THE IMPACT OF CONSTRUCTION SUPPLY CHAIN MANAGEMENT ON VALUE ON PROJECTS

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AUGUST 2009
DECLARATION OF ORIGINAL AUTHORSHIP

I, FIDELIS ABUMERE EMUZE on this day 7th of August 2009 declare that:

- The work in this treatise is my own work;
- All sources used or referred to have been documented and recognised, and
- This treatise has not previously been submitted in full or partial fulfilment of the requirements for an equivalent or higher qualification at any other recognised educational institution.

Signed............................................................................
DEDICATION
This treatise is dedicated to the ALMIGHTY GOD, who gave me the will and enablement to accomplish the goals for this phase of my academic development

Olorun Baba, Olorun Omo, Olorun Emimimon Iba Re
Osaloblua U Wese
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ABSTRACT

Much research work has assessed the construction process and discovered that the process is ineffective and besieged with problems. Analysis of these problems has shown that a major part of them are related to the state and workings of the supply chains. Prior research justifies that waste and problems in construction supply chains are extensively present and persistent.

This anomaly may be ascribed to the nature of the industry. Horizontal integration that is common place in the construction industry tends to fragment the supply chain, resulting in an unstable production environment occasioned by high unpredictability, much rework, low profits and eventual low level of value creation in the process. Therefore, an increased level of integration of interfaces and processes has been canvassed.

The purpose of supply chain management is to achieve the expected increased level of integration of the whole supply chain. Supply chain management is a concept that has flourished in the manufacturing industry through Just in Time production and logistics. Supply chain management represents an autonomous managerial tool, though still largely dominated by logistics. Supply chain management has long been advocated as a means of improving the performance of supply chains in construction.

This research study reports on an investigation into the impact of supply chain management on value creation in the South African construction industry. The research discovered that collaborative working is already in the industry and contractors consider supply chain management important for project success.

Here construction supply chains were approached from the relationship view point. All issues are encouraged to be viewed and resolved in the supply chain from the relationship perspective.

Keywords: Supply Chain Management; Construction; Collaboration; Value Creation; Continuous Improvement
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>DECLARATION OF ORIGINAL AUTHORSHIP</td>
<td>i</td>
</tr>
<tr>
<td>DEDICATION</td>
<td>ii</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>iii</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>iv</td>
</tr>
<tr>
<td>TABLE OF CONTENT</td>
<td>v</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>viii</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>ix</td>
</tr>
</tbody>
</table>

1.0 THE PROBLEM AND ITS SETTING.............................................................. 1

1.1 INTRODUCTION......................................................................................... 1

1.1.1 BRIEF DESCRIPTION OF THE SOUTH AFRICAN CONSTRUCTION SUPPLY CHAIN........ 4

1.2 STATEMENT OF THE PROBLEM..................................................................... 6

1.3 SUB-PROBLEMS ....................................................................................... 6

1.3.1. SUB-PROBLEM 1: ................................................................. 6

1.3.2. SUB-PROBLEM 2: ...................................................................... 6

1.3.3. SUB-PROBLEM 3: ...................................................................... 6

1.3.4. SUB-PROBLEM 4: ...................................................................... 7

1.4 HYPOTHESES .......................................................................................... 7

1.4.1. HYPOTHESIS 1: ...................................................................... 7

1.4.2. HYPOTHESIS 2: ...................................................................... 7

1.4.3. HYPOTHESIS 3: ...................................................................... 7

1.4.3. HYPOTHESIS 4: ...................................................................... 7

1.5 DELIMITATIONS OF THE STUDY ................................................................ 7

PROJECTS COMPLETED WITHIN THE LAST 10 YEARS; ........................................ 7
PROJECTS IN EXCESS OF R250M; .................................................................... 7
PROJECTS UNDERTAKEN NATIONWIDE INSIDE THE REPUBLIC OF SOUTH AFRICA .. 7
BUILDING AND CIVIL ENGINEERING PROJECTS. ................................................ 7

1.6 DEFINITION OF TERMS ........................................................................... 7

1.6.1. SUPPLY CHAIN MANAGEMENT .................................................... 7

1.6.2. SUPPLY CHAIN .......................................................................... 8

1.6.3. PARTNERING ............................................................................... 8

1.6.4. LEAN CONSTRUCTION ................................................................. 8

1.7 ABBREVIATIONS .................................................................................... 8

1.8 ASSUMPTIONS ....................................................................................... 8

1.9 THE IMPORTANCE OF THE STUDY ........................................................ 9

1.10 THE AIMS AND OBJECTIVES OF THE STUDY ........................................ 9

2.0 THE REVIEW OF THE LITERATURE ........................................................ 11
# METHODOLOGY

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 CONSTRUCTION SUPPLY CHAIN MANAGEMENT</td>
<td>11</td>
</tr>
<tr>
<td>2.1.1 Principles Underpinning Supply Chain Management</td>
<td>14</td>
</tr>
<tr>
<td>2.2 EVOLUTION OF SUPPLY CHAIN MANAGEMENT IN CONSTRUCTION</td>
<td>15</td>
</tr>
<tr>
<td>2.3 BENEFITS OF SUPPLY CHAIN MANAGEMENT</td>
<td>19</td>
</tr>
<tr>
<td>2.4 UNDERSTANDING THE CONSTRUCTION SUPPLY CHAIN</td>
<td>21</td>
</tr>
<tr>
<td>2.5 CONSTRUCTION PRODUCTION AND SUPPLY CHAIN MANAGEMENT</td>
<td>23</td>
</tr>
<tr>
<td>2.5.1. Lean Production</td>
<td>23</td>
</tr>
<tr>
<td>2.5.2. Genesis of Lean Production</td>
<td>24</td>
</tr>
<tr>
<td>2.5.3. Supply Chain Viewed as a Production System</td>
<td>25</td>
</tr>
<tr>
<td>2.5.4. Lean Supply Chain Management</td>
<td>25</td>
</tr>
<tr>
<td>2.5.5. Lean Construction</td>
<td>26</td>
</tr>
<tr>
<td>2.5.6. Lean Construction Strategy</td>
<td>26</td>
</tr>
<tr>
<td>2.5.7. Pursuit of Perfection</td>
<td>30</td>
</tr>
<tr>
<td>2.5.8. Measurement of Waste</td>
<td>31</td>
</tr>
<tr>
<td>2.5.9. Integrated Solutions in Construction</td>
<td>34</td>
</tr>
<tr>
<td>2.6 THE CONTRACTOR’S SUPPLY CHAIN</td>
<td>35</td>
</tr>
<tr>
<td>2.6.1. Subcontractors</td>
<td>35</td>
</tr>
<tr>
<td>2.6.2. Traditional Procurement in the UK</td>
<td>36</td>
</tr>
<tr>
<td>2.6.3. Management Procurement</td>
<td>36</td>
</tr>
<tr>
<td>2.6.4. Pre-Contract Liaison</td>
<td>36</td>
</tr>
<tr>
<td>2.6.5. Post Contract Award Liaison</td>
<td>37</td>
</tr>
<tr>
<td>2.6.6. Subcontracting and Cooperation</td>
<td>38</td>
</tr>
<tr>
<td>2.6.7. Supply Chain Management Enablers and Opportunities</td>
<td>41</td>
</tr>
<tr>
<td>2.6.8. Structures of Supply Chains</td>
<td>42</td>
</tr>
<tr>
<td>2.6.9. Operational Strategies for Supply Chain Management</td>
<td>43</td>
</tr>
<tr>
<td>2.7 RELATIONSHIPS IN SUPPLY CHAINS</td>
<td>43</td>
</tr>
<tr>
<td>2.7.1. Inter-Firm Coordination of the Construction Supply Chain</td>
<td>43</td>
</tr>
<tr>
<td>2.7.2. Collaboration in the Supply Chain</td>
<td>48</td>
</tr>
<tr>
<td>2.7.3. Factors Responsible for Successful Collaboration in Construction</td>
<td>49</td>
</tr>
<tr>
<td>2.7.4. Benefits of Inter-Firm Collaboration in the Supply Chain</td>
<td>50</td>
</tr>
<tr>
<td>2.7.5. Trust in the Supply Chain</td>
<td>50</td>
</tr>
<tr>
<td>2.7.6. Communication Management in the Supply Chain</td>
<td>51</td>
</tr>
<tr>
<td>2.8 PROCUREMENT STRATEGIES USED FOR COLLABORATIVE WORKING</td>
<td>53</td>
</tr>
<tr>
<td>2.8.1. Partnering</td>
<td>53</td>
</tr>
<tr>
<td>2.8.2. Emergence of Partnering</td>
<td>56</td>
</tr>
<tr>
<td>2.8.3. Characteristics of Partnering</td>
<td>58</td>
</tr>
<tr>
<td>2.8.4. Types of Partnering Arrangements</td>
<td>58</td>
</tr>
<tr>
<td>2.8.5. Benefits of Partnering</td>
<td>60</td>
</tr>
<tr>
<td>2.8.6. Prime Contracting</td>
<td>62</td>
</tr>
<tr>
<td>2.8.7. Benefits of Prime Contracting</td>
<td>62</td>
</tr>
<tr>
<td>2.8.9. Methodology of Supply Chain Management</td>
<td>62</td>
</tr>
<tr>
<td>2.9 CONTINUOUS IMPROVEMENT</td>
<td>64</td>
</tr>
<tr>
<td>2.9.1. Performance Improvement</td>
<td>64</td>
</tr>
<tr>
<td>2.9.2. Supply Chain Performance Measurement</td>
<td>68</td>
</tr>
<tr>
<td>2.10 THE HEATHROW TERMINAL 5: DELIVERY STRATEGY</td>
<td>71</td>
</tr>
</tbody>
</table>

# METHODOLOGY

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0 METHODOLOGY</td>
<td>80</td>
</tr>
<tr>
<td>3.1 RESEARCH METHOD</td>
<td>80</td>
</tr>
<tr>
<td>3.2 DATA COLLECTION</td>
<td>80</td>
</tr>
<tr>
<td>3.3 QUESTIONNAIRE DESIGN</td>
<td>81</td>
</tr>
<tr>
<td>3.4 THE POPULATION</td>
<td>81</td>
</tr>
</tbody>
</table>
**LIST OF TABLES**

<table>
<thead>
<tr>
<th>Table No.</th>
<th>Title</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 2.1</td>
<td>Aspects of subcontracting in building construction</td>
<td>40</td>
</tr>
<tr>
<td>Table 2.2</td>
<td>Barriers to supply chain integration for subcontractors and solutions</td>
<td>46</td>
</tr>
<tr>
<td>Table 2.3</td>
<td>Traditional versus supplier partnerships</td>
<td>47</td>
</tr>
<tr>
<td>Table 2.4</td>
<td>Main problems of construction</td>
<td>56</td>
</tr>
<tr>
<td>Table 3.1</td>
<td>Sample size distribution</td>
<td>82</td>
</tr>
<tr>
<td>Table 4.1</td>
<td>Spread of response</td>
<td>85</td>
</tr>
<tr>
<td>Table 4.2</td>
<td>Relationship problems</td>
<td>94</td>
</tr>
<tr>
<td>Table 4.3</td>
<td>Statements relative to collaboration</td>
<td>95</td>
</tr>
<tr>
<td>Table 4.4</td>
<td>Supply chain management as a tool</td>
<td>96</td>
</tr>
<tr>
<td>Table 4.5</td>
<td>Mitigation of adversarial relationships</td>
<td>97</td>
</tr>
<tr>
<td>Table 4.6</td>
<td>correlations</td>
<td>97</td>
</tr>
<tr>
<td>Table 4.7</td>
<td>Parametric test</td>
<td>98</td>
</tr>
<tr>
<td>Table 4.8</td>
<td>Non-parametric test</td>
<td>98</td>
</tr>
<tr>
<td>Table 4.9</td>
<td>Elimination of fragmentation</td>
<td>98</td>
</tr>
<tr>
<td>Table 4.10</td>
<td>Correlations</td>
<td>99</td>
</tr>
<tr>
<td>Table 4.11</td>
<td>Parametric test</td>
<td>99</td>
</tr>
<tr>
<td>Table 4.12</td>
<td>Non-parametric tests</td>
<td>99</td>
</tr>
<tr>
<td>Table 4.13</td>
<td>Improvement of information sharing</td>
<td>100</td>
</tr>
<tr>
<td>Table 4.14</td>
<td>Correlations</td>
<td>100</td>
</tr>
<tr>
<td>Table 4.15</td>
<td>Parametric test</td>
<td>100</td>
</tr>
<tr>
<td>Table 4.16</td>
<td>Non-parametric test</td>
<td>101</td>
</tr>
<tr>
<td>Table 4.17</td>
<td>Improvement of reliability</td>
<td>101</td>
</tr>
<tr>
<td>Table 4.18</td>
<td>Correlations</td>
<td>101</td>
</tr>
<tr>
<td>Table 4.19</td>
<td>Parametric test</td>
<td>102</td>
</tr>
<tr>
<td>Table 4.20</td>
<td>Non-parametric test</td>
<td>102</td>
</tr>
<tr>
<td>Figure No.</td>
<td>Title</td>
<td>Page No.</td>
</tr>
<tr>
<td>-----------</td>
<td>-----------------------------------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>Figure 2.1</td>
<td>Model of supply chain in construction</td>
<td>18</td>
</tr>
<tr>
<td>Figure 2.2</td>
<td>The role of SCM in addressing key problems in construction</td>
<td>55</td>
</tr>
<tr>
<td>Figure 2.3</td>
<td>A generic SCM methodology</td>
<td>63</td>
</tr>
<tr>
<td>Figure 4.1</td>
<td>Response to questionnaire</td>
<td>84</td>
</tr>
<tr>
<td>Figure 4.2</td>
<td>Comparison of response to sent questionnaires</td>
<td>85</td>
</tr>
<tr>
<td>Figure 4.3</td>
<td>Respondents type of organisation</td>
<td>86</td>
</tr>
<tr>
<td>Figure 4.4</td>
<td>Type of projects undertaken by respondents’ organisations</td>
<td>87</td>
</tr>
<tr>
<td>Figure 4.5</td>
<td>Number of years respondents’ organisations in the construction industry</td>
<td>87</td>
</tr>
<tr>
<td>Figure 4.6</td>
<td>Number of employees employed by respondents’ organisations</td>
<td>88</td>
</tr>
<tr>
<td>Figure 4.7</td>
<td>Annual turnover of respondents’ organisations</td>
<td>89</td>
</tr>
<tr>
<td>Figure 4.8</td>
<td>Number of projects undertaken by respondents’ organisations</td>
<td>89</td>
</tr>
<tr>
<td>Figure 4.9</td>
<td>Gender of respondents</td>
<td>90</td>
</tr>
<tr>
<td>Figure 4.10</td>
<td>Age of respondents</td>
<td>90</td>
</tr>
<tr>
<td>Figure 4.11</td>
<td>Respondents’ years of construction experience</td>
<td>91</td>
</tr>
<tr>
<td>Figure 4.12</td>
<td>Qualification of respondents</td>
<td>91</td>
</tr>
<tr>
<td>Figure 4.13</td>
<td>Management level of respondents</td>
<td>92</td>
</tr>
<tr>
<td>Figure 4.14</td>
<td>Importance of supply chain management</td>
<td>93</td>
</tr>
<tr>
<td>Figure 4.15</td>
<td>Involvement in collaborative working arrangements</td>
<td>93</td>
</tr>
</tbody>
</table>
1.0 THE PROBLEM AND ITS SETTING

1.1 INTRODUCTION

Management of materials and information flows are key strategic priorities for construction firms. Sound performance in these two areas can provide them with significant benefits and allow the adding of value for clients.

The construction industry has always sought ways of improving performance. Recently, partnering and integration of the supply chain have played a pivotal role in arriving at positive project outcomes as evident in the performance of demonstration projects in the UK (National Audit Office, 2001: 10). Informed thinking suggests that smaller and more integrated supply chains are the answer to demands from clients for increased productivity from the industry and greater regard for completion on time, budget certainty and higher standards of quality and health and safety (H&S) management (Cooke and Williams, 2005: 259).

This ideology has been researched and documented in various forms in the more advanced construction industry. The need to assure continuous improvement and performance certainty in the construction process with a view to satisfying the expectations of all involved in the construction supply chain has been canvassed in previous research works.

The introduction of supply chain management in construction is intended to integrate processes, manage interfaces between companies in projects, reduce uncertainties and weed out inefficiency as much as possible.

