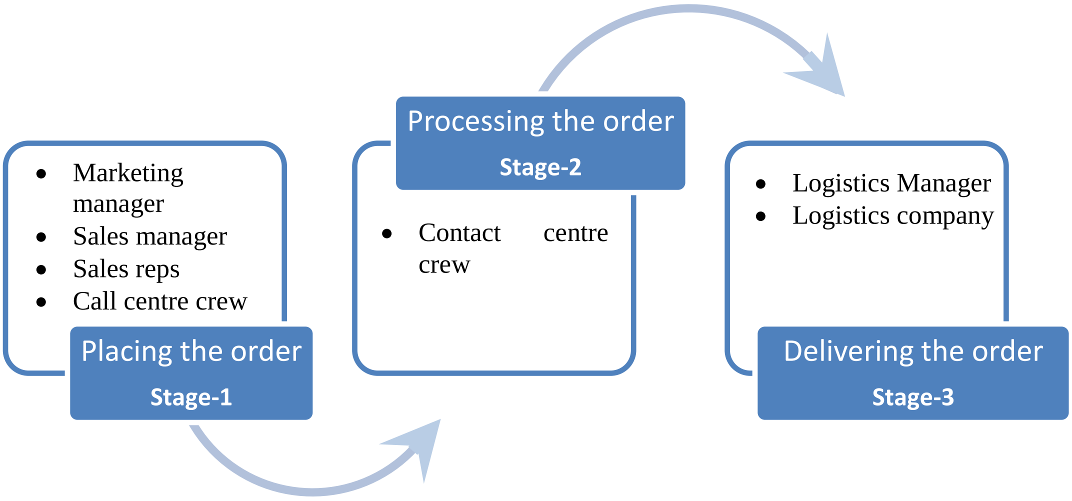


Figure 7.1: Key people involved in the Building Materials Supply Process

The identification of the main stages of the supply process with the key people involved provides opportunities to understand the decision making process related to supplying building materials. Thereby issues associated with the upstream materials supply chain can be properly addressed.

7.2.2 Transportation of Building Materials

Manufacturers/suppliers believe that the delivery service is a means of providing added value to their customers. Therefore the transportation of materials is important to provide on time delivery with a good service. The research identified through the semi-structured interview analysis results (section 4.2.2 of chapter 4) that New Zealand building materials manufacturers/suppliers could use two ways to transport materials: employing a separate logistics company or using their own transportation modes. However, most of the manufacturers/suppliers employ separate logistics companies responsible for supplying freight services to customers. As the New Zealand construction industry is geographically well dispersed, manufacturers/suppliers tend to use logistics companies rather than their own transport outfits (BIFNZ, 2013). However, during the interview validation process SME-01 added that some manufacturers/suppliers may use their own transport modes for short deliveries and for long-distance deliveries they employ separate logistic companies.

7.2.3 Ways of Supplying Building Materials

The first phase of the data collection (section 4.2.1 of chapter 4) found that materials manufacturers/suppliers usually supply materials to other suppliers/BMs or directly to contractors. Some of them follow a combination of both methods. Manufacturers/suppliers tend to supply materials to other suppliers/BMs with the following considerations:

1. Licensed and trained applicators are required for particular products. Therefore those materials are sold to particular suppliers/BMs only.

2. Manufacturers/suppliers are directly paid when materials are supplied to other suppliers/BMs rather than directly to contractors, as some contractors may delay payments.

3. Intermediate suppliers or BMs get discounts from manufacturers/suppliers for making direct or immediate payments.

When materials are directly sold to customers, manufacturers make greater profits. However, due to the limitations of most manufacturers' geographical location, this practice was considered inefficient. Surprisingly, the questionnaire survey analysis results (section 5.4 of chapter 5) showed that the preferred option for supplying materials is directly to contractors (55% of the total responses), rather than supplying to BMs/other suppliers (45%).

7.2.4 Key Considerations in the Supply of Building Materials

The research found some key considerations when supplying building materials by manufacturers/suppliers. The information was collected in three stages. Firstly, the manufacturers' and suppliers' views were collected through semi-structured interviews (sections 4.2.1 and 4.3.2 of chapter 4). Secondly, these views were presented to a wider population of manufacturers and suppliers using a questionnaire survey (section 5.5.1 of chapter 5). Lastly, the key criteria found to be statistically significant were confirmed using an SME (section 6.2.2 of chapter 6). The next sub-sections present the synthesis of the research findings with the relevant literature.

1) The need for strong relationships with customers

The research identified that establishing strong relationships with customers is the primary concern in the supply of building materials. The questionnaire survey indicated that this criteria is statistically significant (M = 4.70, SD = 0.446). During the research validation process, this was confirmed by SME-01. It was revealed that suppliers tend to make continuous performance improvements to maintain trust and reliability with their customers. Customer relationships depend on a customer's experience in terms of payment, how well customers have been able to utilize products in the construction site location, and how accessible and helpful manufacturers were in the materials specification process. Some manufacturers/suppliers conduct workshops with their customers in order to build and strengthen strong relationships. This finding is in accordance with the existing literature that identifies the maintenance of long term relationships as a main concern in SCM (Cooper & Ellram, 1993; Cooper et al., 1997). Ma and Yang (2010) also showed the importance of establishing different relationships with different materials suppliers from the contractors' perspective. One of the ways identified for maintaining strong relationships was by offering discounts to customers (Nicholas & Holt, 1999).

2) Delivery service

The semi-structured interview results revealed that good delivery service was regarded as delivering the materials that customers want to their site, within a given timeframe and in a friendly manner. Offering good delivery service may come at a premium, but customers seem satisfied with this. Therefore, proving customer satisfaction by supplying freight delivery with good service is an important part of the supply chain which helps to maintain strong customer relationships. The questionnaire survey indicated that this criterion is statistically significant (M = 4.58, SD = 0.536), and this was validated by SME-01. The literature survey showed that delivery dependability is the most critical criterion in the construction supplier section (Benton & McHenry, 2010). Accordingly, suppliers consider delivery service as an important aspect of the supply chain. The research found that the adoption of SCM practices (Fawcett et al., 2008), and expediting methods (Bell & Stukhart, 1986), would ensure a good delivery service.

3) Availability and supply of a wide range of materials

Most houses in New Zealand are custom designed and homeowners and contractors look for variety in building materials to fit their bespoke requirements. Therefore the study found that building materials manufacturers/suppliers tend to supply a wide range of materials in order to remain in business. This criterion was found to be statistically significant ($M = 4.48$, $SD = 0.638$), from the questionnaire survey results, and was also confirmed by SME-01.

4) Understanding customers' needs

The results obtained from the analysis of the semi-structured interviews showed that manufacturers/suppliers consider that it is important to understand what customers are really looking for. The questionnaire survey showed that this was statistically significant ($M = 4.44$, $SD = 0.595$), and the research validation exercise confirmed this criterion to be significant. Therefore identifying and making sure that customers understand what they are getting for their purpose is regarded as important, and suppliers should deliver products that do so. The literature shows that the purpose of the SCM is to provide greater customer service. This was explained by Stadtler (2008) with a model called the "house of SCM" as described in chapter 2 of this thesis.

5) Offering a competitive price

The research identified that, because the construction industry is extremely competitive, prices are important among all other criteria when supplying building materials. Also price is an important factor to ensure the long-run stability of businesses. The semi-structured interview analysis found that price was not considered as the sole determinant in supplying building materials, however. Supplying cheaper materials with lower quality would create risks for the manufacturer during the defects liability period (because of rectification provisions). The results obtained from the analysis of the questionnaire survey indicated that offering a competitive price is a statistically significant criterion ($M = 4.44$, $SD = 0.684$). SME-01 confirmed that price is becoming even more important in supplying building materials. Benton and McHenry (2010) showed that the price offered by suppliers is a critical criterion for supplier selection in the construction industry, and suppliers therefore tend to offer competitive prices for their building materials. The study further found that, as the industry is starting to move away from the traditional procurement practices which are based on lowest-price tenders, offering a good price for materials of good quality is essential.

6) Product quality requirements

Customers rely on the manufacturers/suppliers to provide the right quality product which complies with materials standards; therefore, materials quality was considered a key to building trust with customers. According to the semi-structured interview results, product quality is one of the main concerns regarding materials supply in the construction industry. Product quality is always related to product price. Therefore, maintaining a balance between materials quality and competitive prices deserves attention. The questionnaire survey revealed that this criterion-of-product-quality- is statistically significant (M = 4.39, SD = 0.715). Additionally, SME-01 validated this and stated that sustaining materials quality means meeting materials standards. Therefore, maintaining a good quality of materials results in higher prices which ultimately buyers have to bear. Conversely, paying more for good quality materials will probably reduce house maintenance costs. The quality of materials is also one of the primary concerns when materials suppliers are selected in the construction industry, as noted by Benton and McHenry (2010). BIFNZ (2013) suggested that local manufacturers and suppliers in New Zealand can compete against imported materials by offering better quality local products.

7) Having a good logistic systems

Logistics systems are necessary for accurate scheduling of materials, storage provision, and delivering materials to construction sites. The current research found that many manufacturers/suppliers employed separate logistics companies to provide freight deliveries to their customers in New Zealand. This is in line with Hugos (2006). Also Agapiou, Clausen, et al. (1998) explained the significance of a good logistics system from the suppliers' perspective. This criteria was statistically significant (M = 4.2, SD = 0.707) from the questionnaire survey, and further confirmed by SME-01.

8) Having sophisticated software systems

The study identified that manufacturers/suppliers consider it crucial to have a sophisticated software system for efficient estimation of materials requirements and streamlining customer orders to enhance delivery service. The questionnaire survey results revealed that this criteria is statistically significant (M = 4.06, SD = 0.826), and was also confirmed by SME-01 during the research validation process. These software programs can contribute to the speeding up of estimation, warehousing, distribution and delivery to customer. The literature shows that such systems have been suggested to the SCM by several scholars including, Wang, Lin, and Lin (2007), Fox, Barbuceanu, and Teigen (2001), and Beamon (1998). Therefore the current study shows that having sophisticated software systems is one of the important criteria in supplying appropriate building materials.

9) Use of waste minimisation strategies

Waste minimisation is related to cost containment within logistics and optimises the usage of building materials. This was a statistically significant (M = 3.79, SD = 0.979) issue as shown in the questionnaire survey results. During the research validation process SME-01 agreed that this is a key consideration when supplying building materials. Manufacturers/suppliers in New Zealand practice adopting a proper logistics system ("Just in time" or "packed for the work process") to overcome unnecessary materials waste and expenses. Application of the principles of SCM with collaborative decision making on the supply of building materials can also eliminate a significant proportion of material wastes, as highlighted by Parsanejad et al. (2010) and CCG (2008).

7.2.5 Building Materials Purchasing Process

The building materials purchasing process is critical in the sense that having the right materials options (quality and durability) at the right price is a key aspect of business, and one that determines the level of profit at the completion of projects. The construction industry is different to other industries in the sense that a builder has to sell a house through a tendering process, before materials are purchased. Therefore, often the only way to make a profit from a contract is to purchase the materials more cheaply than was initially specified.

The literature reviewed (section 2.3 of chapter 2) for the study revealed that the New Zealand construction industry usually follows the traditional procurement method which separates design and build. This was clearly shown by Hinton (2011) and Wilkinson and Scofield (2010). A house construction project which follows traditional procurement may begin upon an enquiry from a client which is generally in terms of the tender documents. Contractors then go through the project scope and price the project which is then tendered or negotiated. If the contractor is successful, the next step is working through suppliers in terms of purchasing materials. Generally contractors seem to already have approved suppliers (or a pool of suppliers). At the time of tendering, enquiries will go out to the supplier in terms of what materials the contractors want them to price. Consequently, suppliers will price the work in the form of a quotation to the contractors (three to four quotations for each type of product generally). Once the quotations are evaluated, the contractor selects the supplier, based on various criteria. Then, when the contractor wins a tender, a quotation is formally accepted which will be in the form of a purchase order, and then that is passed on to the construction management team in the form of a cost management plan, which basically has all quotations, workings and necessary information.

7.2.6 The People Involved in the Building Materials Supply Process

The study identified the key people involved in the making of materials purchasing decisions at different stages of house construction projects. This is based on the views of the building contractors interviewed (section 4.4.3 of chapter 4) during the semi-structured interview process. Generally, there were three roles recognised who are involved in making purchasing decisions: contract estimator, project manager and contract administration staff, and accounts administrator. Upon receipt of a commission to build, contractors start to make enquiries from their selected suppliers. Subsequently, quotations are evaluated and selected to complete the tender document. This is shown in Figure 7.2 below.

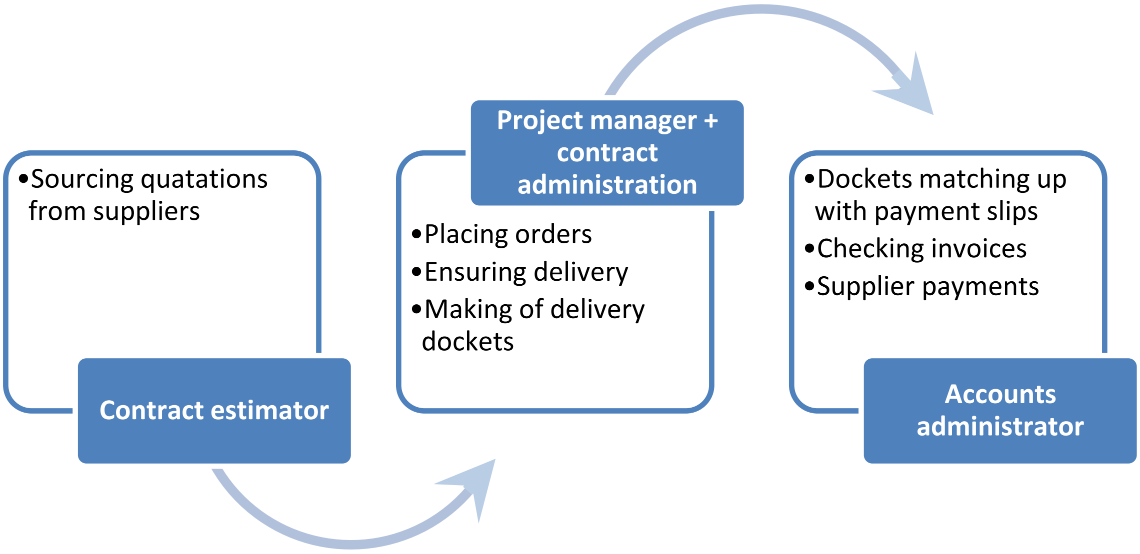


Figure 7.2: Key people involved in the building materials purchasing process

If the contractor wins the tender at a later stage, the validity of the supplier's original quote is reconfirmed by the project management and contract administration team. Additionally, sometimes there might be a requirement to negotiate a revised price for materials. The next stage is when selecting an appropriate supplier receives attention. Aretoulis et al. (2009) showed that an appropriate number of criteria should be included in the supplier selection process. Based on these criteria, the project manager should be able to define the best supplier for the job under consideration. Benton and McHenry (2010) explained that the most critical criteria for supplier selection in the construction industry are material quality, delivery dependability and price. However the degree of importance of each criterion varies in line with the nature of individual firms (Ho et al., 2007). Once the suppliers are selected, purchase orders are issued to the selected suppliers. Finally, the account administrator processes the payments to suppliers.

7.2.7 Ways of Purchasing Building Materials

The semi-structured interviews (section 4.4.2 of chapter 4) found that contractors mainly purchase materials directly from materials manufacturers and through BMs of other suppliers. The questionnaire survey analysis results revealed that 72% of contractors purchase materials from BMs or other materials suppliers, and 28% purchase directly from materials manufacturers. When materials are purchased through

BMs/suppliers all the materials can be purchased from a single place. Contractors usually have strong relationships with selected BMs/suppliers and tend to purchase materials from those selected sources. Generally, consumable items are purchased through BMs. When the building materials are purchased directly from manufacturers, contractors may receive better prices as this avoids middle parties. Generally resource-based products are purchased directly from manufacturers.

7.2.8 Key Considerations in Purchasing Building Materials

The research found that contractors consider the following criteria when they make materials purchasing related decisions: quality of materials, price of materials, their own level of efficiency, materials specifications, degree of negotiation, repetitive business, supplier's flexible delivery schedule, past experience and knowledge, contract liability concerns, and the degree of collaboration with the homeowner, architect, and suppliers/manufacturers to share information on materials. The information was collected in three stages. Firstly, the contractors' views were obtained from semi-structured interviews (section 4.4.4 of chapter 4). Secondly, these views were presented to a wider population of contractors using a questionnaire survey (section 5.5.2 of chapter 5). Lastly, key criteria found as statistically significant were validated using an SME (section 6.2.3 of chapter 6). The following sections explain the aforementioned criteria and synthesize these research findings with the relevant literature.

1) Quality of materials

Semi-structured interview results indicated that contractors believe the quality of materials is the uppermost criterion for selecting materials, as their reputation is based on the quality of houses they build. Sharing information about materials' quality in the industry is considered a way of finding the best quality materials. The questionnaire survey indicated that materials' quality is a statistically significant criterion ($M = 4.7$, $SD = 0.532$). The research validation with SME-02 indicated that it is very important to make sure that materials are of good quality and that they will last the time of the warranties. Scholars such as MarketLine (2013), Benton and McHenry (2010), Ho and Nguyen (2007), and Kannan and Tan (2002) have also shown that materials quality could be considered one of the uppermost criterion when materials purchasing related decisions are made.

2) Price of materials

According to the results of the semi-structured interviews, many contractors tend to purchase materials for lower prices than those quoted in during tendering. It was found that many contractors have confidence that the quality of building materials available in New Zealand is satisfactory. Therefore materials purchasing decisions are often based on the materials prices. The statistical analysis of the questionnaire survey showed that price is a statistically significant ($M = 4.52$, $SD = 0.569$) consideration when contractors make materials purchasing decisions. During the research validation interviews, SME-02 indicated that securing a project is mainly evaluated on price. This price-driven focus is required by the clients and is common throughout the industry. Similarly, the literature review showed that 90% of New Zealand construction projects are based on the traditional procurement system, and securing projects is usually based on the lowest price (Naoum, 2003). Moreover, Benton and McHenry (2010), Ho and Nguyen (2007), and Kannan and Tan (2002) explained that one of the most critical criteria for materials supplier selection in the construction industry is materials price. A recent study conducted by MarketLine (2013) shows that buyer power in the global construction materials market is moderate, and buyers focus heavily on product price when they make purchasing decisions.

3) Contractors' level of efficiency

From the initial semi-structured interviews, the study found that contractor's strategies to become more organized can assist in ensuring the right materials are used. For example, the use of a quality management system which runs alongside each project that controls materials quality. Also keeping up to date with the performance of materials and new materials helps contractors to make best procurement decisions. Moreover, contractors seem to employ sophisticated software systems for estimating materials requirements very effectively to produce purchase orders (the software states what materials are required and when they are needed). Additionally, contractors look for the most up-to-date information about materials in the industry in terms of which materials have failed in the past, which the well-performing, etc. Analysis of the questionnaire survey responses also indicated that this criterion is statistically significant ($M = 4.46$, $SD = 0.679$). During the research validation process, SME-02 expressed the view that the contractors' own level of efficiency is therefore very important when arranging materials purchase orders.

4) Materials specifications

The study found through the semi-structured interviews that sourcing the right materials in line with specifications is important. The materials sourced should comply with the architects'/designers' specifications so that they guarantee quality. This is a significant aspect for the buying firm, although it does not play a large role in the selection of one supplier over another. In addition, products should be properly installed in accordance with the supplier's guidelines. It was revealed from the questionnaire survey results that materials specifications was a statistically significant criterion (M = 4.37, SD = 0.554), and was also confirmed by SME-02.

5) Degree of negotiation

The literature indicated that negotiation with potential suppliers is a part of the general functions of a purchasing department (Barrie & Paulson, 1992; Cooper & Ellram, 1993; Dobler & Burt, 1996; Hadikusumo et al., 2005). In fact the definition of "procurement" describes the significance of negotiation as given by Hugos (2006). For example, in the tendering situation, where a builder wants an alternative solution to what an architect has specified, at that point it becomes a matter of negotiation. Abdul-Malak et al. (2000) also explained that effective negotiation can adjust materials prices offered by suppliers. The questionnaire survey results showed that this criterion was statistically significant (M = 4.23, SD = 0.830). During the research validation exercise SME-02 confirmed that price negotiation is one of the important aspects of building materials purchasing.

6) Repetitive business (long-term relationships)

The findings from the semi-structured interviews showed that the practice is for contractors to deal with a number of particular suppliers who have supplied them building materials in the past. Burton (1988) also showed that repetitive sourcing strategies can enhance materials quality, administrative processes, and increased effectiveness, as such strategies need less expediting and fewer reworks. Having a number of reputable suppliers as a starting point, who back up their product with service and are accountable for their products, is a critical aspect of contractors' decision making processes. Long term relationships established with recognised suppliers greatly support contractors' materials purchasing decisions. This shows the importance of continuity in supplier relationships. The importance of having strong supplier relationships is that it makes for better prices with good quality materials. Strong relationships guarantee good supplier service as the suppliers do not want to lose future business opportunities. The literature review also revealed the importance of strong supplier relationships and closer co-ordination with a few suppliers, as indicated by Cooper and Ellram (1993). The analysis of the questionnaire survey results revealed that this criterion was statistically significant (M = 4.23, SD = 0.736). Also, SME-02 further confirmed that this is a very important criterion in materials purchasing decisions.

7) Supplier's service

Analysis of the semi-structured interviews revealed that building contractors mentioned the materials delivery service as a key criterion that supports their purchasing decisions. That is, the supplier's ability to deliver materials on time and provide a good back-up service (durability and warranty) was regarded as a crucial factor. For example, delivering materials later than the scheduled time can cause project delays, and delivering materials earlier than the scheduled time causes storage issues.

Today's fast-track construction environment boosts the importance of delivery dependability, as construction begins before completing the architect's final design. Loss of delivery deadlines can have costly consequences such as loss of time and additional labour costs for both the owner and contractor, as time is considered money in the construction industry. Companies with faster delivery stand a better chance of being selected as a supplier. Therefore, delivery consideration is a key criterion used in selecting suppliers for the construction industry. Analysis of the questionnaire survey responses also indicated that this criteria is statistically significant (M = 4.22, SD = 0.737). During the research validation process, SME-02 expressed the viewpoint that delivery service is a very important criterion in making material purchasing decisions. Further, in the literature review Kannan and Tan (2002), and Ho and Nguyen (2007) have shown that materials delivery service is one of the five most important criteria in choosing materials suppliers.

8) Past experience and knowledge

It was revealed from the semi-structured interviews that contractors use their past experience and knowledge when they make building materials selection decisions. The contractor's ability to forecast future supplier performance as a result of past performance is one way of using this knowledge for decision making. The questionnaire survey results showed that the contractor's past experience and knowledge is a statistically significant criterion in making materials purchasing decisions (M = 4.19, SD = 0.722), and this was confirmed through SME-02 during the research validation interviews.

9) Degree of collaboration and information sharing

Collaborative working between both suppliers and architect and homeowner was another statistically significant criterion (M = 3.81, SD = 1.075) in making materials purchasing decisions. Research validation through SME-02 showed that contractors' collaboration with architects/homeowners and suppliers was important, as materials selected by the architect/homeowner should be found from materials suppliers. Therefore sharing information on materials between customers (architects/homeowners) and suppliers plays an important role in materials related decisions. For example, contractors usually communicate with architects/homeowners (e.g. through site meetings, email conversations, and telephone conversations) regarding their level of satisfaction on the materials used.

10) Supplier's credit period

The supplier's credit allows the contractor to receive the materials needed without paying immediately on receipt. Contractors pay for materials in accordance with the terms and conditions agreed with their suppliers. The study identified that many small and medium sized builders tend to consider the supplier's credit period when they make materials purchasing decisions. It was found from the questionnaire survey results that the supplier's credit period is a statistically significant criterion (M = 3.74, SD = 1.075). This was also validated through SME-02. However, it should be noted that there are also many issues associated with supplier's credit in the New Zealand construction industry, as suppliers are themselves sometimes not paid by contractors, resulting in payment and cash flow problems.

7.2.9 Selecting Building Materials by Architects and Homeowners

The study identified architects' and homeowners' involvement in the building materials selection process in terms of the various criteria they considered. During the semi-structured interview process, six architects and six homeowners were interviewed to establish a primary understanding (sections 4.5.2 and 4.6.1 of chapter 4). The criteria identified from the initial semi-structured interviews were presented to a wider population through a questionnaire survey (sections 5.5.3 and 5.5.4) and lastly, the statistically significant criteria determined from the questionnaire survey were confirmed using two SMEs (sections 6.2.4 and 6.2.5 of chapter 6). The next two sections synthesise the findings in terms of the key factors considered by architects and homeowners when they select building materials.

7.2.9.1 Key Factors Considered by Architects in Making Materials Selection Decisions

The study found that architects considered the following set of criteria when making decisions on materials to incorporate in their designs: whether the material is fit for purpose, accurate information about materials, quality and satisfactory outcome of materials, materials specifications, the homeowner's brief, the architect's knowledge and experience, good communication with suppliers, site conditions, and research about new materials, when they make materials selection related decisions. Each of the aforementioned criteria is discussed in brief in the following sub-sections.

1) The material is fit for purpose

Based on the different properties of materials, some may be suitable for use in certain places and some are not. Results obtained from the semi-structured interviews showed that architects consider fitness for purpose, based on the properties of materials. In other words, this may be an identification of the safety and other requirements of different materials. This was identified as a statistically significant criterion ($M = 4.86$, $SD = 0.345$) from the questionnaire survey analysis results. SME-03 confirmed this criterion as an important consideration in the selection of building materials also.

2) Accurate information about materials

The study found from the semi-structured interviews that architects consider accurate information about materials (e.g. availability of a sample, testing reports, materials availability, etc.) as an important criterion for materials selection. This information should be legitimate and trustworthy. Architects prefer to access useful information about materials on the Web for free (e.g. supplier's online information about materials). This enables them to get up-to-date information about materials (e.g. which materials have failed, which are performing well, etc.). The questionnaire survey analysis showed that this criterion is statistically significant (M = 4.75, SD = 0.544). It was found from the research validation exercise (SME-03) that the more readily this information is available, the more likely the product will be selected.

3) Quality and satisfactory outcome of materials

According to the semi-structured interview results, the quality and satisfactory outcome of materials was identified as an important criterion which supports architects' materials selection decisions. This includes the supplier's responsibility for a replacement if required (e.g. warranties). This criterion was statistically significant (M = 4.69, SD = 0.500), and was further confirmed by SME-03.

4) Materials specifications

This particular criterion is based on meeting the various code requirements such as NZBC, NZSQ604, BRANZ materials specifications, etc. The results of the semi-structured interviews showed that satisfying all the code requirements means obtaining the best materials suitable for the design in terms of materials treatment levels, moisture levels, UV light, etc. Literature also stressed the fact that imported materials should be able to withstand the extreme climatic conditions (high UV, high humidity, high atmospheric sea salt level, and strong wind conditions) that New Zealand has (BIFNZ, 2013). This was identified as a statistically significant criterion (M = 4.32, SD = 0.819) from the questionnaire survey analysis results. SME-03 also confirmed this criterion to be an important consideration in the selection of building materials by New Zealand architects.

5) Homeowner's brief

The brief that the homeowner gives at the beginning of the house designing process includes their available budget, living style, choices, likes, dislikes and various other requirements. The study found through the semi-structured interviews that a homeowner's budget plays a huge part in choosing the right materials, colours, and aesthetic values of the completed house after construction (e.g. wide span steel roof, a wooden shingle, or concrete tiles, etc). The homeowner's brief also determines the choice of geometry for the structure, its position, exposure to weather, its environment, architectural concepts (e.g. a wooden house or a concrete house, etc.) and so on. Analysis of the questionnaire survey revealed that this criterion is a statistically significant one (M = 4.32, SD = 0.819), and it was also confirmed by SME-03. However, research validation results further found that even though the homeowner's brief is an important criterion in selecting building materials, many materials and product choices are made without the knowledge of the homeowners.

6) Architect's knowledge and experience

The analysis of the semi-structured interviews revealed that architects rely on well-established and previously used materials in order to ensure proper quality. Architects tended to select fairly traditional materials as opposed to newer ones, as they have been used in New Zealand for many years and their quality and durability are known and guaranteed. According to the questionnaire survey results analysis this was a statistically significant criterion (M = 4.17, SD = 0.722). Also, SME-03 confirmed this criterion during the research validation process. The SME interviewed explained that architects tend to be creatures of habit and to generally use materials they have used before. Architects are very careful about new materials so good research would need to be performed on new materials to investigate and ascertain their performance-in-use for them to gain the acceptance of architects.

7) Good communication with suppliers

As found from the semi-structured interview results, architects appear to continuously communicate with materials suppliers so that clear information about materials such as testing reports, specifications, and quality reports can be determined. Further, communication should be based on documents, in order to be unambiguous, rather than using verbal methods. The availability of web-based information from suppliers' websites provides greater opportunities for architects to communicate with materials supply sources. This criterion was statistically significant (M = 3.98, SD = 0.820), based on the questionnaire survey results, and was also confirmed by SME-03 as being important to New Zealand architects.

8) Site conditions

This refers to the physical context that the building is in and the appropriateness of materials for the site. Architects consider soil profiles of the site, surrounding views, natural ventilation, natural lighting, etc., and building materials are selected based on these site conditions. The analysis of the questionnaire survey results revealed that this criterion is statistically significant (M = 3.81, SD = 0.860), and SME-03 was of the opinion that site conditions is an important consideration that could influence building materials related decisions made by architects.

7.2.9.2 Key Factors Considered by Homeowners in Making Materials Selection Decisions

The study identified that homeowners consider the following key criteria when they make building materials selection decisions: the quality and satisfactory outcome of the materials, functionality, properties and feel of the materials; aesthetic values, the homeowner's relationship with the architect, the homeowner's various requirements, their materials supplier's reputation in the industry, the homeowner's relationship with the contractor, and the level of maintenance affordability of the house. The following paragraphs briefly discuss each criterion using data analysis results obtained from the various aspects of the research study.

1) Quality and satisfactory performance of materials

The study identified (based on the semi-structured interview results) that homeowners should consider the quality and satisfactory performance of materials as a criterion for choosing building materials. Homeowners generally look for certified and sustainable materials as a way of selecting long lasting materials with good performance. This criterion was found to be a statistically significant one ($M = 4.78$, $SD = 0.422$), based on the questionnaire survey results. Also it was confirmed by SME-04 during the research validation process. The research validation results showed that materials warranties (especially including installation warranties) are an important way of assessing the quality and satisfactoriness of materials. Therefore the suppliers' level of responsibility for a replacement if required should be considered by homeowners. Overall the aim is to minimise the life cycle costs of the materials over the long term.