Notable scholars in the field such as Cartlidge (2002, cited by Cooke and Williams, 2005: 261) explains that every time waste is removed from the supply chain, value is added to the process, leading to lower costs, shorter construction periods and greater profits. The elimination of waste and inefficiency from the supply chain builds in value in the process. The culture of continuous improvement will then be propagated in the construction process.

Supply chain management, with its strong emphasis on improving relationships is an appropriate strategy for improvement in construction because of its customer focus and process oriented approach. It aims to promote collaboration through leadership, facilitation, training and incentives and replace short-term, contractually driven, project by project, adversarial relationship with a long-term, multi-project relationship, based on mutual trust and co-operation.

It includes the restructuring and integration of project processes and supply networks with fewer strategic supplier partners. These new relationships incorporate continuous
improvement targets to reduce costs, to enhance quality and to focus on the whole life cycle cost and functional performance of facilities.

Supply chain management can also be a very useful approach for construction firms in creating value. This is especially attractive if it is considered that construction is a process characterised by high levels of fragmentation and where the effective integration, coordination and management of the chain, from suppliers to final clients, is a necessary condition to obtain good results.

The research adopts an analytical survey method, which allows the use of structured questionnaires, in depth analysis of case studies and a review of related literature. The research will compare performance of projects based on best practices in the United Kingdom (UK).

The UK construction industry has not been performing optimally for some time now. The Latham 1994 and Egan 1998 reports (cited by Millett et al., 2001) have identified the need for improvements in the construction industry in a number of areas, one of them being the creation, utilisation and effective implementation of processes both at a strategic and operational level. The need for improvement to the conventional design and construction process is well reported in the literature, and both the UK and the South African construction sector have continuously expressed the desire to change the way it perform its primary function - the construction of building and civil engineering works.

Basically, the quest for improvement is linked to poor performance commonly associated with construction projects. Typically, the performance is measured in terms of cost, time and quality. However, these performance indicators are not enough to measure improvement in the process. Cain (2003: 2) suggests that the fragmented state of the construction industry is a direct result of its historical development. He cited a number of reports that documented the fragmented organisational structure of the construction industry, which prohibited the development of efficient supply chain relationships. Dainty et al. (2001: 163) also opine that proliferation in subcontracting has further complicated the relationship within the supply chain through the increased fragmentation of the production process.

The Latham report echoed the abovementioned problem. The report focuses upon the fragmented nature of the industry as a dominant factor contributing to the poor communication between all parties working on a project. Latham proposes that:

- There is a need for more effective collaboration between clients and contractors;
• There is also a need for effective processes throughout the construction life cycle starting from the management of the client brief to the selection of the supply chain participants and eventual construction site processes, and
• Although a number of changes have been identified in previous investigations of the construction industry, the majority of them have not been implemented. This shows that the construction industry might be inherently resistant to change.

The central message of the Latham report is that it calls for significant cost savings by the utilisation and formulation of effective construction processes which will in turn lead to increased performance.

Similarly, Sir John Egan reaffirmed the aforementioned recommendations in his report title ‘Rethinking Construction’ (Egan, 1998: 16). The report identified five key drivers of change, namely:

• Committed leadership;
• Focus on the customer;
• Integrated processes and teams;
• Quality driven agenda, and
• Commitment to people.

With reference to the integrated processes and teams, four key elements were identified which include: product development; project implementation; production of components, and partnering the supply chain. This change into the establishment of consistent processes for the construction industry requires new ways of thinking, necessitates a change of culture, attitude and work practices. It also requires a good understanding of current practices and future trends; effective communication mechanism of such processes and agreement of participating parties. The report suggests that the construction supply chain is critical in driving innovation and in sustaining incremental improvements in the construction industry’s performance (Egan, 1998: 24).

Similarly, reports and research targeted at the South African construction industry have identified disintegrative behaviour or rather fragmentation as being the root cause of many problems in the industry (CIDB, 2004; van Wyk, 2004 cited by Shakantu et al., 2007: 103). This research endeavour intends to focus on the interaction of participating parties in the construction set up. Regardless of the type of contract or procurement strategy between the
client, main contractor and subcontractor, it’s the primary goal of an establishment to ensure the maximization of shareholder’s money.

A need for design and construction operations to form part of a common process best controlled by an integrated system is now gaining acceptance in the industry. The focus of this research is on the supply chain of the main contractor, the first tier supplier.

1.1.1 Brief Description of the South African Construction Supply Chain

Over the past decade, the construction industry in South Africa has undergone several changes in its structure. This is in response to changes in the local environment occasioned by the upsurge in contracting activities financed by both public and private sectors of the economy. One of the major changes is that an increased amount of construction activity is now being subcontracted (Shakantu et al., 2007: 98). It is common knowledge in the industry that a substantial part of the construction work is subcontracted on the majority of major contracts. This suggests that the contractor is at greater risk if the subcontractors fail, as more risk is passed to them. Therefore, construction firms are looking for new ways to reduce their production costs.

The described panorama, together with the inability of construction firms to manage their production and the necessity to reduce fixed costs are pushing these firms towards subcontracting. Vertically integrated production is being replaced by increased use of subcontracting, similar to what happened in the UK and the USA. According to Johansen et al. (2002: 5) the present day trends in the UK are identified as:

- The contractor will become more and more responsible for the end product;
- This means more emphasis on subcontracting and supply chains;
- Contractors are still functionally organised while integrated process control becomes more important, and
- All parties involved in the value-chain are coming more and more to the fore.

Therefore in Johannesburg, the commercial nerve of South Africa, a great number of small firms that specialise in specific construction work such as foundations and earthworks, formwork, masonry, steel fixing, and finishing, are prevalent in the industry.

Given these circumstances, construction firms are beginning to work with a high number of ‘firms’ per project. These subcontractor firms are heterogeneous in nature. While some are well organised firms with many years in the industry, others are new firms with no formal
organisation structure, but mostly formed by a few ex-construction workers from the major firms coming together sometimes to carry out a determined service.

The supply chain in the South African construction industry is now a network formed by a great number of heterogeneous firms working together on the same project. Most of these firms interact with each other during the production stage. With this new structure, new management problems came to the fore. Now firms have to be able to manage a great number of firms on-site. Co-ordination and effective communication become crucial in order to achieve quality standards and to ensure the cost of production to be within project estimation. In a paper presented at the 16th Annual Conference of the International Group for Lean Construction, Roelandt (2007: 3) described the pros and cons of the implementation of lean construction in a South African construction firm. The author focused on the roads and earthworks business unit of the Aveng Group, a JSE listed company, he posited that the implementation of lean concepts have shown significant transformation in the road and earthworks business unit of the company. He also suggested ways and opportunities for more innovative ways of arranging the production process.

Furthermore, Shakantu et al. (2007: 97) suggest that regionalisation is also endemic within the construction industry. They say reduced main contractor size, increased numbers of subcontractors, and increasing fragmentation has had a significant impact on the operational capacity of contractors. The reduction of scope of operations occasioned by a reduction in size creates two effects. Firstly, smaller firms start to operate tactically, concentrating on the micro rather than macro view of the business world. This has a significant impact on the ability of these smaller firms to adopt best practices in the construction process. Secondly, smaller firms move into an economic mindset that emphasises short-term profits, rather than investment on longer-term integrative and strategic approach to operations (Edum-Fotwe et al., 1999; CIDB, 2004 cited by Shakantu et al., 2007: 98).

However, in line with the global trend, the South African government acting both as a regulator and client is actively promoting an efficient and effective construction industry that uses resources efficiently, reduces waste and transforms the working environment of its people for better employment and productivity (CIDB, 2004; van Wyk, 2004 cited by Shakantu et al., 2007: 99). Despite the pressure on the industry to reform, research reports indicate construction remains confined to its old ways of doing business. Risk allocation is consistently disproportionate in the supply chain unlike what is obtainable in other industries. While most industries have undergone important transformations over the past three decades, the South Africa construction industry presents an obvious and glaring exception to
such trends (Shakantu et al., 2007: 100). The CIDB (2004 cited by Shakantu et al., 2007: 100) posits that the South African construction industry is renowned for its inefficiencies as well as the reluctance of its participants to adopt significant improvements. The CIDB report claims fragmentation reduces the efficiency of the industry and leads to much rework and wastage downstream. The summary of the message is that construction projects in South Africa rely on a variety of firms with poorly integrated professional and contractor organisations. Each individual firm performs a variety of wasteful activities within its own discipline which creates inefficiencies resulting in substantial delays and costs.

Shakantu et al. (2007: 103) motivate for further research relative to this subject. They opine that given the predominance of the subcontracting practice and other fragmentation oriented practices in construction, research needs to be conducted to ascertain how supply chain management processes work and how they can be improved in the South African construction sector. This exploratory research is a worthy undertaking in view of benefits canvassed by scholars such as Cain (2003: 26), who rightly say that supply chain management in construction is a way of working in a structured, organised and collaborative manner shared by all participants in a supply chain. He further says that each supply chain member is a link in a chain of activities, adding value at each stage designed ultimately to satisfy the client.

1.2 STATEMENT OF THE PROBLEM

Non-integration of the construction supply chain hinders the creation and improvement of value in the construction process.

Fragmentation and / or discontinuities in the construction supply chain leads to recurrent poor project performance relative to cost, time, quality, and H&S; stakeholder’s dissatisfaction as a result of little or no value creation in the process, and inherent distrust among project partners. This state of affairs in the construction process portends negative image, perception, and also growth of the industry.

1.3 SUB-PROBLEMS

1.3.1 Sub-problem 1:

Recurrent poor project performance.

1.3.2. Sub-problem 2:

Optimum creation of value is lacking in the construction process.

1.3.3. Sub-problem 3:
Supply chain members in the form of contractors and subcontractors blame each other for lack of performance.

1.3.4. Sub-problem 4:
Mutual trust is lacking in the supply chain.

1.4 HYPOTHESES
1.4.1 Hypothesis 1:
Adversarial relationships among subcontractors result in poor project performance.

1.4.2. Hypothesis 2:
Integration of the supply chain eliminates waste and adds value to the process.

1.4.3. Hypothesis 3:
Project delivery outcomes suffer when open and defined communication links are absent in the supply chain.

1.4.3. Hypothesis 4:
Alignment of project goals is difficult without mutual trust in the supply chain.

1.5 DELIMITATIONS OF THE STUDY

- Projects completed within the last 10 years;
- Projects in excess of R250m;
- Projects undertaken nationwide inside the Republic of South Africa, and
- Building and civil engineering projects.

Principally, the study focused on the construction supply chains of general contractor (GC) members of Master Builders South Africa (MBSA). The investigation is limited to actors responsible for transformation and conversion processes on construction sites.

1.6 DEFINITION OF TERMS
1.6.1. Supply Chain Management

Supply chain management is the management of upstream and downstream relationships with suppliers and customers to deliver superior customer value at less cost to the supply chain as a whole (Christopher, 1992 cited by Hong-Minh 2002: 9).
1.6.2 Supply Chain

Supply chain is the firms involved in upstream and downstream contractual relationships, who deliver a commodity, product and / or service related to the core business of a construction project (London and Chen, 2007: 4).

1.6.3. Partnering

Project partnering is a set of actions taken by the work teams that form a project team to help them cooperate in improving their joint performance.

Specific actions are agreed by the project team taking account of the project’s key characteristics, and their own experience and normal performance. The choice of actions is guided by a structured discussion of mutual objectives, decision-making, performance improvements and feedback (Bennett and Peace, 2006: 3).

1.6.4. Lean Construction

Lean construction is a construction philosophy that set clear objectives for project delivery process, designs products and processes concurrently, optimise performance at the project level, and applies production control throughout the life of a construction project (Howell, 1999: 4).

Leanness means developing a value stream to eliminate all waste, including time, and to enable a level schedule (Naylor et al., 1999 cited by Aitken et al., 2005: 6).

1.7 ABBREVIATIONS

BM Benchmarking
H&S Health and Safety
KPI Key Performance Indicators
SCM Supply Chain Management
TQM Total Quality Management
VSM Value Stream Mapping

1.8 ASSUMPTIONS

1.8.1 The procurement methods used are contractually determined, and
1.8.2. Subcontractors are used extensively on major construction projects.
1.9 THE IMPORTANCE OF THE STUDY

Millett et al. (2001: 2) refer to Latham’s 1994 and Egan’s 1998 reports that suggest that the integration of the supply chain can eliminate construction cost and time overruns and also improve performance in the construction process.

With a relatively high level of construction activities in South Africa, possibly the highest in sub-Saharan Africa, it is imperative to analyse the process with a view to ascertain that value is not only created, but that there is also continuous improvement in the construction process.

Major projects such as the Greenpoint stadium in the Western Cape, Medupi power project in Limpopo, and Gautrain in Gauteng, are examples of construction undertakings involving not only major contractors, but also numerous subcontractors. The impact of these construction activities is far reaching in terms of the South Africa economy and the region. The value created in the process can potentially extend benefits to all the stakeholders in the construction industry and the end-users of the built facilities.

1.10 THE AIMS AND OBJECTIVES OF THE STUDY

The common theme after the Latham and Egan’s Rethinking Construction reports are better collaboration across the supply chain from conception through build to support.

The tenets of both reports is that greater partnering and collaboration in the construction sector can improve productivity and profits, and also decrease quality failings and accidents.

The main reason for this research effort is to assess the level of implementation or rather adoption of these best practices in South Africa and to evolve recommendations that will assure continuous improvement in the construction process.

Specifically the research objective is in two folds namely:

- To investigate whether the magnitude and technological requirements of a project influences the relationship between contractors and subcontractors, and
- To explore whether best practice evident in the UK construction industry may be used within the South African environment to improve supply chain integration.

A well managed supply chain offers a range of benefits, from simplification and risk reduction to significant cost savings. Unlike traditional procurement forms which relied on choosing from among a large number of suppliers and subcontractors, with the aim of maintaining competition and driving down cost; supply chain management, takes a radical approach to
procurement, with the aim of setting up long-term relationships with members of the supply chain. So leaner, value-adding and more efficient ways of working can be developed.
2.0 THE REVIEW OF THE LITERATURE

2.1 CONSTRUCTION SUPPLY CHAIN MANAGEMENT

In the context of this research, the supply chain is concerned with firms involved in upstream and downstream contractual relationships, who deliver a commodity, product or service related to the core business of a construction project (London and Chen, 2007: 4).

The position of each member of the chain is said to be inherently conservative, as the majorities have adapted to the status quo and remain in separate silos to protect their interest (Saxon, 2002: 337). Therefore, supply chains need to develop mutual trust and align project goals in order to have a favourable outcome. The co-operation between main contractor and subcontractors and suppliers are subjects of supply chain management, and development of these relationships within the supply system towards arrangements of lean supply and partnership.

In addition, supply chain management is about integrating subcontractors and suppliers’ skills and competencies in order to achieve performance improvement, and to overcome barriers to implementing supply chain management arrangements with small to medium enterprises suggested by Dainty et al. (2001b, cited by O’Brien et al., 2002: 136).

In a nutshell, supply chain management can be seen as a set of practices aimed at managing and co-coordinating the whole supply chain from raw material suppliers to the end consumer (Fewings, 2005: 308). However, Fernie and Thorpe (2007: 323) suggest that underlying all these definitions of supply chain management is the assumption that developing and understanding relationships within and between organisations underpins the ability to optimise flow; breakdown process discontinuities; develop networks; make decisions about managing competencies, and optimise the use of power.

Supply chain management is therefore, closely associated with improvement programmes that have been broadened to include methods of reducing waste and adding value across the entire supply chain. The aim is to evolve greater collaboration and synergy throughout the whole network of suppliers through better integration of both upstream and downstream processes. This significant emphasis on coordination and integration is strongly dependent on the development of more effective and longer-term relationships between buyers and suppliers with increased trust and commitment. It is about adopting a more holistic approach in order to optimise the overall activities of companies working together to build greater mutual competitive advantage and greater customer satisfaction. Baker et al. (2000 cited by Love et al., 2004: 44) say that if the construction industry is to move from an adversarial
environment to one that is founded on collaboration then it should openly embrace the concepts of supply chain management.

Often, construction projects are carried out by short-term teams of architects, contractors, subcontractors and suppliers who have been put together specifically for the execution of the project, only to disperse once the contract reaches its terminal end. In fact, Fearne and Fowler (2006: 283) note that the construction industry is arguably the least integrated of the all major industrial sectors, characterised by adversarial practices, disjointed supply relationships and a lack of trust between clients, contractors and subcontractors.