2) Functionality, properties, specifications, and the feel of materials

As it was revealed from the semi-structured interview results, homeowners consider functionality, properties, specifications, and the feel of materials as a ways of choosing the right building materials for their homes. This may include information on what building materials are made of, insulation levels, ventilation, reflection index, etc. Also materials suitability for the climatic conditions in New Zealand is another way of identifying the functionality of building. This consideration was found to be statistically significant (M = 4.55, SD = 0.582), as shown by the questionnaire analysis results, and was also validated by SME-04.

3) Aesthetic values

Homeowners believe that the visual impression of building materials is important as it affects the whole appearance of the house, according to the semi-structured interview analysis results. Many homeowners look for a range of colours and shapes in order to select attractive materials that satisfy their choices. Finally, homeowners try to achieve a distinctive aesthetic value to their home by using what they regard as aesthetically pleasing building materials. The aesthetic values of materials was a statistically significant criterion (M = 4.39, SD = 0.583), and was further confirmed by SME-04.

4) The level of maintenance affordability of a house

The research found from the semi-structured interviews that as the level of maintenance of a house is affected by the type of materials used, homeowners should carefully choose building materials in accordance with maintenance affordability. This was indicated as a statistically significant criterion (M = 4.30, SD = 0.703), and it was also validated by SME-04. However, the interview validation results showed that even though maintenance affordability is a very important aspect in selecting building materials, it has not been a focus of homeowners in the past. Therefore, it is stressed from this study that consideration of the lifecycle costs of materials should play an important in choosing the right building materials.

5) The homeowner’s requirements

The selection of building materials depends on what homeowners want and their scope in terms of budget, living style, likes, dislikes, emotional reasons, etc. For example, homeowners consider the price of materials critically in order to stay within their budgets. However the semi-structured interview results revealed that even though the price of materials is very important, homeowners should not always choose the lowest price; rather, they should choose reasonable prices along with other considerations (e.g. appearance and quality). Further, the questionnaire survey results showed that this criterion is a statistically significant one (M = 4.30, SD = 0.703). As indicated from the research validation (SME-04) results, excessively personalised houses face difficulties when reselling, as such personalisation limits the value of the property.

6) The materials supplier's reputation in the industry

As it was revealed from the semi-structured interview results, the industry reputation of material sources is an important criterion for homeowners to choose the right building materials. Homeowners believe that having a reputable materials source helps ensure materials quality. Information about reputable supply sources are generally based on the media and word of mouth. The questionnaire survey showed that this consideration is a statistically significant one ($M = 4.00$, $SD = 0.739$). Also SME-04 validated that this criterion is an important aspect of selecting the right materials. However, the results of the research validation indicated that there is considerable misunderstanding about various materials sources and homeowners are indifferent regarding which suppliers to choose. It was revealed that the media plays a significant role in informing people about the reputation of various building materials suppliers.

7) The homeowner's relationship with their contractor

Homeowners collaborate with their building contractor when they make material selection decisions. The analysis of the semi-structured interviews indicated that homeowners do research on various building materials previously used by their contractor. Homeowners may even physically visit previously built houses and sample materials used by contractors. Therefore to a certain extent, homeowners' materials selection is influenced by the contractor's recommendations and what their contractor has used before. This criterion was shown as statistically significant ($M = 3.91$, $SD = 1.083$), as per the questionnaire survey results. Further, this was validated by SME-04, and the results of the research validation exercise showed that homeowners should be aware of background information on materials recommended by contractors, as this recommendation can sometimes be biased. For example, building contractors may recommend a supplier from a pool of suppliers that they have long term relationships with. This recommendation may not necessarily provide the best outcome for homeowners but it may provide some incentive to the contractors.

8) The homeowner's relationship with their architect

Homeowners also collaborate with their architect when they make materials selection decisions. The semi-structured interview results showed that homeowners closely communicate with architects and seek advice on which materials have failed in the past, which materials are performing well, the material's suitability for New Zealand weather conditions, and reliable materials supply sources, etc. Therefore the architect can have a significant impact on the homeowner's materials purchasing decisions. This was indicated as a statistically significant criterion (M = 3.50, SD = 1.340), and was also validated by SME-04.

7.3 Integration of Buyer and Supplier Behaviours to Improve the BMSC

The literature review emphasised that the BMSC in New Zealand is still not using SCM practices but has kept using the traditional procurement method. In other words, materials selection behaviour, buying behaviour, and supply behaviour are all distinct. Since the current study's scope is around the residential construction sector, understanding architects' and homeowners' materials selection behaviour, contractors' materials purchasing behaviour, and suppliers' materials supply behaviour helps to understand how the various parties in the supply chain make materials related decisions. This builds a mutual understanding between the different parties' thoughts and behaviour on materials. This mutual understanding should help to find the right materials for houses and it also supports collaborative practices in the materials supply chain.

So far, the chapter has discussed how suppliers, contractors, architects, and homeowners make their decisions in relation to building materials. Table 7.2 (also see section 8.1.3 of chapter 8) summarises all the key criteria on which materials supply chain decisions are based on. As is shown in Table 7.2, homeowners mainly look for the quality, the nature (functionality, properties, specifications, and feel), and aesthetic values of materials. In line with these requirements, architects pay attention to materials' fitness for purpose, the accuracy of material information and the quality of materials. Therefore materials selection decisions of homeowners and architects are mainly based on:

- Quality and satisfactory performance of materials
- The nature of materials (functionality, properties, specifications, and feel of materials)
- Materials' fitness for purpose
- Accuracy of information about materials
- Aesthetic values

Table 7.2: Key criteria on which supply chain decisions are based

Suppliers' materials supply decisions	Contractors' materials purchasing decisions	Architects' materials selection decisions	Homeowners' materials selection decisions
Having strong relationships with customers	Quality of materials	The material is fit for purpose	Quality and satisfactory performance of materials
Delivery service	Price of materials	Accurate information about materials	Functionality, properties, specifications, and the feel of materials
Having available and supplying a wide range of materials	Being more organised	Quality and satisfactory performance of materials	Aesthetic value
Understanding customer needs	Materials specifications	Materials specifications	The level of maintenance affordability of the house
Offering a competitive price	Degree of negotiation	Homeowner's brief	Homeowner's requirements
Product quality requirements	Repetitive business	Architect's knowledge and experience	Materials supplier's reputation in the industry
Having a good logistics system	Supplier's service	Site conditions	Homeowner's relationship with architect
Having sophisticated computer systems	Past experience and knowledge	Good communication with suppliers	Homeowner's relationship with contractor
Use of waste minimisation strategies	Collaboratively work with homeowner, architect, and suppliers/manufacturers to share information on materials		
	Supplier's credit period		

When compared with architects and homeowners, contractors also prioritized the quality of materials. However contractors do not pay a lot of attention to detailed information on materials, in contrast to architects and homeowners. Materials buying decisions of building contractors are mainly based on:

- Quality of materials

- Price of materials
- Contractors' own level of efficiency

Materials suppliers showed a different behaviour compared to homeowners, architects, and contractors. Suppliers seem to more actively consider different relationships with their customers, unlike all the other aforementioned parties. The materials supply decisions of suppliers are mainly based on:

- Having strong relationships with customers
- Delivery service
- Having available and supplying a wide range of materials

It was stressed in the literature review that each party in the supply chain should have a good understanding about what the other parties' materials purchasing decisions are based on, so that materials related decisions would benefit the entire supplier chain rather than just individual parties. The above criteria (Table 7.2) provides a framework (see section 8.1.3 of chapter 8) to support the understanding of the various parties' materials related decisions. The literature review identified that a collaborative decision making process (rather than on individually based decisions) can improve construction industry efficiency, eliminate waste, raise safety standards, and reduce project risks. Therefore the next section discusses the research findings related to collaboration in the materials supply chain.

7.3.1 The Benefits of Collaboration in the BMSC

The study identified that collaboration is important in achieving better materials supply chain practices. This was clearly shown from the initial semi-structured interview analysis (sections 4.2.7, 4.3.8, 4.4.7, 4.5.5, and 4.6.4 of chapter 4), questionnaire survey results (section 5.7 of chapter 5), and the SME interviews (section 6.2.6 of chapter 6). The key to achieve better collaboration in the BMSC is good communication. The literature review found that many authors have shown the significance of increased collaboration in the construction supply chain as it offers greater opportunities and benefits for the client, contractors, and all the other parties to commit to construction project objectives (Boon, 2007b; CCG, 2008). Overall, collaboration can increase the efficiency and effectiveness of the entire supply chain (Khalfan et al., 2004).

Various benefits of collaboration identified from the literature review and semi-structured interviews were further presented to a wider range of residential construction practitioners through a questionnaire survey. The questionnaire survey analysis (EPA) revealed that the benefits of collaboration can be categorised into three factors: ensuring the right building materials (48.33% of variance), building team work (6.89% of variance), and other benefits (9.40% of variance). The following sections discuss each theme (factor) generated as the benefits of collaboration.

a) Collaboration ensures the right building materials

The three benefits that ensure the right building materials were identified as: increasing understanding of total supply chain goals (M = 3.91, rotated factor loading = 0.690, α = 0.943), bringing better information flow (M = 3.88, rotated factor loading = 0.928, α = 0.942), and understanding the materials flow (M = 3.77, rotated factor loading = 0.727, α = 0.940). The literature review also found that good communication between the various supply chain parties can provide efficient and effective information sharing which could result in the provision of right building materials from upstream of the supply chain to downstream of the supply chain (Hu, 2008; Vrijhoef & Koskela, 2000). All three criteria were statistically significant and were confirmed by SMEs during the research validation exercise. The research validation exercise further showed that an increased information flow due to greater collaboration would improve understanding of building materials in terms of warranties, prices, delivery on time, pre-ordering requirements, etc. Moreover, the use of modern technologies (smartphones, computers, the Web) could substantially help to increase information flow across the supply chain.

b) Collaboration builds better teamwork

The semi-structured interview results showed that integrity in the materials supply chain plays a very important role as a successful house construction project requires a strong team work environment. Past literature also shows that team work is an important aspect of collaboration, leading to better choices than those made by individual parties in the supply chain, as in the traditional fragmented construction procurement process (DPR Construction, 2000). The questionnaire survey results identified seven statistically significant considerations that belong to this theme. The statistical analysis (PFA) showed the following considerations under this theme.

- Collaboration increases the trust between different parties in the supply chain ($M = 3.76$, rotated factor loading = 0.311, $\alpha = 0.931$)
- Collaboration ensures the various building materials related requirements of the different supply chain parties ($M = 4.07$, rotated factor loading = 0.295, $\alpha = 0.943$)
- Collaboration is bringing teams together and making sure that everyone is delivering their bit as opposed to the tendering process ($M = 3.95$, rotated factor loading = 0.338, $\alpha = 0.940$)
- Collaboration requires a partnership approach ($M = 3.89$, rotated factor loading = 0.703, $\alpha = 0.941$)
- Collaboration makes negotiation better ($M = 3.66$, rotated factor loading = 0.901, $\alpha = 0.941$)
- Collaboration makes strong relationships in the materials supply chain ($M = 3.73$, rotated factor loading = 0.554, $\alpha = 0.938$)
- Collaboration spreads specialized knowledge across the materials supply chain ($M = 3.74$, rotated factor loading = 0.402, $\alpha = 0.939$)

The research validation process confirmed that collaboration in the supply chain is the combined teamwork of all the parties involved in construction, and which occurs through exchanges of knowledge and enquiries among the various parties associated in the supply chain. The key to effective teamwork is trust between the supply chain parties.

c) Other benefits of collaboration

The statistical analysis of the questionnaire survey found another set of benefits for collaborative SCM practices, including collaboration ensures cost effectiveness ($M = 3.64$, rotated factor loading = 0.360, $\alpha = 0.941$), diversity of products and methodologies ($M = 3.51$, rotated factor loading = 0.310, $\alpha = 0.943$), materials availability ($M = 3.60$, rotated factor loading = 0.891, $\alpha = 0.939$), right delivery times ($M = 3.67$, rotated factor loading = 1.009, $\alpha = 0.940$), and helps to solve issues in the materials supply chain ($M = 3.65$, rotated factor loading = 0.677, $\alpha = 0.939$), all of which were statistically significant. The literature review showed similar types of benefits from collaboration such as cost and time savings (Boyd, 2011; DPR Construction, 2000; Vrijhoef & Koskela, 2000). The research validation results revealed that collaboration would help to solve supply chain related issues, because good communication across the entire supply chain would ensure better understanding of the existing difficulties related to purchasing and supplying materials.

Figure 7.3 summarises the scenario of collaboration in the New Zealand residential construction sector which was created, using both the qualitative and quantitative data analysis results. It shows how identified benefits are distributed across the supply chain. The study found that all the parties in the materials supply chain would benefit from more collaborative materials supply and purchase practices. However, contractors who construct houses for sale showed that collaboration is not as important to them as it could result in collusion and consequently lower profit margins.

Right building materials, strengthened teamwork, and other benefits

S	C	A — H
▪ Better understanding of total supply chain goals	▪ Better understanding of total supply chain goals	▪ Better understanding of total supply chain goals
▪ Better data flow	▪ Better data flow	▪ Better data flow
▪ Better understanding of materials flow	▪ Better understanding of materials flow	▪ Better understanding of materials flow
▪ Increased trust	▪ Increased trust	▪ Increased trust
▪ Better understanding of various building materials related requirements of different supply chain parties	▪ Better understanding of various building materials related requirements of different supply chain parties	▪ Better understanding of various building materials related requirements of different supply chain parties
▪ Right delivery time ensured	▪ Better negotiation	▪ Better cost effectiveness ensured
	▪ Better cost effectiveness ensured	▪ Strong relationships in the supply chain
	▪ Ensured diversity of products and methodologies	▪ Spreading knowledge across the supply chain
	▪ Ensured materials availability	▪ Solving issues in the supply chain
		▪ Better materials availability ensured

S = Suppliers; C = Contractors; A = Architects; H = Homeowners

Figure 7.3: Benefits of collaboration in the BMSC

Collaboration is gradually developing in the New Zealand building industry. But interactions between contractors and architects/homeowners are unsatisfactory (this is shown as a dotted line between contractors and architects/homeowners in Figure 7.3), compared to interactions between contractors and their suppliers/manufacturers in the supply chain. Therefore, improvement, in the construction supply chain should be focused on contractor-architect/homeowner interactions as it is the weaker portion in terms of collaboration. The study's results have established that the key to collaboration is good communication among the parties in the supply chain. Collaborative decisions made by suppliers and purchasers would result in supplying or purchasing the right materials at the right price that could benefit everyone in the BMSC.

7.4 The Possible Mechanism to Improve the BMSC

The nature of the current BMSC was explored in section 7.1 with an examination of its current issues. In this section, these issues are addressed for possible improvements. The literature review and semi-structured interviews initially identified possible ways of improving the current supply chain and these were statistically validated through a questionnaire survey. Finally, the questionnaire survey findings were confirmed by SMEs to develop a possible mechanism to improve the current BMSC, and the following paragraphs discussed the ten key considerations that emerged from this study.

a) Waste minimization strategies

The study identified that the lack of house standardisation and lack of collaboration in the current supply chain cause a considerable amount of waste in terms of time, energy, and materials. Therefore it is suggested that increased house standardisation and integration should be encouraged in the New Zealand residential building sector. The literature review also found that many authors such as BCPP (2013), BIFNZ (2013), Page (2013b), and MALTBYS (2010) recommended increased house standardisation to achieve 15-20% cost savings. The literature review further showed that the increased use of prefabricated materials and standardised claddings and windows would lead to greater standardization overall. Also, waste minimisation through greater integration is suggested to save time, energy, and materials, as discussed by Page (2013b), Hinton (2011), and Boon (2007a), by implementing collaborative procurement practices. The analysis of the questionnaire survey showed that this suggestion was statistically significant ($M > 3.5$) for all participants. Also the SMEs confirmed that the greater use of standardised houses and better integration would improve the current supply chain.

b) Technical advancement

In order to make materials related decisions better and faster, it is suggested that the industry should more extensively adopt modern electronic equipment and technology. For example, the greater use of technology could assist in making accurate forecasts in terms of delivery service, and help to more evenly regulate variability in demand for materials suppliers. Also modern technology provides various technological infrastructures allowing networking and collaboration in the supply chain and facilitating greater information sharing. For example, the literature review showed that data storage devices can enable increased accessibility of all sorts of information by the various parties in the supply chain (Horvath, 2001). This consideration was indicated as statistically significant ($M > 3.5$) from the questionnaire survey results. The research validation process also revealed the need for online storage of building materials related information so that it would be very easy to effectively communicate across the supply chain.

c) A central materials specification system

The study suggests that there should be a central materials specification system with available sources, relative quality, and price on the Web so that different supply chain members can access materials related information easily and quickly. The semi-structured interview results clearly showed that architects and homeowners have no standard system to seek information from, and they keenly expressed the need for such a system in the construction industry. This system should be able to evaluate different types of products in terms of performance, price, durability, and warranty, etc. so that the choice of products is more empirically based rather than on anecdotal or sales staff evidence. This would help homeowners and architects to make provisional decisions on building materials. The past literature also indicated examples of centralised web-based information systems such as "Autodesk Buzzsaw" which functions in terms of producing informative reports, task assignment, and project tracking (Hu, 2008). The questionnaire survey results showed that this suggestion was indicated as statistically significant ($M > 3.5$). The research validation exercise confirmed this suggestion, and further showed that this kind of system provides an empirical and independent source of information that would enable feedback, particularly about the failure of materials.

d) Increased communication

The analysis of the semi-structured interviews indicated that increased communication would improve the efficiency of the information flow across the whole supply chain and consequently enable procurement of the right building materials. A similar argument was presented by Agapiou, Clausen, et al. (1998) who said the building materials flow can be properly controlled by good co-ordination and communication between project contributors. According to the questionnaire survey results, increased communication was a statistically significant suggestion (M > 3.5) by all participants and it was also confirmed by the SMEs. The research validation results showed that the use of modern communication media and devices should be encouraged more in the construction industry, in order to make faster and smarter decisions with regards to building materials.

e) More research

The study encourages more research to explore the nature of supply chains in New Zealand and other countries so that appropriate recommendations can be made regarding building materials purchasing and selecting behaviours. This would help to secure better materials for New Zealand houses while also considering quality and cost requirements. This consideration was indicated as statistically significant (M > 3.5) from the questionnaire survey results. The research validation also supported this, as more research would identify possible improvements for the New Zealand housing sector, particularly at the current time when house prices are dramatically increasing.

f) More competition

The analysis of the semi-structured interviews revealed that a small member of large companies in New Zealand dominate the market and therefore materials prices and the level of competition are completely controlled. This cartelism was seen on both the suppliers' and contractors' sides. The literature review also clearly indicated that the lack of competition is a characteristic of the housing sector generally (CHRANZ, 2011; Page, 2008). The past literature indicated that generally for most key materials, there seem to be very few manufacturers in New Zealand, which result in higher materials prices. Barriers such as the technology and resources required sustaining a firm in the market, legal activities which limit the number of manufacturers/suppliers, and predatory pricing all limit the level of competition in the New Zealand construction industry (BIFNZ, 2013). “More competition” was a statistically significant suggestion as revealed in the questionnaire survey results. In addition, the SMEs confirmed this and indicated that greater competition could bring about better customer service, better understanding about the strengths and weaknesses of different parties in the supply chain, more creative ideas, more efficient practices in the supply chain, and lower prices for building materials.

g) Improved infrastructure

The literature review found that as the New Zealand construction industry is geographically well spread-out, transport costs are high and contribute to increased building materials prices (BIFNZ, 2013). Many manufacturers and suppliers claim that the low axle loading limits on trucks imposed by the NZTA (9-12% more weight can be carried on NSW trucks), and poor transportation modes further increase the costs of transportation. The analysis of the semi-structured interview results also revealed that Auckland’s heavy traffic is a major barrier for some building materials manufacturers. According to the questionnaire survey results, improved transportation infrastructure was a statistically significant ($M > 3.5$) suggestion for all participants, and it was also confirmed by the SMEs. Therefore the study suggests improving the current transportation system in New Zealand, which would improve the logistical aspects of the building materials supply chain.

h) There should be a system to control payment problems

The study identified that payment problems are a critical issue in the materials supply chain. Often materials suppliers are not properly paid by contractors (BCPP, 2013). The analysis of semi-structured interview results indicated that generally larger companies pay materials suppliers’ bills on time and the payment problem generally lies with small to medium sized companies. Even though payment problems occur in the industry, manufacturers still have to supply materials on credit to maintain sales. Paying suppliers’ bills on time keeps the contractor-supplier relationship strong and leads to better offers from suppliers. This suggestion was statistically significant ($M > 3.5$), and confirmed by the SMEs. Accordingly, obtaining payment and maintaining cash flows were considered as two of the biggest issues among the participants interviewed. It is therefore suggested that some form of government-controlled payment system to overcome these payment problems be developed and implemented.

i) Homeowners should be educated on selecting the appropriate materials

The study suggests that homeowners should be more careful and more responsible for what they choose as building materials. As shown in the semi-structured interview results, education of homeowners on the life cycle cost of materials rather than the upfront capital cost should be emphasised. This suggestion was statistically significant ($M > 3.5$), according to the analysis of the questionnaire survey results. The research validation also further confirmed that educating homeowners in terms of lifecycle costs and total costs over a certain number of years, as well as the upfront capital costs of materials is an essential aspect of improving the current BMSC.

j) Performance warranties on building materials

This suggestion emerged from the research validation exercise. The study indicated that there is a need to consider the significance of performance warranties on building materials. Many products have warranties but not the installation of them. This is an indictment on the construction industry as there is no insurance for improper installation. Therefore it should be a requirement to have performance warranties for building materials and products which include proper installation.

7.5 Overall Evaluation of the Research Objectives

Sections 7.1 to 7.4 discussed accomplishment of the research objectives with respect to the research questions using a triangulation approach. Table 7.3 shows a summary of how each research objective has been addressed in this study, outlining the brief responses to each research objective.

Table 7.3: Evaluation of research objectives

	Objectives	Response
01	To review the nature of the building materials supply chain in the New Zealand residential construction sector	The thesis examined the operational behaviour of New Zealand building materials supply. Also it identified key issues related to building materials in the residential construction sector.

02	To identify building materials supply, purchasing, and selection behaviours of supply chain stakeholders (materials suppliers, building contractors, architects, and homeowners)	The thesis identified key people involved in the building materials supply process, the ways of transporting materials, and the ways of supplying materials. The thesis also established key criteria related to materials supply decisions made by suppliers. The thesis identified key people involved in the building materials purchasing process and the ways of purchasing materials. The thesis also established key criteria related to materials purchasing decisions made by contractors. The thesis established key criteria related to materials selection decisions made by architects and homeowners.
03	To integrate buyer and supplier behaviours to improve the building materials supply chain	The thesis developed a framework for building materials related decisions made by suppliers, contractors, architects, and homeowners. Also the thesis identified the benefits of collaboration (integration) for supply chain decisions related to materials.
04	To suggest an improved framework for current building materials supply chain practices for selecting appropriate building materials	The thesis suggested a possible mechanism to improve the current BMSC in the New Zealand residential construction sector.

7.6 Summary

The chapter synthesised the research findings from three approaches: semi-structured interviews, a questionnaire survey and SME interviews. The synthesis was presented under five key sections in accordance with the research objectives presented in chapter one. The synthesis of findings revealed the operational behaviour and current issues in the New Zealand residential BMSC. Further, the chapter showed three behaviours: suppliers' materials supply behaviour, contractors' materials purchasing behaviour, and architects' and homeowners' materials selection behaviour, in terms of the various criteria considered by the aforementioned parties in relation to building materials. Thereafter the three behaviours were integrated, emphasising the benefits of collaborative supply chain practices and a possible mechanism for improving the current BMSC was also proposed. The chapter concludes with an outline of the overall evaluation of the research objectives.

CHAPTER EIGHT

Conclusions & Recommendations

8.0 Introduction

This chapter outlines the original contributions made by the current research to supply chain management in the New Zealand residential construction sector. The contributions are presented in terms of how each research objective has been achieved. Accordingly, the chapter reviews the research objectives, followed by the key contributions from this study to theory and practice. This is followed by a set of recommendations made from the current study and finally, the chapter provides concluding remarks and suggests possible future research opportunities that would extend the current research.

8.1 Review of the Research Aim and Objectives

The primary aim of this research is to identify system weaknesses limiting the performance of the residential construction sector in New Zealand, and potential ways to address these using interventions operating at whole-of-supply chain level, including barriers to be overcome. With this in mind, the research identified four research objectives, as was stated in chapter one. The research employed a mixed-methods approach (semi-structured interviews, questionnaire survey, and SME interviews) to achieve these objectives. The semi-structured interviews mainly identified the nature of the New Zealand BMSC in terms of the materials supply behaviour from manufacturers and suppliers, and materials selection and buying behaviour from contractors, architects and homeowners.

The next stage of the research involved administering a questionnaire survey among the aforementioned parties to obtain a wider view of the themes that had emerged from the semi-structured interviews. Finally, the research used SME interviews to validate and extend the findings from the prior research stages. The following sub-sections describe how each research objective was fulfilled in the study.

8.1.1 Objective One

To review the nature of the building materials supply chain in the New Zealand residential construction sector

The research addressed this issue by posing two research questions:

- How does the New Zealand residential construction sector operate?
- What are the current issues in the materials supply chain?

The first question was addressed through a review of literature and the second was addressed using a triangulated approach. The review discovered that the New Zealand BMSC is dominated by a large number of small to medium sized organisations and a very few large organisations. The upstream of the supply chain comprises a few large volume suppliers/BMs with a reasonable level of competition, but very few materials manufacturers. Many local suppliers are subjected to international market conditions as they mostly import materials from overseas. On the contractors' side, the sector is dominated by a few volume builders and many small and medium sized builders.

Further characteristics of the New Zealand supply chain, which were determined from the literature review include: a fragmented nature, low levels of innovation, low productivity, growing building costs, poorly informed homeowners, inappropriate procurement strategies, complicated and lengthy consenting procedures, low building quality, demand volatility, inefficient information transmission, and skilled labour issues.

The research further investigated these current issues in the New Zealand residential BMSC from manufacturers/suppliers, contractors, architects, and homeowners, in two stages. Firstly, data was collected using semi-structured interviews, and secondly a wider perspective from the same participant group was obtained, using a New Zealand-wide questionnaire survey. These results obtained from the two stages were then validated using SMEs. The current issues in the New Zealand residential BMSC are listed below:

1) The high price of building materials due to high labour costs, extreme weather conditions and seismic activity, high transport costs, and low demand.

2) Cheap, attractive products with lower quality (that is inferior products) are available in the market which could cause leaky home issues/similarly costly issues.

3) Poor collaboration across the BMSC: lack of collaboration and communication between parties all the way through the supply chain, from manufacturers to suppliers, to contractors, to architects, and to clients, was a critical issue that could cause project overrunning, over budgeting, defects, disputes, and poor performance.

4) Materials wastage: the bespoke nature of New Zealand houses and lack of collaboration across the supply chain cause a sizable amount of building materials waste.

5) High materials transport costs, due to wide geographical spread, small demand for building materials, and low truck axle loading limits imposed by the NZTA.

6) High labour costs due to skilled labour shortages in the New Zealand construction industry.

7) Expensive building materials certifications: BRANZ appraisal is expensive for small scale building materials manufacturers/suppliers.

8) Materials substitution (non-adherence to materials specified): when the architect specifies a particular material, contractors may change it to a different material which may look the same but with different performance characteristics.

9) Materials delivery issues: late deliveries, early deliveries, and damaged materials can cause problems such as construction delays, storage problems, and cash flow maintenance problems.

10) No supplier quality assurance: there are no warranties for materials installations and the available 10 year warranty in the Building Act 2004 is insufficient.

11) Poor contractor service: poor information transmission between manufacturers and contractors creates materials installation issues, leading to leaky homes.

12) Complicated consenting process: the documentation related to materials approval is unnecessary, time consuming and complicated.

8.1.2 Objective Two

To identify the building materials selection, purchasing, and supply behaviours of supply chain stakeholders (materials suppliers, building contractors, architects, and homeowners)

The research developed the following research questions to help fulfill objective two:

1. Who are the people involved in the building materials supply process?
2. How do manufacturers/suppliers transport building materials?
3. How do materials suppliers supply building materials?
4. What are the key criteria considered by building materials suppliers in making their materials supply decisions?
5. Who are the people involved in the building materials purchasing process?
6. How do contractors purchase building materials?
7. What are the key criteria considered by residential building contractors in making their materials purchasing decisions?
8. What are the key criteria considered by architects in making their materials selection decisions?
9. What are the key criteria considered by homeowners in making their materials selection decisions?

The first and second questions were addressed through the semi-structured interviews and validated by an SME. The third question was initially addressed through the semi-structured interviews but a wider opinion was collected through the questionnaire survey. These views were validated by an SME during the research validation exercise.

The fourth and fifth questions were addressed through the semi-structured interviews and validated by SME-02. The sixth question was initially addressed through the semi-structured interviews and a wider view was taken through the questionnaire survey.

The seventh and eighth questions were initially addressed through the semi-structured interviews and a wider view was taken through the questionnaire survey. These views were then validated by two SMEs during the research validation exercise.

The interview results found that the building materials supply process comprises the main stages of placing the order, and processing and delivering the order. When the orders are placed, marketing managers, sales managers, sales reps, BMs, and call centre crew are all involved in the supply process. Order processing is carried out by contact centre crews while order delivery is mainly performed by logistics managers and logistics companies.

Building materials manufacturers/suppliers mostly employ separate logistics companies to accomplish a good delivery service to their customers. The research identified two ways by which building materials are supplied: through builders' merchants/other suppliers, and directly to building contractors. The supply of materials through builders' merchants/other suppliers would normally require licensed and trained applicators. Manufacturers/suppliers prefer to supply to builders' merchants or other suppliers because their payment is guaranteed, and because contractors could present payment risks to them. The direct supply of materials to contractors by suppliers occurs mainly because it is more profitable, compared to supplying through builders' merchants or other suppliers.

To further understand the behavior of building materials suppliers in building materials supply management, the study identified the key criteria for building materials supply related decisions as listed below:

1) Strong customer relationships - maintaining trust and reliability
2) Delivery service - freight delivery with good service
3) Having available and supplying a wide range of materials to cater for the bespoke nature of houses
4) Understanding customer needs - delivering products that fit the customer's purpose
5) Offering a competitive price to ensure the long-term stability of the business
6) Product quality requirements - materials standards and specifications
7) Having a good logistics system (accurate scheduling of materials, storage provisions, and delivering materials to construction sites)
8) Having sophisticated software systems that allow efficient estimation, warehousing, distribution, customer deliveries, and streamlining customer orders

9) Use of waste minimisation strategies such as good logistics systems, JIT, SCM and collaboration

The materials purchasing process is critical for contractors in the sense that having the right product options (specifications, quality, and durability), at the right price, and using an effective and efficient delivery service, is a key component of their businesses. This determines the level of profit they could make on their projects. The materials purchasing process is a combination of various decisions taken by key people from the contractors' side are: the contract estimator (sourcing quotations from suppliers), the project manager and contract administration (placing orders, ensuring delivery, and making delivery dockets), and the accounts administrator (dockets matching up with payment slips, checking invoices, and supplier payments).

Building contractors have the option of purchasing materials from builders' merchants/suppliers and/or materials manufacturers. Consumable materials are usually sourced from selected builders' merchants/suppliers with whom they have built strong relationships. This enables contractors to purchase a variety of materials from one supply source, whereas resource-based products are sourced directly from manufacturers which provide lower prices as they avoid intermediate transactions.

To further understand the behavior of residential building contractors in building materials supply management, the study identified the key criteria for building materials purchasing related decisions as listed below:

1) Quality of materials

2) Price of materials

3) Contractors' own level of efficiency (onsite quality management system, sophisticated software systems for estimating and preparing purchase orders, and up-to-date information about materials)

4) Materials specifications - compliance with the architect's recommended specifications and proper installation according to the supplier's specifications

5) Degree of negotiation - negotiation with suppliers for possible alternative solutions

6) Repetitive business (long-term relationships) - having a set of reputable suppliers to maintain strong supplier relationships

7) Supplier's service - on-time delivery and backup service

8) Past experience and knowledge - forecasting future supplier performance based on past experience

9) Degree of collaboration and information sharing - materials related information sharing between customers (contractors/architects/homeowners)

10) Supplier's credit period - receiving the materials needed without paying immediately on receipt

In the same light, building architects, when making decisions concerning materials selection and purchasing, consider a list of criteria. These key criteria are listed below:

1) The material is fit for purpose – that is, properties of materials

2) Accurate information about materials that is legitimate and trustworthy, availability of samples, testing reports, and information on materials availability

3) Quality and satisfactory performance of materials (warranties including installation warranties)

4) Materials specifications such as materials treatment levels, moisture levels, UV levels, etc

5) Homeowner's brief including budget, living style, likes and dislikes, and various other requirements

6) Architect's knowledge and experience - well-established and previously used materials as opposed to newer materials

7) Good communication with suppliers - Clear information about materials (materials testing reports, specifications, quality reports, and availability of web-based information)

8) Site conditions - soil profiles of the site, surrounding views, natural ventilation, and natural lighting, etc

Similarly homeowners, when making decisions regarding materials selection and purchasing, consider a list of criteria. These key criteria are listed below:

1) Quality and satisfactory performance of materials - certified and sustainable materials and warranties (including installation warranties)

2) Functionality, properties, specifications, and the feel of materials

3) Aesthetic values - range of colours and shapes

4) The level of maintenance affordability of a house - cleaning regularity and painting regularity, etc

5) Homeowner’s requirements - budget, living style, likes, dislikes, emotional reasons, etc

6) Materials supplier’s reputation in the industry - media and word of mouth

7) Homeowner’s relationship with contractor - contractor’s recommendations

8) Homeowner’s relationship with architect - architect’s recommendations

8.1.3 Objective Three

To integrate buyer and supplier behaviours to improve the building materials supply chain

Having identified the behaviors of respective stakeholders in the materials supply chain, objective 3 was formulated to integrate them. The study developed 2 research questions to address this objective. They are:

- What are the key benefits of collaboration in the materials supply chain?
- How can buyer and supplier behaviours be integrated to improve the materials supply chain?

The study found that collaboration is important in achieving better materials supply chain practices across the entire supply chain. The industry has begun to move away from traditional procurement practices to more integrated approaches. The study established the main benefits of collaboration. Firstly, it ensures that the right building materials are used, in terms of ensuring the various building materials related requirements of the different supply chain parties, and it brings better understanding of materials information and the flow of materials. Secondly, collaboration builds better teamwork by: increasing trust between the different parties in the supply chain; increasing understanding of total supply chain goals; bringing teams together and making sure that everyone is fulfilling their role; improving negotiation; making strong relationships in the materials supply chain; and spreading specialized knowledge across the materials supply chain. Thirdly, collaboration offers other advantages such as ensuring cost effectiveness, enabling a diversity of products and methodologies, enabling materials availability, ensuring right delivery time, and helping to resolve issues in the materials supply chain.

As shown in Figure 8.3, the current study developed a framework for building materials related decisions made by stakeholders in the supply chain. Building materials related decisions can be divided into demand side decisions and supply side decisions. Demand side decisions comprise decisions made by homeowners, architects, and contractors, while supply side decisions are made by building materials suppliers. The study identified that quality and satisfactory performance, price, and specifications of materials are common criteria for all stakeholders (homeowners, architects, and contractors) on the demand side.

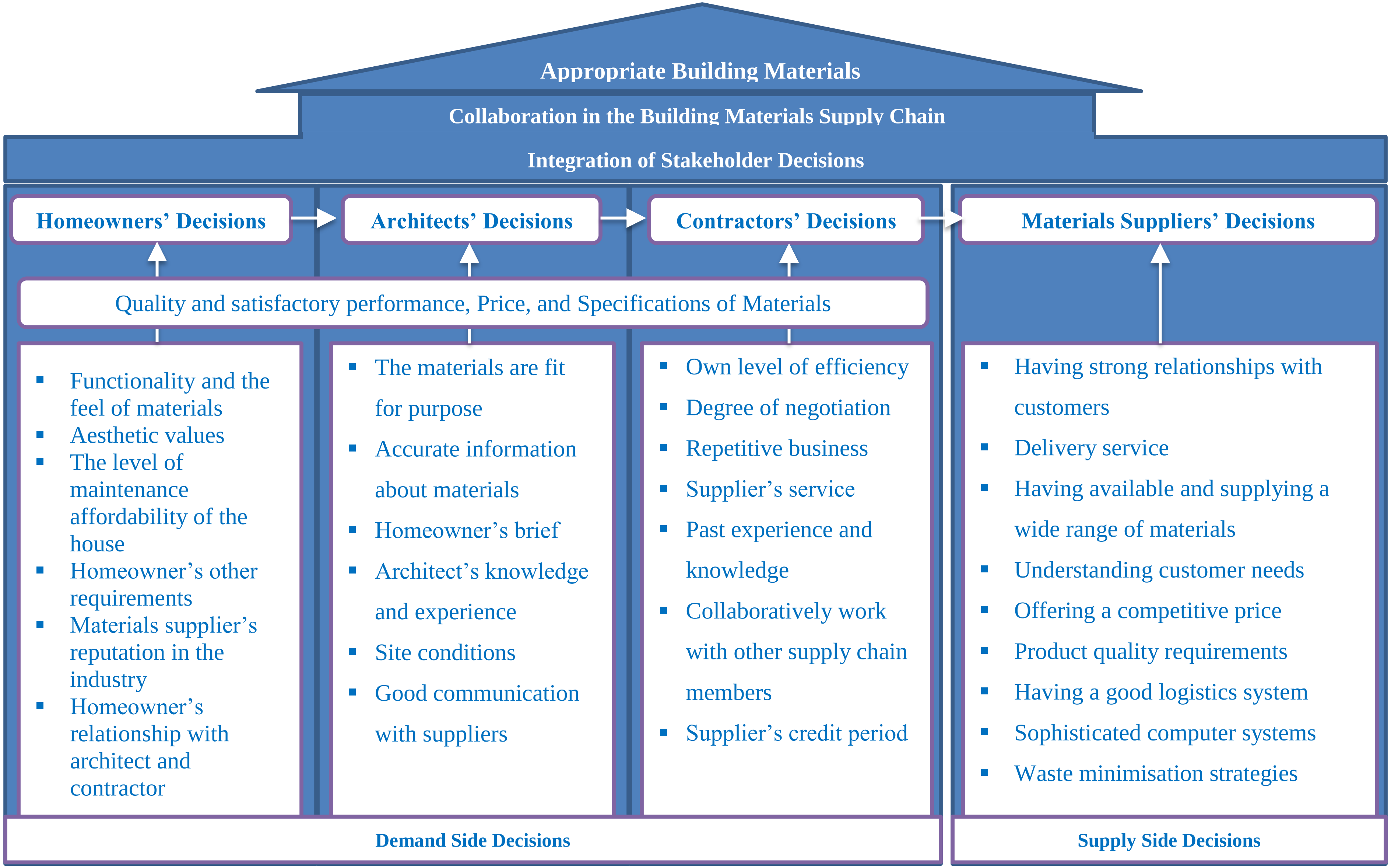


Figure 8.3: Framework for building materials related decisions

The other criteria considered by the demand side stakeholders are given in Figure 8.3. There are many similarities between homeowners' and architects' decisions as these stakeholders generally work together. Architects' decisions are mainly based on the requirements of homeowners, and homeowners' decisions are greatly influenced by architects. Homeowners decisions related to building materials are also influenced by the contractors and suppliers. Architects already seem to be collaborating with homeowners and materials suppliers when they make materials related decisions. However, the study found that architects' decisions are quite independent from the contractors'.

Building contractors materials related decisions seem to be influenced by all the other three stakeholders. The supply side of the supply chain is connected to the demand side mainly through contractors. Contractors seem to maintain a pool of suppliers based on their business history. On the demand side, materials suppliers consider customer relationships as the main criteria when they make materials related decisions, followed by delivery service, and having available and supplying a wide range of materials.

Therefore the demand side decisions generated by homeowners, architects, and contractors are transferred to the supply side mainly via contractors. Subsequently, materials suppliers make their supply decisions in order to fulfill their customers' needs. This study emphasised that both demand and supply side decisions should be integrated to find the most appropriate building materials. The supply side stakeholders should understand the criteria that demand side stakeholders are looking for, and demand side stakeholders should understand what supply side stakeholders are looking for. Therefore greater collaboration across the BMSC is greatly required, as recommended by the current study. To conclude, integration of the decisions made by BMSC stakeholders could better secure appropriate building materials.

8.1.4 Objective Four

To suggest an improved framework for current building materials supply chain practices for selecting appropriate building materials.

The study established a mechanism that could improve the current BMSC practices. The mechanism was determined mainly from the views of the research participants (the study also looked at the relevant past literature where appropriate). This mechanism is presented below as a list of suggestions for the materials supply chain in the New Zealand residential construction sector.

1) Increased house standardisation and integration in the supply chain as waste minimization strategies

2) Technical advancement - industry should adopt modern electronic equipment and ICT

3) There should be a central materials specification system which can evaluate different types of products, in terms of their performance, price, durability, and warranty

4) Increased communication - increase the efficiency of the information flow across the supply chain

5) More research on building materials and materials supply chain decisions

6) More competition to bring better customer service, increased efficiency, creative ideas, and lower prices for building materials

7) Improved infrastructure - higher truck axle loading limits

8) An improved system to control payment problems - the need for a government body to devise a system by which parties can obtain financial satisfaction more quickly

9) Homeowners should be educated on selecting right materials, especially homeowners' education on the life cycle costs of materials rather than the initial capital cost

10) Performance warranties on building materials - warranties should include installation

8.2 Contribution of the Research to Theory and Practice

The study has contributed to the material supply chain management body of knowledge in both theory and practice. The following is a list of specific contributions that this study has made to knowledge.

a) The study has given useful information on SCM and its applicability in the construction industry, focusing on New Zealand's residential sector. The study has gone further to identify the nature of the New Zealand housing sector and the current issues in its materials supply chain. The New Zealand construction industry is characterised by a large number of small to medium sized organisations and a very small number of large organisations. Building materials are expensive in New Zealand compared to other countries, and there are many inferior products available in the market.

b) The study has established that the New Zealand construction supply chain is fragmented and characterised by poor communication, resulting in a misalignment of needs among materials supply chain stakeholders.

c) The other issues identified are: high materials wastage due to the bespoke nature of New Zealand houses, high transport and labour costs, expensive product certification methods, materials substitution (non-adherence to materials specified), materials delivery issues, insufficient supplier quality assurance, poor contractor service, and the excessive documentation process involved in the consenting process. Altogether, these provide a good foundation for further investigations to determine feasible improvements to current industry practice. Some of the improvement areas are detailed in section 7.4 of chapter 7.

d) The study has advanced the understanding of the building materials supply chain in terms of the suppliers' materials supply behavior, contractors' materials purchasing behavior, and architects' and homeowners' materials selection behaviour. These behaviours were presented in terms of the key people involved in the decision making process, the ways of transporting building materials, and the key criteria made by the aforementioned parties. Especially, the study established a number of criteria considered by suppliers, contractors, architects, and homeowners when they make materials related decisions.

e) The study has found that collaboration is weak in the New Zealand building materials supply chain, especially between contractors and architects. Also the study elaborated the benefits of collaboration in the building materials supply chain into a way of finding the right building materials, a way which strengthens teamwork and other benefits. Moreover, the study developed a framework for building materials related decisions made by the different parties in the residential building materials supply chain.

f) The study suggests that the New Zealand residential construction sector should adopt more standardised houses (e.g. the greater use of prefabricated materials and standardised claddings and windows) in order to control materials costs. Also, greater communication would assist in diminishing waste in terms of time, energy, and building materials.

g) The study further found that the New Zealand construction sector should adopt better technology to support effective communication across the whole supply chain. A need for a central materials specification system has emerged from this study, so that project parties can access and evaluate different building materials in the market. The need for more research in the BMSC, increased competition, and better infrastructure are also included in its research findings.

h) Moreover, the study found that it is essential to have a government body to handle payment problems in the construction industry. Finally, it is essential that homeowners be made aware of and be responsible for what they select in terms of building materials, and should consider lifecycle costs, including performance warranties of building materials when they do so.

8.3 Recommendations

The recommendations arising from the current study are presented, firstly as specific recommendations to key stakeholders, secondly as general recommendations to the construction industry, and lastly as recommendations for future work.

8.3.1 Specific Recommendations to Key Stakeholders

To Building Materials Manufacturers and Suppliers

The following is an outline of recommendations to building materials manufacturers and suppliers that could assist their materials supply practices.

- Increase the range of products/materials to the New Zealand market. This will help with the customisation of residential homes from high-end to low-end and eventually New Zealand houses will be more affordable.

- Maintain a high degree of quality and service as this can increase materials demand despite relatively high materials prices.
- Employing sufficient skilled workers to make more building materials is a good way of facing the highly cyclical nature of the industry with its variable demands.
- The lack of forecasting facilities makes supply planning challenging, because suppliers have to base their decisions on historical information rather than factual and guaranteed forecasts. Therefore the study recommends that materials manufacturers and suppliers should be equipped with good materials demand forecasting technologies in order to make sure that shipping and delivery happens on time, and suppliers have sufficient stocks to meet demand.
- By maintaining a good level of trust and fostering good relationships with all parties within the supply chain, the right quantity and quality of materials can be efficiently supplied along the chain. This would also help to reduce costs associated with call-backs.

To Residential Building Contractors

The following is an outline of recommendations to residential building contractors that could assist their materials purchasing practices.

- Maintain onsite materials using a quality management system for each project so that appropriate materials quality is ensured.
- Contractors should use sophisticated building materials management software that estimate materials requirements very effectively, and to produce purchase orders which accurately state which materials are required and when they are needed.

- Contractors should have the most up-to-date information possible about materials in the industry (e.g. which materials have failed, which are the best-performing, etc.)
- Contractors should endeavour to ascertain exactly what homeowners are looking for in order to eliminate many of the issues related to materials.
- Contractors should obtain homeowners' opinions on materials used, through means of customer surveys, and should also conduct onsite meetings on homeowner satisfaction regarding materials used.
- Contractors should collaboratively work with homeowners, architects, and suppliers/manufacturers to share information on materials, and thereby improve collaboration amongst the various parties.

Recommendations to Architects

The following is an outline of recommendations to residential building architects that could assist their materials selection practices.

- Obtain accurate information about building materials through visually examining the quality of the product being specified before it is ordered.
- Greater use of materials that have been proven in use in the industry would be beneficial in helping to ensure the overall quality of building materials.
- Maintain good relationships with material suppliers in order to remain up-to-date in terms of what the latest/newest materials are, so that clear information about building materials can be obtained in terms of materials testing reports, specifications, quality, suitability, etc.

Recommendations for Homeowners

The following is an outline of recommendations to new homeowners that could assist their materials selection practices.

- When materials are selected, homeowners should clearly express their views and ask questions. This will help secure the most suitable materials. Therefore, the study recommends homeowners being prepared to confront, disagree with, negotiate, and appreciate project team members.
- Homeowners should seek education on the life cycle costs of materials rather than simply the upfront capital costs, by accessing detailed online information (material library databases).

- Homeowners should consider the associated values of building materials when they choose them. For example, the level of technical support, background support, logistics supply, etc.
- Homeowners should form strong relationships with architects and builders which will assist them in securing the best materials. Having good relationships with experienced architects and builders also creates opportunities for homeowners to see samples of building materials, and to review previously built houses, all of which will improve their materials selecting decisions.
- Homeowners should choose local building materials as much as possible, given that such appropriate materials are locally available.

8.3.2 General Recommendations to the Construction Industry

The following is an outline of general recommendations to the construction industry including responsible organisations that could assist building materials purchasing and supply practices.

- Efforts should be made by responsible organisations (e.g. BRANZ) to reduce the incidence of poor quality building materials entering the construction market.
- Associated with the above, the level of testing and monitoring of building material products should be increased, especially materials-in-use. It is not enough to simply certify new building products but also ongoing checks on quality-in-use would determine durability/reliability issues.
- The study encourages the setting-up of a web-based data base of building materials where detailed information on all available building products, their characteristics, specifications, etc, will be available to all key stakeholders. Also this database should be updated as and when new information on products are available.
- A feature of the New Zealand building materials supply chain is that each party is disconnected from the materials supply chain. In other words, the collaboration between the supply side and the purchasing side is insufficient, and as a result homeowners face difficulties in selecting building materials. Therefore the study strongly encourages greater collaboration in the materials supply chain.

- The study recommends that construction industry practitioners use modern electronic equipment and technology in the supply chain in order to make the decision process quicker and smarter.
- More effective communication is greatly required in the construction industry. Modern communication media and devices should be used further in the construction industry to increase the degree of communication with the different parties in the supply chain. Increased effective communication would help support faster and smarter decisions with regards to materials.
- Poor collaboration between building inspectors and builders results in the poor performance of New Zealand houses. Therefore building inspectors should improve relationships with builders so that building materials in houses satisfy the necessary quality and specification requirements.
- There is a need for performance warranties for building materials. Many products are installed but although the product itself may be warranted, the installation is not, which is an indictment on the industry.
- As the New Zealand construction supply chain is geographically spread out, transporting building materials is a challenge. Trans-shipping between the North and South Islands is a major cost for everyone associated with the building industry, because of the bulky nature of the products. Therefore the study emphasises the need for better transport infrastructure in New Zealand in order to improve the logistics aspects of the building materials supply chain.
- The study emphasises the need for a system by which parties in the residential building sector get satisfaction payments quicker, via a government body.
- The study showed that much of the documentation related to the materials approval consenting process is time-consuming in the view of the various research participants. Therefore the study suggests that all the documentation involved with getting approval for the materials chosen for a house should be digitised.
- The study emphasised the need for the necessary amendments required to the building code in order to compare the performance based nature as opposed to specification based nature of construction materials.
- The study recommends creating New Zealand codes for all building materials (for example, New Zealand still uses Australian brick standards which were accepted in

the 1930s) as New Zealand has a completely different climate - wet, windy and humid - compared to Australia/and many other countries.

- The study encourages more competition in the construction industry to decrease materials prices and provide more choice for customers.
- More research should be conducted continuously on building materials, which would help the supply chain decision making process. Currently there is little research conducted both on building materials and their purchasing and supply behaviours in New Zealand. Therefore there is wide scope to conduct more research to support various aspects of supply chain behaviours and to investigate issues.

8.3.3 Recommendations for Future Studies

The study recommends further studies in the following areas that could expand the current research findings.

- The study identified current issues in the New Zealand BMSC from a wider perspective. Therefore further studies are required to extend the current research findings with more depth. For example, the various factors associated with each issue can be identified in order to redefine those issues, and to understand causes and remedies.
- The study has provided a basic understating of the key criteria involved in materials related decisions made by key parties in the supply chain. Further studies based on a questionnaire survey can establish a metric, including key decision factors regarding key players in the supply chain.
- Further studies could establish a construction materials supplier selection framework, based on the contractors' materials selection criteria established by the current study.
- The scope of the current study lies within the boundary of the residential construction sector in New Zealand. More specific case study research projects can further extend the current research findings as applicable in the commercial construction sector.
- The study showed the need for a centralised materials information management system to increase information transmission across the supply chain. Further research on this would help to develop a data materials information database so that

construction industry practitioners can upload and download building materials related information.

- The study recommends the employment of more qualitative research approaches (in-depth interviews with SMEs) to address CSCM related issues as they require in-depth information which sometimes cannot be generalised to a wider group of participants with questionnaire surveys.

8.4 Concluding Statements

The research has explored the nature of the New Zealand housing sector with the focus on the materials supply chain. The study belongs to the pragmatist paradigm and it employed both qualitative and quantitative methods a mixed methods approach to gather four different sets of perceptions from materials suppliers, building contractors, architects, and homeowners on the research problem. The study found that the New Zealand construction industry mostly used the traditional procurement system and the supply chain is very fragmented with numerous issues related to building materials. A framework for decisions made by supply chain parties was developed so that each party in the supply chain could get a good understanding of how other parties think and make materials related decisions.

Currently supply chain decisions are individual-based and less collaborative. However, the industry has started moving away from the traditional procurement system to SCM, which would advantage the entire supply chain in terms of finding the right materials, in improved teamwork, and in many other ways. Consequently there would be an improvement in the overall performance of the housing sector and the whole construction industry. Integrating materials supply chain related decisions should therefore increase the overall supply chain performance, which will eventually result in more affordable housing in New Zealand. Further, the study has suggested many improvements in the current materials supply chain in the New Zealand housing sector. Improving the materials supply chain would also help to increase construction productivity, which would support the BCPP's aim of increasing the construction industry's productivity by 20% no later than 2020. In the long run the study will assist in finding the right building materials for New Zealand houses which in turn will eventually create more affordable houses and increase the GDP of the New Zealand economy.

To finish, it is hoped that this thesis has contributed to the existing body of knowledge and practice which will enhance the performance of materials supply chain. Ultimately this will support supply chain members to find the right building materials for New Zealand houses.

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APPENDIX – 1

MEMORANDUM

Auckland University of Technology Ethics Committee (AUTEC)

To:	John Tookey
From:	Rosemary Godbold, Executive Secretary, AUTEC
Date:	24 August 2012
Subject:	Ethics Application Number **12/112 Securing best prices for construction materials: An exploratory study of the New Zealand construction industry.**

Dear John

Thank you for providing written evidence as requested. I am pleased to advise that it satisfies the points raised by the Auckland University of Technology Ethics Committee (AUTEC) at their meeting on 14 May 2012 and I have approved your ethics application. This delegated approval is made in accordance with section 5.3.2.3 of AUTEC's *Applying for Ethics Approval: Guidelines and Procedures* and is subject to endorsement by AUTEC at its meeting on 10 September 2012.

Your ethics application is approved for a period of three years until 23 August 2015.

I advise that as part of the ethics approval process, you are required to submit the following to AUTEC:

- A brief annual progress report using form EA2, which is available online through http://www.aut.ac.nz/research/research-ethics/ethics. When necessary this form may also be used to request an extension of the approval at least one month prior to its expiry on 23 August 2015;
- A brief report on the status of the project using form EA3, which is available online through http://www.aut.ac.nz/research/research-ethics/ethics. This report is to be submitted either when the approval expires on 23 August 2015 or on completion of the project, whichever comes sooner;

It is a condition of approval that AUTEC is notified of any adverse events or if the research does not commence. AUTEC approval needs to be sought for any alteration to the research, including any alteration of or addition to any documents that are provided to participants. You are reminded that, as applicant, you are responsible for ensuring that research undertaken under this approval occurs within the parameters outlined in the approved application.

Please note that AUTEC grants ethical approval only. If you require management approval from an institution or organisation for your research, then you will need to make the arrangements necessary to obtain this.

To enable us to provide you with efficient service, we ask that you use the application number and study title in all written and verbal correspondence with us. Should you have any further enquiries regarding this matter, you are welcome to contact me by email at ethics@aut.ac.nz or by telephone on 921 9999 at extension 6902. Alternatively you may contact your AUTEC Faculty Representative (a list with contact details may be found in the Ethics Knowledge Base at http://www.aut.ac.nz/research/research-ethics/ethics).

On behalf of AUTEC and myself, I wish you success with your research and look forward to reading about it in your reports.

Yours sincerely

Dr Rosemary Godbold
Executive Secretary
Auckland University of Technology Ethics Committee

Cc: Don Amila Sajeeevan Samarasinghe amila.samarasinghe@aut.ac.nz, James Rotimi; Thomas Neitzert

APPENDIX – 2 (A)

Consent Form

(Semi-Structured Interviews)

AUT UNIVERSITY
TE WĀNANGA ARONUI O TAMAKI MAKAU RAU

Project title: ***Improving Materials Supply Chain in New Zealand Residential Construction Industry: An Exploratory Study***

Project Supervisor: ***Dr. John E Tookey***

Researcher: ***Don Samarasinghe***

○ I have read and understood the information provided about this research project in the Information Sheet dated 01 August 2012.

○ I have had an opportunity to ask questions and to have them answered.

○ I understand that notes will be taken during the interviews and that they will also be audio-taped and transcribed.

○ I understand that I may withdraw myself or any information that I have provided for this project at any time prior to completion of data collection, without being disadvantaged in any way.

○ If I withdraw, I understand that all relevant information including tapes and transcripts, or parts thereof, will be destroyed.

○ I agree to take part in this research.

○ I wish to receive a copy of the report from the research (please tick one): Yes○ No○

Participant's signature:
....

Participant's name:
....

Participant's Contact Details (if appropriate):

………………………………………………………………………………………..

………………………………………………………………………………………..

………………………………………………………………………………………..

………………………………………………………………………………………..

Date:

Approved by the Auckland University of Technology Ethics Committee on 24 August 2012 AUTEC Reference number 12/112

Note: The Participant should retain a copy of this form.

APPENDIX – 2 (B)

Participant Information Sheet

Date Information Sheet Produced:

01 August 2012

Project Title

Improving Materials Supply Chain in the New Zealand Residential Construction Industry: An Exploratory Study

An Invitation

My name is Don Samarasinghe and I am a doctoral candidate at AUT University. I invite you to participate in this research on securing best materials procurement practices in the New Zealand residential construction industry. This research will form the basis of my doctorate thesis. Your participation in this research is voluntary and you may withdraw from this research at any time, without providing an explanation and this will not affect you in anyway.

What is the purpose of this research?

This research aims to identify the best materials procurement practices in the New Zealand residential construction industry. It will first review and analyse the nature of the construction materials procurement process and identify existing problems in this process. Based on that, a deeper understanding of the complexities involved in procurement decisions is expected so that appropriate strategies could evolve to secure best procurement practices for key material inputs. The results of this study will contribute to the body of knowledge regarding the residential construction industry, and about how best construction materials could be procured. The outcome of this research would be used for my thesis and any possible conference and journal publications.

How was I identified and why am I being invited to participate in this research?

My main participants in this research are contractors, sub-contractors, materials suppliers, manufacturers, designers, architects and homeowners in the New Zealand residential construction industry. You have been invited to participate in this research as one of the aforementioned participants.

What will happen in this research?

It is important to understand that your involvement in this study is voluntary. While I would be pleased to have you participate, I respect your right to decline. If you agree to participate in this project, I will invite you participate in this interview, and it will take you approximately 30 minutes to complete. The research will ask questions on your opinions on the significance of materials selection as a homeowner.

What are the discomforts and risks?

Participants are not required to divulge any personal feelings about their work or their organisation and therefore there should be no emotional or psychological risks to the participants in this research. Participants' privacy and confidentiality are assured as the interviews are anonymous and no personal information is sought that may divulge a participant's identity. Any reporting of findings will have no names or details of demographics that will permit identification of participants.

How will these discomforts and risks be alleviated?

At any time during the interview, you may choose not to answer questions that you may find distressing. You may also withdraw from the interview and request for your data to be destroyed. You may also request for a copy of my final thesis when it is available. It is most unlikely that any discomfort of any type will be felt since the research involved is the discussion of professional practice within a professional organization by recognized professionals in their field. Consequently, given that anonymity can be guaranteed using the protocol explained, there is minimal likelihood of discomfort.

What are the benefits?

You will be contributing valued information that could assist this proposed research study, which intends to provide a deeper understanding of the complexities involved in procurement decisions so that appropriate strategies could evolve to secure best practices for key material inputs. In addition, you will be assisting me in completing my PhD thesis.

How will my privacy be protected?

All information collected from you will be kept strictly confidential. The interview transcript and your consent form will be stored under lock and key. Only the researcher and supervisors have access to them. None of your personal information will be disclosed to any third parties or in any part of this research output (thesis, journal/conference papers).

What are the costs of participating in this research?

There is no financial cost involved in participating in this research. The only cost of participating is the time given to answer the questions.

What opportunity do I have to consider this invitation?

Your participation is voluntary. It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep and be requested to participate in the interview.

How do I agree to participate in this research?

Your consent to participate in this research is obtained through a consent form. If you decide to participate by signing the consent form, this will be considered as your consent.

Will I receive feedback on the results of this research?

All participants are entitled to feedback from this study. A summary of research findings will be provided through an open access website (http://www.constructionproductivity.org.nz/). I will also inform any imminent publications concerning the findings of the project.

What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, Associate Professor Dr. John E. Tookey (email: jtookey@aut.ac.nz or office telephone: 09-921 9512). Concerns regarding the conduct of the research should be notified to the Executive Secretary, AUTEC, Dr Rosemary Godbold, rosemary.godbold@aut.ac.nz , 921 9999 ext 6902.

Whom do I contact for further information about this research?

Researcher Contact Details:

Don Samarasinghe (email: asamaras@aut.ac.nz or office telephone: 09-921 9999 ext.8109).

Project Supervisor Contact Details:

Associate Professor Dr. John E. Tookey (email: jtookey@aut.ac.nz or office telephone: 09-921 9512).

Approved by the Auckland University of Technology Ethics Committee on *type the date final ethics approval was granted*, AUTEC Reference number *12/112*.