In order to overcome this problem, the concept of longer-term contractual relationships was evolved. These supply chain partners include architects, engineers, main contractors, specialist contractors and suppliers of a variety of goods and services appropriate to the project at hand. But experience has shown that this principle tends not to penetrate the first tier of the supply chain so as to encourage integration and the long-term relationships between main contractors and their subcontractors.

Informed thinking suggests that smaller, and more integrated supply chains are the remedy to prevalent cost and time overruns on projects. To this end most top rate contractors have changed the way business is done. Fewer and better supplier and subcontractors now work closely with main contractors and the client reaps the benefits of this new phenomenon.

The reasons for large networks of suppliers and subcontractors on the data base of main contractors lies in the outmoded belief that large numbers encourage competition and lower prices. This effort achieves the contrary and a significant amount of time and effort is put to use to obtain competitive quotations from this large pool of subcontractors.

However, a reduction of the number of the supply chain members and signing long-term contracts with them precludes prolonged and expensive formalities, thus adding the much needed value to the supply chain.

Latham (1994: 60) highlights some of the industry problems, and underlines the reliance of the construction sector on competitive tendering for subcontracted work. He also mentions the adversarial attitudes that commonly exist between main contractors and their suppliers. One-off contracts and a failure to develop longer-term relationships between main contractors and key suppliers is common place in the construction industry.

Supply chain theory indicates that value must be added to the process faster than cost (Lamming, 1996 cited by Dainty et al., 2001: 164). Industry and Government reports would suggest that this is probably often not the case for the construction industry, as cost
overruns and low profits are both endemic in the industry. The implementation of supply chain management principles in construction have started to address these issues. The current discourse of change proposes the need for a journey away from adversarial attitudes towards enlightened cooperative relations and appears to demonise adversarial opportunistic behaviours over cooperative and collaborative behaviour (Fernie and Thorpe, 2007: 320).

Much research to date has concentrated on improving interactions between clients and main contractors, and in particular the formation of partnering arrangements and project alliances. It is the larger firms that tend to have taken responsibility for supply chain performance improvement (Dainty et al., 2001: 165). For instance in a research work which examined the relations between clients and contractors, Bresnen and Marshall (2000: 830) suggest that lack of continuity of relationships hinders gaining the full reward of long-term collaboration and transfer of experience and knowledge across projects. But, researchers have largely ignored the influence and contribution of small subcontractors on the supply chain or they have chosen to focus on large contractors (Holti et al., 1999: 6). Subcontractors continually contribute to the supply chain and for full integration, it is important that their case be looked into comprehensively.

Similarly, Khalfan et al. (2005: 110) mention the work of Proverbs and Holt (2000) that advocated the use of supply chain management philosophy as a means to effectively reduce overall construction costs. They proposed early involvement of subcontractors and suppliers in a manner similar to the early involvement of the contractor during the procurement process. According to them, this would give an opportunity to the supply chain members to offer their expertise which could result in significant cost savings and potentially improve collaboration and communication within the chain. The need to build inter-firm relationships based on mutual trust was also explained. According to them it is crucial to take away the deep-rooted barriers of traditional relationships and the adversarial culture, and instead, introduce a change management framework to facilitate the implementation of supply chain management at the operational level.

Dainty et al. (2001a cited by Khalfan et al., 2005: 110) suggest that structural changes are necessary to make supply chain integration effective. These changes include developing trust within the supply chain; ensuring fair payments; early involvement with projects; educating the construction workers; improving communication skills; knowing the operations of other parties in the supply chain; knowing the benefits of supply chain integration and partnering; understanding new contractual documents; client and main contractor
acknowledging the fact that subcontractor brings added values to the construction production process and willingness to share expertise.

2.1.1 Principles underpinning supply chain management

Supply chain management is actually concerned with more than the movement of materials from point to point. Handfield and Nichols (2002: 5) suggest that the goal of supply chain management is the creation of value for the supply chain member organisations with particular emphasis on the client in the supply chain. For this reason, they refer to the improved supply chains that create maximum value for the supply chain members as ‘value systems’. However, there are some principles attached to the use of supply chain management posited by Handfield and Nichols (2002: 6). These principles are described as follows:

- The only entity that injects money into a supply chain is the end customer. That is until the client initiates a procurement process, the supply remains idle;

- The solution that is stable over the long term is one in which every element of the supply chain, from raw material to end customer, profits from the process. It is short sighted for businesses to believe they can solve their cost problems by punishing suppliers and customers. Shifting costs and problems without solving root causes is inherently unstable and mostly unsuccessful over the long term. The best supply chains will solve problems, implement the best solutions, and share the benefits among their members, and

- Supply chain management is about economic value added. Supply chain management is not just about cost reduction. It’s about the total content of a final product or service, including quality, technology, delivery, and after-sales service. It’s about managing the total process and ultimately meeting the needs of the client. The integrated management of information and materials across the supply chain offers the benefits of increasing the value-added by supply chain members, removing waste, reducing cost, and improving customer satisfaction (Handfield and Nichols, 2002: 32). In the same sense, Pryke (2002: 17) suggests that the observation of construction project governance through the analysis of transactions classified broadly into information exchange, performance incentives and contractual relationships, provides benefits in relation to clarity and quantification, particularly as procurement methods move away from the traditional contracting system previously prevalent in the UK.
Therefore supply chain managers strive to achieve the ideas of fully integrated efficient and effective supply chains, capable of creating and sustaining competitive advantage (Christopher and Towill, 2002 cited by Christopher and Peck, 2004: 1). To this end they must balance downward cost pressures and the need for efficiency, with effective means to manage the demands of market-driven service needs and the known risks of routine supply chain failures (Christopher and Peck, 2004: 1).

2.2 EVOLUTION OF SUPPLY CHAIN MANAGEMENT IN CONSTRUCTION

Supply chain management has its beginnings in physical distribution and logistics, and it has recently concentrated on close relationships between parties involved in the flow of goods from the supplier to the customer. Relationships should extend beyond the exchange of materials or services for a price towards the alignment of goals. Handfield and Nichols (2002: 8) define generic supply chain and supply chain management clearly, they say the supply chain encompasses all organisations and activities associated with the flow and transformation of goods from the raw materials stage, through to the end user, as well as the associated information flows. These materials and information flow up and down the supply chain. While, supply chain management is the integration and management of supply chain organisations and activities through cooperative organisational relationships, effective business processes, and high levels of information sharing to create high-performing value systems that provide member organisations a sustainable competitive advantage.

This definition identified managing information systems, inventory management, warehousing, customer service, and after-market disposition of packaging and materials as part of the supply chain (Handfield and Nichols, 2002: 9). The network of the supplier consists of all organisations that provide inputs, either directly or indirectly, to the focal firm. For example, a general contractor supplier network consists of all firms that provide inputs, ranging from raw material such as steel and cement to complex assemblies such as specialist subcontractors for piling. In a nutshell, supply chain management is a philosophy that describes how companies should manage their supply chains to achieve strategic competitive advantages. Its objective is to synchronize the client requirements with the materials and information flows along the supply chain, until reaching a balance between client satisfaction and cost. It refers to the coordination of the activities of all the participants of the supply chain, to knowing the production requirements with the purpose of satisfying the client, to delivering products of higher value and to reducing the cost of the firm that apply these principles (Serpell and Heredia, 2006: 456).
The application of supply chain management, mainly in the manufacturing industry, has been successful and has achieved the expected benefits (Proverbs and Holt, 2000, cited by Serpell and Heredia, 2006: 456). They advocate the use of supply chain management philosophy as an avenue to effectively reduce the overall construction costs. They posit early involvement of subcontractors and suppliers in a manner similar to the early involvement of the contractor during the procurement process. They said this would give an opportunity to the concerned parties to offer their expertise which could result in potential cost savings and can become a stepping stone in improving two way communication among the collaborating partners. Dainty et al. (2001: 3) also stress the need to facilitate inter-firm relationships, achieve mutual benefits, and build trust among key interfaces in the supply chain. According to them it is crucial to take away the deep-rooted barriers of traditional relationships and adversarial culture, and instead, introduce a change management framework to facilitate the implementation of supply chain management on construction sites. The inherent complexity of buildings and infrastructure has caused the industry to fragment into thousands of small, specialist firms. As a result, project teams comprise many individual work teams. For instance, it is common to have subcontractors for formwork, concrete mixing and placement, steel fixing, and scaffold erection on major construction sites. The activities of these entities brings about the realisation of the vision of the project sponsor hence it is wise to monitor and coordinate the subcontractors.

Traditional construction site projects set up has no explicit coordination or control on the relationship between contractors and their subcontractors. It relies on the clauses in the contract data to govern the relations on site. However, experience has shown that consultants fiercely maintain their independence, contractors compete for work and subcontractors struggle to maintain the integrity of their skills and knowledge against market driven demands for lower cost and speedy delivery. The introduction of project management provides a better approach for construction. Cost, time, and quality are controlled to achieve the client’s objectives. Project management improves the performance of project teams by creating a management role with strong links to the client and all the work teams (Bennett and Peace, 2006: 5). For example in a typical construction process in the UK, the end customer will appoint the construction firm and professional services where needed (Egbru et al., 2004: 223). Within the generic supply chain, the construction firm plays the major ‘integrating’ role for the upstream supply chains. The role of the subcontractor is also very important. This is increasingly the case, given the rise in subcontracting in the construction industry in the last decade. But extensive subcontracting has led to strategic and operational
The three major developments that brought supply chain management to the attention of management are (Handfield and Nichols, 2002: 11):

- The ever-increasing customer demands in areas of product and service cost, quality, delivery, technology, and cycle time brought about competition;
- The emergence of and acceptance of higher-order cooperative inter-firm relationships, and
- The revolution witnessed in the use of information technology in the business world.

The aforementioned developments instigated the emergence of an integrated supply chain management approach and in doing so a value system was created. A value system is defined as a connected series of organisations, resources, and knowledge streams involved in the creation and delivery of value to end customers (Handfield and Nichols, 2002: 11). Value systems integrate supply chain activities, from determination of customer needs through product or service development, production or operation distribution, including the tiers in the supply chain.

However, to apply supply chain management in construction it is necessary to differentiate some characteristics of the construction process from factory production, as follows:

- The construction product is for a single client most of the time;
- The product is unique for each project undertaken;
- The place, equipment and methods of production are not constant; construction professionals have a high rotation index during the construction time and between projects;
- All parts and materials can not be on-site at the same time, and
- It is not easy to take advantage from economies of scale and learning.

Though the construction process is different from production processes in factories, supply chain management can be useful and effective in construction (O’Brien, 1999: 1). When working effectively and efficiently modern supply chains allow goods to be produced and delivered in the right quantities, to the right places, at the right time and in a cost effective manner (Christopher and Peck, 2004: 2). The huge fragmentation in the construction process as evidenced by the lack of integration of its supply chain, makes supply chain
management a very appealing approach to achieve integration between internal and external suppliers, designers, contractors, subcontractors and clients (Serpell and Heredia, 2006: 457).

<table>
<thead>
<tr>
<th>Client</th>
<th>Consultants</th>
<th>Constructor</th>
<th>Subcontractors</th>
<th>Suppliers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Need</td>
<td>Design and Studies</td>
<td>Management</td>
<td>Fabrication</td>
<td>Parts Production</td>
</tr>
<tr>
<td>Use</td>
<td>Site Construction</td>
<td>Capacity</td>
<td></td>
<td>Materials Production</td>
</tr>
</tbody>
</table>

Information Flow (orders, programs, estimates, procedures, etc)

Resources Flow (supplies, finished products, equipments, etc)

Figure 2.1 Model of Supply Chain in construction (Koskela, 1999).

From the above figure, it is evident that a construction firm has as many supply chains as it has construction projects, because for each project the client’s requirements and the project’s characteristics might be different. The supply chain in construction represents a system of multiple suppliers. The purpose of incorporating the principles of supply chain management in construction is to obtain competitive and comparative advantages through value creation, cost reduction and the integration of all the parties in the construction process, with the goal of satisfying both internal and external clients. Sterzi et al. (2007: 167) also affirm that supply chain management may be approached as the development of techniques and tools which enable a firm or a group of firms to gain a competitive advantage. In reality, it deals with integration and managerial improvement of the whole supply chain through a close collaboration between the focal companies with suppliers.
Because of the aforementioned, leading firms in the construction industry have adopted supply chain management and their key suppliers contribute to project decisions as full members of the project team. Established supply chains have robust processes aimed at improving the efficiency of the construction process. They seek to streamline each component of the supply chain and enhance all aspects of quality and H&S on site. The optimum gain and efficiency come from integrated project teams comprising fully integrated supply chains selected to meet the specific requirements of the project.

2.3 BENEFITS OF SUPPLY CHAIN MANAGEMENT

Transparency, trust and efficiency in the management of the supply chain present benefits to all parties involved in project delivery:

- Clients can develop improved ability to identify strengths, weaknesses, opportunities and threats in the chain, and increased value for money and efficiency;
- Contractors can access improved early and continuous communications with clients and stakeholders, and a more competitive subcontractor base offering better skills, expertise, innovation and value for money, and
- Subcontractors can engender improved communication with contractors and assurance of continuity in business.

Supply chain integration in practice enables the clients and main contractors to co-opt the subcontractor and suppliers into the construction programme at the early stage of a project. Consequently, construction lead time is vastly reduced and just-in-time delivery can be assured. The whole supply chain is assured of continuity of work and the contractor assured of his ring-fenced profit.

The application of lean thinking to the construction process is one good attribute of supply chain integration and management. The Egan Report ‘Rethinking Construction’ advocated this principle. Part of the lean thinking approach is the use of just-in-time production where materials and components are manufactured, transported and delivered to site as and when required without the need for a long lead-time and stockpiling on site.

Egan describes lean production as a generic version of the Toyota production system, which is recognised as the most efficient in the world. Lean thinking principles include:

- Elimination of non-value adding activities;
- Removal of waste from all activities involved in delivering the product;
- Establishment of relationships with all members of the supply chain, and
Removal of delays in the construction design and production process.

All the aforementioned can be successfully applied to the construction process through innovative design and assembly.

Recent construction supply chain management publications have identified key drivers of integrated supply chains. These drivers include changes in the corporate culture, trust and communication among all the parties involved, information sharing, and sharing common goals of waste elimination and increased efficiency. Dainty et al. (2001, cited by Khalfan et al., 2006: 323) suggest ways of making supply chain integration successful. They posit that trust between parties; fair and prompt payment; early involvement with projects; educating the construction workers; improving communication skills; knowing the operations of other type of firms within the construction supply chain; knowing the benefits of supply chain integration and partnering; understanding new contractual documents; client and main contractors accepting that subcontractors brings added value to the construction process and most importantly a willingness to share knowledge.

Barratt (2004, cited by Khalfan et al., 2006: 324) suggests that the adoption of a ‘collaborative culture’ can enhance integration and improve relationships between the supply chain members. He opines that the collaborative culture is made up of a number of elements including; mutual trust; mutual pain and gain share; flow of information and transparency in the supply chain; communication and understanding, process alignment; joint decision making; use of performance measurement tools, and corporate focus on collaboration of the supply chain.

These benefits have persuaded the industry and academics to propose diverse initiatives in order to achieve the optimised level of integration of the whole supply chain. The contractor normally has overall responsibility for the management of his supply chain to meet his contractual obligations. This is done through the duties assigned to the contractor’s project or construction manager. The project manager has the duty to assure that this supply chain is being effectively managed so as to avoid any potential delay, unnecessary cost implications or any other adverse effects on the project outcome. This is an important issue on construction site because often time problems further down the supply chain can be responsible for long delays and if attention is not given to the problem in a timely manner, major disputes right through the whole chain may cause disruption on site. This can potentially damage the relationships between the supply chain members and have a knock-on effect on project performance.
2.4 UNDERSTANDING THE CONSTRUCTION SUPPLY CHAIN

The construction industry’s structure has been characterised by complexity, referring to the demography of the industry and the organisation of construction, including the configuration and coordination of construction supply chains. The world over, construction is seen as a less structured industry compared to other industries, with a vast network of actors of different kinds involved in project execution.

Construction is also a make-to-order, engineered-to-order delivery and craftsmanship venture. Project engineering and management is important for success in construction. The fact that construction is a demand-driven make-to-order process, and design is often disconnected from production (except Design and Build Contracts), leads to various problems of production. The producer is not the designer and the production process is very much dependent on craftsmanship. This results in problems originating upstream in the supply chain to persist, and often become worse downstream if addressed quickly, because of the mechanisms of causality and interdependence within the supply chain.