APPENDIX – 2 (C)

Indicative Questions (Semi-Structured Interviews) – Building Materials Manufacturers

1. Could you briefly describe your company?
2. What is your role?
   - Job title?
   - Responsibilities?
   - Years in the position/how many projects involved in?
3. What types of key building materials do you produce?
4. How do you find the raw materials for your products (purchase locally or purchase internationally)?
5. How do you supply building materials? (to other suppliers, to BMs or to contractors directly?)
6. Does your company own any transportation facilities? If so, what are they?
7. Who are the personnel involved in your supply process?
8. How do you communicate with clients?
9. What would be the best distributions system?
   - Direct from workshop or material production factory to site?
   - Direct from contractor/supplier depot or warehouse to site?
   - Travelling pickup of materials from several suppliers to site?
10. What are the existing problems related to materials manufacturing and supply in the New Zealand residential construction industry?
11. How do you define best practices in the construction materials manufacturing and supplying industry? Please give reasons for your answers.
12. What are the factors that we need to consider in achieving the best procurement practices for construction materials from the manufacturer's perspective?
13. Do you think that integrating the ideas of the construction supply chain (collaboration in the construction industry) will bring better practice? Please give reasons for your answers.
14. What are the major challenges in the materials supply chain?
15. What do you suggest in order to have better materials supply practices in the New Zealand residential construction industry?
16. How would you benefit from improving the supply chains?
17. Are there particular barriers that prevent you from realizing these benefits?
18. How do you make sure you are getting what you want?

APPENDIX – 2 (D)

Indicative Questions (Semi-Structured Interviews) – Building Materials Suppliers

1. Could you briefly describe your company?
2. What is your role?
    - Job title?
    - Responsibilities?
    - Years in the position/how many projects involved in?
3. What types of key building materials do you supply?
4. How do you get materials (do you produce by yourself? purchase locally or purchase internationally)?
5. How do you supply building materials? (directly or through BMs?)
6. Does your company own any transportation facilities? If so, what are they?
7. Who are the personnel involved in your supply process?
8. How do you communicate with clients?
9. What would be the best distributions system?
    - Direct from workshop or material production factory to site?
    - Direct from contractor/supplier depot or warehouse to site?
    - Travelling pickup of materials from several suppliers to site?
10. What are the existing problems related to materials supply in the New Zealand residential construction industry?
11. How do you define best practices in the construction materials supply industry? Please give reasons for your answers.
12. What are the factors that we need to consider in achieving the best procurement practices for construction materials from the supplier's perspective?
13. Do you think that integrating the ideas of the construction supply chain (collaboration in the construction industry) will bring better practice? Please give reasons for your answers.
14. What are the major challenges in regards to materials?
15. What do you suggest in order to have better materials supply practices in the New Zealand residential construction industry?
16. How would you benefit from improving your supply chains?
17. Are there particular barriers that prevent you from realizing these benefits?
18. How do you make sure you are getting what you want?

APPENDIX – 2 (E)

Indicative Questions (semi-Structured Interviews) – Residential Building Contractors

1. Could you briefly describe your company?
2. What is your role?
    - Job title?
    - Responsibilities?
    - Experience (years in the position/how many projects involved in)?
3. What types of key building materials do you purchase?
4. How important is the building material purchasing process to you as a building contractor?
5. Do you purchase materials locally or internationally?
6. Could you explain the main stages involved in the purchasing process?
7. Could you explain the ways of procuring building materials? (through suppliers, BMs or directly from the manufacturer ?)
8. What is the most preferable option and why?
9. Who are the people involved in the building material purchasing process?
10. What factors do you consider when you select materials suppliers?
11. How do you communicate with suppliers/BMs/Manufacturers?
12. What are the existing problems related to the materials purchasing process in the New Zealand residential construction industry?
13. How do you define best practices in the construction materials purchasing function? Please give reasons for your answers.
14. What are the factors that we need to consider in achieving the best procurement practices for construction materials from your perspective?
15. Where do you rank “materials prices” among the above mentioned factors?
16. How do you see collaboration (integration of ideas in the construction supply chain) in the construction industry?
17. Do you think collaboration will bring better practice? Please give reasons for your answers.
18. What are the major challenges in the materials supply chain?
19. What do you suggest in order to have better materials purchasing practices in the New Zealand residential construction industry?
20. How would you benefit from improving your supply chains?
21. Are there particular barriers that prevent you from realising these benefits?
22. How do you make sure you are getting what you want?

APPENDIX – 2 (F)

Indicative Questions (Semi-Structured Interviews) – Architects

19. Could you briefly describe your company?
20. What is your role?
    - Job title?
    - Responsibilities?
    - Years in the position/how many projects involved in?
21. Can you describe the main stages in designing a house?
22. What are the main considerations when a house design is carried out?
23. How important is materials selection in the designing process?
24. How does materials selection relate with other aspects (e.g. construction efficiency and energy efficiency) of designing a house?
25. How do you make sure that you are using the best materials (in terms of quality, price, durability, etc)?
26. Who are the people involving in the materials selection process?
27. What are their main roles?
28. How are you involved in the materials selection process?
29. What are the current issues related to materials selection?
30. How do you define the *best practices* in the construction materials supply chain from a designer/architect's perspective?
31. What are the factors that need to be considered in achieving the best materials procurement practices (considering the supply chain) for construction materials, from your perspective?
32. Do you think that by integrating the ideas of the construction supply chain (collaboration in the construction industry) will bring better practice? Please give reasons for your answers.
33. From your experience what are the major challenges in the materials supply chain?
34. What do you suggest in order to have better materials procurement practices in the New Zealand residential construction industry?
35. How would you benefit from improving your supply chains?
36. How do you make sure you are getting what you want?

APPENDIX – 2 (G)

Indicative Questions (Semi-Structured Interviews) – Homeowners

1. Could you tell me a little about yourself and your house please?
2. What were the main considerations that you had in your mind when you began to build/purchase a new house?
3. Why did you want to build a house rather than buying a built house?
4. How important is the selection of different materials? Could you explain?
5. How did you select the designer/architect?
6. How did you select the main contractor?
7. How did you connect with the designer/architect to bring your ideas into the materials selection process?
8. How did you connect with the designer/architect to bring your ideas into the materials selection process?
9. What do you think about the level of collaboration in the construction supply chain?
10. What are the existing problems or issues related to materials in the New Zealand residential construction sector?
11. What are the major challenges in regards to materials in New Zealand?
12. What do you suggest to have better practices in regards to materials selection and procurement?
13. How did you make sure that you were getting what you wanted?

APPENDIX – 3 (A)

QUESTIONNAIRE

Improving Materials Supply Chain in New Zealand Residential Construction Industry: An Exploratory Study
(Manufacturers and Suppliers)

Consent to Participate

Dear Participant,

You are about to participate in a survey which is a part of research undertaken at AUT University. The primary objective of this research is to develop an empirical understanding of the critical factors influencing the building materials supply chain and to integrate those factors to bring about better practices in the New Zealand residential construction materials supply chain. Your participation in the survey is voluntary and your responses will be kept strictly confidential.

This questionnaire comprises six sections:

Section A: Building materials supply practices
Section B: Issues in the construction materials supply chain
Section C: Suggestions for improving the building materials supply chain
Section D: Collaboration in the building materials supply chain
Section E: Challenges in the building materials supply chain
Section F: Demographic data

It will take you not more than 20 minutes to complete the questionnaire.Your kind cooperation is highly appreciated.

ALL RESPONSES WILL BE TREATED IN THE STRICTEST CONFIDENCE.

Any inquiries regarding this questionnaire please contact:

Researcher
Name: Don Samarasinghe
E-mail: asamaras@aut.ac.nz
Phone: 09 921 9999 ext.8109
Fax: 09 92109999

Research Supervisors

Name: Associate Professor John E. Tookey
E-mail: jtookey@aut.ac.nz
Phone: 09 921 9512
Fax: 09 92109999

Name: Dr James Rotimi
E-mail: jrotimi@aut.ac.nz
Phone: 09 921 9999 ext 6450
Fax: 09 92109999

Section A: Building Materials Supply Practices

1. Who do you supply building materials to? (You may tick more than one box)

☐ Contractors/subcontractors ☐ Builders' merchants ☐ Suppliers

Other (please specify)

2. How significant are the following criteria when you make materials supply decisions?

	Unimportant	Of little importance	Moderately important	Important	Very important
Advertising	○	○	○	○	○
Availability of variety of products when they are needed	○	○	○	○	○
Collaboration and partnership in the materials supply chain	○	○	○	○	○
Competitive prices	○	○	○	○	○
Customer satisfaction/understanding customer needs	○	○	○	○	○
Discounts	○	○	○	○	○
Good logistics (transportation and warehousing)	○	○	○	○	○
Having a sophisticated computer system	○	○	○	○	○
On time delivery services	○	○	○	○	○
Product quality requirements	○	○	○	○	○
Streamlining payments and orders by customers	○	○	○	○	○
Strong relationships with customers	○	○	○	○	○
Waste minimisation strategies	○	○	○	○	○

Other (please specify)

Section B: Issues in the Construction Supply Chain

3. How serious are the following issues in current building materials supply chain practices in New Zealand?

	Is not a serious issue	Is not an issue	Neutral	Is an issue	Is a serious issue
Expensive products' certification methods	○	○	○	○	○
Fewer choices	○	○	○	○	○
Fragmented industry	○	○	○	○	○
High labour costs	○	○	○	○	○
High transport cost	○	○	○	○	○
Homeowner's lack of understanding about materials	○	○	○	○	○
Inferior products	○	○	○	○	○
IT infrastructure	○	○	○	○	○
Poor collaboration across the supply chain	○	○	○	○	○
Price of materials	○	○	○	○	○
Road traffic	○	○	○	○	○
Site safety	○	○	○	○	○
There are no real NZ standards for materials	○	○	○	○	○
Wastage (bespoke nature of houses)	○	○	○	○	○

Other (please specify)

Section C: Suggestions for Improving the Building Materials Supply Chain

4. How significant are the following criteria in improving current building materials supply practices?

	Unimportant	Of little importance	Moderately important	Important	Very important
An improved system to control payment problem					
Better infrastructure					
Building consents should not allow contractors to change the materials specified by architects					
Central materials specification system on Web					
Customer opinions and surveys					
Enhanced building inspector and builder relationship					
Good communication					
Homeowner education on materials					
Independent qualification, for materials testing					
More competition in the materials supply chain					
More fashionable materials					
More research					
NZ standards system for materials, controlled by the government					
Technical advancement					
Transparency around stock levels					
Waste minimization					
Workshops with suppliers and manufacturers					

Other (please specify)

Section D: Collaboration in the Building Materials Supply Chain

Collaboration in the materials supply chain refers to the working practice whereby building materials manufacturers, suppliers, building contractors, architects and homeowners work together to successfully complete a house construction project.

5. Please indicate the scale that best reflects your agreement with the following statements concerning collaboration in the building materials supply chain.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Collaboration brings better data flow					
Collaboration brings better understanding about the material flow					
Collaboration ensures cost effectiveness					
Collaboration ensures diversity of products and methodologies					
Collaboration ensures materials availability					
Collaboration ensures right delivery time					
Collaboration ensures various building materials related requirements of different supply chain parties					
Collaboration helps to solve issues in the materials supply chain					
Collaboration increases the trust between different parties in the materials supply chain					
Collaboration increases understanding of total supply chain goals					
Collaboration is bringing teams together and making sure that everyone's delivering their bit as opposed to the tendering process					
Collaboration makes negotiation better					
Collaboration makes strong relationships in the materials supply chain					
Collaboration requires a partnership approach					
Collaboration spreads specialized knowledge across the materials supply chain					

Other (please specify)

Section F: Demographic Data

7. What is the highest level of school you have completed or the highest degree you have received?

- Certificate
- Degree
- Diploma
- Postgraduate

Other (please specify)

8. How many years have you worked in the construction industry?

- Less than 5 years
- 11 – 15 years
- 21 - 25 years
- 6 – 10 years
- 16 – 20 years
- More than 25 years

9. Please indicate the number of employees your company employs

- 0-5
- 16-20
- More than 30
- 6-10
- 21-25
- 11-15
- 26-30

10. Generally, in what region/s are your material supply yards/branches located? (You may tick more than one box)

- Auckland
- Wellington
- Canterbury
- Waikato
- Otago
- Southland
- Northland
- Taranaki
- West Coast
- Bay of Plenty
- Manawatu-Wanganui
- Marlborough
- Gisborne
- Tasman
- Hawke's Bay
- Nelson

Other (please specify)

11. What are the key materials that you manufacture/ supply?

- Wood, carpentry
- Timber
- Compressed earth block, mud brick, rammed earth
- Surface finishing
- Concrete
- Doors/Windows
- Composites
- Electrical systems and equipment
- HVAC
- Metals
- Masonry, mortar, grout
- Thermal protection
- Plumbing fixtures and equipment
- Moisture protection
- Fire suppression equipment
- Conveying systems

Other (please specify)

End of Questionnaire

You have now reached the end of the survey. Thank you for your cooperation in completing this questionnaire. Your effort and time is highly appreciated. We are confident that the information you provided will greatly assist us in our research. If you have any queries please do not hesitate to contact me by phone or email. If you would like to request a copy of my research findings or have any comments/suggestions, you are more than welcome to do so.

Once again thank you for your support!

Any inquiries regarding this questionnaire please contact:

Researcher
Name: Don Samarasinghe
E-mail: asamaras@aut.ac.nz
Phone: 09 921 9999 ext.8109
Fax: 09 92109999

Research Supervisors

Name: Associate Professor John E. Tookey
E-mail: jtookey@aut.ac.nz
Phone: 09 921 9512
Fax: 09 92109999

Name: Dr James Rotimi
E-mail: jrotimi@aut.ac.nz
Phone: 09 921 9999 ext 6450
Fax: 09 92109999

APPENDIX – 3 (B)

QUESTIONNAIRE

Improving Materials Supply Chain in New Zealand Residential Construction Industry: An Exploratory Study

(Contractors and Sub contractors)

Contractors for the thesis

Consent to Participate

Dear Participant,

You are about to participate in a survey which is a part of research undertaken at AUT University. The primary objective of this research is to develop an empirical understanding of the critical factors influencing the building materials supply chain and to integrate those factors to bring about better practices in the New Zealand residential construction materials supply chain. Your participation in the survey is voluntary and your responses will be kept strictly confidential.

This questionnaire comprises six sections:

Section A: Building materials purchasing practices
Section B: Issues in the construction materials supply chain
Section C: Suggestions for improving the building materials supply chain
Section D: Collaboration in the building materials supply chain
Section E: Challenges in the building materials supply chain
Section F: Demographic data

It will take you not more than 20 minutes to complete the questionnaire.Your kind cooperation is highly appreciated.

ALL RESPONSES WILL BE TREATED IN THE STRICTEST CONFIDENCE.

Any inquiries regarding this questionnaire please contact:

Researcher
Name: Don Samarasinghe
E-mail: asamaras@aut.ac.nz
Phone: 09 921 9999 ext.8109
Fax: 09 92109999

Research Supervisors

Name: Associate Professor John E. Tookey
E-mail: jtookey@aut.ac.nz
Phone: 09 921 9512
Fax: 09 92109999

Name: Dr James Rotimi
E-mail: jrotimi@aut.ac.nz
Phone: 09 921 9999 ext 6450
Fax: 09 92109999

Section A: Building Materials Purchasing Practices

1. From whom do you purchase building materials? (You may tick more than one box)

- ☐ Directly from manufacturers
- ☐ Builders' merchants
- ☐ Suppliers

Other (please specify)

2. How significant are the following criteria when you make your materials purchasing decisions?

	Unimportant	Of little importance	Moderately important	Important	Very important
Collaboratively working with the supply chain	○	○	○	○	○
Credit periods	○	○	○	○	○
Degree of negotiation	○	○	○	○	○
Exchange rate	○	○	○	○	○
Good feedback from suppliers	○	○	○	○	○
Having sophisticated software system	○	○	○	○	○
Materials quality and satisfactory outcome	○	○	○	○	○
Materials specifications	○	○	○	○	○
Own level of efficiency	○	○	○	○	○
Past experience	○	○	○	○	○
Price	○	○	○	○	○
Relationship with other contractors/subcontractors	○	○	○	○	○
Repetitive business	○	○	○	○	○
Supplier's service	○	○	○	○	○

Other (please specify)

Section B: Issues in the Construction Supply Chain

3. How serious are the following issues in the current building materials supply chain practices in New Zealand?

	Is not a serious issue	Is not an issue	Neutral	Is an issue	is a very serious issue
Complexity in the building code	○	○	○	○	○
Constant flux in the building code	○	○	○	○	○
Delivery issues	○	○	○	○	○
Fewer choices	○	○	○	○	○
Fragmented industry	○	○	○	○	○
High transport cost	○	○	○	○	○
Inferior products	○	○	○	○	○
IT infrastructure	○	○	○	○	○
No supplier quality assurance	○	○	○	○	○
Poor collaboration across the supply chain	○	○	○	○	○
Price of materials	○	○	○	○	○
Road traffic	○	○	○	○	○
Wastage (bespoke nature of houses)	○	○	○	○	○

Other (please specify)

Section C: Suggestions for Improving the Building Materials Supply Chain

4. How significant are the following criteria in improving the current building materials supply practices?

	Unimportant	Of little importance	Moderately important	Important	Very important
Better infrastructure					
Central materials specification system on Web					
Customer opinions and surveys					
Good communication					
Homeowner education on materials					
Independent qualification for materials testing					
More competition in the materials supply chain					
More fashionable materials					
More research					
NZ standards system for materials controlled by the government					
Technical advancement					
Waste minimization (increased house standardisation and integration in the supply chain)					
Workshops with suppliers and manufacturers					

Other (please specify)

Section D: Collaboration in the Building Mmaterials Supply Chain

Collaboration in the materials supply chain refers to the working practice whereby building materials manufacturers, suppliers, building contractors, architects and homeowners work together to successfully complete a house construction project.

5. Please indicate the scale that best reflects your agreement with the following statements concerning collaboration in the building materials supply chain.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Collaboration brings better data flow					
Collaboration brings better understanding about the materials flow					
Collaboration ensures cost effectiveness					
Collaboration ensures diversity of products and methodologies					
Collaboration ensures materials availability					
Collaboration ensures right delivery time					
Collaboration ensures various building materials related requirements of different supply chain parties					
Collaboration helps to solve issues in the materials supply chain					
Collaboration increases the trust between different parties in the materials supply chain					
Collaboration increases understanding of total supply chain goals					
Collaboration is bringing teams together and making sure that everyone's delivering their bit as opposed to the tendering process					
Collaboration makes negotiation better					
Collaboration makes strong relationships in the materials supply chain					
Collaboration requires a partnership approach					
Collaboration spreads specialized knowledge across the materials supply chain					

Other (please specify)

Section E: Demographic Data

6. What is the highest level of school you have completed or the highest degree you have received?

- Certificate
- Degree
- Diploma
- Postgraduate

Other (please specify)

7. How many years have you worked in the construction industry?

- Less than 5 years
- 11 – 15 years
- 21 - 25 years
- 6 – 10 years
- 16 – 20 years
- More than 25 years

8. Please indicate the number of employees your company employs

- 0-5
- 16-20
- More than 30
- 6-10
- 21-25
- 11-15
- 26-30

9. Generally, in what region/s are your material supply yards/branches located? (You may tick more than one box)

- Auckland
- Wellington
- Canterbury
- Waikato
- Otago
- Southland
- Northland
- Taranaki
- West Coast
- Bay of Plenty
- Manawatu-Wanganui
- Marlborough
- Gisborne
- Tasman
- Hawke's Bay
- Nelson

Other (please specify)

End of questionnaire

You have now reached the end of the survey. Thank you for your cooperation in completing this questionnaire. Your effort and time is highly appreciated. We are confident that the information you provided will greatly assist us in our research. If you have any queries please do not hesitate to contact me by phone or email. If you would like to request a copy of my research findings or have any comments/suggestions, you are more than welcome to do so.

Once again thank you for your support!

Any inquiries regarding this questionnaire please contact:

Researcher
Name: Don Samarasinghe
E-mail: asamaras@aut.ac.nz
Phone: 09 921 9999 ext.8109
Fax: 09 92109999

Research Supervisors

Name: Associate Professor John E. Tookey
E-mail: jtookey@aut.ac.nz
Phone: 09 921 9512
Fax: 09 92109999

Name: Dr James Rotimi
E-mail: jrotimi@aut.ac.nz
Phone: 09 921 9999 ext 6450
Fax: 09 92109999

APPENDIX – 3 (C)

QUESTIONNAIRE

Improving Materials Supply Chain in New Zealand Residential Construction Industry: An Exploratory Study

(Architects)

Consent to participate

Dear Participant,

You are about to participate in a survey which is a part of research undertaken at AUT University. The primary objective of this research is to develop an empirical understanding of the critical factors influencing the building materials supply chain and to integrate those factors to bring about better practices in the New Zealand residential construction materials supply chain. Your participation in the survey is voluntary and your responses will be kept strictly confidential.

This questionnaire comprises six sections:

Section A: Building materials selecting practices
Section B: Issues in the construction materials supply chain
Section C: Suggestions for improving the building materials supply chain
Section D: Collaboration in the building materials supply chain
Section E: Challenges in the building materials supply chain
Section F: Demographic data

It will take you not more than 20 minutes to complete the questionnaire.Your kind cooperation is highly appreciated.

ALL RESPONSES WILL BE TREATED IN THE STRICTEST CONFIDENCE.

Any inquiries regarding this questionnaire please contact:

Researcher
Name: Don Samarasinghe
E-mail: asamaras@aut.ac.nz
Phone: 09 921 9999 ext.8109
Fax: 09 92109999

Research Supervisors

Name: Associate Professor John E. Tookey
E-mail: jtookey@aut.ac.nz
Phone: 09 921 9512
Fax: 09 92109999

Name: Dr James Rotimi
E-mail: jrotimi@aut.ac.nz
Phone: 09 921 9999 ext 6450
Fax: 09 92109999

Section A: Materials Selection Practices

1. How significant are the following criteria when you select building materials?

	Unimportant	Of little importance	Moderately important	Important	Very important
Accurate information					
Architectural concepts					
Good communication with suppliers					
Homeowner's brief					
Knowledge and experience					
Materials specifications					
New products in the market					
Quality and satisfactory outcome					
Relationships with other architects					
Relationships with suppliers/manufacturers					
Site conditions					
The material is fit for purpose					

Other (please specify)

Section B: Issues in the Construction Supply Chain

2. How serious are the following issues in current building materials supply chain practices in New Zealand?

	Is not a serious issue	Is not an issue	Neutral	Is an issue	Is a serious issue
Complexity in the building code					
Complicated consenting process					
Constant flux in the building code					
Fewer choices					
Fragmented industry					
Homeowners lack of understanding about materials					
Inferior products					
IT infrastructure					
Materials substitution (non-adherence to materials specified)					
Poor collaboration across the supply chain					
Poor contractor service					
Price of materials					
Site safety					
There are no real NZ standards for materials					
Unreliable suppliers/manufacturers					
Wastage (bespoke nature of houses)					

Other (please specify)

Section C: Suggestions for Improving the Building Materials Supply Chain

3. How significant are the following criteria in improving the current building materials supply practices?

	Unimportant	Of little importance	Moderately important	Important	Very important
Building consent should not allow contractors to change the materials specified by architects					
Central materials specification system on Web					
Customer opinions and surveys					
Enhanced building inspector and builder relationship					
Good communication					
Homeowner education on materials					
Independent qualification for materials testing					
More competition in the materials supply chain					
More fashionable materials					
More research					
NZ standards system for materials controlled by the government					
Technical advancement					
Waste minimization (increased house standardisation and integration in the supply chain)					

Other (please specify)

Section D: Collaboration in the Building Materials Supply Chain

Collaboration in the materials supply chain refers to the working practice whereby building materials manufacturers, suppliers, building contractors, architects and homeowners work together to successfully complete a house construction project.

4. Please indicate the scale that best reflects your agreement with the following statements concerning collaboration in the building materials supply chain.

	Unimportant	Of little importance	Moderately important	Important	Very important
Collaboration brings better data flow					
Collaboration brings better understanding about the material flow					
Collaboration ensures cost effectiveness					
Collaboration ensures diversity of products and methodologies					
Collaboration ensures materials availability					
Collaboration ensures right delivery time					
Collaboration ensures various building materials related requirements of different supply chain parties					
Collaboration helps to solve issues in the materials supply chain					
Collaboration increases the trust between different parties in the materials supply chain					
Collaboration increases understanding of total supply chain goals					
Collaboration is bringing teams together and making sure that everyone's delivering their bit as opposed to the tendering process					
Collaboration makes negotiation better					
Collaboration makes strong relationships in the materials supply chain					
Collaboration requires a partnership approach					
Collaboration spreads specialized knowledge across the materials					

Other (please specify)

Section E: Demographic Data

5. What is the highest level of school you have completed or the highest degree you have received?

- Certificate
- Degree
- Diploma
- Postgraduate

Other (please specify)

6. How many years have you worked in the Zealand construction industry?

- Less than 5 years
- 11 – 15 years
- 21 - 25 years
- 6 – 10 years
- 16 – 20 years
- More than 25 years

7. Please indicate the number of employees your company employs

- 0-5
- 16-20
- More than 30
- 6-10
- 21-25
- 11-15
- 26-30

8. Generally, in what region/s have you undertaken housing projects? (You may tick more than one box)

- Auckland
- Wellington
- Canterbury
- Waikato
- Otago
- Southland
- Northland
- Taranaki
- West Coast
- Bay of Plenty
- Manawatu-Wanganui
- Marlborough
- Gisborne
- Tasman
- Hawke's Bay
- Nelson

Other (please specify)

End of questionnaire

You have now reached the end of the survey. Thank you for your cooperation in completing this questionnaire. Your effort and time is highly appreciated. We are confident that the information you provided will greatly assist us in our research. If you have any queries please do not hesitate to contact me by phone or email. If you would like to request a copy of my research findings or have any comments/suggestions, you are more than welcome to do so.

Once again thank you for your support!

Any inquiries regarding this questionnaire please contact:

Researcher
Name: Don Samarasinghe
E-mail: asamaras@aut.ac.nz
Phone: 09 921 9999 ext.8109
Fax: 09 92109999

Research Supervisors

Name: Associate Professor John E. Tookey
E-mail: jtookey@aut.ac.nz
Phone: 09 921 9512
Fax: 09 92109999

Name: Dr James Rotimi
E-mail: jrotimi@aut.ac.nz
Phone: 09 921 9999 ext 6450
Fax: 09 92109999

APPENDIX – 3 (D)

QUESTIONNAIRE

Improving Materials Supply Chain in New Zealand Residential Construction Industry: An Exploratory Study

(Home Owners)

Consent to participate

Dear Participant,

You are about to participate in a survey which is a part of research undertaken at AUT University. The primary objective of this research is to develop an empirical understanding of the critical factors influencing the building materials supply chain and to integrate those factors to bring about better practices in the New Zealand residential construction materials supply chain. Your participation in the survey is voluntary and your responses will be kept strictly confidential.

This questionnaire comprises six sections:

Section A: Building materials selecting practices
Section B: Issues in the construction materials supply chain
Section C: Suggestions for improving the building materials supply chain
Section D: Collaboration in the building materials supply chain
Section E: Challenges in the building materials supply chain
Section F: Demographic data

It will take you not more than 15 minutes to complete the questionnaire.Your kind cooperation is highly appreciated.

ALL RESPONSES WILL BE TREATED IN THE STRICTEST CONFIDENCE.

Any inquiries regarding this questionnaire please contact:

Researcher
Name: Don Samarasinghe
E-mail: asamaras@aut.ac.nz
Phone: 09 921 9999 ext.8109
Fax: 09 92109999

Research Supervisors

Name: Associate Professor John E. Tookey
E-mail: jtookey@aut.ac.nz
Phone: 09 921 9512
Fax: 09 92109999

Name: Dr James Rotimi
E-mail: jrotimi@aut.ac.nz
Phone: 09 921 9999 ext 6450
Fax: 09 92109999

Section A: Materials Selection Practices

1. How significant are the following criteria when you make materials selection decisions?

	Unimportant	Of little importance	Moderately important	Important	Very important
Appearance					
Availability of bigger showroom					
Fashion and trends					
Functionality, properties, specifications, and the feel of materials					
Homeowner's requirements					
Maintenance					
Material supplier's reputation					
Materials information availability on the Web					
Opinions from others (e.g. friends)					
Quality and Satisfactory outcome					
Relationship with architect					
Relationship with contractor					
Relationships with materials suppliers and manufacturers					
Support local industry by choosing local products					
Where they come from					

Other (please specify)

Section B: Issues in the Construction Supply Chain

2. How serious are the following issues in current building materials supply chain practices?

	Is not a serious issue	Is not an issue	Neutral	Is an issue	Is a serious issue
Fewer choices					
Fragmented industry					
Inferior products					
Materials substitution (non-adherence to materials specified)					
Poor collaboration across the supply chain					
Price of materials					
Wastage (Bespoke nature of houses)					

Other (please specify)

Section C: Suggestions for Improving the Building Materials Supply Chain

3. How serious are the following criteria in improving the current building materials supply practices?

	Is not a serious challenge	Is not a challenge	Neutral	Is a challenge	Is a serious challenge
Central materials specification system on Web					
Customer opinions and surveys					
Good communication					
Homeowner education on materials					
More fashionable materials					
More research					
Technical advancement					
Transparency around stock levels					
Waste minimization					

Other (please specify)

Section D: Collaboration in the Building Mmaterials Supply Chain

Collaboration in the materials supply chain refers to the working practice whereby building materials manufacturers, suppliers, building contractors, architects and homeowners work together to successfully complete a house construction project.

4. Please indicate the scale that best reflects your agreement with the following statements concerning collaboration in the building materials supply chain.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Collaboration brings better data flow					
Collaboration brings better understanding about the material flow					
Collaboration ensures cost effectiveness					
Collaboration ensures diversity of products and methodologies					
Collaboration ensures materials availability					
Collaboration ensures right delivery time					
Collaboration ensures various building materials related requirements of different supply chain parties					
Collaboration helps to solve issues in the materials supply chain					
Collaboration increases the trust between different parties in the materials supply chain					
Collaboration increases understanding of total supply chain goals					
Collaboration is bringing teams together and making sure that everyone's delivering their bit as opposed to the tendering process					
Collaboration makes negotiation better					
Collaboration makes strong relationships in the materials supply chain					
Collaboration requires a partnership approach					
Collaboration spreads specialized knowledge across the materials					

Other (please specify)

Section E: Demographic data

5. What is the highest level of school you have completed or the highest degree you have received?

- ○ Postgraduate
- ○ Diploma
- ○ Degree
- ○ Certificate

Other (please specify)

6. Where is your house located in?

- ☐ Auckland
- ☐ Hawke's Bay
- ☐ Tasman
- ☐ Waikato
- ☐ Wellington
- ☐ Nelson
- ☐ Northland
- ☐ Otago
- ☐ Southland
- ☐ Bay of Plenty
- ☐ Taranaki
- ☐ West Coast
- ☐ Gisborne
- ☐ Manawatu-Wanganui
- ☐ Marlborough

Other (please specify)

End of questionnaire

You have now reached the end of the survey. Thank you for your cooperation in completing this questionnaire. Your effort and time is highly appreciated. We are confident that the information you provided will greatly assist us in our research. If you have any queries please do not hesitate to contact me by phone or email. If you would like to request a copy of my research findings or have any comments/suggestions, you are more than welcome to do so.

Once again thank you for your support!

Any inquiries regarding this questionnaire please contact:

Researcher
Name: Don Samarasinghe
E-mail: asamaras@aut.ac.nz
Phone: 09 921 9999 ext.8109
Fax: 09 92109999

Research Supervisors

Name: Associate Professor John E. Tookey
E-mail: jtookey@aut.ac.nz
Phone: 09 921 9512
Fax: 09 92109999

Name: Dr James Rotimi
E-mail: jrotimi@aut.ac.nz
Phone: 09 921 9999 ext 6450
Fax: 09 92109999

APPENDIX – 4 (A)

Consent Form

(SME Interviews)

Project title: ***Improving Materials Supply Chain in New Zealand Residential Construction Industry: An Exploratory Study***

Project Supervisors: ***Professor John E Tookey and Dr James Rotimi***

Researcher: ***Don Samarasinghe***

- ○ I have read and understood the information provided about this research project in the Information Sheet dated 01 August 2012.
- ○ I have had an opportunity to ask questions and to have them answered.
- ○ I understand that notes will be taken during the interviews and that they will also be audio-taped and transcribed.
- ○ I understand that I may withdraw myself or any information that I have provided for this project at any time prior to completion of data collection, without being disadvantaged in any way.
- ○ If I withdraw, I understand that all relevant information including tapes and transcripts, or parts thereof, will be destroyed.
- ○ I agree to take part in this research.
- ○ I wish to receive a copy of the report from the research

Participant's signature: ……………………………………………………………………………………

Participant's name: ……………………………………………………………………………………

Participant's Contact Details (if appropriate):

………………………………………………………………………………………..

………………………………………………………………………………………..

………………………………………………………………………………………..

………………………………………………………………………………………..

Date:

Approved by the Auckland University of Technology Ethics Committee on 24 August 2012 AUTEC Reference number 12/112

Note: The Participant should retain a copy of this form.

APPENDIX – 4 (B)

Participant Information Sheet

(SME Interviews)

Date Information Sheet Produced:

01 August 2012

Project Title

Improving Materials Supply Chain in the New Zealand Residential Construction Industry: An Exploratory Study

An Invitation

My name is Don Samarasinghe and I am a doctoral candidate at AUT University. I invite you to participate in this research on improving materials supply chain in the New Zealand residential construction industry. This research will form the basis of my doctorate thesis. Your participation in this research is voluntary and you may withdraw from this research at any time, without providing an explanation and this will not affect you in anyway.

What is the purpose of this research?

This research aims to develop an empirical understanding of the critical factors influencing the building materials supply chain and to integrate those factors in terms of buying and supply behaviours to bring better practices in the New Zealand residential construction materials supply chain. This survey is a follow-on exercise to a set of semi-structured interviews and an online survey administered earlier this year. The data from both interviews and the online survey have been analysed and the results are now presented to you for verification and additional input.

How was I identified and why am I being invited to participate in this research?

You are invited to participate in this survey as a professional who has knowledge of supply chain management in the New Zealand residential construction sector. It will be highly appreciated if you could fill out the attached questionnaire and supply any additional information which you feel is useful based, on your experience.

What will happen in this research?

It is important to understand that your involvement in this study is voluntary. While I would be pleased to have you participate, I respect your right to decline. If you agree to participate in this project, I will invite you participate in this interview. It will take you approximately 30 minutes to complete this survey.

What are the discomforts and risks?

Participants are not required to divulge any personal feelings about their work or their organisation and therefore there should be no emotional or psychological risks to the participants in this research. Participants' privacy and confidentiality are assured. No personal information is sought that may divulge a participant's identity. Any reporting of findings will have no names or details of demographics that will permit identification of participants.

How will these discomforts and risks be alleviated?

At any time during the survey, you may choose not to answer questions that you may find distressing. You may also withdraw from the survey and request for your data to be destroyed. You may also request for a copy of my final thesis when it is available. It is most unlikely that any discomfort of any type will be felt since the research involved is the discussion of professional practice within a professional organization by recognized professionals in their field. Consequently, given that anonymity can be guaranteed using the protocol explained, there is minimal likelihood of discomfort.

What are the benefits?

You will be contributing valued information that could assist this proposed research study. In addition, you will be assisting me in completing my PhD thesis.

How will my privacy be protected?

All information collected from you will be kept strictly confidential. Your answers to survey and your consent form will be stored under lock and key. Only the researcher and supervisors have access to them. None of your personal information will be disclosed to any third parties or in any part of this research output (thesis, journal/conference papers).

What are the costs of participating in this research?

There is no financial cost involved in participating in this research. The only cost of participating is the time given to answer the questions.

What opportunity do I have to consider this invitation?

Your participation is voluntary. It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep and be requested to participate in the interview.

How do I agree to participate in this research?

Your consent to participate in this research is obtained through a consent form. If you decide to participate by signing the consent form, this will be considered as your consent.

Will I receive feedback on the results of this research?

All participants are entitled to feedback from this study. A summary of research findings will be provided through an open access website (http://www.constructionproductivity.org.nz/). I will also inform any imminent publications concerning the findings of the project.

What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisors, Professor John E. Tookey (email: jtookey@aut.ac.nz or office telephone: 09-921 9512) or Dr James Rotimi [email: jrotimi@aut.ac.nz or office telephone: 09-921 9999 (ext 6450)]. Concerns regarding the conduct of the research should be notified to the Executive Secretary, AUTEC, Dr Rosemary Godbold, rosemary.godbold@aut.ac.nz , 921 9999 ext 6902.

Whom do I contact for further information about this research?

Researcher Contact Details:

Don Samarasinghe (email: asamaras@aut.ac.nz or office telephone: 09-921 9999 ext.8109).

Project Supervisors Contact Details:

Professor John E. Tookey (email: jtookey@aut.ac.nz or office telephone: 09-921 9512).

Dr James Rotimi [email: jrotimi@aut.ac.nz or office telephone: 09-921 9999 (ext 6450)].

Approved by the Auckland University of Technology Ethics Committee on *type the date final ethics approval was granted*, AUTEC Reference number *12/112*.

APPENDIX – 4 (C)

Improving Materials Supply Chain in New Zealand Residential Construction Industry: An Exploratory Study

Validation Exercise - Manufacturers/Suppliers (SME-01)

This questionnaire is a follow-on exercise to a set of semi-structured interviews and an online survey administered within the New Zealand residential construction sector earlier this year. The data from interviews and the online survey have been analysed and the results are now presented to you for verification and additional input.

You are requested to provide your comments for the following key research findings.

1. The current research identified that building materials manufacturers/suppliers consider 10 main criteria (see Table 1) when they make materials supply decisions. Could you explain the significance of the most important criteria in the space provided?

Table 4

Rank	Criteria
01	Having strong relationships with customers: This would allow manufacturers/suppliers to stay in the supply chain.
02	On time delivery (shortest possible time of delivery), delivery with a good service to ensure that the customer is satisfied.
03	Having available and supplying a wide range of materials as most houses are customised in New Zealand.
04	Customer satisfaction/understanding customer needs (this is a mix of how well customers have experienced the business in terms of payment; how well customers have been able to utilize the product on the construction site and how accessible and helpful manufacturers were in that specification process).
05	Offering a competitive price with good quality. Price is an important factor because low profit margins do not ensure the long-run stability of the business.
06	Product quality requirements.
07	Collaboration and partnership in the materials supply chain to ensure the lowest supply chain cost and supply chain time.
08	Having a good logistics system (transportation and warehousing).
09	Having a sophisticated computer system to estimate materials requirements (demand) very efficiently.
10	Use of waste minimisation strategies.

2. The current research identified 07 major issues (see Table 2) in the New Zealand building materials supply chain from the manufacturers/suppliers point of view. Could you explain the significance of the most serious issues in the space provided?

Table 5

Rank	Issues
01	High building materials prices
02	Cheap products with lower quality are available in the market. This could create leaky home

	issues/ similarly costly issues.
03	Poor communication (collaboration) in the supply chain that significantly increases the time taken to find the right product.
04	Materials wastage. This could be because of the lack of collaboration in the supply chain and bespoke nature of the houses. Having very customised houses also requires purchasing specific sizes, colours, shapes, and various other very-customised requirements. This creates less efficiency in the building materials supply chain as the supplying process becomes more complicated.
05	High transport costs.
06	High labour costs.
07	Expensive products certification methods

3. The current research identified 10 main suggestions (see Table 3) to improve the New Zealand building materials supply chain from the manufacturers/suppliers point of view. Could you briefly explain the significance of the most important suggestions in the space provided?

Table 6

Rank	Suggestions
01	Waste minimization strategies (e.g. house standardisation, increased integration in the supply chain). For example, lack of focus on collaboration between developer/owner, architect/designer, contractor, and supplier/manufacturer could lead to enormous waste (time, energy, materials).
02	Technical advancement: use of modern electronic equipment and technology in the supply chain to make the decision process much quicker and smarter.
03	There should be a central materials specification system with available sources, relative quality, and price on the Web. This system should be able to evaluate different types of products, in terms of performance, price, durability, and warranty. So that the choice between products is more empirical rather than based on anecdotal or sales staff evidence. This would help homeowners make provisional decisions on materials.
04	Increased communication in the supply chain would increase the efficiency of the information flow across it. This will more efficiently enable finding the right materials.
05	Homeowners should be educated on selecting right materials. This would eliminate having unsuitable materials in houses which result in excessive house maintenance costs.
06	More research on building materials supply chain practices.
07	More competition in the materials supply chain.
08	There should be an independent qualification for materials testing. This would be a central body that is responsible for the analysis of certain materials and then architects are able to find information on materials easily and quickly. This central body should assist architects to obtain real life samples of those materials cost information (which would come from the suppliers).
09	Having better infrastructure in New Zealand would improve the logistical aspects of the building materials supply chain.
10	An improved system to control payment problem

4. Current research identified 15 main constructs under 3 main themes (see Table 4) that describe the significance of collaboration in the New Zealand building materials supply chain. Could you briefly comment on them?

Table 4

Constructs
Collaboration ensures the right building materials
Collaboration ensures various building materials related requirements of different supply chain parties
Collaboration brings better understanding about the information flow
Collaboration brings better understanding about the materials flow
Collaboration builds better teamwork
Collaboration increases trust between different parties in the supply chain
Collaboration increases understanding of total supply chain goals
Collaboration is bringing teams together and making sure that everyone is delivering their bit (as opposed to the tendering process).
Collaboration requires a partnership approach
Collaboration makes negotiation better
Collaboration makes strong relationships in the materials supply chain
Collaboration spreads specialized knowledge across the materials supply chain
Other benefits
Collaboration ensures cost effectiveness
Collaboration ensures diversity of products and methodologies
Collaboration ensures materials availability
Collaboration ensures right delivery time
Collaboration helps to solve issues in the materials supply chain

Demographic information

Organisation profile in brief
Profession
Main roles played
Work experience in the construction industry
Educational qualifications

You have now reached the end of the survey. Thank you for your cooperation in completing this questionnaire. *Your effort and time is highly appreciated.* We are confident that the information you provided will greatly assist us in our research.

APPENDIX – 4 (D)

Improving Materials Supply Chain in New Zealand Residential Construction Industry: An Exploratory Study

Validation Exercise – Contractors (SME-02)

This questionnaire is a follow-on exercise to a set of semi-structured interviews and an online survey administered within the New Zealand residential construction sector earlier this year. The data from interviews and the online survey have been analysed and the results are now presented to you for verification and additional input.

You are requested to provide your comments for the following key research findings.

1. The current research identified that building contractors consider 10 major criteria (see Table 1) when they make materials purchasing decisions. Could you briefly explain the significance of the most important criteria in the space provided?

Table 1

Rank	Criteria
01	Making sure that materials are good quality products that are not going to fail in the near future, and they will last the time of the warranties.
02	Price of materials: Securing a project is evaluated based on price. That price driven focus is required by the clients and goes right through the business.
03	Being more organized. for example, there can be a quality management system which runs alongside each project and that controls materials quality and testing.
04	Sourcing the right materials in terms of specifications (what the homeowner wants) and the products are installed and completed in accordance with them.
05	Degree of negotiation with suppliers.
06	Repetitive business: This would yield best possible deal.
07	Supplier’s service
08	Ability to forecast future supplier performance as a result of past performance.
09	Past experience and knowledge.
10	Collaboratively working with the supply chain

2. The current research identified 09 major issues (see Table 2) in the New Zealand building materials supply chain from the contractors’ point of view. Could you briefly explain the significance of the most serious issues in the space provided?

Table 2

Rank	Issues
01	High building materials prices
02	Cheap products with lower quality are available in the market. This could create leaky home issues/ similarly costly issues.

03	Poor communication (collaboration) in the supply chain that significantly increases the time taken to find the right product.
04	Materials wastage. This could be because of the lack of collaboration in the supply chain and bespoke nature of the houses. Having very customised houses also requires purchasing specific sizes, colours, shapes, and various other very-customised requirements. This creates less efficiency in the building materials supply chain as the supplying process becomes more complicated.
05	High transport costs.
06	Constant flux in the building code: The materials that are available in the codes and what is permitted to be used are changing constantly.
07	Complexity in the building code: Complexity in the current building code creates the issues of understanding what is right and not right, and what system needs to go with what other system to give the best outcome.
08	No supplier quality assurance.
09	Delivery issues

3. The current research identified 09 main suggestions (see Table 3) to improve the New Zealand building materials supply chain from the contractors' point of view. Could you explain the significance of the most important suggestions in the space provided?

Table 3

Rank	Suggestions
01	Waste minimization strategies (e.g. house standardisation, increased integration in the supply chain). For example, lack of focus on collaboration between developer/owner, architect/designer, contractor, and supplier/manufacturer could lead to enormous waste (time, energy, materials).
02	Technical advancement: use of modern electronic equipment and technology in the supply chain to make the decision process much quicker and smarter.
03	There should be a central materials specification system with available sources, relative quality, and price on the Web. This system should be able to evaluate different types of products, in terms of performance, price, durability, and warranty. So that the choice between products is more empirical rather than based on anecdotal or sales staff evidence. This would help homeowners make provisional decisions on materials.
04	Increased communication in the supply chain would increase the efficiency of the information flow across it. This will more efficiently enable finding the right materials.
05	Homeowners should be educated on selecting right materials. This would eliminate having unsuitable materials in houses which result in excessive house maintenance costs.
06	More research on building materials supply chain practices.
07	More competition in the materials supply chain.
08	There should be an independent qualification for materials testing. This would be a central body that is responsible for the analysis of certain materials and then architects are able to find information on materials easily and quickly. This central body should assist architects to obtain real life samples of those materials cost information (which would come from the suppliers).
09	Having better infrastructure in New Zealand would improve the logistical aspects of the building materials supply chain.

4. Current research identified 15 main constructs under 3 main themes (see Table 4) that describe the significance of collaboration in the New Zealand building materials supply chain. Could you briefly comment on them?

Table 4

Constructs
Collaboration ensures the right building materials
Collaboration ensures various building materials related requirements of different supply chain parties
Collaboration brings better understanding about the information flow
Collaboration brings better understanding about the materials flow
Collaboration builds better teamwork
Collaboration increases trust between different parties in the supply chain
Collaboration increases understanding of total supply chain goals
Collaboration is bringing teams together and making sure that everyone is delivering their bit (as opposed to the tendering process).
Collaboration requires a partnership approach
Collaboration makes negotiation better
Collaboration makes strong relationships in the materials supply chain
Collaboration spreads specialized knowledge across the materials supply chain
Other benefits
Collaboration ensures cost effectiveness
Collaboration ensures diversity of products and methodologies
Collaboration ensures materials availability
Collaboration ensures right delivery time
Collaboration helps to solve issues in the materials supply chain

Demographic information

Organisation profile in brief
Profession
Main roles played
Work experience in the construction industry
Educational qualifications

You have now reached the end of the survey. Thank you for your cooperation in completing this questionnaire. *Your effort and time is highly appreciated.* We are confident that the information you provided will greatly assist us in our research.

APPENDIX – 4 (E)

Improving Materials Supply Chain in New Zealand Residential Construction Industry: An Exploratory Study

Validation Exercise – Architects (SME-03)

This questionnaire is a follow-on exercise to a set of semi-structured interviews and an online survey administered within the New Zealand residential construction sector earlier this year. The data from interviews and the online survey have been analysed and the results are now presented to you for verification and additional input.

You are requested to provide your comments for the following key research findings.

1. The current research identified that architects consider 09 main criteria (see Table 1) when they make materials selection decisions. Could you briefly explain further explain the significance of the most important criteria in the space provided?

Table 1

Rank	Criteria
01	The material is fit for purpose based on its properties.
02	Architect should be able to find accurate information about materials (e.g. availability of a sample, testing reports, materials availability, etc.) Most updated information about materials in the industry (e.g. what materials have failed, what are the well-performing materials, etc.).
03	Quality and satisfactory outcome of materials (suppliers' responsibility for a replacement if required): Having low quality building materials would increase the life cycle cost of the materials.
04	Materials specifications (NZBC requirements, drawing specifications)
05	Homeowner's brief (e.g. budget, living style, likes, dislikes, etc.).
06	Architect's knowledge and experience.
07	Good communication with suppliers so that clear information about materials can be obtained (e.g. materials testing reports, specifications, quality, suitability, etc.).
08	Architectural concepts (e.g. wood house or a concrete house, or a glassy house).
09	Site conditions.

2. The current research identified 8 major issues (see Table 2) in the New Zealand building materials supply chain from the architects' point of view. Could you briefly explain the significance of the most serious issues in the space provided?

Table 27

Rank	Issues
01	High building materials prices
02	Cheap products with lower quality are available in the market. This could create leaky home issues/ similarly costly issues.

03	Poor communication (collaboration) in the supply chain that significantly increases the time taken to find the right product.
04	Constant flux in the building code: The materials that are available in the codes and what is permitted to be used are changing constantly.
05	Complexity in the building code: Complexity in the current building code creates the issues of understanding what is right and not right, and what system needs to go with what other system to give the best outcome.
06	Materials substitution (non-adherence to materials specified): where the architect specifies a particular material but the contractor wants to change to different materials which look the same but its performance could be different.
07	Complicated consenting process involved with getting approval for the materials chosen for a house.
08	Poor contractor service A lot of products fail because they are not properly assembled. The reason is the poor information transmission between manufacturer/supplier and assembler.

3. The current research identified 10 main suggestions (see Table 3) to improve the New Zealand building materials supply chain from the architects' point of view. Could you briefly explain the significance of the most important suggestions in the space provided?

Table 3

Rank	Suggestions
01	Waste minimization strategies (e.g. house standardisation, increased integration in the supply chain). For example, lack of focus on collaboration between developer/owner, architect/designer, contractor, and supplier/manufacturer could lead to enormous waste (time, energy, materials).
02	Technical advancement: use of modern electronic equipment and technology in the supply chain to make the decision process much quicker and smarter.
03	There should be a central materials specification system with available sources, relative quality, and price on the Web. This system should be able to evaluate different types of products, in terms of performance, price, durability, and warranty. So that the choice between products is more empirical rather than based on anecdotal or sales staff evidence. This would help homeowners make provisional decisions on materials.
04	Increased communication in the supply chain would increase the efficiency of the information flow across it. This will more efficiently enable finding the right materials.
05	Homeowners should be educated on selecting right materials. This would eliminate having unsuitable materials in houses which result in excessive house maintenance costs.
06	More research on building materials supply chain practices.
07	More competition in the materials supply chain.
08	There should be an independent qualification for materials testing. This would be a central body that is responsible for the analysis of certain materials and then architects are able to find information on materials easily and quickly. This central body should assist architects to obtain real life samples of those materials cost information (which would come from the suppliers).
09	Building consents should not allow contractors to change the materials specified by architects
10	Enhanced building inspector and builder relationship

4. Current research identified 15 main constructs under 3 main themes (see Table 4) that describe the significance of collaboration in the New Zealand building materials supply chain. Could you briefly comment on them?

Table 4

Constructs
Collaboration ensures the right building materials
Collaboration ensures various building materials related requirements of different supply chain parties
Collaboration brings better understanding about the information flow
Collaboration brings better understanding about the materials flow
Collaboration builds better teamwork
Collaboration increases trust between different parties in the supply chain
Collaboration increases understanding of total supply chain goals
Collaboration is bringing teams together and making sure that everyone is delivering their bit (as opposed to the tendering process).
Collaboration requires a partnership approach
Collaboration makes negotiation better
Collaboration makes strong relationships in the materials supply chain
Collaboration spreads specialized knowledge across the materials supply chain
Other benefits
Collaboration ensures cost effectiveness
Collaboration ensures diversity of products and methodologies
Collaboration ensures materials availability
Collaboration ensures right delivery time
Collaboration helps to solve issues in the materials supply chain

Demographic information

Organisation profile in brief
Profession
Main roles played
Work experience in the construction industry
Educational qualifications

You have now reached the end of the survey. Thank you for your cooperation in completing this questionnaire. *Your effort and time is highly appreciated.* We are confident that the information you provided will greatly assist us in our research.

APPENDIX – 4 (F)

Improving Materials Supply Chain in New Zealand Residential Construction Industry: An Exploratory Study

Validation Exercise – Homeowners (SME-04)

This questionnaire is a follow-on exercise to a set of semi-structured interviews and an online survey administered within the New Zealand residential construction sector earlier this year. The data from interviews and the online survey have been analysed and the results are now presented to you for verification and additional input.

You are requested to provide your comments for the following key research findings.

1. The current research identified that homeowners consider 8 main criteria (see Table 1) when they make materials selection decisions. Could you briefly explain the significance of the most important criteria in the space provided?

Table 1

Rank	Criteria
01	Quality and satisfactory outcome of materials (suppliers' responsibility for a replacement if required): Having low quality building materials would increse the life cycle cost of the materials.
02	Functionality, properties, and feelings of materials (e.g. insulation, ventilation, reflection index, etc.).
03	Aesthetic value: Visual impression of the building materials is important as it affects the appearance of the house.
04	The level of maintenance affordability of the house: The level of maintenance of the house is affected by the type of materials used. Therefore, materials should be carefully chosen in accordance with maintenance affordability.
05	Homeowner's requirements (Budget, number of people that are expected to stay in the home and their living styles, emotional backgrounds, what they like, what they dislike, etc.)
06	Materials supplier's reputation in the industry.
07	Homeowner's relationship with contractor: Homeowners collaborate with building contractor when they make material selection decisions.
08	Homeowner's relationship with architect: Homeowners collaborate with architect when they make material selection decisions.

2. The current research identified 5 major issues (see Table 2) in the New Zealand building materials supply chain from the homeowners' point of view. Could you explain the significance of the most serious issues in the space provided?

Table 2

Rank	Issues

01	High building materials prices
02	Cheap products with lower quality are available in the market. This could create leaky home issues/ similarly costly issues.
03	Poor communication (collaboration) in the supply chain that significantly increases the time taken to find the right product.
04	Materials wastage. This could be because of the lack of collaboration in the supply chain and bespoke nature of the houses. Having very customised houses also requires purchasing specific sizes, colours, shapes, and various other very-customised requirements. This creates less efficiency in the building materials supply chain as the supplying process becomes more complicated.
05	Materials substitution (non-adherence to materials specified): where the architect specifies a particular material but the contractor wants to change to different materials which look the same but its performance could be different.

3. The current research identified 6 main suggestions (see Table 3) to improve the New Zealand building materials supply chain from the homeowners' point of view. Could you explain the significance of the most important suggestions in the space provided?

Table 3

Rank	Suggestions
01	Waste minimization strategies (e.g. house standardisation, increased integration in the supply chain). For example, lack of focus on collaboration between developer/owner, architect/designer, contractor, and supplier/manufacturer could lead to enormous waste (time, energy, materials).
02	Technical advancement: use of modern electronic equipment and technology in the supply chain to make the decision process much quicker and smarter.
03	There should be a central materials specification system with available sources, relative quality, and price on the Web. This system should be able to evaluate different types of products, in terms of performance, price, durability, and warranty. So that the choice between products is more empirical rather than based on anecdotal or sales staff evidence. This would help homeowners make provisional decisions on materials.
04	Increased communication in the supply chain would increase the efficiency of the information flow across it. This will more efficiently enable finding the right materials.
05	Homeowners should be educated on selecting right materials. This would eliminate having unsuitable materials in houses which result in excessive house maintenance costs.
06	More research on building materials supply chain practices.

4. Current research identified 15 main constructs under 3 main themes (see Table 4) that describe the significance of collaboration in the New Zealand building materials supply chain. Could you briefly comment on them?

Table 4

Constructs
Collaboration ensures the right building materials
Collaboration ensures various building materials related requirements of different supply chain parties
Collaboration brings better understanding about the information flow
Collaboration brings better understanding about the materials flow
Collaboration builds better teamwork
Collaboration increases trust between different parties in the supply chain

Collaboration increases understanding of total supply chain goals
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Collaboration spreads specialized knowledge across the materials supply chain
Other benefits
Collaboration ensures cost effectiveness
Collaboration ensures diversity of products and methodologies
Collaboration ensures materials availability
Collaboration ensures right delivery time
Collaboration helps to solve issues in the materials supply chain

Demographic information

Organisation profile in brief
Profession
Main roles played
Work experience in the construction industry
Educational qualifications

You have now reached the end of the survey. Thank you for your cooperation in completing this questionnaire. *Your effort and time is highly appreciated.* We are confident that the information you provided will greatly assist us in our research.