Often, construction jobs are not only a one-off undertaking, but also it’s always done on site. The factory is organised on site while very few materials are prefabricated off-site. It is said that the logistics in construction are converging, meaning relatively many suppliers are directly involved for the production of an end product for one or specific clients. The roles of clients in construction cannot be over emphasised because the process begins and ends with the client. This also causes the make-to-order mechanism and the need for reactivity in construction supply chains. This is why built environment products are rarely launched and marketed the way other industry’s products are marketed. The construction industry is different from manufacturing mainly because most contractors are not producers of integrated end products while most products are also not standard, and the construction processes are usually not repetitive, and often result in high levels of waste (Vrijhoef and Ridder, 2007: 5).

Vrijhoef and Ridder suggest that low levels of integration and repetitiveness in construction lead to problems and underperformance of the construction supply chain as a production system. A way of resolving this is to apply concepts that increase integration and repetition within and between project supply chains, such as partnering. Researchers have pointed out the need for more alignment and more structured ways of working in the construction supply chain. Improving the supply chain by supply chain integration can help companies to react to market conditions and reduce cost levels. All firms in a supply chain should be connected, operating as it were a ‘factory without wall’. While it is simply impossible to fully integrate an
entire supply chain because of the temporary nature of construction, a real effort should be made to realise an optimum outcome from the construction process. The relations between firms are typically maintained for the duration of the project though temporarily. Supply chains are not only directed towards minimising transaction costs, but also towards enhancing the transfer of expertise and systematic feedback on planning, design, construction and maintenance between actors, and ultimately towards striving for joint value maximisation. Arbulu and Ballard (2005: 4) illustrate how supply complexity impacts temporary production systems in construction creating waste and potentially affecting on-time project completion. Challenges across the construction industry may vary accordingly with the complexity of each project. However, a challenge shared by all projects is the match between site demand and supply. Any type of variability in both demand and supply will be critical to effective project management and will impact the total production system performance increasing cost and time and reducing quality as well as health and safety. The authors proposed a strategy that targets the reduction of demand variability by stabilising workflow on construction sites. The strategy also presented a way of reducing materials inventories on site by implementing pull techniques such as kanban. It proposes the combination of the use of logistics centres and a distributed production control tool that increases visibility across supply chains as well as provides better forecast information. Arbulu and Ballard (2005: 12) suggest that successful implementation of their proposed strategy will require a holistic view that includes not only a supply chain view, but also a multi-project view. It is important to keep in mind that because of competition in the construction industry, it is no longer enough to be the best in order to have a competitive advantage. They conclude that the lowest cost for each step in the value stream will not guarantee the lowest cost for the whole value stream. To adopt this view, this strategy requires the creation of a different environment where owners, contractors, and subcontractors do business based on mutual trust and respect. They argue that strategic relationships are therefore pre-requisites to extending lean concepts to supply chain management. It is noteworthy that the strategy discussed above is operational. Supply chain management is frequently viewed from two perspectives, which are the strategic view and the operational view (Fernie and Thorpe, 2007: 323). The operational view is concerned with efficiencies in operational activities within and across organisational boundaries. This research work concentrates on the changes occurring within the construction supply chain via the operational view. The operational view is said to draw upon the use of
relationships and relational forms as required in achieving and facilitating the objective of efficiency gains in transactions (Fernie and Thorpe, 2007: 323). However, the operational efficiency might fall apart if not backed up with astute organisational strategy to develop collaborative relationships in the marketplace to support, maintain and consolidate the firm’s position in the industry (Fernie and Thorpe, 2007: 327).

2.5 CONSTRUCTION PRODUCTION AND SUPPLY CHAIN MANAGEMENT

2.5.1. Lean Production

In construction, the production system and the supply chain in particular have been deemed to be relatively disintegrated (Vrijhoef and Ridder, 2007: 1). A more integrated approach to construction has been coined very often as a remedy for the many problems existing in construction. They suggest that, the underlying principle of the supply chain as a production system that is delivering a single product should not be fragmented, nor consist of distributed functions. Instead supply chain integration must lead to improvement by developing a more stable repetitive production environment, similar to what is obtainable in other industries. The premise posited is that supply chains would function better when approached as a single entity.

Production theory, particularly lean production, has been another major influence on supply chain management. The term lean was first coined to describe the Toyota production system pioneered by the Japanese executive Ohno. The epistemology of lean production is contrasted with craft and mass production. Mass production deals with performance of tasks with skilled or unskilled workers as long as a manager is there to give instructions and directions. The rationale behind lean production centres on waste removal in the supply chain. Waste removal is fundamental to a lean value stream. The reason for this is that improved productivity leads to leaner operations, which helps to expose further waste and quality problems in the system (Fearne and Fowler, 2006: 283).

An important lesson from the lean approach is that it attempts customisation of high volume production, to provide customers with exactly what they want at the time they want it. To achieve this end, the lean approach involves improving flexibility, reducing waste and improving flow along the supply chain (London and Kenley, 2001: 780). Koskela (1999: 241) suggests that the traditional way of managing construction is essentially based on a conversion or transformation view on production, whereas supply chain management is based on a flow view of production. The conversion view suggests that each stage of production is controlled independently, whereas the flow view focuses on the control of the total flow of production.
The flow is improved through management and control of each actor along the supply chain. O’Brien (1995, cited by London and Kenley, 2001: 780) expresses concern with materials flow, which raises important questions for workflow. He investigated the production and inventory decisions of quite a number of firms within the construction supply chain. He suggests that any managerial philosophy, such as JIT, applied to one site for one project in the construction industry is problematic due to the temporary nature of project organisation. In 1998, O’Brien presented a systems view of the construction production supply chain, identifying that supply chain management offers the potential to optimise supply chain cost performance. He carried out research to determine how capacity constraints of subcontractors and suppliers affect the cost associated with the construction project schedule and scope changes.

The transformation view and the flow view are the two major conceptualisations of production. The common practice in construction is the transformation view. However, the transformation view is an idealisation, and in a complex production situation the associated idealisation error might be huge (Koskela, 1999: 241). Transformation view, or rather task management assumes that certainty prevails in production. But in reality, due to the inherent variability of production in construction, intended task management becomes mutual adjustment by construction teams on site. To remedy this, the research by Childerhouse et al. (2003: 405) indicates that product delivery ‘best practice’ is transferable across market sectors, for instance the transfer of best practice knowledge from manufacturing to construction, and that frameworks for change, streamlined material flow principles, and various toolkits may be utilised for this particular purpose.

2.5.2. Genesis of Lean Production:

Lean production was developed by Toyota, led by Engineer Ohno. The Toyota production system developed after the Second World War was small compared with the volume and variety of cars it needed to market. A production system was required that was capable of short product, rapid change to kinds and models of cars and the smallest amount of work in process possible. Engineer Ohno and his team very much aware of the American mass production system, decided that there were too much waste in the production process. He understood that the pressure to keep each machine running at maximum production led to extensive inventories that he called ‘the waste of over production’.

Engineer Ohno shifted his attention to the entire production system from the narrow focus of craft production on worker productivity and mass production on machine. Ohno followed the work of Henry Ford and continued the development of flow based production management.
Engineer Ohno devoted his time to perfecting processes for producing cars to the requirements of specific customers, deliver it instantly, and maintain no inventory or intermediate stores a policy which is a direct opposite of standardisation initiative of Ford.

### 2.5.3. Supply chain viewed as a production system

Vrijhoef and Ridder (2007: 7) suggest that a supply chain is aimed at the delivery of a product or service to an end market of a single customer. This means a production process which is purposeful. They suggest that management of production needs to address the transformation, flow and value aspects of production in an integrated manner resulting in a transformation-flow-value generation model for production management. Their research affirms that the supply chain should be value driven and not the present practice of it being cost driven (Peat and McCrea, 2009: 3).

In construction, three fields of production management have been put forward: contract management, process management, and value management. Contract management creates and maintains the relations between the delivery of value and the performance delivered by the contract parties. Process management performs the role of coordinating the production flow, as well as the flow of information, materials and equipment. Value management ensures that the construction process generates the value wanted by the client. On an aggregate level, production management must address all three management aspects in order to be successful.

### 2.5.4. Lean Supply Chain Management

Lean supply chain management can be defined as “planning, executing, and designing across multiple supply chain partners to deliver products of the right design, in the right quantity, at the right place, at the right time”, which integrates lean thinking with supply chain activities (Reeve, 2002 cited by Rivera et al., 2007: 248). Similarly, Vitasek et al. (2005 cited by Rivera et al., 2007: 248) defines lean supply chain management as “a set of organisations directly linked by upstream and downstream flows of product, services, finances, and information that collaboratively work to reduce cost and waste by efficiently pulling what is needed to meet the needs of the client.” From these definitions it can be inferred that lean thinking assist supply chains to align their capabilities and capacities with clients’ requirements and reduce the waste in the process. Lean thinking seeks to remove or significantly reduce variability in the operating environment, to capture efficiencies in the production process, reduce buffer stocks and streamline capacity (Fearne and Fowler, 2006: 284).
The objective is to eliminate waste, and the non value-adding activities existing in the flow of the overall value stream in the supply chain (Rivera et al., 2007: 248). The waste in the three flows associated with lean supply chains namely; product / service, information, and financial flow must be identified and eliminated. In order to be able to identify a lean supply chain, the characteristic of a lean supply chain must be known. Rivera et al. (2007: 249) enumerate the following as characteristics of a lean supply chain:

- Close relationships must be established among all supply chain members who are sharing gains and responsibilities;
- A collaboration based on trust is the foundation for all activities that integrate the supply chain;
- Information needs to be transparent throughout the supply chain, including the end customer’s demand, opportunities and responsibilities;
- Lean logistics approaches should be implemented to physically carry out and benefit from lean thinking, and
- Performance must be monitored, maintained and improved.

2.5.5. Lean Construction

Lean construction is a new way to manage construction. The lean construction movement has, from 1993, led much research work on supply chains through the International Group for Lean Construction annual conferences. Lean construction is an off shoot of lean production, an evolving field that is centred primarily upon a production philosophy for construction. Recent works by O’Brien and Koskela have explored workflow and conversion processes, waste reduction and efficient use of resources, through lean project management, lean supply, lean design, lean partnering and co-operative supply chain management (London and Kenley, 2001: 780) the main message has been eliminating waste and improving workflow in construction. A condition to move towards leanness is the construction of long-term, trust-based, and mutually beneficial relationships among firms, and these characteristics researchers said must be present in a lean supply chain (Rivera et al., 2007: 242).

2.5.6. Lean Construction Strategy

The application of lean thinking throughout the supply chain brings opportunities for additional improvements in each individual firm as well as in the supply chain as a whole.
(Rivera et al., 2007: 243). To this end Garnett et al. (1998: 5) describe the five key principles within which they saw lean techniques being successful. The five key principles are:

- Value;
- Value stream;
- Flow;
- Pull, and
- Perfection.

The use of these principles resulted in the development and implementation of tools and techniques such as kaizen, quality circles, and just in time (JIT) delivery system. To achieve a lean enterprise these principles need to be considered at a strategic level. Lean supply chain integrates the activities of all the firms interacting in a supplier network to present the client with a certain ‘offer of value’. This offer of value goes beyond the mere product or service that the client acquires, it encompasses the whole experience starting from the moment the client expresses interest in a given product or service to the moment where the triggering need is satisfied completely and satisfactorily (Rivera et al., 2007: 242).

2.5.6.1. Value

The issue of value in construction is a complex one requiring several different value strategies to be combined within one project. The client may have one definition of value whilst end-users or stakeholders have another. By not being product focused, the industry gives itself a steep hill to climb at the start of each new project where the newly formed team has to spend time and energy eliciting the value definitions and trying to arrive at a consensus from which the project can progress (Garnett et al., 1998: 5).

In contrast by applying the principles of lean thinking several key differences become immediately obvious. Firstly by focusing on the client’s needs, construction has to adopt a product focus. Product focus enables a long-term dialogue to be started concerning the nature of value and how the product delivers it. More explicitly, the fact is that the client requires a facility to suit its purpose and provide value for money. What the client is less concerned with is how the facility is developed and how many people are involved in it. More recently the concern has come from the clients simply because they are so dissatisfied with what they are offered and are forced to become involved in the construction process to minimise their own risk. The vision that this product and customer focus suggests is not new.
Aspects of it have been alluded to in many previous reports, but the ideas have not been developed by the industry.

2.5.6.2. Value Stream

The value stream identifies all those steps required to make a facility. The key technique behind the value stream is that of process mapping. However, it is process mapping for a very specific reason; that of understanding how value is built in to the building product from the point of view of the client. At a strategic level it offers a perspective on defining what is to be done. By taking this top down approach, the idea of identifying value streams such as the structure and the building envelope and considering how these systems will be designed, supplied and constructed, offers a different way of organising for construction. At a more tactical level the value stream mapping can be used to identify where waste lies in a particular process and how it can be achieved more effectively. Process mapping is an essential tool for understanding supply chains. A process can be defined as ‘a logical series of related transactions that converts input to output’ (Handfield and Nichols, 2002: 40).

A business process is ‘a chain of logically connected repetitive activities that utilises the enterprise’s resources to refine an object for the purpose of achieving specified and measurable results for customers.’ Handfield and Nichols (2002: 41), contend that the improvement of businesses is at the very core of supply chain management. The development of a process map assists in the understanding and documentation of a process, be it the construction process or a factory production process. Process maps serve the following purposes (Handfield and Nichols, 2002: 42):

- It creates a common understanding of the content of the process activities’ results, and performs different functions;
- It defines the scope of the process, as well as the boundaries of the process relevant to adjacent processes, and
- It provides a baseline against which to measure improvements in the future.

Relationship mapping and flow charts assist to understand the ‘as is’ situation in the supply chain. Relationship mapping provides a broad picture while the flow chart provides a detailed situation in the supply chain (Handfield and Nichols, 2002: 44). The lean movement gave rise to the understanding that value is created in a value stream. By organising activities that add value for the client we have a process that is without waste. People refer to value with an unexamined supposition of the presence of a value stream or process. Researchers acknowledge that great good has come from seeing production activities as value streams
that can be standardized and continuously improved for the benefit of customers and company (Macomber and Howell, 2006: 4). The overall value stream from raw material supplier to end user need to be lean for it to serve its intended purpose (Rivera et al., 2007: 247).

After determining what value a product or service has for a customer, the transformation of an organisation’s current practices to become lean will include eliminating waste from the system of interdependent activities and operations that are executed to bring that product or service to market. This set of activities, operations, and associated information make up the value stream. A value stream perspective looks across individual functions, activities, departments, and organisations, and focus on system efficiency rather than local efficiency within any one of these. Value streams are mapped and analysed using a tool known as value stream mapping (VSM). The VSM shows graphically every step involved in the material and information flows. It includes creating a map of the flow of material through production and flow of information from the customer back to the production process. A current state map of in-plant value streams then serves as the basis for the development of a future state maps that leave out wasted steps while pulling resources through the system and smoothing flow. The difference between the current state and potential future states provides a road map to start the implementation of performance improvement (Arbulu and Tommellein, 2002: 185; Bulhoes et al., 2005: 100).

2.5.6.3. Flow

Strategically, flow is used to attack the fragmentation that is inherent in the construction industry by showing fragmentation to be highly wasteful. Many have recognised this wastefulness (Latham 1994: 62) and the leading panacea is seen to be partnering. As Bennett (1998 cited by Garnett et al., 1998: 6) point out in his publications, the early stages of partnering are a necessary pre-requisite for improving construction, but without the concept of flow production applied at a strategic level. Partnering will remain a partial solution unless organised to achieve seamless flow delivery of a product.

2.5.6.4. Pull

At a strategic level, pull really identifies the need to be able to deliver the product to the client as soon as the client needs it. The traditional construction process pushes the client into an often long development process where risk and uncertainty are common. The principle of flow suggests a vision where the ability to define quickly what the client needs from a building in relation to his business and subsequently customising a well understood product
to best fit those needs means that buildings can be delivered more predictably when the client requires them.

2.5.6.5. Perfection

This is a key concept at the strategic level because what it defines is the need for a perfect way of working and organising construction production to deliver construction products and thus become a way of life as inherent culture. To achieve perfection means constantly considering what is being done and how it is being done and harnessing the expertise and knowledge of all those involved in the construction processes to improve it.