APPENDIX – 5

Table 1: Descriptive statistics - Issues in the BMSC

Issues	Participant group	N	Mean (M)	Std. deviation	Std. error	95% confidence interval for mean	
						Lower bound	Upper bound
Price of materials	Manufacturers & Suppliers	36	3.97	0.878	0.146	3.67	4.26
	Contractors	28	4.33	0.588	0.111	4.11	4.56
	Architects	59	4.06	0.752	0.098	3.87	4.26
	Homeowners	23	4.09	0.793	0.165	3.74	4.43
	Total	146	4.09	0.766	0.063	3.97	4.22
Materials substitution (non-adherence to materials specified)	Architects	59	4.09	0.691	0.090	3.91	4.27
	Homeowners	23	3.55	0.891	0.186	3.16	3.93
	Total	82	3.91	0.780	0.065	3.73	3.99
Inferior products	Manufacturers & Suppliers	36	3.80	1.025	0.171	3.45	4.15
	Contractors	28	3.74	0.951	0.180	3.37	4.11
	Architects	59	3.71	0.830	0.108	3.49	3.92
	Homeowners	23	4.30	0.822	0.171	3.95	4.66
	Total	146	3.83	0.919	0.076	3.68	3.98
Poor collaboration across the supply chain	Manufacturers & Suppliers	36	3.67	1.078	0.180	3.30	4.03
	Contractors	28	4.08	0.978	0.185	3.70	4.46
	Architects	59	3.54	0.885	0.115	3.31	3.77
	Homeowners	23	4.09	0.848	0.177	3.72	4.46
	Total	146	3.76	0.969	0.080	3.61	3.92
Fewer choices	Manufacturers & Suppliers	36	3.27	1.040	0.173	2.91	3.62
	Contractors	28	3.09	0.857	0.162	2.75	3.42
	Architects	59	3.41	0.927	0.121	3.17	3.65
	Homeowners	23	3.52	0.790	0.165	3.18	3.86
	Total	146	3.33	0.926	0.077	3.18	3.48
Fragmented industry	Manufacturers & Suppliers	36	3.40	0.913	0.152	3.09	3.71
	Contractors	28	3.30	0.998	0.189	2.92	3.69
	Architects	59	3.24	0.974	0.127	2.99	3.50
	Homeowners	23	3.09	0.848	0.177	2.72	3.45
	Total	146	3.27	0.941	0.078	3.12	3.42
IT infrastructure	Manufacturers & Suppliers	36	3.40	0.701	0.117	3.16	3.64
	Contractors	28	3.30	1.200	0.227	2.84	3.77
	Architects	59	2.96	0.809	0.105	2.75	3.17
	Total	123	3.09	.933	0.077	2.94	3.24
Road traffic	Manufacturers & Suppliers	36	2.75	0.882	0.147	2.45	3.05
	Contractors	28	3.25	1.063	0.201	2.84	3.66
	Total	64	2.75	0.961	0.080	2.59	2.91
Wastage (bespoke nature of houses)	Manufacturers & Suppliers	36	3.36	0.880	0.147	3.07	3.66
	Contractors	28	3.80	0.886	0.167	3.46	4.14
	Architects	59	3.68	0.987	0.158	3.41	4.15
	Homeowners	23	3.70	1.185	0.247	3.18	4.21
	Total	146	3.59	0.979	0.105	3.38	3.80
High transport cost	Manufacturers &	36	3.73	0.954	0.159	3.41	4.06

	Suppliers						
	Contractors	28	3.88	0.955	0.180	3.50	4.25
	Total	64	3.80	0.950	0.119	3.56	4.03
Constant flux in the building code	Contractors	28	3.79	0.902	0.170	3.44	4.14
	Architects	59	3.80	0.965	0.126	3.54	4.05
	Total	87	3.79	0.940	0.101	3.59	3.99
Complexity in the building code	Contractors	28	3.83	0.801	0.151	3.52	4.14
	Architects	59	3.88	0.958	0.125	3.63	4.12
	Total	87	3.86	0.906	0.097	3.67	4.05
Homeowners' lack of understanding about materials	Manufacturers & Suppliers	36	3.63	1.000	0.167	3.30	3.97
	Architects	59	3.16	0.878	0.114	2.93	3.39
	Total	95	3.34	0.949	0.097	3.15	3.53
Site safety	Manufacturers & Suppliers	36	3.80	0.968	0.161	3.47	4.13
	Architects	59	3.17	1.039	0.135	2.90	3.44
	Total	95	3.41	1.053	0.108	3.19	3.62
There are no real New Zealand standards for building materials	Manufacturers & Suppliers	36	3.28	1.119	.186	2.90	3.65
	Architects	59	3.11	1.086	.141	2.83	3.39
	Total	95	3.17	1.096	.112	2.95	3.40

Table 2: One-way ANOVA - Issues in the BMSC

Issues	Participant group	Sum of Squares	*df*	Mean Square	*F*	Sig. (*p*)
Price of materials	Between Groups	2.247	3	0.749	1.282	0.283
	Within Groups	82.939	142	0.584		
	Total	85.186	145			
Materials substitution (non-adherence to materials specified)	Between Groups	5.792	3	1.931	3.329	0.021
	Within Groups	82.344	142	0.580		
	Total	88.136	145			
Inferior products	Between Groups	6.312	3	2.104	2.575	0.056
	Within Groups	116.021	142	0.817		
	Total	122.333	145			
Poor collaboration across the supply chain	Between Groups	8.523	3	2.841	3.159	0.027
	Within Groups	127.731	142	0.900		
	Total	136.255	145			
Fewer choices	Between Groups	3.004	3	1.001	1.173	0.322
	Within Groups	121.269	142	0.854		
	Total	124.273	145			
Fragmented industry	Between Groups	1.449	3	0.483	0.540	0.655
	Within Groups	126.957	142	0.894		
	Total	128.406	145			
IT infrastructure	Between Groups	9.345	3	3.115	3.785	0.012
	Within Groups	116.856	142	0.823		
	Total	126.201	145			
Road traffic	Between Groups	13.843	3	4.614	5.460	0.001
	Within Groups	120.011	142	0.845		
	Total	133.854	145			
Wastage (bespoke nature of houses)	Between Groups	3.336	2	1.668	1.770	0.177
	Within Groups	79.160	84	0.942		
	Total	82.496	86			
High transport cost	Between Groups	.316	1	0.316	0.347	0.558

	Within Groups	56.492	62	0.911		
	Total	56.808	63			
Unreliable supplier/manufacturers	Contractors	3.024	1	3.024	3.821	0.054
	Architects	67.268	85	0.791		
	Total	70.291	86			
Constant flux in the building code	Between Groups	3.024	1	3.024	3.821	0.054
	Within Groups	67.268	85	0.791		
	Total	70.291	86			
Complexity in the building code	Between Groups	0.000	1	0.000	0.000	0.984
	Within Groups	75.918	85	0.893		
	Total	75.918	86			
Homeowner's lack of understanding about materials	Between Groups	0.033	1	0.033	0.040	0.843
	Within Groups	70.583	85	0.830		
	Total	70.616	86			
Site safety	Between Groups	4.940	1	4.940	5.768	0.018
	Within Groups	79.661	93	0.857		
	Total	84.601	94			
There are no real New Zealand standards for materials	Between Groups	8.868	1	8.868	8.641	0.004
	Within Groups	95.438	93	1.026		
	Total	104.306	94			

Table 3: Hochberg's GT2 post-hoc test – Issues

Dependent variable	(I) Group	(J) Group	Mean differen ce (I – J)	Std. error	Sig. *p*	95% confidence interval	
						Lower bound	Upper bound
Price of materials	Manufacturers & Suppliers	Contractors	-0.367	0.193	0.303	-0.88	0.15
		Architects	-0.096	0.162	0.992	-0.53	0.34
		Homeowners	-0.120	0.204	0.992	-0.66	0.42
	Contractors	Manufacturers & Suppliers	0.367	0.193	0.303	-0.15	0.88
		Architects	0.271	0.175	0.546	-0.20	0.74
		Homeowners	0.246	0.215	0.824	-0.33	0.82
	Architects	Manufacturers & Suppliers	0.096	0.162	0.992	-0.34	0.53
		Contractors	-0.271	0.175	0.546	-0.74	0.20
		Homeowners	-0.024	0.188	1.000	-0.53	0.48
	Homeowners	Manufacturers & Suppliers	0.120	0.204	0.992	-0.42	0.66
		Contractors	-0.246	0.215	0.824	-0.82	0.33
		Architects	0.024	0.188	1.000	-0.48	0.53
Inferior products	Manufacturers & Suppliers	Contractors	0.061	0.228	1.000	-0.55	0.67
		Architects	0.092	0.191	0.997	-0.42	0.60
		Homeowners	-0.504	0.241	0.208	-1.15	0.14
	Contractors	Manufacturers & Suppliers	-0.061	0.228	1.000	-0.67	0.55
		Architects	0.031	0.207	1.000	-0.52	0.58
		Homeowners	-0.565	0.254	0.155	-1.24	0.11
	Architects	Manufacturers & Suppliers	-0.092	0.191	0.997	-0.60	0.42
		Contractors	-0.031	0.207	1.000	-0.58	0.52
		Homeowners	-0.596*	0.222	0.048	-1.19	0.00
	Homeowners	Manufacturers & Suppliers	0.504	0.241	0.208	-0.14	1.15
		Contractors	0.565	0.254	0.155	-0.11	1.24
		Architects	0.596*	0.222	0.048	0.00	1.19

Poor collaboration across the supply chain	Manufacturers & Suppliers	Contractors	-0.417	.239	.403	-1.05	0.22
		Architects	0.123	0.201	0.990	-0.41	0.66
		Homeowners	-0.424	.253	.450	-1.10	0.25
	Contractors	Manufacturers & Suppliers	0.417	0.239	0.403	-0.22	1.05
		Architects	0.540	0.218	0.082	-0.04	1.12
		Homeowners	-0.008	0.267	1.000	-0.72	0.70
	Architects	Manufacturers & Suppliers	-0.123	0.201	0.990	-0.66	0.41
		Contractors	-0.540	0.218	0.082	-1.12	0.04
		Homeowners	-0.547	0.233	.115	-1.17	0.07
	Homeowners	Manufacturers & Suppliers	0.424	0.253	0.450	-0.25	1.10
		Contractors	0.008	0.267	1.000	-0.70	0.72
		Architects	0.547	0.233	0.115	-0.07	1.17
Fewer choices	Manufacturers & Suppliers	Contractors	0.180	0.233	0.969	-0.44	0.80
		Architects	-0.141	0.195	0.977	-0.66	0.38
		Homeowners	-0.255	0.247	0.882	-0.91	0.40
	Contractors	Manufacturers & Suppliers	-0.180	0.233	0.969	-0.80	0.44
		Architects	-0.321	0.212	0.568	-0.89	0.24
		Homeowners	-0.435	0.260	.453	-1.13	0.26
	Architects	Manufacturers & Suppliers	0.141	0.195	0.977	-0.38	0.66
		Contractors	0.321	0.212	0.568	-0.24	0.89
		Homeowners	-0.114	0.227	0.997	-0.72	0.49
	Homeowners	Manufacturers & Suppliers	0.255	0.247	0.882	-0.40	0.91
		Contractors	0.435	0.260	0.453	-0.26	1.13
		Architects	0.114	0.227	0.997	-0.49	0.72
Wastage (Bespoke nature of houses)	Manufacturers & Suppliers	Contractors	0.333	0.246	0.685	-0.32	0.99
		Architects	0.173	0.206	0.953	-0.38	0.72
		Homeowners	0.283	0.260	0.857	-0.41	0.98
	Contractors	Manufacturers & Suppliers	-0.333	0.246	0.685	-0.99	0.32
		Architects	-0.160	0.224	0.979	0-0.76	0.44
		Homeowners	-0.051	0.274	1.000	-0.78	0.68
	Architects	Manufacturers & Suppliers	-0.173	0.206	0.953	-0.72	0.38
		Contractors	0.160	0.224	0.979	-0.44	0.76
		Homeowners	0.109	0.240	0.998	-0.53	0.75
	Homeowners	Manufacturers & Suppliers	-0.283	0.260	0.857	-0.98	0.41
		Contractors	0.051	0.274	1.000	-0.68	0.78
		Architects	-0.109	0.240	0.998	-0.75	0.53
Fragmented industry	Manufacturers & Suppliers	Contractors	0.096	0.238	0.999	-0.54	0.73
		Architects	0.155	0.200	0.968	-0.38	0.69
		Homeowners	0.313	0.252	0.765	-0.36	0.99
	Contractors	Manufacturers & Suppliers	-0.096	0.238	0.999	-0.73	0.54
		Architects	0.059	0.217	1.000	-0.52	0.64
		Homeowners	0.217	0.266	0.959	-0.49	0.93
	Architects	Manufacturers & Suppliers	-0.155	0.200	0.968	-0.69	0.38
		Contractors	-0.059	0.217	1.000	-0.64	0.52
		Homeowners	0.158	0.232	0.983	-0.46	0.78
	Homeowners	Manufacturers & Suppliers	-0.313	0.252	0.765	-0.99	0.36

	Contractors	-0.217	0.266	0.959	-0.93	0.49
	Architects	-0.158	0.232	0.983	-0.78	0.46

Table 4: Homogeneous Subsets - Issues

Hochberg[a,b]
Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 32.279.
b. The group sizes are unequal.
The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Price of materials			Wastage (Bespoke nature of houses)		
Group	N	Subset for alpha = 0.05	Group	N	Subset for alpha = 0.05
		1			1
Manufacturers & Suppliers	36	3.97	Contractors	28	3.17
Architects	59	4.06	Homeowners	23	3.22
Homeowners	23	4.09	Architects	59	3.33
Contractors	28	4.33	Manufacturers & Suppliers	36	3.50
Sig.		.289	Sig.		.673

Inferior products			Fragmented industry		
Group	N	Subset for alpha = 0.05	Group	N	Subset for alpha = 0.05
		1			1
Architects	59	3.71	Homeowners	23	3.09
Contractors	28	3.74	Architects	59	3.24
Manufacturers & Suppliers	36	3.80	Contractors	28	3.30
Homeowners	23	4.30	Manufacturers & Suppliers	36	3.40
Sig.		.052	Sig.		.704

Poor collaboration across the supply chain			Fewer choices		
Group	N	Subset for alpha = 0.05	Group	N	Subset for alpha = 0.05
		1			1
Architects	59	3.54	Contractors	28	3.09
Manufacturers & Suppliers	36	3.67	Manufacturers & Suppliers	36	3.27
Contractors	28	4.08	Architects	59	3.41
Homeowners	23	4.09	Homeowners	23	3.52
Sig.		.123	Sig.		.311

Table 5: Descriptive statistics - Collaboration

Statements related to collaboration	Participant group	N	Mean (M)	Rank	Std. deviation	Std. error	95% confidence interval for mean	
							Lower bound	Upper bound
Collaboration	Manufacturers & Suppliers	36	3.86	07	0.852	0.142	3.57	4.15

increases understanding of total supply chain goals	Contractors	28	4.14	05	0.493	0.093	3.95	4.33
	Architects	59	3.86	02	0.733	0.095	3.67	4.05
	Homeowners	23	3.86	07	1.013	0.211	3.43	4.30
	Total	146	3.91	03	0.777	0.064	3.79	4.04
Collaboration brings better data flow	Manufacturers & Suppliers	36	3.96	05	0.654	0.109	3.74	4.19
	Contractors	28	4.00	10	0.544	0.103	3.79	4.21
	Architects	59	3.81	03	0.676	0.088	3.63	3.99
	Homeowners	23	3.77	10	0.794	0.166	3.43	4.12
	Total	146	3.88	05	0.667	0.055	3.77	3.99
Collaboration brings better understanding about the material flow	Manufacturers & Suppliers	36	3.96	04	0.560	0.093	3.77	4.15
	Contractors	28	4.00	09	0.385	0.073	3.85	4.15
	Architects	59	3.51	09	0.833	0.108	3.30	3.73
	Homeowners	23	3.86	08	0.814	0.170	3.51	4.21
	Total	146	3.77	06	0.727	0.060	3.65	3.89
Collaboration ensures cost effectiveness	Manufacturers & Suppliers	36	3.68	12	0.864	0.144	3.39	3.97
	Contractors	28	3.81	14	0.700	0.132	3.54	4.08
	Architects	59	3.50	10	0.914	0.119	3.26	3.74
	Homeowners	23	3.76	11	0.996	0.208	3.33	4.19
	Total	146	3.64	13	0.879	0.073	3.50	3.79
Collaboration ensures diversity of products and methodologies	Manufacturers & Suppliers	36	3.68	11	0.795	0.132	3.41	3.95
	Contractors	28	3.62	15	0.507	0.096	3.42	3.82
	Architects	59	3.36	14	0.762	0.099	3.16	3.56
	Homeowners	23	3.48	14	1.071	0.223	3.01	3.94
	Total	146	3.51	15	0.791	0.065	3.38	3.63
Collaboration ensures materials availability	Manufacturers & Suppliers	36	3.61	13	0.936	0.156	3.29	3.92
	Contractors	28	3.90	13	0.812	0.153	3.59	4.22
	Architects	59	3.45	13	0.969	0.126	3.20	3.70
	Homeowners	23	3.62	13	1.065	0.222	3.16	4.08
	Total	146	3.60	14	0.953	0.079	3.45	3.76
Collaboration ensures right delivery time	Manufacturers & Suppliers	36	3.56	15	0.873	0.145	3.26	3.85
	Contractors	28	3.95	11	0.637	0.120	3.70	4.20
	Architects	59	3.54	07	0.892	0.116	3.26	3.74
	Homeowners	23	4.05	03	0.928	0.194	3.64	4.45
	Total	146	3.70	10	0.840	0.090	3.63	3.99
Collaboration helps to solve issues in the materials supply chain	Manufacturers & Suppliers	36	3.71	10	0.823	0.137	3.44	3.99
	Contractors	28	4.00	08	0.544	0.103	3.79	4.21
	Architects	59	3.34	15	0.921	0.120	3.10	3.58
	Homeowners	23	3.90	05	0.848	0.177	3.54	4.27
	Total	146	3.65	12	0.861	0.071	3.51	3.79
Collaboration increases the trust between different parties in the materials supply chain	Manufacturers & Suppliers	36	3.86	06	0.706	0.118	3.62	4.10
	Contractors	28	4.14	04	0.493	0.093	3.95	4.33
	Architects	59	3.49	12	0.873	0.114	3.26	3.72
	Homeowners	23	3.86	09	0.967	0.202	3.44	4.28
	Total	146	3.76	07	0.821	0.068	3.63	3.90
Collaboration ensures various building materials related requirements of different supply chain parties	Manufacturers & Suppliers	36	4.04	02	0.654	0.109	3.81	4.26
	Contractors	28	4.38	01	0.507	0.096	4.18	4.58
	Architects	59	3.86	01	0.709	0.092	3.67	4.04
	Homeowners	23	4.32	01	0.631	0.132	4.05	4.59
	Total	146	4.07	01	0.678	0.056	3.96	4.19
Collaboration is bringing teams together and making sure that	Manufacturers & Suppliers	36	4.18	01	0.588	0.098	3.98	4.38
	Contractors	28	4.15	03	0.563	0.106	3.93	4.37

everyone's delivering their bit as opposed to the tendering process	Architects	59	3.63	05	0.905	0.118	3.40	3.87
	Homeowners	23	4.14	02	0.625	0.130	3.87	4.41
	Total	146	3.95	02	0.772	0.064	3.82	4.07
Collaboration requires a partnership approach	Manufacturers & Suppliers	36	4.00	03	0.756	0.126	3.74	4.26
	Contractors	28	4.29	02	0.617	0.117	4.05	4.53
	Architects	59	3.63	06	0.886	0.115	3.40	3.86
	Homeowners	23	3.91	04	0.793	0.165	3.57	4.25
	Total	146	3.89	04	0.823	0.068	3.76	4.03
Collaboration makes negotiation better	Manufacturers & Suppliers	36	3.57	14	0.939	0.156	3.25	3.89
	Contractors	28	4.05	07	0.693	0.131	3.78	4.32
	Architects	59	3.68	04	0.797	0.104	3.48	3.89
	Homeowners	23	3.27	15	0.914	0.191	2.88	3.67
	Total	146	3.66	10	0.859	0.071	3.52	3.80
Collaboration makes strong relationships in the materials supply chain	Manufacturers & Suppliers	36	3.82	08	0.719	0.120	3.58	4.06
	Contractors	28	4.14	06	0.563	0.106	3.92	4.36
	Architects	59	3.49	11	0.812	0.106	3.28	3.70
	Homeowners	23	3.68	12	0.819	0.171	3.33	4.04
	Total	146	3.73	09	0.780	0.065	3.60	3.85
Collaboration spreads specialized knowledge across the materials	Manufacturers & Suppliers	36	3.82	09	0.678	0.113	3.59	4.05
	Contractors	28	3.90	12	0.603	0.114	3.67	4.14
	Architects	59	3.54	08	0.892	0.116	3.30	3.77
	Homeowners	23	3.90	06	0.848	0.177	3.54	4.27
	Total	146	3.74	08	0.796	0.066	3.61	3.87

Table 6: One-way ANOVA - Collaboration

Challenges	Participant group	Sum of Squares	*df*	Mean Square	*F*	Sig. (*p*)
Collaboration increases understanding of total supply chain goals	Between Groups	1.832	3	0.611	1.011	0.390
	Within Groups	85.734	142	0.604		
	Total	87.566	145			
Collaboration brings better data flow	Between Groups	1.216	3	0.405	0.909	0.438
	Within Groups	63.304	142	0.446		
	Total	64.520	145			
Collaboration brings better understanding about the material flow	Between Groups	6.936	3	2.312	4.705	0.004
	Within Groups	69.780	142	0.491		
	Total	76.715	145			
Collaboration ensures cost effectiveness	Between Groups	2.353	3	0.784	1.016	0.388
	Within Groups	109.655	142	0.772		
	Total	112.008	145			
Collaboration ensures diversity of products and methodologies	Between Groups	2.758	3	0.919	1.484	0.221
	Within Groups	87.940	142	0.619		
	Total	90.698	145			
Collaboration ensures materials availability	Between Groups	3.895	3	1.298	1.442	0.233
	Within Groups	127.845	142	0.900		
	Total	131.740	145			
Collaboration ensures right delivery time	Between Groups	8.701	3	2.900	3.711	0.013
	Within Groups	110.976	142	0.782		
	Total	119.677	145			
Collaboration helps to	Between Groups	10.688	3	3.563	5.229	0.002

solve issues in the materials supply chain	Within Groups	96.743	142	0.681		
	Total	107.431	145			
Collaboration increases the trust between different parties in the materials supply chain	Between Groups	9.031	3	3.010	4.813	0.003
	Within Groups	88.815	142	0.625		
	Total	97.847	145			
Collaboration ensures various building materials related requirements of different supply chain parties	Between Groups	6.837	3	2.279	5.409	0.001
	Within Groups	59.832	142	0.421		
	Total	66.669	145			
Collaboration is bringing teams together and making sure that everyone's delivering their bit as opposed to the tendering process	Between Groups	9.684	3	3.228	5.971	0..001
	Within Groups	76.760	142	0.541		
	Total	86.444	145			
Collaboration requires a partnership approach	Between Groups	8.690	3	2.897	4.590	0.004
	Within Groups	89.616	142	0.631		
	Total	98.306	145			
Collaboration makes negotiation better	Between Groups	7.970	3	2.657	3.809	0.012
	Within Groups	99.051	142	0.698		
	Total	107.021	145			
Collaboration makes strong relationships in the materials supply chain	Between Groups	8.586	3	2.862	5.099	0.002
	Within Groups	79.695	142	0.561		
	Total	88.281	145			
Collaboration spreads specialized knowledge across the materials	Between Groups	4.061	3	1.354	2.186	0.092
	Within Groups	87.921	142	0.619		
	Total	91.983	145			

Table 7: Hochberg's GT2 post-hoc test - Collaboration

Dependent variable	(I) Group	(J) Group	Mean difference (I – J)	Std. error	Sig. *p*	95% confidence interval	
						Lower bound	Upper bound
Collaboration increases understanding of total supply chain goals	Manufacturers & Suppliers	Contractors	-0.286	0.196	0.609	-0.81	0.24
		Architects	0.000	0.164	1.000	-0.44	0.44
		Homeowners	-0.006	0.207	1.000	-0.56	0.55
	Contractors	Manufacturers & Suppliers	0.286	0.196	0.609	-0.24	0.81
		Architects	0.286	0.178	0.503	-0.19	0.76
		Homeowners	0.279	0.219	0.741	-0.30	0.86
	Architects	Manufacturers & Suppliers	0.000	0.164	1.000	-0.44	0.44
		Contractors	-0.286	0.178	0.503	-0.76	0.19
		Homeowners	-0.006	0.191	1.000	-0.52	0.50
	Homeowners	Manufacturers & Suppliers	0.006	0.207	1.000	-0.55	0.56
		Contractors	-0.279	0.219	0.741	-0.86	0.30
		Architects	0.006	0.191	1.000	-0.50	0.52
Collaboration brings better data	Manufacturers & Suppliers	Contractors	-0.036	0.168	1.000	-0.48	0.41
		Architects	0.155	0.141	0.851	-0.22	0.53
		Homeowners	0.192	0.178	0.862	-0.28	0.67

flow	Contractors	Manufacturers & Suppliers	0.036	0.168	1.000	-0.41	0.48
		Architects	0.190	0.153	0.763	-0.22	0.60
		Homeowners	0.227	0.188	0.785	-0.27	0.73
	Architects	Manufacturers & Suppliers	-0.155	0.141	0.851	-0.53	0.22
		Contractors	-0.190	0.153	0.763	-0.60	0.22
		Homeowners	0.037	0.164	1.000	-0.40	0.47
	Homeowners	Manufacturers & Suppliers	-0.192	0.178	0.862	-0.67	0.28
		Contractors	-0.227	0.188	0.785	-0.73	0.27
		Architects	-0.037	0.164	1.000	-0.47	0.40
Collaboration brings better understanding about the material flow	Manufacturers & Suppliers	Contractors	-0.036	0.177	1.000	-0.51	0.44
		Architects	0.452*	0.148	0.016	0.06	0.85
		Homeowners	0.107	0.187	0.993	-0.39	0.61
	Contractors	Manufacturers & Suppliers	0.036	0.177	1.000	-0.44	0.51
		Architects	0.488*	0.161	0.017	0.06	0.92
		Homeowners	0.143	0.197	0.977	-0.38	0.67
	Architects	Manufacturers & Suppliers	-0.452*	0.148	0.016	-0.85	-0.06
		Contractors	-0.488*	0.161	0.017	-0.92	-0.06
		Homeowners	-0.345	0.172	0.250	-0.80	0.11
	Homeowners	Manufacturers & Suppliers	-0.107	0.187	0.993	-0.61	0.39
		Contractors	-0.143	0.197	0.977	-0.67	0.38
		Architects	0.345	0.172	0.250	-0.11	0.80
Collaboration ensures cost effectiveness	Manufacturers & Suppliers	Contractors	-0.131	0.221	0.992	-0.72	0.46
		Architects	0.179	0.186	0.914	-0.32	0.67
		Homeowners	-0.083	0.235	1.000	-0.71	0.54
	Contractors	Manufacturers & Suppliers	0.131	0.221	0.992	-0.46	0.72
		Architects	0.310	0.202	0.553	-0.23	0.85
		Homeowners	0.048	0.247	1.000	-0.61	0.71
	Architects	Manufacturers & Suppliers	-0.179	0.186	0.914	-0.67	0.32
		Contractors	-0.310	0.202	0.553	-0.85	0.23
		Homeowners	-0.262	0.216	0.783	-0.84	0.31
	Homeowners	Manufacturers & Suppliers	0.083	0.235	1.000	-0.54	0.71
		Contractors	-0.048	0.247	1.000	-0.71	0.61
		Architects	0.262	0.216	0.783	-0.31	0.84
Collaboration ensures diversity of products and methodologies	Manufacturers & Suppliers	Contractors	0.060	0.198	1.000	-0.47	0.59
		Architects	0.321	0.166	0.287	-0.12	0.77
		Homeowners	0.202	0.210	0.913	-0.36	0.76
	Contractors	Manufacturers & Suppliers	-0.060	0.198	1.000	-0.59	0.47
		Architects	0.262	0.181	0.616	-0.22	0.74
		Homeowners	0.143	0.221	0.987	-0.45	0.73
	Architects	Manufacturers & Suppliers	-0.321	0.166	0.287	-0.77	0.12
		Contractors	-0.262	0.181	0.616	-0.74	0.22
		Homeowners	-0.119	0.193	0.990	-0.63	0.40
	Homeowners	Manufacturers & Suppliers	-0.202	0.210	0.913	-0.76	0.36
		Contractors	-0.143	0.221	0.987	-0.73	0.45
		Architects	0.119	0.193	0.990	-0.40	0.63
Collaboration ensures materials availability	Manufacturers & Suppliers	Contractors	-0.298	0.239	0.762	-0.94	0.34
		Architects	0.155	0.201	0.969	-0.38	0.69
		Homeowners	-0.012	0.253	1.000	-0.69	0.66
	Contractors	Manufacturers	0.298	0.239	0.762	-0.34	0.94

		& Suppliers					
		Architects	0.452	0.218	0.213	-0.13	1.03
		Homeowners	0.286	0.267	0.865	-0.43	1.00
	Architects	Manufacturers & Suppliers	-0.155	0.201	0.969	-0.69	0.38
		Contractors	-0.452	0.218	0.213	-1.03	0.13
		Homeowners	-0.167	0.233	0.979	-0.79	0.46
	Homeowners	Manufacturers & Suppliers	0.012	0.253	1.000	-0.66	0.69
		Contractors	-0.286	0.267	0.865	-1.00	0.43
		Architects	0.167	0.233	0.979	-0.46	0.79
Collaboration ensures right delivery time	Manufacturers & Suppliers	Contractors	-0.394	0.223	0.385	-0.99	0.20
		Architects	0.103	0.187	0.994	-0.40	0.60
		Homeowners	-0.490	0.236	0.214	-1.12	0.14
	Contractors	Manufacturers & Suppliers	0.394	0.223	0.385	-0.20	0.99
		Architects	0.498	0.203	0.088	-0.04	1.04
		Homeowners	-0.095	0.249	0.999	-0.76	0.57
	Architects	Manufacturers & Suppliers	-0.103	0.187	0.994	-0.60	0.40
		Contractors	-0.498	0.203	0.088	-1.04	0.04
		Homeowners	-0.593*	0.217	0.042	-1.17	-0.01
	Homeowners	Manufacturers & Suppliers	0.490	0.236	0.214	-0.14	1.12
		Contractors	0.095	0.249	0.999	-0.57	0.76
		Architects	0.593*	0.217	0.042	0.01	1.17
Collaboration helps to solve issues in the materials supply chain	Manufacturers & Suppliers	Contractors	-0.286	0.208	0.672	-0.84	0.27
		Architects	0.373	0.175	0.188	-0.09	0.84
		Homeowners	-0.190	0.220	0.946	-0.78	0.40
	Contractors	Manufacturers & Suppliers	0.286	0.208	0.672	-0.27	0.84
		Architects	0.659*	0.189	0.004	0.15	1.16
		Homeowners	0.095	0.232	0.999	-0.52	0.71
	Architects	Manufacturers & Suppliers	-0.373	0.175	0.188	-0.84	0.09
		Contractors	-0.659*	0.189	0.004	-1.16	-0.15
		Homeowners	-0.563*	0.203	0.037	-1.10	-0.02
	Homeowners	Manufacturers & Suppliers	0.190	0.220	0.946	-0.40	0.78
		Contractors	-0.095	0.232	0.999	-0.71	0.52
		Architects	0.563*	0.203	0.037	0.02	1.10
Collaboration increases the trust between different parties in the materials supply chain	Manufacturers & Suppliers	Contractors	-0.286	0.199	0.628	-0.82	0.25
		Architects	0.369	0.167	0.160	-0.08	0.82
		Homeowners	0.000	0.211	1.000	-0.56	0.56
	Contractors	Manufacturers & Suppliers	0.286	0.199	0.628	-0.25	0.82
		Architects	0.655*	0.181	0.003	0.17	1.14
		Homeowners	0.286	0.223	0.736	-0.31	0.88
	Architects	Manufacturers & Suppliers	-0.369	0.167	0.160	-0.82	0.08
		Contractors	-0.655*	0.181	0.003	-1.14	-0.17
		Homeowners	-0.369	0.194	0.305	-0.89	0.15
	Homeowners	Manufacturers & Suppliers	0.000	0.211	1.000	-0.56	0.56
		Contractors	-0.286	0.223	0.736	-0.88	0.31
		Architects	0.369	0.194	0.305	-0.15	0.89
Collaboration ensures various building materials	Manufacturers & Suppliers	Contractors	-0.345	0.164	0.199	-0.78	0.09
		Architects	0.179	0.137	0.724	-0.19	0.54
		Homeowners	-0.282	0.173	0.483	-0.74	0.18
	Contractors	Manufacturers & Suppliers	0.345	0.164	0.199	-0.09	0.78

related requirements of different supply chain parties		Architects	0.524*	0.149	0.004	0.13	0.92
		Homeowners	0.063	0.183	1.000	-0.42	0.55
	Architects	Manufacturers & Suppliers	-0.179	0.137	0.724	-0.54	0.19
		Contractors	-0.524*	0.149	0.004	-0.92	-0.13
		Homeowners	-0.461*	0.160	0.026	-0.89	-0.04
	Homeowners	Manufacturers & Suppliers	0.282	0.173	0.483	-0.18	0.74
		Contractors	-0.063	0.183	1.000	-0.55	0.42
		Architects	0.461*	0.160	0.026	0.04	0.89
Collaboration is bringing teams together and making sure that everyone's delivering their bit as opposed to the tendering process	Manufacturers & Suppliers	Contractors	0.029	0.185	1.000	-0.47	0.52
		Architects	0.544*	0.155	0.004	0.13	0.96
		Homeowners	0.042	0.196	1.000	-0.48	0.57
	Contractors	Manufacturers & Suppliers	-0.029	0.185	1.000	-0.52	0.47
		Architects	0.516*	0.169	0.016	0.07	0.97
		Homeowners	0.014	0.207	1.000	-0.54	0.57
	Architects	Manufacturers & Suppliers	-0.544*	0.155	0.004	-0.96	-0.13
		Contractors	-0.516*	0.169	0.016	-0.97	-0.07
		Homeowners	-0.502*	0.181	0.036	-0.98	-0.02
	Homeowners	Manufacturers & Suppliers	-0.042	0.196	1.000	-0.57	0.48
		Contractors	-0.014	0.207	1.000	-0.57	0.54
		Architects	0.502*	0.181	0.036	0.02	0.98
Collaboration requires a partnership approach	Manufacturers & Suppliers	Contractors	-0.286	0.200	0.633	-0.82	0.25
		Architects	0.366	0.168	0.171	-0.08	0.81
		Homeowners	0.091	0.212	0.999	-0.47	0.66
	Contractors	Manufacturers & Suppliers	0.286	0.200	0.633	-0.25	0.82
		Architects	0.652*	0.182	0.003	0.17	1.14
		Homeowners	0.377	0.224	0.444	-0.22	0.97
	Architects	Manufacturers & Suppliers	-0.366	0.168	0.171	-0.81	0.08
		Contractors	-0.652*	0.182	0.003	-1.14	-0.17
		Homeowners	-0.275	0.195	0.647	-0.80	0.25
	Homeowners	Manufacturers & Suppliers	-0.091	0.212	0.999	-0.66	0.47
		Contractors	-0.377	0.224	0.444	-0.97	0.22
		Architects	0.275	0.195	0.647	-0.25	0.80
Collaboration makes negotiation better	Manufacturers & Suppliers	Contractors	-0.476	0.210	0.141	-1.04	0.08
		Architects	-0.111	0.177	0.989	-0.58	0.36
		Homeowners	0.299	0.223	0.697	-0.30	0.89
	Contractors	Manufacturers & Suppliers	0.476	0.210	0.141	-0.08	1.04
		Architects	0.365	0.192	0.303	-0.15	0.88
		Homeowners	0.775*	0.235	0.007	0.15	1.40
	Architects	Manufacturers & Suppliers	0.111	0.177	0.989	-0.36	0.58
		Contractors	-0.365	0.192	0.303	-0.88	0.15
		Homeowners	0.410	0.205	0.252	-0.14	0.96
	Homeowners	Manufacturers & Suppliers	-0.299	0.223	0.697	-0.89	0.30
		Contractors	-0.775*	0.235	0.007	-1.40	-0.15
		Architects	-0.410	0.205	0.252	-0.96	0.14
Collaboration makes strong relationships in the	Manufacturers & Suppliers	Contractors	-0.321	0.189	0.431	-0.82	0.18
		Architects	0.334	0.158	0.201	-0.09	0.76
		Homeowners	0.140	0.200	0.981	-0.39	0.67
	Contractors	Manufacturers & Suppliers	0.321	0.189	0.431	-0.18	0.82

materials supply chain		Architects	.655*	0.172	0.001	0.20	1.11
		Homeowners	0.461	0.211	0.168	-0.10	1.02
	Architects	Manufacturers & Suppliers	-0.334	0.158	0.201	-0.76	0.09
		Contractors	-0.655*	0.172	0.001	-1.11	-0.20
		Homeowners	-0.194	0.184	0.873	-0.69	0.30
	Homeowners	Manufacturers & Suppliers	-0.140	0.200	0.981	-0.67	0.39
		Contractors	-0.461	0.211	0.168	-1.02	0.10
		Architects	0.194	0.184	0.873	-0.30	0.69
	Manufacturers & Suppliers	Contractors	-0.083	0.198	0.999	-0.61	0.45
		Architects	0.285	0.166	0.425	-0.16	0.73
		Homeowners	-0.083	0.210	0.999	-0.64	0.48
Collaboration spreads specialized knowledge across the materials	Contractors	Manufacturers & Suppliers	0.083	0.198	0.999	-0.45	0.61
		Architects	0.368	0.181	0.231	-0.11	0.85
		Homeowners	0.000	0.221	1.000	-0.59	0.59
	Architects	Manufacturers & Suppliers	-0.285	0.166	0.425	-0.73	0.16
		Contractors	-0.368	0.181	0.231	-0.85	0.11
		Homeowners	-0.368	0.193	0.303	-0.88	0.15
	Homeowners	Manufacturers & Suppliers	0.083	0.210	0.999	-0.48	0.64
		Contractors	0.000	0.221	1.000	-0.59	0.59
		Architects	0.368	0.193	0.303	-0.15	0.88

Table 8: Homogeneous Subsets - Collaboration

Hochberg[a,b]
Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 32.279.
b. The group sizes are unequal.
The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Collaboration increases understanding of total supply chain goals

Group	N	Subset for alpha = 0.05
		1
Manufacturers & Suppliers	36	3.86
Architects	59	3.86
Homeowners	23	3.86
Contractors	28	4.14
Sig.		0.596

Collaboration brings better understanding about the material flow

Group	N	Subset for alpha = 0.05	
		1	2
Architects	59	3.51	
Homeowners	23	3.86	3.86
Manufacturers & Suppliers	36	3.96	3.96
Contractors	28		4.00
Sig.		0.061	0.958

Collaboration brings better data flow

Group	N	Subset for alpha = 0.05
		1
Homeowners	23	3.77
Architects	59	3.81
Manufacturers & Suppliers	36	3.96
Contractors	28	4.00
Sig.		0.677

Collaboration ensures right delivery time

Group	N	Subset for alpha = 0.05	
		1	2
Architects	59	3.45	
Manufacturers & Suppliers	36	3.56	3.56
Contractors	28	3.95	3.95
Homeowners	23		4.05
Sig.		0.141	0.153

Collaboration ensures cost effectiveness

Group	N	Subset for alpha = 0.05
		1
Architects	59	3.50
Manufacturers & Suppliers	36	3.68
Homeowners	23	3.76
Contractors	28	3.81
Sig.		0.642

Collaboration helps to solve issues in the materials supply chain

Group	N	Subset for alpha = 0.05	
		1	2
Architects	59	3.34	
Manufacturers & Suppliers	36	3.71	3.71
Homeowners	23		3.90
Contractors	28		4.00
Sig.		0.357	0.660

Collaboration ensures diversity of products and methodologies

Group	N	Subset for alpha = 0.05
		1
Architects	59	3.36
Homeowners	23	3.48
Contractors	28	3.62
Manufacturers & Suppliers	36	3.68
Sig.		0.475

Collaboration increases the trust between different parties in the materials supply chain

Group	N	Subset for alpha = 0.05	
		1	2
Architects	59	3.49	
Manufacturers & Suppliers	36	3.86	3.86
Homeowners	23	3.86	3.86
Contractors	28		4.14
Sig.		0.319	0.615

Collaboration ensures materials availability

Group	N	Subset for alpha = 0.05
		1
Architects	59	3.45
Manufacturers & Suppliers	36	3.61
Homeowners	23	3.62
Contractors	28	3.90
Sig.		0.296

Collaboration ensures various building materials related requirements of different supply chain parties

Group	N	Subset for alpha = 0.05	
		1	2
Architects	59	3.86	
Manufacturers & Suppliers	36	4.04	4.04
Homeowners	23		4.32
Contractors	28		4.38
Sig.		0.846	0.188

Collaboration spreads specialized knowledge across the materials

Group	N	Subset for alpha = 0.05
		1
Architects	59	3.54
Manufacturers & Suppliers	36	3.82
Homeowners	23	3.90
Contractors	28	3.90
Sig.		0.317

Collaboration is bringing teams together and making sure that everyone's delivering their bit as opposed to the tendering process

Group	N	Subset for alpha = 0.05
		1
Architects	59	3.63
Homeowners	23	
Contractors	28	
Manufacturers & Suppliers	36	
Sig.		1.000

Collaboration makes negotiation better		
Group	N	Subset for alpha = 0.05
		1
Homeowners	23	3.27
Manufacturers & Suppliers	36	3.57
Architects	59	3.68
Contractors	28	
Sig.		0.265

Collaboration requires a partnership approach		
Group	N	Subset for alpha = 0.05
		1
Architects	59	3.63
Homeowners	23	3.91
Manufacturers & Suppliers	36	4.00
Contractors	28	
Sig.		0.335

Collaboration makes strong relationships in the materials supply chain		
Group	N	Subset for alpha = 0.05
		1
Architects	59	3.49
Homeowners	23	3.68
Manufacturers & Suppliers	36	3.82
Contractors	28	
Sig.		0.373

Table 9:Descriptive statistics – Suggestions

Suggestions	Participant group	N	Mean (M)	Std. deviation	Std. error	95% Confidence interval for mean	
						Lower bound	Upper bound
Good communication	Manufacturers & Suppliers	36	4.24	0.661	0.110	4.02	4.47
	Contractors	28	4.24	0.538	0.102	4.03	4.45
	Architects	59	3.90	0.715	0.093	3.72	4.09
	Homeowners	23	4.09	0.793	0.165	3.75	4.43
	Total	146	4.08	0.695	0.058	3.97	4.19
Technical advancement	Manufacturers & Suppliers	36	3.90	0.691	0.115	3.66	4.13
	Contractors	28	4.05	0.693	0.131	3.78	4.32
	Architects	59	4.00	0.557	0.073	3.85	4.15
	Homeowners	23	3.85	0.692	0.144	3.55	4.15
	Total	146	3.96	0.637	0.053	3.86	4.06
Independent qualification for materials testing	Manufacturers & Suppliers	36	4.00	0.793	0.132	3.73	4.27
	Contractors	28	3.90	0.715	0.135	3.63	4.18
	Architects	59	3.83	0.889	0.116	3.60	4.06
	Total	123	3.89	0.841	0.070	3.74	4.02
Waste minimization (increased house standardisation and integration in the supply chain)	Manufacturers & Suppliers	36	3.83	0.830	0.138	3.55	4.11
	Contractors	28	4.05	0.693	0.131	3.78	4.32
	Architects	59	3.72	0.694	0.090	3.54	3.90
	Homeowners	23	4.00	0.905	0.189	3.61	4.39

	Total	146	3.85	0.769	0.064	3.73	3.98
Better infrastructure	Manufacturers & Suppliers	36	3.72	0.789	0.132	3.46	3.99
	Contractors	28	3.90	0.765	0.145	3.61	4.20
	Total	64	3.79	0.799	0.072	3.59	3.88
Central materials specification system on Web	Manufacturers & Suppliers	36	3.48	0.882	0.147	3.18	3.78
	Contractors	28	3.55	0.744	0.141	3.26	3.84
	Architects	59	3.86	0.733	0.095	3.67	4.05
	Homeowners	23	3.82	0.936	0.195	3.41	4.22
	Total	146	3.70	0.817	0.068	3.57	3.83
More research	Manufacturers & Suppliers	36	3.21	0.874	0.146	2.91	3.50
	Contractors	28	3.71	0.675	0.127	3.45	3.98
	Architects	59	3.74	0.744	0.097	3.54	3.93
	Homeowners	23	3.41	0.887	0.185	3.03	3.79
	Total	146	3.55	0.814	0.067	3.42	3.68
More competition in the materials supply chain	Manufacturers & Suppliers	36	2.90	1.024	0.171	2.55	3.24
	Contractors	28	3.45	0.576	0.109	3.23	3.67
	Architects	59	3.93	0.680	0.088	3.75	4.11
	Total	123	3.52	0.889	0.080	3.36	3.68
NZ standards system for materials controlled by the government	Manufacturers & Suppliers	36	3.34	1.022	0.170	3.00	3.69
	Contractors	28	3.33	0.956	0.181	2.96	3.70
	Architects	59	3.29	0.934	0.122	3.04	3.53
	Total	123	3.31	0.969	0.080	3.20	3.52
Homeowner education on materials	Manufacturers & Suppliers	36	3.34	1.050	0.175	2.99	3.70
	Contractors	28	3.38	0.838	0.158	3.06	3.71
	Architects	59	2.93	0.752	0.098	2.73	3.12
	Homeowners	23	3.68	1.017	0.212	3.24	4.12
	Total	146	3.24	0.926	0.077	3.09	3.39
Customer opinions and surveys	Manufacturers & Suppliers	36	3.38	1.106	0.184	3.01	3.75
	Contractors	28	3.29	0.675	0.127	3.02	3.55
	Architects	59	2.57	0.769	0.100	2.37	2.77
	Homeowners	23	3.45	0.988	0.206	3.03	3.88
	Total	146	3.05	0.960	0.079	2.89	3.20
More fashionable materials	Manufacturers & Suppliers	36	2.67	0.894	0.149	2.36	2.97
	Contractors	28	3.10	0.857	0.162	2.76	3.43
	Architects	59	2.36	0.715	0.093	2.17	2.54
	Homeowners	23	2.59	1.073	0.224	2.13	3.05
	Total	146	2.61	0.884	0.073	2.47	2.76

Table 10: One-way ANOVA - Suggestions

Suggestions	**Participant group**	**Sum of Squares**	***df***	**Mean Square**	***F***	**Sig. (*p*)**
Good communication	Between Groups	3.452	3	1.151	2.455	0.066
	Within Groups	66.557	142	0.469		
	Total	70.009	145			
Technical advancement	Between Groups	0.733	3	0.244	0.596	0.619
	Within Groups	58.192	142	0.410		
	Total	58.925	145			

Independent qualification for materials testing	Between Groups	0.928	3	0.309	0.433	0.730
	Within Groups	101.506	142	0.715		
	Total	102.435	145			
Waste minimization (increased house standardisation and integration in the supply chain)	Between Groups	2.683	3	0.894	1.530	0.209
	Within Groups	82.985	142	0.584		
	Total	85.668	145			
Better infrastructure	Between Groups	1.156	2	0.578	0.903	0.408
	Within Groups	76.822	120	0.640		
	Total	77.978	122			
Central materials specification system on Web	Between Groups	4.107	3	1.369	2.099	0.103
	Within Groups	92.607	142	0.652		
	Total	96.714	145			
More research	Between Groups	7.538	3	2.513	4.032	0.009
	Within Groups	88.482	142	0.623		
	Total	96.019	145			
More competition in the materials supply chain	Between Groups	23.978	2	11.989	19.864	0.000
	Within Groups	72.425	120	0.604		
	Total	96.404	122			
NZ standards system for materials, controlled by the government	Between Groups	1.678	3	0.559	0.590	0.622
	Within Groups	134.590	142	0.948		
	Total	136.268	145			
Homeowner education on materials	Between Groups	11.162	3	3.721	4.673	0.004
	Within Groups	113.063	142	0.796		
	Total	124.225	145			
Customer opinions and surveys	Between Groups	22.735	3	7.578	9.708	0.000
	Within Groups	110.854	142	0.781		
	Total	133.589	145			
More fashionable materials	Between Groups	10.489	3	3.496	4.831	0.003
	Within Groups	102.771	142	0.724		
	Total	113.259	145			

Table 11: Hochberg's GT2 post-hoc test - Suggestions

Dependent variable	(I) Group	(J) Group	Mean difference (I – J)	Std. error	Sig. *p*	95% confidence interval	
						Lower bound	Upper bound
Good communication	Manufacturers & Suppliers	Contractors	0.003	0.173	1.000	-0.46	0.46
		Architects	0.337	0.145	0.121	-0.05	0.72
		Homeowners	0.150	0.183	0.957	-0.34	0.64
	Contractors	Manufacturers & Suppliers	-0.003	0.173	1.000	-0.46	0.46
		Architects	0.333	0.157	0.194	-0.09	0.75
		Homeowners	0.147	0.193	0.970	-0.37	0.66
	Architects	Manufacturers & Suppliers	-0.337	0.145	0.121	-0.72	0.05
		Contractors	-0.333	0.157	0.194	-0.75	0.09
		Homeowners	-0.186	0.168	0.846	-0.63	0.26
	Homeowners	Manufacturers & Suppliers	-0.150	0.183	0.957	-0.64	0.34
		Contractors	-0.147	0.193	0.970	-0.66	0.37
		Architects	0.186	0.168	0.846	-0.26	0.63
Technical advancement	Manufacturers & Suppliers	Contractors	-0.151	0.161	0.923	-.058	0.28
		Architects	-0.103	0.135	0.970	-0.46	0.26

		Homeowners	0.047	0.171	1.000	-0.41	0.50
	Contractors	Manufacturers & Suppliers	0.151	0.161	0.923	-0.28	0.58
		Architects	0.048	0.147	1.000	-0.34	0.44
		Homeowners	0.198	0.180	0.851	-0.28	0.68
	Architects	Manufacturers & Suppliers	0.103	0.135	0.970	-0.26	0.46
		Contractors	-0.048	0.147	1.000	-0.44	0.34
		Homeowners	0.150	0.157	0.917	-0.27	0.57
	Homeowners	Manufacturers & Suppliers	-0.047	0.171	1.000	-0.50	0.41
		Contractors	-0.198	0.180	0.851	-0.68	0.28
		Architects	-0.150	0.157	0.917	-0.57	0.27
Waste minimization (increased house standardisation and integration in the supply chain)	Manufacturers & Suppliers	Contractors	-0.222	0.193	0.819	-0.74	0.29
		Architects	0.110	0.162	0.984	-0.32	0.54
		Homeowners	-0.172	0.204	0.952	-0.72	0.37
	Contractors	Manufacturers & Suppliers	0.222	0.193	0.819	-0.29	0.74
		Architects	0.332	0.175	0.309	-0.14	0.80
		Homeowners	0.050	0.215	1.000	-0.52	0.62
	Architects	Manufacturers & Suppliers	-0.110	0.162	0.984	-0.54	0.32
		Contractors	-0.332	0.175	0.309	-0.80	0.14
		Homeowners	-0.282	0.188	0.578	-0.78	0.22
	Homeowners	Manufacturers & Suppliers	0.172	0.204	0.952	-0.37	0.72
		Contractors	-0.050	0.215	1.000	-0.62	0.52
		Architects	0.282	0.188	0.578	-0.22	0.78
Central materials specification system on Web	Manufacturers & Suppliers	Contractors	-0.067	0.203	1.000	-0.61	0.48
		Architects	-0.374	0.171	0.166	-0.83	0.08
		Homeowners	-0.335	0.216	0.537	-0.91	0.24
	Contractors	Manufacturers & Suppliers	0.067	0.203	1.000	-0.48	0.61
		Architects	-0.307	0.185	0.463	-0.80	0.19
		Homeowners	-0.268	0.227	0.803	-0.87	0.34
	Architects	Manufacturers & Suppliers	0.374	0.171	0.166	-0.08	0.83
		Contractors	0.307	0.185	0.463	-0.19	0.80
		Homeowners	0.039	0.199	1.000	-0.49	0.57
	Homeowners	Manufacturers & Suppliers	0.335	0.216	0.537	-0.24	0.91
		Contractors	0.268	0.227	0.803	-0.34	0.87
		Architects	-0.039	0.199	1.000	-0.57	0.49
More research	Manufacturers & Suppliers	Contractors	-0.507	0.199	0.068	-1.04	0.02
		Architects	-0.531*	0.167	0.011	-0.98	-0.09
		Homeowners	-0.202	0.211	0.914	-0.76	0.36
	Contractors	Manufacturers & Suppliers	0.507	0.199	0.068	-0.02	1.04
		Architects	-0.024	0.181	1.000	-0.51	0.46
		Homeowners	0.305	0.222	0.672	-0.29	0.90
	Architects	Manufacturers & Suppliers	0.531*	0.167	0.011	0.09	0.98
		Contractors	0.024	0.181	1.000	-0.46	0.51
		Homeowners	0.329	0.194	0.436	-0.19	0.85
	Homeowners	Manufacturers & Suppliers	0.202	0.211	0.914	-0.36	0.76
		Contractors	-0.305	0.222	0.672	-0.90	0.29
		Architects	-0.329	0.194	0.436	-0.85	0.19
NZ	Manufacturers	Contractors	0.011	0.245	1.000	-0.64	0.67

standards system for materials, controlled by the government	& Suppliers	Architects	0.059	0.206	1.000	-0.49	0.61
		Homeowners	-0.255	0.260	0.905	-0.95	0.44
	Contractors	Manufacturers & Suppliers	-0.011	0.245	1.000	-0.67	0.64
		Architects	0.048	0.223	1.000	-0.55	0.64
		Homeowners	-0.267	0.274	0.909	-1.00	0.46
	Architects	Manufacturers & Suppliers	-0.059	0.206	1.000	-0.61	0.49
		Contractors	-0.048	0.223	1.000	-0.64	0.55
		Homeowners	-0.314	0.239	0.716	-0.95	0.32
	Homeowners	Manufacturers & Suppliers	0.255	0.260	0.905	-0.44	0.95
		Contractors	0.267	0.274	0.909	-0.46	1.00
		Architects	0.314	0.239	0.716	-0.32	0.95
Homeowner education on materials	Manufacturers & Suppliers	Contractors	-0.036	0.225	1.000	-0.64	0.56
		Architects	0.416	0.189	0.161	-0.09	0.92
		Homeowners	-0.337	0.238	0.642	-0.97	0.30
	Contractors	Manufacturers & Suppliers	0.036	0.225	1.000	-0.56	0.64
		Architects	0.452	0.205	0.159	-0.09	1.00
		Homeowners	-0.301	0.251	0.792	-0.97	0.37
	Architects	Manufacturers & Suppliers	-0.416	0.189	0.161	-0.92	0.09
		Contractors	-0.452	0.205	0.159	-1.00	0.09
		Homeowners	-0.753*	0.219	0.005	-1.34	-0.17
	Homeowners	Manufacturers & Suppliers	0.337	0.238	0.642	-0.30	0.97
		Contractors	0.301	0.251	0.792	-0.37	0.97
		Architects	0.753*	0.219	0.005	0.17	1.34
Customer opinions and surveys	Manufacturers & Suppliers	Contractors	0.094	0.223	0.999	-0.50	0.69
		Architects	0.808*	0.187	0.000	0.31	1.31
		Homeowners	-0.075	0.236	1.000	-0.70	0.55
	Contractors	Manufacturers & Suppliers	-0.094	0.223	0.999	-0.69	0.50
		Architects	0.714*	0.203	0.003	0.17	1.25
		Homeowners	-0.169	0.249	0.983	-0.83	0.49
	Architects	Manufacturers & Suppliers	-0.808*	0.187	0.000	-1.31	-0.31
		Contractors	-0.714*	0.203	0.003	-1.25	-0.17
		Homeowners	-0.883*	0.217	0.000	-1.46	-0.30
	Homeowners	Manufacturers & Suppliers	0.075	0.236	1.000	-0.55	0.70
		Contractors	0.169	0.249	0.983	-0.49	0.83
		Architects	0.883*	0.217	0.000	0.30	1.46
More fashionable materials	Manufacturers & Suppliers	Contractors	-.429	0.214	0.251	-1.00	0.14
		Architects	0.310	0.180	0.419	-0.17	.079
		Homeowners	0.076	0.227	1.000	-0.53	0.68
	Contractors	Manufacturers & Suppliers	0.429	0.214	0.251	-0.14	1.00
		Architects	0.738*	0.195	0.001	0.22	1.26

		Homeowners	0.504	0.239	0.200	-0.13	1.14
	Architects	Manufacturers & Suppliers	-0.310	0.180	0.419	-0.79	0.17
		Contractors	-0.738*	0.195	0.001	-1.26	-0.22
		Homeowners	-0.234	0.209	0.840	-0.79	0.32
	Homeowners	Manufacturers & Suppliers	-0.076	0.227	1.000	-0.68	0.53
		Contractors	-0.504	0.239	0.200	-1.14	0.13
		Architects	0.234	0.209	0.840	-0.32	0.79

Table 12: Homogeneous Subsets - Suggestions

Hochberg[a,b]
Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 32.279.
b. The group sizes are unequal.
The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Good communication

Group	N	Subset for alpha = 0.05
		1
Architects	59	3.90
Homeowners	23	4.09
Contractors	28	4.24
Manufacturers & Suppliers	36	4.24
Sig.		0.263

More research

Group	N	Subset for alpha = 0.05	
		1	2
Manufacturers & Suppliers	36	3.21	
Homeowners	23	3.41	3.41
Contractors	28	3.71	3.71
Architects	59		3.74
Sig.		0.063	0.451

Technical advancement

Group	N	Subset for alpha = 0.05
		1
Homeowners	23	3.85
Manufacturers & Suppliers	36	3.90
Architects	59	4.00
Contractors	28	4.05
Sig.		0.765

More fashionable materials

Group	N	Subset for alpha = 0.05	
		1	2
Architects	59	2.36	
Homeowners	23	2.59	2.59
Manufacturers & Suppliers	36	2.67	2.67
Contractors	28		3.10
Sig.		0.608	0.106

Independent qualification for materials testing

Group	N	Subset for alpha = 0.05
		1
Homeowners	23	3.77
Architects	59	3.83
Contractors	28	3.90
Manufacturers & Suppliers	36	4.00
Sig.		0.860

Homeowner education on materials

Group	N	Subset for alpha = 0.05	
		1	2
Architects	59	2.93	
Manufacturers & Suppliers	36	3.34	3.34
Contractors	28	3.38	3.38
Homeowners	23		3.68
Sig.		0.232	0.566

Waste minimization

Group	N	Subset for alpha = 0.05
		1
Architects	59	3.72
Manufacturers & Suppliers	36	3.83
Homeowners	23	4.00
Contractors	28	4.05
Sig.		0.402

Customer opinions and surveys

Group	N	Subset for alpha = 0.05	
		1	2
Architects	59	2.57	
Contractors	28		3.29
Manufacturers & Suppliers	36		3.38
Homeowners	23		3.45
Sig.		1.000	0.969

Central materials specification system on Web

Group	N	Subset for alpha = 0.05
		1
Manufacturers & Suppliers	36	3.48
Contractors	28	3.55
Homeowners	23	3.82
Architects	59	3.86
Sig.		0.327

APPENDIX – 6

Manufacturers	6	184	4/04/201
Best practices	5	34	3/04/2013
Advertising	1	1	4/04/2013
Delivary in full on time (IDIFOTIS)	1	1	3/04/2013
Delivary service	4	9	4/04/2013
Timeframe	1	2	8/04/2013
Originality	1	1	4/04/2013
Price	3	10	4/04/2013
Product quality	4	8	4/04/2013
Standards	2	2	4/04/2013
Specifications	1	1	4/04/2013
Supplier realationships	1	1	8/04/2013
Trust	1	1	4/04/2013
Workshop with suppliers	1	1	8/04/2013
Challengers	5	7	3/04/2013
Customers are not keen to try som	1	1	4/04/2013
Suggestions	1	1	4/04/2013
Price Vs Quality	1	1	8/04/2013
Purchasing on the basis of the bes	1	1	4/04/2013
Right staff	1	1	8/04/2013
Transportation of products	2	2	3/04/2013
How to overcome	2	3	3/04/2013
Additional cost	1	1	3/04/2013
Unique buildings	1	1	4/04/2013
Collaboration	4	8	4/04/2013
Good communication	1	1	8/04/2013
I will not benifit directly	1	1	4/04/2013
Important	3	4	4/04/2013
Prtnership approach	1	1	4/04/2013
Team work	1	1	4/04/2013
Communication	2	2	3/04/2013
Company	6	6	3/04/2013
Experiance	6	6	3/04/2013
How to communicate	1	1	4/04/2013
Issues	5	31	3/04/2013
Big companies own evrything	2	4	4/04/2013
Competition	2	2	4/04/2013

Name	Sources	References	Created (
Price	2	2	4/04/2013
BRANZ appraisal	1	1	8/04/2013
Demand variability	1	2	3/04/2013
Exchange rates	1	1	3/04/2013
Finding money and cashflow	1	3	8/04/2013
Geographic spread	1	1	3/04/2013
Incorrect decisions by archtects - i	1	4	8/04/2013
Leaky building	1	1	8/04/2013
Less competition	1	1	4/04/2013
No issues	1	1	8/04/2013
No NZ standard	1	4	8/04/2013
Plant maintenance and repairs	1	1	8/04/2013
Road traffic	1	1	8/04/2013
Safety	1	2	4/04/2013
Skilled worker	1	1	3/04/2013
Small industry and high labour cos	1	1	8/04/2013
Use of foreign products	1	2	8/04/2013
Key considerations	4	15	4/04/2013
Choosing	0	0	4/04/2013
Delivery time	1	1	4/04/2013
Good coomunication	1	1	8/04/2013
Minimisation of wastes	1	1	4/04/2013
Paying level	1	1	4/04/2013
Customer satisfication	1	1	4/04/2013
Streamlining the payments an	0	0	4/04/2013
Playing	1	1	4/04/2013
Quality	1	1	8/04/2013
Technical advancement	1	3	8/04/2013
Use level	1	4	4/04/2013
Logistics	1	1	4/04/2013
Service	1	2	4/04/2013
Using	1	1	4/04/2013
Wide range of products	1	1	4/04/2013
People in the supplying process	2	11	3/04/2013
Call centre	1	1	3/04/2013
Contractor	2	2	3/04/2013
Logistic team	1	4	3/04/2013
Logistic manager	1	1	3/04/2013
Marketing manager	1	1	3/04/2013
Sales manager	1	1	3/04/2013
Sales reps	1	1	3/04/2013
Merchant	1	2	3/04/2013

Name	Sources	References	Created (
Resposibilities	5	5	3/04/2013
Role	6	7	3/04/2013
Suggestions for issues	3	6	4/04/2013
A system for identifying liable for n	1	1	8/04/2013
Good forecasting	1	1	8/04/2013
More competition	1	1	4/04/2013
NZ Standards	1	2	8/04/2013
Government control	1	1	8/04/2013
Quick payments	1	1	8/04/2013
Supply behaviour	6	35	3/04/2013
BMs	2	3	3/04/2013
Combination of direct and BMs	2	4	8/04/2013
Customer pickup	3	4	4/04/2013
Delivary time	1	3	3/04/2013
Direct	2	5	3/04/2013
Cash sales	1	1	8/04/2013
Inefficient	1	1	4/04/2013
Make more money	1	1	4/04/2013
Struggle to get money	1	1	8/04/2013
Discount	1	2	3/04/2013
Suppliers	4	5	4/04/2013
Direct payments	1	1	8/04/2013
Transportation	3	6	8/04/2013
Logistic company	2	4	3/04/2013
Own transportation	1	2	8/04/2013
Trust	2	2	3/04/2013
Types of building materials	4	10	3/04/2013
Source internationally	3	3	4/04/2013
Source locally	4	5	4/04/2013

Suppliers	6	215	4/04/201
Best practices	4	18	13/04/201:
Collaboration	2	2	13/04/201:
Educating customers on products	1	1	14/04/201:
Least wastage	1	1	13/04/201:
Material availability	1	1	13/04/201:
Minimisatio of suply chain time	2	2	13/04/201:
On time delivary	1	1	14/04/201:
Price	1	4	14/04/201:
Quality	1	4	14/04/201:
Service	1	1	14/04/201:
Specification at the begining	1	1	13/04/201:
Challengers	6	22	13/04/201:
Appropriate forecasting	2	2	13/04/201:
Building site access	1	1	13/04/201:
Fragmented industry	1	1	14/04/201:
Houses are custom	2	2	13/04/201:
Imported products	2	4	13/04/201:
Availability of products	1	1	13/04/2013
Competitive price	1	1	13/04/2013
Exchange rate	1	1	14/04/2013
IT infrastructure	1	1	13/04/201:
Logistics	1	2	14/04/201:
Low sophistication of suppliers	2	2	13/04/201:
Range of products	1	1	14/04/201:
Sheduling the products to the site	3	4	13/04/201:
Site safety	1	1	13/04/201:
Wastage	1	1	13/04/201:
Collaboration	6	12	13/04/201:
Ensure materials availability	1	1	14/04/201:
Ensure right product	1	1	13/04/201:
Ensure right time	1	1	13/04/201:
Ideal	1	1	14/04/201:
Company	6	6	9/04/2013
Experiance	6	6	9/04/2013
Isuues	5	21	13/04/201:
Batch type nature of timber	1	2	13/04/201:
Bespoke nature of homes	1	3	13/04/201:

Capacity and size of the market	1	1	13/04/201
Complex nature of the building cod	1	2	13/04/201
Design faults	1	1	14/04/201
Heavy traffic	2	3	13/04/201
Home owner's lack of understandi	1	3	13/04/201
Inferior products	1	2	14/04/201
Materials standards	1	1	13/04/201
Range of products	1	1	14/04/201
Weather	1	2	14/04/201
Key considerartions	5	14	13/04/201
Alignment and dialogue	1	1	13/04/201
Competitive price	1	1	14/04/201
Compliance requirements	1	1	13/04/201
Cost	1	1	13/04/201
Market	2	2	13/04/201
Quality	2	3	13/04/201
Service	1	2	14/04/201
Specification	1	1	13/04/201
Time	1	1	13/04/201
Understandig customer needs	1	1	14/04/201
Own transportation	1	2	14/04/201
People in the supply process	3	5	13/04/201
Dispatch and inventory controller	1	1	13/04/201
Logistic company	1	1	13/04/201
Trade supports	1	1	13/04/201
Responsibilities	5	5	9/04/2013
Role	6	6	9/04/2013
Sourcing materials	6	31	9/04/2013
Fitting the purpose	1	1	9/04/2013
Internationally	4	5	9/04/2013
Non-structural	1	1	9/04/2013
Locally	6	10	9/04/2013
Cheap	2	2	13/04/201
More efficient	1	1	13/04/201
Structural parts	1	1	9/04/2013
Sourcing considerations	2	5	9/04/2013
Earthquakes	1	1	9/04/2013
Price	2	2	9/04/2013
Quality	2	2	9/04/2013
Vagaries of the climate	0	0	9/04/2013
Sourcing strategies	1	9	9/04/2013

Hierarchy of sourcing decision	1	7	9/04/2013
Appropriate quality-3	1	1	9/04/2013
Efficiency of the supplier s	1	1	9/04/2013
Longevity of the supplier-4	1	1	9/04/2013
Price-7	1	1	9/04/2013
Warranty and technical su	1	1	9/04/2013
What's the appropriate qua	1	1	9/04/2013
What's the right answer for	1	1	9/04/2013
Looking through the lens of the	1	2	9/04/2013
Sourcing installation servic	1	1	9/04/2013
Standards	1	1	9/04/2013
Suggestions for issues	4	11	13/04/201
Better infrastucure in AKL	1	1	14/04/201
Good forecasting	1	1	13/04/201
Home owner education	1	3	13/04/201
Increased standardisation	1	1	13/04/201
Keep the fashion side of materials	1	1	14/04/201
Pre-ordering	1	1	13/04/201
Tighter integration	1	1	13/04/201
Understanding what people want	1	1	14/04/201
Supply behaviour	6	47	11/04/201
Coomunication	2	6	13/04/201
Direct sales reps	2	2	13/04/201
Internal advertising	1	1	13/04/201
National advertising	1	1	13/04/201
Web presence	2	2	13/04/201
Directly to contractor	5	11	11/04/201
Knowledge	1	2	14/04/201
Less people involved	1	1	14/04/201
More money	1	1	14/04/201
Payment risk	1	1	14/04/201
Profit sharing	1	1	14/04/201
Directly to subcontractor	1	1	13/04/201
Discounts	1	1	13/04/201
Volume	1	1	13/04/201
Frame and truss	1	1	11/04/201
Freight delivery	1	1	11/04/201
Logistic company	5	13	11/04/201
Economical	1	1	14/04/201
Geographic spread	2	2	13/04/201
Insurance	1	1	13/04/201

Overheads	1	1	13/04/201
Site constraints	1	1	13/04/201
Planning the delivary	2	4	13/04/201
Architectural plans	1	1	13/04/201
Product substitutions	1	1	13/04/201
Price	1	1	13/04/201
Quality	1	1	13/04/201
Supplying process	3	5	11/04/201
Through BMs	1	2	14/04/201
Guaranteed payment	1	1	14/04/201
Types of building materials	6	9	9/04/2013
Services	1	3	9/04/2013
Mobile phones	1	1	9/04/2013
Qunatity surveying	1	1	9/04/2013
Safety equipments	1	1	9/04/2013

Contractors	6	229	4/04/201
Best practices	6	16	16/04/2013
Being explorative	1	1	17/04/2013
Being organised	2	2	16/04/2013
Best price	3	3	16/04/2013
Durability	1	1	17/04/2013
Integrity	1	1	16/04/2013
Quality control	1	1	17/04/2013
Right materials	2	2	17/04/2013
Sharing information	1	3	16/04/2013
Supplier relationships	1	1	16/04/2013
Buying behaviour	6	67	15/04/2013
Combination of manufacturers, su	5	7	15/04/2013
Add value to relationships	1	1	15/04/2013
Quality products for the best pr	1	1	16/04/2013
Directly from manufacturer	4	11	15/04/2013
Cheaper	2	4	17/04/2013
Hard working	1	1	17/04/2013
Durability	2	2	17/04/2013
Internationally	2	3	15/04/2013
Exchange rate	1	1	15/04/2013
Locally	5	11	15/04/2013
Back-up of service	1	2	17/04/2013
Considerate about the country	1	1	17/04/2013
Ease of purchase	1	1	17/04/2013
Pool of suppliers	6	16	15/04/2013
Manintaing relationships	3	4	15/04/2013
More options	1	2	15/04/2013
Trust	1	1	17/04/2013
Price	1	2	17/04/2013
Purchasing process	5	5	15/04/2013
Quality, price and service all toget	2	7	16/04/2013
Recognised channels	1	2	15/04/2013
Backup and warranty	1	1	15/04/2013
Challengers	6	14	16/04/2013
Cashflow	1	1	17/04/2013
Delivery time	1	2	17/04/2013
Finding the right products	1	1	17/04/2013
Geographical spread	1	2	16/04/2013

Transport	1	1	16/04/201
Price	2	3	16/04/201
Scale	1	2	16/04/201
Spikes in demand	1	1	17/04/201
Collaboration	6	10	16/04/201
Rare	2	2	16/04/201
Communication	6	6	16/04/201
Phone calls, Text, E-mail, meeting	4	4	16/04/201
Web-based	1	1	16/04/201
Company	5	6	15/04/201
Experiance	5	5	15/04/201
Issues	4	11	16/04/201
Bespoke nature of houses	1	1	16/04/201
Big companies dominating	1	1	17/04/201
Cheap imports from China	1	1	16/04/201
High transport cost	1	1	17/04/201
Less competition	1	2	17/04/201
Non-supply	1	1	17/04/201
Price	1	3	16/04/201
Volume price	1	1	16/04/201
Traffic congestion	1	1	17/04/201
Key considerartions	6	29	15/04/201
People in the buying process	4	4	16/04/201
Responsibilities	5	5	15/04/201
Role	6	6	15/04/201
Significance of the materials purchasin	6	15	15/04/201
Contribution to profit	1	1	16/04/201
Durability	1	1	17/04/201
Right price	3	5	15/04/201
Right product	3	4	15/04/201
Right service	1	1	15/04/201
Suggestions for better materials purch	4	15	16/04/201
Being more informative	1	1	17/04/201
Better web-based systems	1	1	16/04/201
Customer opinions and survey	2	3	16/04/201
Greater commmunication	2	3	17/04/201
Standardization of house plans	1	6	16/04/201
Supplier selection criteria	4	14	15/04/201
Credits period	1	1	17/04/201
Long term relationship	2	3	16/04/201

On time payments	1	1	16/04/201
Price	2	4	16/04/201
Quality	2	3	16/04/201
Service	2	3	16/04/201
Types of building materials	5	6	15/04/201

Architects	6	254	4/04/201
Benifits from improving supply chain	2	4	20/04/20
Best materials	6	34	18/04/20
Accurate information	1	1	20/04/20
Collaboration with client	1	2	20/04/20
Fitting for purpose	2	2	20/04/20
Fitting with NZBC	1	8	21/04/20
Knowladge and experiance	3	5	20/04/20
Methods to avoid pitfalls	1	1	21/04/20
Safe to use	1	2	21/04/20
Well established materials	6	11	18/04/20
Challengers	3	11	20/04/20
Availability	1	1	20/04/20
Cost	1	3	20/04/20
Longevity	1	2	20/04/20
Performance	1	1	20/04/20
Specifying products	1	4	20/04/20
Collaboration	5	15	18/04/20
Better understanding of the industr	1	1	22/04/20
Cost effectiveness	1	1	21/04/20
Data flow	1	1	21/04/20
Diversity of product and methodolo	1	1	20/04/20
Negotiation	2	2	20/04/20
Publications	1	1	22/04/20
Specialist knowledge	1	1	20/04/20
Company	6	6	18/04/20
Contractor and Architect relationship	2	4	18/04/20
Designing process	6	7	18/04/20
Experiance	6	9	18/04/20
Issues	6	36	18/04/20
Building code and building act	3	8	20/04/20
Complex	1	1	22/04/20
Constant flux in the codes	1	1	21/04/20
Execess documentation	1	1	22/04/20
Cartelism by a big company	1	1	20/04/20
Contractor disagreements	1	1	21/04/20
Expesive products certification met	1	1	20/04/20
Inefficiency in terms of production	1	2	22/04/20
Import	1	1	22/04/20
Irresponsible manufacturers	1	1	22/04/20
JIT	1	1	22/04/20
Lack of collaboration in the materia	1	1	20/04/20

Leaky building crisis	1	1	18/04/20
Material availability	1	1	18/04/20
Monopoly or a duopoly	1	1	21/04/20
Nobody making enough money	1	1	22/04/20
Poor information transmision betw	1	1	22/04/20
Poor service	0	0	22/04/20
Price	1	2	22/04/20
Price driven	1	1	20/04/20
Subcontractor bad workmanship	1	1	22/04/20
Substitution	2	3	20/04/20
Too much choice	1	2	21/04/20
Undersupply	1	1	22/04/20
Unreliable suppliers	1	1	20/04/20
UV	2	2	18/04/20
Weather driven and production driv	1	1	22/04/20
Key considerations	6	23	18/04/20
Being involved in the build	3	5	18/04/20
Being updated	2	4	18/04/20
Communication	2	4	20/04/20
Drawing specifications	1	1	20/04/20
New products	1	2	20/04/20
Pay attention to details	1	1	21/04/20
Supplier relationships	4	4	18/04/20
Trustworthy information	1	1	21/04/20
Material selection in the designing proc	6	64	18/04/20
Architectural concept	1	1	21/04/20
Budget	2	6	21/04/20
Client's brief	3	5	20/04/20
Collaboration with other architects	1	1	18/04/20
Experiance	1	1	21/04/20
Home owner's contribution to mate	6	25	18/04/20
Assiting the home owner	6	23	18/04/20
Constrains	1	1	21/04/201
Cost and benifits of materia	2	2	20/04/201
Supplier selection	4	13	20/04/201
Good feedback and sp	1	1	20/04/201
Information availability	2	5	20/04/201
Material specifications	3	5	18/04/20
People	4	5	20/04/20
Quality and durable outcome	1	2	21/04/20
Quality information	2	4	21/04/20
Researching on new materials	1	1	18/04/20
Site conditions	5	6	18/04/20

Time frame		1	1	21/04/20
Materials selection and enegrgy effice		4	5	18/04/20
Responsibilities		4	4	18/04/20
Role		5	5	18/04/20
Significance of the materials selection i		4	9	20/04/20
Construction efficiency		1	1	20/04/20
Specifications		1	3	20/04/20
Value of the final output		1	2	21/04/20
Suggestions for issues		5	18	20/04/20
Being able to see		1	1	20/04/20
Building inspector and builder relati		1	2	21/04/20
Change the building code		1	1	20/04/20
Consent should not allow contracto		1	2	21/04/20
Educate people		1	1	20/04/20
Flow of information flow		1	2	21/04/20
Home owner education		1	1	22/04/20
Independent qualification or testing		1	2	20/04/20
Materials evaluating system		1	1	20/04/20
More materials production and imp		1	1	22/04/20
Rely on established suppliers		2	2	20/04/20
Research		1	1	22/04/20
Transparency around stock levels		1	1	21/04/20

Home Owners	4	185	4/04/201
Build Vs Buying	4	9	23/04/201
Better feeling	2	2	24/04/201
Compromises and high cost of ren	2	2	23/04/201
Customisation	3	4	23/04/201
Good architect	1	1	24/04/201
Collaboration in the supply chain	3	6	23/04/201
Good coomunication	1	1	24/04/201
Problem solving	2	3	23/04/201
Home owner and Architect collaborati	2	13	23/04/201
Home owner preferences	1	7	23/04/201
Meetings	1	1	23/04/201
Home owner and contractor collabora	3	12	23/04/201
Home owner site visits	1	3	23/04/201
Progress meetings	2	2	23/04/201
Trust	1	1	23/04/201
Updating home owner on constru	1	1	23/04/201
House	1	1	23/04/201
Issues	2	9	23/04/201
Bestpork nature of houses	1	1	23/04/201
High markup	1	1	23/04/201
Lack of collaboration	1	1	23/04/201
Less choices	2	4	23/04/201
PMs management	1	1	23/04/201
Range of products	1	1	23/04/201
Key considerations	4	13	23/04/201
Being prepared to confront	1	1	24/04/201
Better understandiung of tasks	1	1	24/04/201
Good architect	2	3	24/04/201
Knowing what you want	1	1	24/04/201
knowladge on materials	1	1	23/04/201
Discisions with friends and ind	1	1	23/04/201
Manage the PM	1	2	23/04/201
Proper dicision making	1	2	23/04/201
Regular meetings with architect	1	1	24/04/201
Site inspections	1	1	23/04/201
Key criteria at the begining	4	13	23/04/201
Better conditions	1	1	23/04/201
Budget	1	1	24/04/201

Environment	2	2	23/04/201:
High quality finish	1	1	23/04/201:
Location	1	1	24/04/201:
Low maintainance	1	1	24/04/201:
Private spaces	1	1	24/04/201:
Size	2	3	23/04/201:
View	1	2	24/04/201:
Lifestyle	4	5	23/04/201:
Materials selection criteria	4	31	23/04/201:
Appearence	2	6	23/04/201:
Fashon and trend	1	1	23/04/201:
Local industry supportive	1	1	23/04/201:
Maintenance	1	1	23/04/201:
Materials properties	1	1	24/04/201:
Price driven	3	8	23/04/201:
Quality and durability	2	8	23/04/201:
Specifications	1	1	23/04/201:
Understanding who is doing what	1	1	24/04/201:
Where they come from	1	1	23/04/201:
Selection of Architect	4	18	23/04/201:
Builder recommendation	1	1	23/04/201:
Communication	2	2	23/04/201:
Emotional reasons	1	2	24/04/201:
Experiance	2	4	24/04/201:
Personal relationships	1	2	24/04/201:
Previous works	3	3	23/04/201:
Price	1	1	23/04/201:
Reputation	1	1	24/04/201:
Trust	1	1	24/04/201:
Selection of contractors	4	11	23/04/201:
Architects sugesstions	1	3	24/04/201:
Good communication	1	1	24/04/201:
Previous creations	2	2	24/04/201:
Trustworthiness	1	2	24/04/201:
Selection of materials sources	3	15	23/04/201:
Bigger show room	1	1	23/04/201:
Functionality and feeling	1	4	23/04/201:
Price	2	5	23/04/201:
Recommendation by the Architect	1	1	23/04/201:
Reputation	1	1	23/04/201:
Search through Web	1	1	23/04/201:
Significance of the materials selection	4	14	23/04/201:

Appearence	2	2	23/04/201:
Budget	1	2	24/04/201:
Feelings	1	1	24/04/201:
Living style	1	1	24/04/201:
Maintanance	1	1	24/04/201:
Non structural materials	1	1	23/04/201:
Weather	1	1	24/04/201:
Suggestions	3	15	23/04/201
Better look	1	1	23/04/201:
Central materials specifications o	1	1	23/04/201:
Cheap	1	3	23/04/201:
Comprehensive information on int	1	3	23/04/201:
Indication of relative quality an	1	1	23/04/2013
Good choices	0	0	24/04/201:
Strong relationship with Architect	2	4	23/04/201:
Wise choices at the begining	1	1	24/04/201:

APPENDIX – 7

38th Australian Universities Building Educators Association (AUBEA) International Conference

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Auckland, New Zealand

SUPPLY CHAIN COLLABORATION IN NEW ZEALAND HOUSE CONSTRUCTION

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ABSTRACT

Concurrent with the development of interest in supply chain management (SCM) in the broad manufacturing sector, there has been increasing interest and research in SCM in relation to construction. The construction supply chain comprises a network of project parties connected upstream and downstream to produce what the end consumer wants – much like in any production process. However in construction there is little by way of aggregation or integration in the supply chain. Indeed historically disintegration has been the default state in the construction supply chain.

The key to achieving project success within a defined timeframe is based on collaborative interactions within the supply chain. Collaboration is the key to solving issues in on-going construction. The study collects the views of construction materials manufacturers, suppliers, architects, and homeowners on the significance of collaboration in the New Zealand residential construction sector. The study collated data from 30 semi-structured interviews. Thematic analysis of the responses identified the significance of collaborative materials supply chain practices in the residential building construction sector.

The study found that collaboration is appreciated by all the parties in the construction supply chain in order to find appropriate building materials for use on projects. Further, good communication across the supply chain was identified as a key driving factor to strengthening existing collaborative efforts.

Keywords: Building materials, collaboration, New Zealand, supply chain management.

INTRODUCTION

The purpose of construction supply chain management (CSCM) is to manage and co-ordinate the complete supply chain from raw materials suppliers to end users (Ryan and Bernard, 2003). It involves aspects of

EXAMINING CONSTRUCTION MATERIALS PURCHASING PRACTICES

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ABSTRACT

Construction materials occupy a large proportion of construction cost contributing nearly 50% although the exact proportion varies from project to project. Therefore, having a proper materials management system with defined criteria for materials purchasing decisions creates the opportunity to obtain the best price for construction materials. The paper investigates the construction materials purchasing practices and examines significant factors which could impact on the best building material price to a project. The rational for the examination is based on the fact that knowledge of the purchasing practices that brings about the best construction material price on a site is largely unknown. There is evidence to support a strong relationship between the implementation of an efficient and effective material management system; and the competitiveness of any construction business. The paper proposes a set of guidelines and purchase practice, based on theoretical study, as a first step towards a comprehensive empirical study of securing best construction material prices.

Keywords: Best buy, construction materials, construction materials management, purchasing methods

INTRODUCTION

Every building facility incorporates varieties of material items, which require to be understood in terms of their properties, availability, fabrication and the energy required to produce the structure, energy consumption during its lifetime, the required maintenance, the end-of-life properties, and especially the purchase cost of the materials (Domone and Illston, 2010). The sourcing, procurement and use of these building materials are important in the quest for every project success. However in spite of improvements to general management and procurement systems in the construction industry (Tookey et al., 2001), building material purchasing strategies seem not have achieved similar positive developments considering the centrality of materials in construction activities. Because materials represent a major expense in construction, minimizing their purchase costs presents important opportunities for reducing overall construction costs. Wise management practices in the purchasing of and paying for such materials are essential to accomplish successful construction works at the best price (Abdul-Malak et al., 2000; Zavadskas et al., 2008; Hadikusumo et al., 2005).

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Supplier Selection in the Construction Material Purchasing Function

Don Amila Sajeevan Samarasinghe*, John E Tookey**, James Olabode Bamidele Rotimi***, and Sivadass Thiruchelvam****

Construction materials occupy a significant part of the construction's value contributing nearly 50%. Thus when selecting construction materials, it is very important that painstaking decisions should be made. Past literature and anecdotal evidences show that the main issue with building materials purchasing comes with supplier selection, and depend on careful examination of supplier economics among other criteria. Supplier selection is the purchasing function that forms the foundation for the success or failure of projects. Therefore supplier selection criteria should be well defined. Supplier selection is a multi-criteria decision making problem which includes both qualitative and quantitative considerations. A trade-off between tangible and intangible criteria is important in selecting the best supplier. This paper presents a review of supplier selection processes and decision making methods reported in academic and other literature related to the construction industry. The study is a part of an on-going doctoral research study on construction material purchasing decisions aimed at determining how small to medium scale (SME) construction contractors could secure 'best prices' for their key material inputs in New Zealand construction industry. This is a first step towards a comprehensive empirical study of securing best construction material prices.

JEL Codes: C0, D82 and L74

1. Introduction

According to the definition provided by McConville (as cited in Hadikusumo et al., 2005, pp 48), purchasing is "a fundamental function of material procurement that refers to the acquisition of goods and services and an establishment of mutually acceptable terms and conditions between a seller and a buyer". Considerable attention has been paid to the purchasing function in past literature mainly due to its contribution to profitability, survival of business organisations and firms' performances (Bayazit et al., 2006, Carr and Pearson, 1999). Gadde and Hakansson (2001) found that purchasing is not seen as a separate function but as an integral part of running a company. As far as the construction industry is concerned, purchasing can occur in all phases of a construction project.

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Securing Best Prices for Construction Materials: An Exploratory Study of the New Zealand Construction Industry

Don Amila Sajeevan Samarasinghe*, John E Tookey**, James Olabode Bamidele Rotimi***, and Sivadass Thiruchelvam****

Maintaining an efficient and effective material purchasing system as well as purchasing materials at the right price, quality and time are essential for contractors to remain competitive in today's environment. Construction contractors purchase materials through many sources such as builders' merchants (BMs), direct purchases and consumer clubs. Less well known is the fact that BMs offer multiple tiers of discounts to the trade rather than to the public and some contractors have to pay more than others. In addition, suppliers normally sell non stocked items with added mark-ups to the base prices, consequently final construction often costs more than it should. Nevertheless, material purchasing dynamics in the construction industry have rarely been studied in a systematic manner. As such, this exploratory study is expected to understand how small-to-medium-scale contractors could secure "best" prices for materials. The research will be undertaken in conjunction with contractor's clients and their professional advisors, BMs and other suppliers. It is expected that information will be gathered through questionnaire surveys throughout New Zealand. An extensive literature survey will precede such surveys. Finally, the impact of various behaviours (contractors' buying behaviour, suppliers' supply behaviour and clients' procurement behaviour) will be evaluated in order to understand the impact on pricing, using mathematical models. The major benefit of this study will come from understanding the complexities involved in procurement decisions, thus making it easier for construction firms to adopt suitable strategies to secure best prices for construction materials.

JEL Codes: C1, D81, L74

1. Introduction

Building contractors purchase materials through many sources such as Builders' Merchants (BMs), consumer clubs and direct purchases. Sourcing construction materials from a BM is common practice since they provide good discounts to traders rather than the public (Zavadskas et al., 2005). However, experience shows that not all contractors get good discounts because BMs offer different tiers of discounts to their preferred contractors; total sales volume for construction material increases a real-time discount rate in multi-tier discount schemes (Arbietman et al., 2000).

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How Power Utility Engineers Can Better Select Equipment Suppliers?: The Malaysian Case

S. Thiruchelvam*, J. E. Tookey*, D.A.S. Samarasinghe*, K.N. Mustapha** and K. Kadirgama***

Reliable supply of electricity meant that good electricity generation, transmission and distribution infrastructures must be in place. The electricity supply industry must work closely with reliable suppliers for delivery of products and services needed for building a good electricity infrastructure. These suppliers are selected from a rigorous process of supplier selection based on a set of evaluation criteria. Traditionally, price has been used as the key determinant for selecting a supplier. Quality, delivery time and services are other important criteria that have been used in selecting suppliers. In recent times, a shift has occurred towards other non-price attributes like environmental issues, social responsibilities and so forth. With so many constant changes, it is difficult for organizations nowadays to come up with a standard measurement of criteria for effective supplier selection. This lack of standardization meant that criteria for selection is left at the discretion and personal opinions of the executives and managers in charge of purchasing and it is plausible that their interpretations may not be aligned to that of their organizations' suggesting a gap in existing practices. Eighteen criteria considered for this study were mapped onto their respective cluster, namely: supplier's organizational system and technology, buyer-supplier relationship and economic value. The findings of this study should assist various groups of stakeholder (e.g. suppliers, buyers and end-users) to gain a better understanding of social behaviour in making decisions of purchase, particularly with regard to power utilities.

JEL Codes: L94 and H57

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The material purchasing function is the central factor to minimise the overall cost of a building construction project as it contributes to approximately half of the final construction cost. Contractors, subcontractors, clients and consultants are the key personnel involved in the purchasing function in most building construction projects. Clients and their professional advisers could play a significant role in material purchasing functions, but there is evidence to suggest that far too little attention has been paid to their relevance in developing material purchasing strategies. Literature does not provide answers on how the roles of clients can be described in relation to various purchasing activities such as sourcing, selection and procurement of key material inputs; and other routines including feedback and evaluation in relation to price. The paper presents information to show the significance of clients and professional advisers in material management. The paper is an aspect of a wider research that explores how contractors could secure best prices for key materials on construction projects in New Zealand. It describes the methodology for data collection and analyses that will meet the research objectives identified. It is hoped that the result of the research investigations will be beneficial to project participants and the wider construction industry by understanding the complexities involved in procurement decisions and strategies for securing best prices for construction materials.

Keywords: clients, construction materials, purchasing function

INTRODUCTION

A large portion of total construction costs is constituted by construction materials which is usually between 40-50% of the total construction cost for many types of projects (Agapiou et al. 1998). Therefore, maintaining an efficient and effective material purchasing system as well as purchasing materials at the right price, quality and time, are essential for contractors to remain competitive in today's environment. There appears to be opportunities to minimise costs through purchasing strategies particularly with respect to prices. Fellows et al. (2002) confirm that a small percentage reduction in materials costs could bring about a sizable increase in profits for building contractors. However, questions have been raised about how construction materials prices can be better managed considering that it is affected by trade deals between merchants and contractors, and by factors (e.g. political, social, etc.) external to construction (Vidalakis & Tookey 2005). Thus careful materials selection, sourcing and purchasing is essential if it must contribute positively to the realisation of optimum benefits in projects. Key project participants (clients, contractors, architects and designers) should be involved in the material acquisition process so that the best value is realisable on particular projects. Decision making for material acquisition could be associated with economic, technical and aesthetic (comfort and prestige) reasons. However, it is important that the construction materials are suitable to meet functional requirements which satisfy all project participants. Construction management literature show that far too little attention has been paid to cost minimisation strategies in terms of construction materials prices. Sourcing best prices for materials is as much an issue for clients as for contractors and is also an aspect that has rarely received any attention. Eitelberg et al. (2010) conclude that clients' leadership is vital to achieving the best value (Eitelberg et al. 2010) from construction materials. Similarly decisions taken by clients and their professional advisers have a significant impact on the successful construction procurement process (Brisco et al. 2004). The authors believe that it is worthwhile to incorporate clients' decisions into the construction materials purchasing process.

The paper reviews extant literature on the material purchasing and the roles that clients and their professional advisers could play in construction materials purchasing decisions. The paper is an aspect of a larger research programme which explores the opportunities for securing the best prices for key materials used in construction projects in New Zealand. The paper concludes with contextual information on the larger research on which this paper is based. Information provided includes the overarching aim of the research, its objectives and a brief description about the research methods which will be adopted to accomplish the given research objectives.

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SUPPLIER SELECTION CRITERIA IN A POWER UTILITY IN MALAYSIA: ENGINEERS' PERCEPTIONS

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ABSTRACT

Supplier selection of electricity power generating, transmitting and distributing system is part of problem solving environment in a power utility as it is a long-term investment for the organization. Therefore, the supplier selection decision making directly influences the operational and financial positions of a power utility. In addition, the supplier selection of a power-related system is a complex multi-criteria decision problem. While some criteria may be common across different industries, there is no denying the fact that some criteria are likely to be unique to the power industry. This research aims to understand what constitutes the suitable supplier selection criteria in a power utility. This study reveals some interesting findings in regard to how engineers perceive the importance of each criterion and strongly suggest that product quality, price and delivery are key determination in the supplier evaluation process. Eighteen criteria considered for this study were mapped onto their respective cluster, namely: supplier's organizational system and technology, buyer-supplier relationship and economic value. The findings of this study should assist various groups of stakeholder (e.g. suppliers, buyers and end-users) to gain a better understanding of social behaviour in making decisions of purchase, particularly with regard to power utilities.

Keywords: Procurement; evaluating purchasing performance; supplier selection; case study; statistical analysis

INTRODUCTION

Sourcing from the right suppliers ensures business growth and prosperity. In this current climate of economic uncertainty, evaluation of suppliers with due diligence in the electricity supply industry is becoming increasingly crucial to business-related success. The three main components of the industry namely generation, transmission and distribution involve purchasing goods and services required for set-up of new installations, as well as maintenance, repair and operations (MRO). The consequences of poor decision-making become more severe as organisations become more dependent on their supplier's performance. In industrial companies, purchasing share in the total turnover typically ranges between 40 to 80 % (Karthik, 2006), and therefore decision making about purchasing strategies and operations are primary determinants for cost reduction and increasing profits. Apart from that, globalization and advancement in information technology provides more alternatives for supplier selection. Advanced computer models enabling more data input in decision-making coupled with the increasing number of decision makers result in the increase of complexity of purchasing

INTEREC 2012
INTERNATIONAL REAL ESTATE CONFERENCE 2012

UTM-IBIMA INTERNATIONAL REAL ESTATE CONFERENCE (INTEREC) 2012
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At Grand Seasons Hotel, Kuala Lumpur

A conceptual framework to evaluate suppliers for building infrastructure in the Malaysian electricity supply industry

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Abstract

In the current competitive business environment the relationship between buyers and suppliers is no longer antagonistic. Emphasis has shifted to the forging of partnerships that benefits all parties in any business setting. The emergence of supply chain concepts have brought about the realization of long-term cooperation based on mutual trusts. Frequently high priority is given towards suppliers that are able to deliver, and are committed to buyer's business objectives. However, proper supplier selection is pertinent to meeting these business objectives as it dictates operational and financial positions. The current study discusses a construct that could facilitate supplier selection in a typical government linked company. It presents the key items that could be considered in a supplier selection metric using a comprehensive approach. The study is an aspect of a doctoral research programme that aims to develop a supplier selection model for an electricity supply organization. The paper concludes that having a good set of supplier selection metric is of critical importance to business success in any supply chain.

Key words: Supplier selection, Decision making, Power utility, Malaysia