2.5.7. Pursuit of Perfection

Waste is defined by the performance criteria for a production system (Howell, 1999: 2). Failure to meet the unique requirements of a client is waste. Zero time delivery of a car meeting customer requirements, with nothing in inventory required that the rapid movement of each car down the line be closely monitored with the arrival of parts from the supply chains. The elimination of rework is the key to continuous workflow and minimisation of inventory.

Moving towards perfection starts with understanding the value stream, the way value to the customer is delivered. Once the value stream is mapped, the task becomes making workflow continuous and reliable. In transformation view attention is given to improvement of activities rather than a concern for value or flow. The concepts used in the propagation of lean production include:

- Identify and deliver value to the customer: eliminate anything that does not add value;
- Organise production as a continuous flow;
- Perfect the product and create reliable flow through stopping the line, pulling inventory, and distributing information and decision making, and
- Pursue perfection: deliver on order a product meeting customer requirements with nothing in inventory.

Because of the aforementioned concepts lean construction accepts Toyota’s production system design criteria as a standard of perfection. Waste in construction and manufacturing come about because of focus on activity rather than work flow. Maintain intense pressure for production on every activity because reducing the cost and duration of each step is the key to improvement. Managing a construction project under lean entails focus on:

- A clear set of objectives for the delivery process;
• Maximising performance for the customer at the project level, and
• Designing the product and process concurrently and applying production control techniques throughout the life of the project.

Lean supports the development of team work and a willingness to shift burdens along supply chains. Partnering relationships coupled with lean thinking make rapid implementation possible. Where partnering is about building trust, lean is about building reliability. Trust is the human attitude that arises in conditions of reliability. Project teams are likely to trust one another very long if they demonstrate reliability. Reliability is the result of the way systems are designed. Though people manage systems, production systems do not work well when every person tries to optimise their performance without understanding how their actions affect the larger project team.

Supply chain management is a continuously evolving management philosophy that seeks to tie the collective productive competencies and resources of the business functions found both within the company and outside in the firm’s allied business partners located along intersecting supply route with a highly competitive, customer-enriching supply system focused on developing innovative solutions and synchronizing the flow of marketplace products, services and information to create unique, individualised sources of customer value (London and Kenley, 2001: 6).

2.5.8. Measurement of Waste

In lean construction the term waste is said to be synonymous with the term non-value adding cost, as any activity that absorbs resources, but creates no value or any losses produced by activities that generate direct or indirect costs but do not add any value to the product from the point of view of the client (Forsberg and Saukkoriipi, 2007: 69). The study conducted by Forsberg and Saukkoriipi sought to capture the amount of all types of waste in construction projects with emphasis on Swedish construction projects. The waste that was identified was then categorised as follows:

• Defects and checks: Besides defects costs, this category also included costs for checks, insurance, theft and destruction of property. Waste in this group accounted for more than 10% of the projects’ production cost;
• Use of resources: This category included inefficient use of labour, machines and materials. This waste accounted for 10% of the projects’ production cost;
• Health and safety: waste associated with work-related injuries and illnesses represented about 12% of the projects’ production cost. The greatest portion of the cost was for
rehabilitation and early retirement, which indirectly adds extra cost to projects via taxes, and

- Systems and structures: Waste related to the structure of the construction industry, such as long land use planning processes, extensive purchasing processes and a great deal of documentation, together corresponding to approximately 5% of the projects' production cost, although this category was thought to be underestimated in the inventory to a high extent. They posited that just considering activities in terms of value and non-value adding could be helpful when trying to achieve cost reductions.

The common sense definition of waste is anything or an action that is not value. Engineer Taiichi Ohno’s seven wastes in organisations and projects are (Koskela, 2000: 58);

- Overproduction;
- Correction;
- Material movement;
- Processing;
- Inventory;
- Waiting, and
- Motion.

It can be seen that the work done by researchers in relating these types of waste to construction over the years has contributed to the built environment body of knowledge. They have on various occasions tried to propose a particular anomaly as the eight great wastes. However, all these efforts point to an incontrovertible conclusion - the presence of waste in the construction process. Concerning the waste of motion or rather waste generated through logistics, it would seem that waste minimisation is often considered a low priority in the strategic planning of projects. Indeed, by the time that construction commences, many of the opportunities for waste reduction have already elapsed, with the management team only being able to control waste through reactive minimisation measures (Dainty and Brooke, 2004: 22). Supply chain alliances and integration has been suggested as the most effective measure, inter-alia, as one policy used in waste minimisation initiatives in the UK (Dainty and Brooke, 2004: 23). In order to understand waste then value must be understood. Value depends on perspective. The lean movement defines value from the customers’ perspective. Value is thus the difference construction clients derive from the
resulting experience of doing business with a contracting organisation. Likewise in extreme cases, this derivation can be one of waste.

Construction supply chains are networks of interrelated processes created to satisfy the needs of the client. A lot of supply chains are established for a multitude of commercial and practical reasons, resulting in a whole that is sub optimal. The issue here is that individual processes in and by themselves, but also the handoffs between processes, disciplines, and organisations, are all subject to the effects of dependence and variation that may cause waste in the system. The removal of this waste will improve the performance of the supply chain. Case studies to document value added and non-value-added times along the supply chain as well as to identify possible causes of waste can be found in the construction literature. For example, the work done by Arbulu and Tommelein (2002: 187) examines the value stream analysis of construction supply chains on a power project. They used value stream analysis as a tool to determine the amount of waste in the supply chains of pipe supports, and then identify the most relevant causes of waste for the supply chain. The authors also present considerations for achieving performance improvement based on a flow perspective rather than an activity-based perspective on the supply chain. Removal of waste from the construction process is part of the six flow principles proposed by Koskela (2000: 56): reduce the share of non-value-adding activities (waste); reduce lead time; reduce variability; simplify by minimizing the number of steps, parts, and linkages; increase flexibility, and increase transparency.

The supply chain lead time depends on various factors such as complexity of a product as this affects the time required to make and inspect it. There are four elements of supply chain lead time (Koskela, 2000: 58) namely:

- Processing time;
- Inspection time;
- Wait time, and
- Move time.

According to Arbulu (2002 cited by Arbulu and Tommelein, 2002: 185) the significant contributor to wait time is decision-making time which may be critical especially when there are quite a number of project participants that must interact, playing different roles for different firms. Because of delay in decision making, information may await processing for days or even weeks. Therefore, the identification and elimination of this wait time is crucial for lead time compression.
Benefits of supply chain lead time compression are (Koskela, 2000: 60):

- Faster delivery of the product or service to the client;
- Reduced need to forecast future demand;
- Less opportunity for disruption in the supply chain due to design changes;
- Greater possibility that participants will interact in a timely fashion with other supply chain participants;
- Easier synchronization of one supply chain with others, and
- Less opportunity for products to become obsolete.

The paper by Arbulu and Tommelein (2002: 186) illustrates the possibility of directly attacking the most visible waste just by flowcharting the process, then pinpointing and measuring non-value-adding activities.

2.5.9. Integrated solutions in construction

Despite its attractiveness as solution to product-service, the ultimate realisation of integrated solutions will be determined by the ability of the industry and its organisations to transform their capabilities, structures, culture, mindsets and positions in the value stream (Dainty, 2007: 48).

Understanding the extent to which a shift to integrated solutions in construction might hold the key to maximising the value jointly created for all stakeholders, demands an understanding of the structural and cultural features of the sector which provide the context within which it will be enacted. Dainty (2007: 49) identifies key constraints to integrated solution in construction as:

**Fragmentation**: Whereas the majority of capital goods sectors have consolidated with a few major suppliers and clients and high interdependency, the construction sector remains highly fragmented, dominated by small firms and clients with low level of interdependency. According to the Small Business Service small companies in the UK collectively account for almost 70% of private sector turnover and 83% of the workforce. The well known and uninteresting suggestions and proposals about fragmentation hardly do justice to the numerous small firms operating in virtually every project, which renders the delivery of integrated solutions problematic. Apart from this structural fragmentation, the low level of trust, skills equilibrium and the socio-economic factor can also be problematic.
Cyclical demand and structural flexibility of the sector: The construction industry is highly cyclical in output because its product is not transportable and durable. The industry is often used as an economic pressure valve to regulate capital investment and the health of an economy - recession or boom. In response, major construction firms continue to place a premium on structural flexibility by subcontracting the majority of their productive capability and retaining core managers and site agents.

Project-based nature: The temporary multiple organisation which is formed for virtually every project springs up a temporary set of inter-organisational relationships which characterise project-defined interactions block the long-term development of social capital or the collective learning which underpins integrated solutions business models in other capital goods sectors. The labour used on projects rarely commits to the customer because of their disconnection from the organisation procuring the work and a sense of uncertainty regarding which project they will be working on next.

The above discourse has presented the premise on which the introduction of integrated solutions, with its capabilities to add value through systems integration can remedy the structural fragmentation and other agents of waste in the construction process. Dainty (2007: 50) suggests that achieving better value is predicated on the integration of products and services, and then the industry must accelerate its transition toward product-service integration to focus on the configuration of bundles of practices.

2.6 THE CONTRACTOR’S SUPPLY CHAIN

2.6.1. Subcontractors

There are very few major projects undertaken solely by general contractors in the construction business these days. The norm is to mandate a managing contractor to organise and supervise the work and a series of specialist subcontractors to carry out the site operations.

Characteristics of subcontracting:

- The main contractor engages the services of a subcontractor by signing a legally binding contract;
- Subcontractors may sublet their work to subcontractors;
- The main contractor retains contractual responsibility for the subcontractor’s work, and
- Attendances are normally provided by the main contractor, which may include the provision of power, scaffolding and tower cranes.
The categories of subcontractors can be broadly defined by the procurement route followed in the contract:

2.6.2. Traditional Procurement in the UK

A. Domestic Subcontractors:

Domestic subcontractors are often chosen and engaged directly by the main contractor to carry out a particular trade e.g. formwork. They may be labour-only or supply and fix, and usually appointed under a standard form of contract or using the main contractor’s bespoke conditions.

B. Nominated Subcontractors:

Nominated subcontractors are chosen by the Architect (JCT 98) or Engineer (ICE 7) to carry out specialist work in the UK. They are appointed on the expenditure of a provisional sum or prime cost sum included in the contract bills of quantities or data, and enters into a contract with the main contractor though there may be a collateral warranty between the nominated subcontractor and the client.

C. Work Package Contractor:

Work package contractors are often used as a synonym for domestic subcontractors, but might also imply responsibility for a specific section of the works, and they may provide a complete service with little or no reliance on main contractor’s attendances.

2.6.3. Management Procurement

A. Trade Contractors:

Trade contractors are contractors who carry out the work under the JCT construction management trade contract, and also engaged and paid directly by the client.

B. Works Contractors:

Works contractors are subcontractors responsible for carrying out the works under the JCT management contract, and engaged and paid directly by the managing contractor.

2.6.4. Pre-contract Liaison

The control and coordination of subcontractors follows similar stages to those that the main contractors go through i.e. pre-tender, pre-contract, and contract planning.

Following the selection process, prospective subcontractors are informed that their tenders have been accepted and that a contract will follow. However, checklists of some pre-construction issues that need to be clarified include:
• Confirmation of order or letter of intent;
• Preparation of contract documents for signature;
• Agreement on key project dates, activity sequence and programme integration;
• Confirmation of requirements for insurances and financial issues;
• Obtaining of client approval of subcontractor if the contract dictates so;
• Agreement of attendance provision, and
• Agreement of mode and frequency of job evaluation and payments.

It is always in the best interest of the project that an open channel of communication is established between the main contractor and the subcontractors as early as possible.

2.6.5. Post Contract Award Liaison

The control of subcontractors is central to the success of a construction project. The success of a project depends on the performance and quality of those who carry out the work on site therefore good liaison and mutual respect must be established at the beginning of the construction process.

This goodwill should continue throughout the construction phase and a good avenue for this is the weekly progress meetings that should be open and all inclusive. A summary of issues discussed at weekly or daily site meetings may include review of progress and quality of work; actions to maintain progress on site; Investigate site problems and hold-ups; review of the target programme; review of the plant and material supply situation; overview of the health, safety, and environmental situation; site instructions and variations, and valuations and payment situation to date. It is important that all members of the supply chain have an input in these meetings so that issues are resolved almost immediately as they arise.

The relation between main contractors and subcontractors is the key to a successful construction project outcome. Analysis of this relationship has attracted a lot of research effort in the last two decades and recommendations have not stopped flowing into the industry. This is particularly important because subcontractors tend to focus on achieving high utilisation rates for their labour and pay little attention to task completion within the stipulated construction programme (Fearne and Fowler, 2006: 283).

However, optimum utilisation of the supply chain to create value in the construction process can be achieved in an environment where collaborative working is encouraged.
2.6.6. Subcontracting and Cooperation

Owing to the prevalence of construction production being primarily subcontracted, it is now imperative to improve the management of the supply chains including the management of subcontractors. Cooperation networks appear to be a competitive way of supply chain organisation, which is beneficial to subcontractors and construction firms. Cooperation networks are results of strategic alliances between some members of the supply chain. These firms, organised together, cooperate, reaching better results than they would obtain individually.

A pioneer of lean construction is Professor Laurie Koskela. In his earlier research work he proposed the need to understand construction production as a combination of conversion and flow processes, and not as a mere number of disjointed conversion processes. Lean construction concept deals with the production process and aims at the adoption of methodologies that allow for the attainment of favourable results in terms of generation of value, without incurring cost increases or quality losses.

As a result of the implementation of this philosophy, the following can be mentioned:

- Systematic waste reduction;
- Operational costs reduction, and
- Attainment of commitment and teamwork.

In construction literature several definitions of subcontracting can be found. Shimizu and Cardoso (2002: 4) highlight a number including “a legal-economic relationship between two agents, in which the characteristic criteria are substitution and subordination.” The substitution criterion means that the subcontractor executes the operation with technical and financial risks, instead of the main contractor; the subordination criterion means the subcontractor must follow the direction given by the contractor.

Even in the mainstream manufacturing industry the role of supplier involvement is well documented. Wang et al. (2008: 253) suggest that a good method for integrating supplier innovation and creativity in the product development stage is supplier involvement, which strives to create synergy through mutually interacting deliverables and decisions between core enterprises and its suppliers. They say this leads to a win-win situation to both sides and that quality and increased regulation, faster innovation, good inter-firm collaboration is critical. This involves managing enterprise’s strategic issues, risks, schedules, resources, processes, and collaboration protocols. This means in the construction industry context, the
most critical requirement for success in the construction process is the collaboration between contractors and their subcontractors, not limiting the role of suppliers also.

In addition, because as per the definition given by Christopher (1992, cited by Christopher and Peck, 2004: 4), supply chains will normally extend across different corporate entities there will need to be a high level of collaborative working if risks in the processes are to be identified and managed (Christopher and Peck, 2004: 13). In this research endeavour, the processes are the various sequences of value-adding and managerial activities undertaken by the focal firm in the supply chain.

Some main aspects involved in job subcontracting in building construction are tabulated in Table 2.1.
### Table 2.1 Aspects of subcontracting in building construction

<table>
<thead>
<tr>
<th>Aspects</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexibility</td>
<td>Subcontracting appears as an answer to market uncertainties</td>
</tr>
<tr>
<td>Quality</td>
<td>Subcontracting, on the one hand, can improve product quality because it uses specialised workforce, and on the other hand, can get worse, because it leads to problems of control and coordination</td>
</tr>
<tr>
<td>Costs</td>
<td>Fixed costs become smaller, while transaction costs increase. Fixed costs are lesser because subcontracting eliminates equipment maintenance and an underutilised workforce. Transaction costs can become bigger, because each new contract negotiation can involve some proposals by subcontractors</td>
</tr>
<tr>
<td>Productivity</td>
<td>Subcontracting tends to further tie the labourer to the firm subcontractor. Thus, the effects of replication, continuity and learning lead to higher productivity of the workforce. Easy access to specialised equipment and constant training also lead to higher productivity</td>
</tr>
<tr>
<td>Controls</td>
<td>Controlling the quality of work is difficult with subcontracting, because the high amount of independent organisations in the site makes the control of work progress difficult</td>
</tr>
<tr>
<td>Planning</td>
<td>Intensive subcontracting makes the planning process difficult. Moreover, conflicting interests can intervene negatively with the programming of activities</td>
</tr>
<tr>
<td>Technology</td>
<td>Market instability leads the contracting firms not to establish stable agreements with the subcontractors, thus not allowing technology transfer</td>
</tr>
<tr>
<td>Training</td>
<td>The contractors tend to pass the responsibility of training to the subcontractors, but generally they are not apt to accomplish it, due to financial features and lack of time for training</td>
</tr>
<tr>
<td>Health and Safety (H&amp;S) at work</td>
<td>The final responsibility for H&amp;S at work falls on the main contractor, as well as the implementation of an H&amp;S program, the commitment and supervision of the subcontractors. The disinterest of the contractor in investing in programs of H&amp;S for floating and unknown workers and the lack of familiarity of the working environment aggravates the problem</td>
</tr>
<tr>
<td>Consumption of materials</td>
<td>Subcontracting can magnify materials waste; subcontractors tend to finish the job as fast as possible</td>
</tr>
</tbody>
</table>

Adapted from Shimizu and Cardoso (2002: 4)

Construction contractors are becoming project managers or construction managers, transferring construction production to specialist subcontractors. Subcontractors are specialist agents in the execution of a specific job, supplying labour, besides materials, equipments, tools or designs. They respond only for the executed part of the workmanship, acting as agents of the production system of the main contractor.
The construction industry is thus dependent on subcontractors and suppliers of materials. However, it is characterised by opportunistic behaviour and the lack of cooperation. Researchers have attributed these shortcomings to the industry traditional approach of the organisational structure of the construction process, which result in a subordinate position for the subcontractors within the hierarchy of relationships forming the traditional design-management-construction process. It is no surprise to see the strain in the relationship between subcontractors and main contractors. A case study of the Brazilian construction industry conducted by Shimizu and Cardoso (2002: 8), determined that in the relationship between constructors and subcontractors, one is dissatisfied with the other: on the one hand, constructors state that the low organisational level of subcontractors makes the relationship difficult; on the other hand, subcontractors stated that constructors usually take advantage of high competition to impose low prices. Also excluding relationships concerning this last type of subcontracting, the lack of partnering relations between Brazilian contractors and subcontractors was equally noted.

Similarly, the British experience and other countries record the same state of affairs within the supply chain. Therefore, rethinking the production system design according to lean construction philosophy can be a good opportunity to change the organisational structure of the supply chain, this being a prerequisite for successful partnering. The objective is to evolve a strategy that will enable the design of multi-organisational structures to effectively execute lean production systems and bring together contractors and subcontractors. The need of strategy analysis that makes the construction sector more competitive is noticed. Amongst these strategies, subcontracting (vertical disintegration) appears as a good alternative, providing flexibility, lean structures, productivity, and cost reduction amongst other pluses (Shimizu and Cardoso, 2002: 10).

2.6.7. Supply Chain Management enablers and opportunities

A detail review of supply chain management literature reveals that most supply chain management research focuses on three main areas: literature related to supply chain structures; literature related to the type of relationships between the supply chain members, and literature related to the operational strategies that can be used.

Supply chain management enablers according to Handfield and Nichols (1999 cited by Hong-Minh, 2002: 28) include:

**Structure:**

- Demand forecast;
• IT and information systems;
• Communication and information sharing;
• Single point of control, and
• One entity and holistic view.

**Relationships:**

• Partnering, and
• Culture, trust and confidence.

**Operational Strategies:**

• Reduced delays;
• Reduced cycle time;
• Just in time delivery of materials;
• Focus on customers;
• Information on inventory;
• Cost transparency;
• Process orientation, and
• Co-ordination.

### 2.6.8. Structures of Supply Chains

A distinct feature of supply chain management is the elimination of waste from the construction process. An effective way to achieve that is to reduce the supplier base and also the elimination of unwanted echelons. Lamming (1996 cited by Hong-Minh, 2002: 30) suggests a single point of control of the supply chain “usually occupied by the firm or organisation conducting the last significant transformation of the product before it reaches the consumer.”

Another significant feature in the supply chain structures is the flow of information, where IT systems become very important for effective project delivery especially in the construction phase of major projects. Equally noteworthy is the fact that when a supply chain is properly designed and managed it should improve customer service, and achieve the necessary balance between costs and service.
2.6.9. Operational strategies for Supply Chain Management

Operational strategies for supply chain management involve the use of diverse concepts for instance:

- Reduction of production cycle;
- Just in Time techniques;
- Quick response;
- Process orientation, and
- Synchronisation of processes.

Much discussion on these can be found in the earlier discussion relative to lean production and construction.

2.7 RELATIONSHIPS IN SUPPLY CHAINS

2.7.1. Inter-firm coordination of the construction supply chain

The supply chain management theme was first presented at the 1995 conference of the International Group for Lean Construction and since then it has remained a constant feature of the annual event. Despite the progress that has been achieved on the application of supply chain management to construction, it is still a burning issue due to the difference between the application of supply chain management in factory production and the construction industry.

In the construction industry, the nature of organisation is predominantly temporary, the products are one-of-a-kind, and the production is on-site and full of high levels of complexity (Vrijhoef and Koskela, 2005: 19). The construction process is thus essentially project-based, and the project itself can be considered as a temporary multi-firm. Research on the application of supply chain management to construction has been related primarily to the construction industry as a whole, or to its companies’ supply chains. Supply chains that arise due to construction projects have very rarely been the focus of attention, and when this happens they are in general analysed from the point of view of the client or the most powerful company that is part of the supply chain. But because of the temporary nature of the construction project and the existence of project-specific transactions, its supply chain differs from the company supply chain in that it arises, develops, and finally dissolves. Due to the specialisation of the work and the fragmentation of the overall process among supply chain members, it is not possible to assume that a single firm would have the power or the
ability to individually coordinate the whole supply chain, but that every member can influence and be influenced by the whole supply chain (Isatto and Formoso, 2006: 294).

Based on this, a construction project supply chain can be regarded as a specific kind of human system made of multiple firms that are connected through economic linkages and conceived with the aim of delivering a construction project. According to the aforementioned, the firm is the fundamental block that builds a project supply chain, stressing that the organisational properties are the main factors to be taken into consideration for describing and understanding inter-firm coordination (Isatto and Formoso, 2006: 294). The flow concept is another concept that is closely related to supply chain management. In general, the literature mentions four kinds of flows: the flow of products; the flow of information; the flow of money, and the flow of value. Most construction literature considers the flow of value to be the most important one. Taking these flows into consideration, Isatto and Formoso (2006: 294) identify three dimensions of coordination within the supply chain, namely:

- The process dimension: the aim of the supply chain is to create value. It comprises the flow of the objects of the work: products or, in managerial processes, the share of the information flow that carries value;

- The social dimension: the purpose of the supply chain is to coordinate actions of people and firms, the subjects of the work. It includes the flow of the information that is intended to coordinate the work among people or to create a common context among people for mutual understanding, and

- The economic dimension: the purpose of the supply chain is to provide the economic stimulus for the firms to take part in the exchanges that are necessary for delivering value to the client.

Due to their temporary nature, all the flows must be simultaneously coordinated to forestall the collapse of the supply chain as a result of lack of cooperation or poor coordination or even due to loss of competitiveness of the supply chain. In order to describe a supply chain in terms of coordination, these three dimensions of coordination must be taken into consideration. Consequently, three questions might guide this choice: (i) How to organise the work among supply chain members? (ii) How to achieve and maintain cooperation among these firms? (iii) How to coordinate processes execution among people from different companies that are autonomous. They suggest three theoretical approaches to assist to answer the questions: the theory of coordination; the transaction costs theory, and the language-action perspective. The authors applied these theories to a study undertaken in Brazil. The case study was done through a clear illustration of the three dimension
approaches in a building project in Brazil. The research work was presented by the description of the organisation of the building work, the economic cooperation and the process coordination in the supply chain.

The case study is an illustrative example of how each of the three theoretical approaches complements the other in explaining the phenomenon of the inter-firm coordination in a construction project supply chain. Though the theory of coordination does not address specifically situations of temporary organisations or the inter-firm context, its application to this kind of context helps to understand the way the purpose of the construction project supply chain can be decomposed into smaller tasks and assigned to each of the firms that take part on it. In the case study presented by Isatto and Formoso (2006: 301), such process of planning the supply chain structure was not conducted by a single company. Instead it assumed the shape of a fractal-like organisation, as the client had very little influence over the way the main contractor decomposed and assigned the tasks that are under his responsibility, and nor the main contractor over the subcontractor. Also, the theory of coordination has shown that a strong relationship exists between the way activities are decomposed and assigned and the dependences that arise among the companies involved.

The transaction costs theory has offered an alternative approach for understanding the inter-organisation coordination of the construction project supply chain. This was derived primarily from its ability in explaining how the mixed nature of construction contracts results in mutual interdependence among firms even in situations in which one of the parties proves to be more powerful than the others.

The main contribution of the language / action perspective was in explaining how managerial processes that occur in the inter-firm context can be coordinated even when little control exists over the sequence and content of the activities from the perspective of a single firm. The management of commitments has shown to be an effective alternative to coordinate the actions among the members of the construction project supply chain even when each of the firms is an independent entity.

These theories emphasise the dimensions involved in the inter-firm coordination of the supply chain. While the theory of coordination focuses on the process dimension, the transaction theory targets the economic angle and the social part is taken care off by the language/action perspective. Isatto and Formoso (2006: 306) suggest that these theories are complimentary and should be applied simultaneously.

Supply chain relationships and theories are the focus of numerous academic papers. Often quoted cases of supply chain management in the construction industry are in fact addressing
the issue of relationships via partnering. It is important to note that the major barriers in implementing supply chain management are people based. Some researchers speculate that in the real world supply chains “more than 60% of problems that arise are due to people, not technology.” One of the main barriers to supply chain integration is the non-integrated structures of supply chains where co-ordination and governance problems arise (Mason-Jones et al., 2001 cited by Hong-Minh, 2002: 31). Other major barriers to supply chain management, with regards to relationships, are the cultural differences, lack of trust and unwillingness of senior management to provide necessary support. A culture that is more collaborative, innovative, embraces change, and which is non-adversarial in nature is desirable in the industry (Peat and McCrea, 2009: 3).

Table 2.2 Barriers to supply chain integration for subcontractors and possible solutions

<table>
<thead>
<tr>
<th>Issues</th>
<th>Barriers to integration of subcontractors</th>
<th>Possible solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial</td>
<td>Late and incorrect payments</td>
<td>Fair payments from main contractors</td>
</tr>
<tr>
<td></td>
<td>Tendering process</td>
<td>Main contractors to place value over price</td>
</tr>
<tr>
<td></td>
<td>Retention</td>
<td>Trust needs to exist between parties</td>
</tr>
<tr>
<td>Programming</td>
<td>Unrealistic programme times</td>
<td>Early involvement of project team</td>
</tr>
<tr>
<td>Contractual</td>
<td>Traditional contracts do not engender good working relationships</td>
<td>New contract forms that encourage collaboration</td>
</tr>
<tr>
<td>Contractors</td>
<td>Estimators are too demanding on small firms that can not comply</td>
<td>Education of staff on people and communication skills</td>
</tr>
<tr>
<td></td>
<td>with price related issues</td>
<td></td>
</tr>
<tr>
<td>Knowledge and</td>
<td>Inaccurate understanding of the businesses of other parties in</td>
<td>Time needs to be taken to learn from partner organisations</td>
</tr>
<tr>
<td>information</td>
<td>the supply chain</td>
<td></td>
</tr>
<tr>
<td>sharing</td>
<td>Some partnering relationships are executed for the wrong reasons</td>
<td>All employers should be educated about the benefits of partnering</td>
</tr>
<tr>
<td></td>
<td>Many partnering relationships are one sided and benefits are not</td>
<td>Benefits should include not only contractors but subcontractors</td>
</tr>
<tr>
<td></td>
<td>evenly distributed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lack required skills for partnering in subcontracting firms</td>
<td>Continuous education of subcontractors</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>Main contractors do not treat subcontractors fairly</td>
<td>Main contractors need to be educated about the business needs of small firms.</td>
</tr>
</tbody>
</table>

Adapted from Dainty et al. (2001: 172)
Latham (1994 cited by Dainty et al., 2001: 165) reports that the relationship between main contractor and subcontractors tends to be strained and adversarial. The prevalent use of labour only subcontractors has further prevented the integration of the project team in the construction process into a seamless supply chain. The basic differences between the traditional and modern approach to construction procurement was highlighted in the doctoral dissertation by Hong-Minh.

Dornier et al. (1998 cited by Hong-Minh, 2002: 32) summarises the main differences between a traditional approach and a supplier partnership approach as presented below

<table>
<thead>
<tr>
<th>Traditional Approach</th>
<th>Supplier Partnerships</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary emphasis on price</td>
<td>Multi criteria</td>
</tr>
<tr>
<td>Short term contracts</td>
<td>Longer term contracts</td>
</tr>
<tr>
<td>Evaluation by bids</td>
<td>Intensive and extensive evaluation</td>
</tr>
<tr>
<td>Many suppliers</td>
<td>Fewer selected supplier</td>
</tr>
<tr>
<td>Improvement benefits shared based on relative power</td>
<td>Improvement benefits are shared more equitably</td>
</tr>
<tr>
<td>Improvement at discrete time intervals</td>
<td>Continuous improvement is sought</td>
</tr>
<tr>
<td>Problems are suppliers’ responsibility to correct</td>
<td>Problems are jointly solved by all members of the supply chain</td>
</tr>
<tr>
<td>Clear delineation of business responsibility</td>
<td>Quasi-vertical integration</td>
</tr>
<tr>
<td>Information is proprietary</td>
<td>Information is shared</td>
</tr>
</tbody>
</table>

Peat and McCrea (2009: 3) affirm that some key issues therefore need to be addressed in order to engender a new culture in the industry. These key issues are:

- Decisions should be made on a cost and not price basis that is developing a more holistic understanding of the supply chain;
- Where possible, products / materials should be modularised so as to standardise and simplify the supply chain, and
All process activities should be evaluated for improvement purposes and where a process is assumed to be important to the undertaken but adds no value, effort should be made to eliminate it from the supply chain.

In addition, Handfield and Nichols (2002: 14) state that relationship management is perhaps the most fragile and tenuous issue in a supply chain and is therefore the most susceptible to breakdown. They opine that a poor relationship at any link in the supply chain can have disastrous consequences for the entire supply chain. For example, an undependable source of materials can virtually cripple a construction site activity, leading to inflated lead times, higher costs, and resultant problems across the supply chain. However, effective management of subcontractors, which translates to a positive construction process outcome, can be achieved when parties regard the subcontractor as being part of the supply chain; share a full picture of the project; share the values that are requested by the supply chain, and invite input where the subcontractor can add value (Peat and McCrea, 2009: 4).

Therefore, the contribution of the subcontractors as a value adding member of the construction supply chain is vital for performance improvement in the construction industry.

2.7.2. Collaboration in the Supply Chain

Supply chain management is a long, complex and dynamic process, which implementation requires a thorough understanding of the real concept behind it (Egbu et al., 2004: 223). Its implementation is said to be dependent upon the ability to create, manage and reshape relationships between individuals, firms and networks within the supply chain. The introduction of supply chain management in an organisation has to be progressively done and control mechanisms must be put in place taking into cognisance issues such as the identification of key strategic supply chain partners; sharing of plans and visions; Learning from each other; avoidance of confrontations; be proactive rather than reactive; exploration of joint initiatives and be receptive to change, and setting realistic objectives for marketing, operations and financial performance (Egbu et al., 2004: 223).

Collaboration can have a considerable positive impact on project performance, not only with regard to time, cost, and quality objectives, but also with regards to more general outcomes such as greater innovation and improved client satisfaction (Akintoye and Main, 2007: 604). Hinks et al. (1996 cited by Akintoye and Main, 2007: 604) suggest that collaboration can also have numerous benefits which include improved working relationships, effective information exchange, less conflicts and risks, higher productivity, cost savings, improved quality, faster processes and better customer responsiveness.
2.7.3. Factors responsible for Successful Collaboration in Construction

The principal success factors responsible for collaboration in construction are commitment of adequate resources from the partners, equity of relationship, recognition of the importance of non-financial benefits and clarity of objectives (Akintoye and Main, 2007: 614). The survey conducted in the UK by Akintoye and Main (2007: 604) indicated that the main reasons for construction collaborative relationships are customer driven rather than competitor driven. It is also a direct response to market opportunities and customer demand, rather than pressures of competition in the construction industry. The study showed that the UK contractors enter into collaborative relationships with the hope of financial gains from reductions in development costs and risks. The results also suggest that contractors would only enter into collaboration if it’s a viable proposition for them and not as a result of what their competitors are doing (Akintoye and Main, 2007: 614). They say the most important factor is top management commitment to the success of the partnering arrangement. A situation corroborated by the study of Bresnan and Marshall (2000: 830) which determined that senior management support is essential in making a collaborative approach both credible and legitimate. The factors responsible for successful construction collaboration in the development process include:

- Importance of the relationship and even distribution of benefits;
- High level of top management commitment and trust;
- Shared risk and response to client needs;
- Good communication;
- Sufficient resources;
- Improved efficiency, and
- Understanding the role of each member of the partnering arrangement must play.

In addition, Cooper et al. (1996a cited by Akintoye and Main, 2007: 612) opine that the success of long term co-operation is highly dependent on cultural and attitudinal factors displayed by the participants. They said the success is also dependent on the achievement of identifiable and sustainable performance improvements and mutual benefits for all collaborating parties (Cooper et al., 1996b cited by Akintoye and Main, 2007: 612). A significant step towards collaboration in construction is to rise above the common culture of conflict, and adopt more ethical conduct marked by honesty and integrity. Hence, collaboration could be seen as a process of improving relationships, and a means for
encouraging cultural shift from adversarial to non-adversarial behaviour (Hellard, 1995 by Akintoye and Main, 2007: 612). Similarly, relationship marketing in construction has been shown to create value for clients in an environment that facilitates realignment of processes in support of value creation. This is achieved through collaborative effort and long-term commitment that in turn engenders trust and overall satisfaction within the supply chain (Davis, 2008: 322).

2.7.4. Benefits of Inter-firm Collaboration in the Supply Chain

Handfield and Nichols (2002: 50) list the following as benefits of collaboration in the supply chain:

- Establishment of contacts across the supply chain;
- Acquisition of insights into present organisational practices, and
- Identification of opportunities for joint projects among supply chain members.

In order to effectively implement integrated supply chain management, a relationship based on mutual benefits and trust must exist in the supply chain (Handfield and Nichols, 2002: 16). It is also noted that the nature of inter-firm interaction within the construction industry which is based solely on strict adherence to contractual terms is not conducive for collaborative relationships (Peat and McCrea, 2009: 4). However, Wood and McDermott (1999 cited by Ingirige and Sexton, 2007: 8) state that there is a general desire of the construction industry to move beyond narrow self interest, towards a spirit of cooperation and trust because it seems collaborative advantage emphasises the creation of new value together rather than the neutral exchange of resources between firms.

A high level of collaborative working across supply chains can also significantly help mitigate risk. The challenge is to create the conditions under which collaborative working becomes possible. The underlying principle of collaborative working in the supply chain is that the exchange of information can reduce uncertainty (Christopher and Peck, 2004: 17).

2.7.5. Trust in the Supply Chain

Dwyer et al. (1987 cited by Davis, 2008: 313) affirm that trust may be defined as the belief that a party’s word or promise is reliable and a party will fulfil its obligations in an exchange relationship. A collaboration based on trust is the foundation for all activities that integrate the supply chain (Rivera et al., 2007: 249). As the level of trust between clients and suppliers in the supply chain evolves, a smoother flow of both materials and information among the firms within the supply chain occurs (Handfield and Nichols, 2002: 15). Trust in all relationships is never automatic. But it can develop when a firm’s performance history and
reliability of its supply chain linkages can be established. Gambetta (1998 cited by Akintoye and Main, 2007: 612) describe reputation as a key to trust in relationships, reputations are expectations others hold of your likely conduct in a partnering relationship. A partner with a good reputation is more likely to be seen to be reliable and trusted. Handfield and Nichols (2002: 165) suggest the following as major types of trust:

- **Reliability:** The partners should follow through on their commitments and their acts also have to be predictable;
- **Competence:** Be sure that a firm and its supply chain partners have assigned competent, knowledgeable, and experienced people to manage the alliance relationship;
- **Goodwill:** In selecting the primary interface with supply chain partners, it’s wise to choose an individual who has extensive knowledge of the technology or function, good people skills, and good character;
- **Vulnerability:** The perception of vulnerability needs to be carefully managed by supply chain partners through information sharing, which helps assure the other partner that its interests are being protected, and
- **Loyalty:** There should be genuine responsiveness to supply chain partner’s needs and willingness to go the ‘extra mile’ if necessary should be in the relationship.

2.7.6. Communication management in the Supply chain

Speaking is the universal means by which information, including thoughts and ideas, is conveyed to the minds of other people. Speech and writing is the every day vehicle for inter-communication whether it is a conversation between friends, a business conference or specifically between contractors and their supply chains. The knowledge and understanding of the basic principles fundamental to this particular accomplishment may mean the difference between success and failure in a construction manager’s career. Calvert *et al.* (1995: 83) identify the sender’s thought; encoding; transmission; reception; decoding; understanding, and action as the seven stages of the communication process.

The interaction of these stages is the medium of transfer of information. The sender’s thoughts are converted into a message, which is transmitted to the required person who receives the message, decodes and ideally understands the message. In construction this understanding implies the undertaking of a specific scheduled activity. A workman may well understand an instruction, but till the instruction is carried out effectively, the communication process has not been successful. It is the transfer of information that always gives rise to the use of a communication medium.
Information and communication technology is undoubtedly a catalyst for change in the construction industry. However, it requires the integration of the human element for it to be effective and productive (Peat and McCrea, 2009: 5). Capabilities such as flexibility, adaptability and decision-making abilities are executed best using the human mind. The contribution of the internet in information sharing within the supply chain is immense. Information moved through the internet has a number of characteristics that can change the way in which supply chains are managed and configured. Similarly, electronic data interchange (EDI) as a standard communication system used in supply chain of many industries is crucial for effectiveness of information sharing. It serves to link business processes with business partners and increase the accuracy of information exchange. EDI activity in construction is said to be traditionally focused on the supply chain cycle and financial activities of the business value chain (Peat and McCrea, 2009: 5). But internet-based EDI has the potential to address some communication and information exchange issues in the construction process. Various barriers in EDI utilisation are currently being addressed through the use of the internet. Peat and McCrea (2009: 6) also suggest that construction-specific application service provider (API) might be able to address the requirements of the construction industry that stems from the one-off nature of its projects.

Sharing information is a key component for accurate integration of the supply chain to optimise its performance. It assists to produce the highest quality, lowest practicable cost and minimum time to service. Therefore, information must be managed to introduce value into the construction process. Information plays a profound role in a construction environment, in particular during the project implementation stage. Information has to be captured and communicated efficiently between relevant parties in a construction supply chain. Better means of managing the flow of information guarantees enhanced productivity on construction projects. Titus and Brochner (2005: 77) suggest that once the construction supply chain is identified at the post-contract phase of project procurement, information regarding specific tasks, materials and other resources are communicated to the project partners. And that based on the project requirement a flow of information occurs. The flow of materials and services is added along with the managing information among supply chain partners. Information related to material supply, labour supply, finance and scheduling of tasks for timely delivery all need to be managed for the proper completion of the project.

Supply chain management in construction deals with the management of materials, information, and financial flows in a network. The co-ordination and integration of these flows within and across this network is critical for effective supply chain management. Lee and Whang (2000 cited by Titus and Brochner, 2005: 75) assert that information technology has
facilitated the sharing of information, which is central to the integration of supply chains. The large numbers of project participants in construction and complexities attached to major projects make information sharing facilitation difficult. These difficulties can be attributed to the nature of construction that includes one-of-a-kind-projects, and inherent fragmentation. However, as the current practice across industries indicates, having real-time information available at the right time can reduce lead-time as well as increase accountability for tracking purposes (Titus and Brochner, 2005: 75).

Titus and Brochner (2005: 79) present a model for understanding the flow of information in complex construction projects. According to them the flow within supply chains is bidirectional. The requirement and fulfilment flow is based on the decision making efficiency associated with each member of the supply chain. Therefore, when a request for material with specific project requirements is sent to a subcontractor, a decision making environment in the subcontractor organisation is engendered. Based on the decision made, the subcontractor causes the fulfilment flow as information is sent to the responsible party - that is a response generates a fulfilment flow. Each member of the supply chain has a decision making role in managing the information flow within the network of the construction project. The resulting information is combined with the decider's motivations, goals, experiences, and understanding of the problem. The decision making process entails the use of a feedback loop.

The supply chain of a construction project identifies the partners involved and their respective roles in handling the flow of information. The quality of information received, the timeliness of the receipt thereof, and the cost effectiveness in obtaining the information, determines the efficiency of a project partner (Titus and Brochner, 2005: 81). The framework presented by Titus and Brochner can be used as a tool for managing information within the construction supply chain and it supports managers in better decision making while utilising innovative technologies. It is obvious that proper management of information brings in value. The value is obtained when information enables a flawless construction process. Therefore, the purpose of managing information is to provide and optimise the application of services needed across supply chains.

2.8 PROCUREMENT STRATEGIES USED FOR COLLABORATIVE WORKING

2.8.1. Partnering

Project partnering is a set of actions taken by the work teams that form a project team to help them cooperate in improving their joint performance.
Specific actions are agreed by the project team taking account of the project’s key characteristics, and their own experience and normal performance. The choice of actions is guided by a structured discussion of mutual objectives, decision-making, performance improvements and feedback (Bennett and Peace, 2006: 3).

Achieving excellence in construction procurement guidance 05 (OGC, 2003: 4) says partnering involves the integrated project team working together to improve performance through agreeing mutual objectives, devising a way for resolving any disputes and committing themselves to continuous improvement, measuring progress and sharing the gains.

Simply put, partnering promotes improved performance through collaborative business relationships based on best value rather than lowest cost. Lamont has this to say about partnering:

“Partnering is an important part of the project management process. It incorporates a set of actions that project teams take, working in cooperation, to improve their joint performance. Generally, these actions are: agreeing mutual objectives, working to agreed decision making processes, and actively searching for improvement in performance. In my view, partnering on any given project provides the best balance of cost, time, risk, quality and performance, for the parties involved in attaining the best value for money.” (Bennett and Peace, 2003: 1)

Partnering is an approach which supports the inclusive management of all project objectives to build a shared stakeholder perspective of best value for the project. Establishment of shared project goals means that the outcomes of a construction undertaking can be better managed. In the last two decades, partnering in construction has played a significant role in the performance improvement initiatives of the industry. It’s a major shift from fragmentation and short-term adversarial relationships to greater integration and longer-term inter-organizational relationships. Partnering is also seen by many as a way of improving the relationship between main contractors and subcontractors (Lingard and Rowlinson, 2005: 131). According to them, research in the UK and the USA has shown that partnering can facilitate better relationships, with the overall aim of benefiting everyone within the construction process.

The recent interest in supply chain management in the construction industry stems from the belief that supply chain management, with its strong emphasis on improving relationships, a process-oriented approach and increasing customer focus, is an appropriate strategy for improvement in construction. Partnering is adopted in an attempt to increase the degree of collaboration between main contractors, subcontractors and suppliers. The implementation
of supply chain management leads to greater integration of both participants and the construction process.

Figure 2.2 the role of SCM in addressing key problems in construction (adapted from Fewing, 2005: 328).
Table 2.4 Main problems of construction

<table>
<thead>
<tr>
<th>Relationship</th>
<th>Processes</th>
<th>Customer Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Lack of trust leading to conflict</td>
<td>1. Fragmented nature of the design process</td>
<td>1. Fragmented nature of the construction process and poorly integrated value chain</td>
</tr>
<tr>
<td>2. Onerous contract conditions and unfair loading of risk</td>
<td>2. Inadequate design period</td>
<td>2. Insufficient focus on internal and external customer requirements</td>
</tr>
<tr>
<td>3. Lack of understanding of the risks involved and their consequences</td>
<td>3. Inadequate design information</td>
<td>3. Ambiguous tender packages</td>
</tr>
<tr>
<td>4. Unfair selection procedures</td>
<td>4. Poor overall planning with inadequate lead time</td>
<td>4. Insufficient understanding of specialist contractors requirements</td>
</tr>
<tr>
<td>5. Unfair payment procedures and failure to view subcontractors as equal project partners</td>
<td>5. Fluctuations in demand for the products and services of the specialists</td>
<td>5. Unclear statements of requirements and ambiguous project information and tender packages</td>
</tr>
<tr>
<td>6. Perceived poor status of specialist contractors</td>
<td>6. Failure to involve subcontractors early enough in the process</td>
<td></td>
</tr>
</tbody>
</table>

Source: (Adapted from Fewings, 2005: 329)

A number of clients and main contractors in the UK and the USA are beginning to extend the adoption of long-term and more collaborative relationships downstream of the supply chain.

2.8.2. Emergence of Partnering

Partnering delivers significant improvements in performance by empowering supply chain members to do their best work. Partnering in construction begins with very careful selection procedures. Price and cost play a minor role; rather it’s the willingness of the supply chain members to work in a cooperative manner that determines the direction of the project. The
objective is to select an effective project team able to concentrate on doing its best work. It empowers contractors and subcontractors to use cooperative team work in making their own decisions through a network of well developed communication links. The industry’s poor performance is caused by project teams being forced into an adversarial defence of their own interests by competitive tendering, tough contracts or out dated management ideas. Time and time again low prices that represent good value are not achieved by ruthless competitive tendering backed up by tough contracts. To get the best project results, contractors integrate their supply chain and new forms of contract that deal explicitly with cooperative team work is available for use for that purpose; an example is the Institution of Civil Engineer’s NEC partnering option. Key issues inside a bespoke partnering contract include:

- Customer satisfaction;
- Construction firms profits;
- Early appointment of all key members of the project team;
- Core team working arrangements;
- Quality, H&S, time and cost control systems;
- Open book accounting;
- Joint value and risk management, and
- Problem resolution mechanism.

Bennett and Peace (2006: 61) also reiterate the main aims of partnering as being two fold. Firstly, working in cooperation with firms that form a project team can provide more benefits for the clients. Secondly, firms that work together have to make a fair rate of return on their investment.

Best practice takes account of total life of the facility by stating limits and constraints that apply to operational and maintenance costs rather than focusing on initial capital outlay of a project. Construction organisations that take single point responsibility for producing an original design are called prime contractors. The prime contractor takes responsibility for integrating the design and construction activities. There is always a strong case for supply chain management and partnering in this approach (Holti et al., 1999: 5). Relentless pressure by project teams to make sure that they never slip up on a project milestone makes a major contribution to efficiency in construction. So also it is always energising when people
agree that they want to make money and understand that the only way to do this is to cooperate with each other.

The significant contribution of partnering to supply chain management is that it focuses on controlling time, quality, and H&S because when these parameters are rigorously controlled, cost control is simply automatic. This ensures value for clients and profits for contractors and subcontractors.

2.8.3. Characteristics of Partnering

- All participants seek ‘win-win’ situations;
- Value is placed on a long-term relationship;
- Trust and openness are norms;
- An environment for long-term profitability exists;
- All are encouraged to openly address any problems;
- Innovation is encouraged, and
- Overall performance is improved.

2.8.4. Types of Partnering Arrangements

Strategic Partnering

- This is where a relationship is developed over an indefinite period and where there is a long-term commitment to the partnering approach. Mathews et al. (2000 cited by Fortune and Setiawan, 2005: 183) identify the potential of partnering to contribute to the wider debates on sustainable construction. They assert that the adoption of upstream strategic supply chain partnering could contribute to the reduction of waste in projects’ downstream delivery processes.

Project Partnering

- This can also be referred to as an alliance arrangement because it is project specific. Reid et al. (2001 cited by Ingirige and Sexton, 2007: 10) define alliances as partnerships between firms that work together to achieve some strategic objectives. Strategic partnering alliances, while having long term goals, need also to prove their short term success whereas project based partnering schemes are oriented towards achieving short term results targeting a single project. The dominant factor of differentiation of alliance operations is the duration of collaboration (Ingirige and Sexton, 2007: 30).
The partnering arrangement may be based on a formal contractual arrangement between parties or better still on a Partnering Charter. The Centre for Construction Innovation, UK (2008) suggests that project delivery on time; within budget; high level of satisfaction of all team members; zero defects; design quality, and environmental performance are typical contents of a partnering charter.

The implementation of ‘open book’ costing approaches has been recommended by leading advocates of strategic partnering practice. Zsidism and Ellram (2001 cited by Fortune and Setiawan, 2005: 184) identify the principal features of effective open book costing approaches as the establishment of the cost of ownership, the sharing of cost information, the monitoring of market prices and the establishment of agreed target costs. The implementation of these activities called for an understanding of supplier’s costs to be shared across the supply chain from the earliest stages of any proposed partnering framework. Similarly, the use of appropriate risk management approaches within strategic partnering alliances was seen as being a key feature of good practice that would ensure partnered projects were delivered with greater predictability in terms of anticipated time; cost and quality performance measures (Fortune and Setiawan, 2005: 184). They say Baker (1999) asserted that the implementation of an effective risk management process involves risk analysis, risk evaluation, risk response and risk monitoring. Such a risk management process ensures appropriate transfer of risks along the construction supply chain. While Flanagan and Norman (1996 cited by Fortune and Setiawan, 2005: 184) state that a risk transfer strategy should involve the placement of risk on organisations that were best able to manage the factor that gave rise to the risk, Baker (1999 cited by Fortune and Setiawan, 2005: 184) suggest that risks should be accepted by the party that was best able to accept the consequences of the risk occurring. However, both views are yet to be proved by the situation on the ground in the UK construction industry though the use of partnering as a vehicle for executing construction projects in a collaborative way has increased significantly in recent years due to various initiatives to improve the management of construction supply chains (Ingirige and Sexton, 2007: 11).
2.8.5. Benefits of Partnering

The benefits of partnering enumerated in Construction Excellence’s partnering fact sheet (2004: 1) include increased customer satisfaction; better value for the client; recognition and protection of profit margins for contractors and suppliers; staff development and satisfaction; creation of an environment that encourages innovation and technical development; better understanding between partners and a reduction of real costs; design integration with specialists in the supply chain; improved ‘project outcome’ through early involvement of the contractors; duplication eliminated; better predictability of time and cost; shorter overall delivery period, and stability, which provides enhanced confidence for better planning and investment in resources.

Haksever et al. (2001: 1) affirm that contractors who are in a mode of long-term relationships with their subcontractors have mainly experienced indirect benefits such as effective communication, less conflict, and risk. In a research work that focused on the relationship between contractors and subcontractors in the UK, they determined that the benefits of long-term relationships mentioned in theory and achieved in Japan have been experienced by most of the UK contractors who have worked with their subcontractors in a long-term relationship mode. It was observed that sub-contractual relationships are more likely to be based on negotiation than competition. This means that conflicts about payment and claims for additional expense can be avoided. This approach also assists to stem the paperwork involved. The subcontractor can get on and worry about technical and engineering issues rather than get involved in cost checking every activity. In return for all these advantages, the contractor goes to great lengths to try and provide continuous employment and fair returns for the subcontractors. These long-term relationships are based on trust and a sense of belonging. Contractors set tough standards, but help their subcontractors to achieve them. Contractors also pay a fair price for work and feel responsible for ensuring that their subcontractors are profit making and have opportunities for growth. Similarly, the Australia Constructors Association (1999: 10) suggests that relationship contracting is founded on the principle that there is a mutual benefit to the client and the contractor to deliver the project at the lowest cost, when costs increase, both the contractor and the client are worse off.

The initial costs of establishing partnering are rapidly out weighted by the benefits, which include lower prices for the clients, higher profits for consultants, contractors and subcontractors, earlier completion, greater certainty, and zero defects. Bennett and Peace (2006: 19) posit that project partnering can reduce cost by 30% and time by 40%, while strategic collaborative working over a series of projects can reduce cost by 50% and time by 80%. To this end, greater efficiency delivered by partnering is used by experienced clients to
improve the performance of the end product, provide higher quality, more sophisticated controls, lower life-cycle costs, greater sustainability and better improvements of value to the client.

Similarly, when people cooperate by adopting a ‘win-win’ attitude, they produce enough for everyone to have everything they reasonably want. In the spirit of cooperation, supply chain members can agree mutual objectives that give the client a lower price and consultant, contractor, and subcontractor higher profits. The construction industry accepts that firms look after their own interest. However, a tough-minded contractor stands to get what he needs if subcontractors have a realistic opportunity to do good work and make reasonable profits. This focus on mutual objectives gives expression to the notion that when people buy into a concept, they can generate enough returns that can delight all the supply chain members. In agreeing mutual objectives it is essential to sort out the financial arrangements so that everyone gets a fair return on business terms. In fact some clients have adopted the open book accounting principle in terms of money disbursement to encourage the principles of partnering (Holti et al., 1999: 13). Contractual arrangements that ensure that supply chain members contribute their best effort will not loose out relative to other procurement methods in the construction industry. The essential quality of good value for clients and fair profits for the supply chain members provides the platform on which supply chain management can flourish. Bennett and Peace (2006: 20) state that project teams must agree to certain objectives which include value for money; guaranteed profits; reliable quality; fast construction; handover to owner on time; cost reduction; costs within agreed budget; operating and maintenance efficiency; improved efficiency for users; architectural / engineering quality; a specific technical innovation; excellent site facilities; healthy and safe construction; shared risks; timely design information; shared use of computer systems; effective meetings; trainings in decision-making skills; training in management control systems, and no claims.

Conclusively, Chan et al. (2005: 11) recommend that partnering be adopted across a wider spectrum of the construction industry to reap sustainable benefits and achieve construction excellence. They observe from an Australian case study that project partnering when properly implemented, can generate a workable model for people to communicate more effectively and efficiently thus eliminating unnecessary misunderstanding and possible conflicts. Similarly, the survey conducted by Fortune and Setiawan (2005: 191) in the UK, revealed that the use of long-term partnering arrangements with principal contracting organisations, standardised and pre-fabricated components, strategic open book cost management methods and risk analysis procedures by housing associations clients are now
widespread. The research findings indicate that there is the potential to achieve significant contributions to the actual delivery of a cultural change towards non-adversarial longer-term strategic alliances between supply chains organisations involved in the delivery of socially owned housing schemes.

2.8.6. Prime Contracting

Prime contracting was selected as the model for procurement of construction and maintenance services for the defence estates in the 1997 strategic defence review when it was determined that a more effective and efficient process was necessary for the billion pounds a year that MOD spend on its estates.

In prime contracting, a single high value ‘prime’ contract for delivery of property management services is placed with one company or a consortium with payment linked to performance and innovation (Egbu et al., 2004: 227). The prime contractor coordinates and actively manages the supply chain and ensures that subcontractors are all working to the same goals of meeting set targets and improving efficiency. In addition, prime contracting offers considerable advantages in terms of providing an overall single point of responsibility, the harmonization of a pre-appointed supply chain, the principle of whole service procurement, economies of scale, collaborative working and the adoption of an output specification of requirements (Egbu et al., 2004: 228). Prime contracting also emphasises the significance of ‘soft issues’ such as the ability to manage cost, market awareness, innovation, trust and flexibility.

2.8.7. Benefits of Prime Contracting

Egbu et al. (2004: 228) suggest that benefits accrue from the proactive management initiative of the prime contractor. These paybacks include:

- Easy fault reporting;
- Appointment agreed with the clients and customers;
- A quick, flexible and timely service for routine repairs;
- Consistency in the procurement approach and construction process;
- Continuous improvement and innovation, and
- Greater emphasis on quality control as a result of reduction in bureaucracy in the process.

2.8.9. Methodology of Supply Chain Management

62
Literature pertaining to supply chain management proposes many supply chain methods. However, the method suggested by Vrijhoef and Koskela (1999: 136) accurately fits the purpose of this research. They suggest that the methodology of supply chain management consists of four main elements: supply chain assessment; supply chain redesign; supply chain control, and continuous supply chain improvement.

Figure 2.3 A generic SCM methodology (Vrijhoef and Koskela, 1999: 136)

The first move is to check if the current process across the supply chain is without waste and problems. The aim here is to find the causality between the waste and problems, and locate their origins. Once the causality is understood, and having found out about the root causes, the next stage is to redesign the supply chain in order to introduce structural resolution of the problems. This includes redistribution of roles, tasks and responsibilities among the actors in the supply chain, and a review of procedures through a feedback mechanism.

The next step is the control of the supply chain according to its new configuration. A monitoring mechanism to continuously assess the modus operandi of the supply chain can be deployed at this stage. This includes systems to measure and estimate waste across the supply chain process, and feedback systems to discuss and evaluate underlying problems. The aim is to identify new opportunities, and find new ways of developing the supply chain. Finally the improvement stage literally implies the continuous evaluation of the process and recurring deployment of the previous three steps.

From case studies (Vrijhoef and Koskela, 1999: 140), three main conclusions were drawn. First, waste and problems exist in the construction supply chain. In the supply chain, most members appear to be managing just their own parts, securing their own businesses. Second, most of the waste and problems originate from another tier of the supply chain.
Third, waste and problems are largely caused by myopic control of the construction supply chain. Most actors are oblivious to the effects of their actions and inactions as it relates to the entire supply chain.

Based on the insight gained by means of supply chain assessment, supply chain arrangements counteracting adversarial relations with other actors are needed to enlarge the magnitude of the supply chain management methodology. For instance the scope of supply chain management between main contractors and their subcontractors may focus on the impact of the supply chain on site activities. Here, the objective is to reduce site costs and duration. In this case, the primary consideration is to ensure material and labour flows to the site continuously and as at when needed for the sake of avoiding disturbances in the workflow.

2.9 CONTINUOUS IMPROVEMENT

2.9.1. Performance Improvement

A key driver for partnering in construction is continuous improvement, which leads to greater efficiency and competitive advantage. Key performance indicators must be determined and measured. These can be compared with internal or external benchmarks.

The key performance indicators to be measured must be relevant to the project and not too numerous to track. The information produced through the key performance indicators should be used to promote action that is a continuous cycle of ‘measure, review, identify and implement actions’ should be adopted.

An important feature of firms experienced in partnering is that they evolve efficient and cooperative relationships with their subcontractors and main suppliers. Leading organisations in the construction industry, which adopt supply chain management, permit their key suppliers to contribute to project decisions as full members of a partnering team in order to achieve the set project goals.

It is said that the improvement of organisational performance is a complex and dynamic process. Organisational, technical and human factors interact over time even as the variables change. The literature pertaining to improving construction performance identifies productivity studies, total quality management, and benchmarking as methodologies used for improving performance in construction (Mitropoulos and Howell, 2001: 2). The authors propose a model that is based on a conceptual framework that identifies the organisational variables that influence a company’s ability to improve its performance. Such variables include organisational resources, performance targets, work load, skills, performance levels,
and motivation. The model illustrates the dynamic interaction of these variables and it was presented as a causal-loop diagram. The goal of the model was to help construction managers and site agents to better understand the conditions that facilitate and obstruct the improvement process and identify actions and policies that can make the improvement process more effective.

The authors proposed model variables and causal-loop diagram relationships were identified from several sources for instance; it was identified from construction literature. The literature pertaining to the application of Total Quality Management (TQM) in construction proposes factors required for the success of improvement efforts namely management commitment and leadership, training, teamwork, statistical methods, cost of quality, supplier involvement, and customer service.

Mitropoulos and Howell (2001: 4) suggest that operational improvements are the changes the organisations implement, which results in improvement with a time lag. They suggest that the development of operational improvements depends on three key factors, which include:

- Time spent on improvement

  Time spent on production reduces time spent on improvement. The work load and project pressures increase time spent on production. Market conditions increase the work load. As a result of increased volume of work, and the difficulty to hire qualified people in a growing market, the project staffs are stretch thin and cannot spend more time on improvement. Hence the time spent on production increases the organisational performance. Management support increases time spent on improvement. Construction literature identified management support as a critical factor for the success of an improvement effort. Management support is indicated by the following: personal involvement in improvement efforts; acknowledging and rewarding the efforts and successes; hiring employees who can contribute to improvement; evaluating middle management performance based on their contribution to the improvement initiative, and providing resources for training and bringing in external experts as needed. Also employee motivation increases time spent on improvement. In every organisation there are always a percentage of the employees who are actively looking for ways to improve the work or rather trigger improvement effort. Finally, perceived need for improvement increases time spent on improvement. This is the gap between the organisational performance and the target performance. Thus, organisational performance reduces the perceived need for improvement. Good market conditions, when volume and profit are
high increases organisational performance. The need for improvement is directly affected by perspectives and goals of the improvement process. Improvement goals create pressures for improvement when there is a wide gap between performance and goals. Based on these, managers can increase the perceived need for improvement by setting high performance goals. This is when benchmarking against ‘world class’ construction companies comes in.

- Performance improvement skills and mechanisms

Mitropoulos and Howell (2001: 5) say that the mechanisms for learning can be grouped into three categories:

Learning from experience: such mechanisms include observation and analysis of existing processes, after action reviews, and any methods for the review and evaluation of organisational activities.

Gathering intelligence: another way to identify potential improvements is by monitoring the external environment. This includes exploring developments outside the company; keep up with new designs, methods and technologies that take place outside the company.

Learning through experimentation: experimentation includes using innovative methods and techniques. These could be management methods, production technologies, information systems or incentive systems.

The use of learning mechanisms increases the organisation’s ability to identify problems and improvements. However, this ability depends on performance improvement skills. The steps in performance improvement skill include:

- Acquiring information: when the organisation collects measurements, observations, and data such as statistical date of defects, time and productivity;

- Interpreting information: when the organisation analyses the data to understand what it means, and what the cause-effect relationships at work are, and what the real causes of the observed data are, and

- Applying the information: when the organisation develops and implements improvement initiatives.

An effective performance of these steps requires organisational skills in data mining as well as skills in analysing the information, and creating effective changes. Skills in
process analysis, and root cause analysis are essential in order to discover the key factors affecting the performance, and develop effective interventions.

- **Perspective and goals**

  The term 'perspective' refers to whether the improvement is result-focused or process-focused. Result-focused are critical success factors for example targets relative to cost, H&S, estimating, and schedule. TQM and lean construction are process-focused. Mitropoulos and Howell (2003: 6) propose that the different focus of the improvement process has important implications for the direction of improvement efforts as it leads to the following parameters.

  Different goals: Result-based goals are typically oriented towards customer expectations. For instance, the schedule improvement goal in a result-focused approach is expressed as ‘complete all projects on or ahead of the promised schedule,’ versus ‘reduce cycle time of a particular process’ from a process-focused perspective. Similarly, the quality goal may be ‘zero punch lists at time of completion’, which is result-focused versus ‘eliminate defects and rework’, which is process-focused.

  Result-focused goals and process-focused goals are both needed, but at different organisational levels. At the strategic level, management needs to establish result-focused strategic improvement goals in the areas critical for competitive advantage of the firm. While in order to meet the strategic improvement goals, improvement effort needs to focus on the production processes. The main point is that result-focused goals emphasise results with or without process improvement while process-focused approaches emphasise both the components of the process and the interdependencies between the components of the complex production system. Mitropoulos and Howell (2003: 8) also suggest that result based improvement efforts may even increase the ‘waste’ in the process by increasing inspections and tracking defects, rather than reducing waste by preventing defects.

  The main element of improved customer-supplier relationships is the use of an objective performance measurement system, which helps ensure that all parties operate according to expectations and are meeting stated goals (Handfield and Nichols, 2002: 16). In addition, supply chain members have to state clear objectives, expectations and potential sources of disagreement in order to smooth the progress of communication and joint problem solving. Therefore, to facilitate accurate appraisal of the performance of a supply chain and its related processes, objective performance measure has to be deployed.
2.9.2. Supply chain performance measurement

The significance of performance measurement in the framework of supply chain management as stated above cannot be over emphasised. Well-timed and precise assessment of overall system and individual system component performance is vital. Handfield and Nichols (2002: 68) list the attributes of an effective performance measurement system as follows:

- Provide the basis to understand the system;
- Influences the behaviour of all concerned throughout the system, and
- Provides information regarding the results of system efforts to supply chain members and other stakeholders.

Consequently, performance measurement is the bond that holds the complex value-creating system together, directing strategy crafting as well as playing a major role in monitoring the implementation of that strategy. Handfield and Nichols (2002: 68) clearly state that research findings thus far suggest that measuring supply chain performance leads to improvements in overall performance. Benchmarking the results against best in industry performance indicators provides an avenue to know the 'as it is' situation and thereafter evolve the 'as it should be' situation in the supply chain. Benchmarking provides a means to focus the supply chain management efforts on the areas most in need of improvement.

Benchmarking analysis has been shown to be an effective means of determining the supply chain’s performance relative to other organisations in the same industry. Cooke (1995 cited by Handfield and Nichols, 2002: 52) defines benchmarking as “the process of identifying, understanding, and adapting outstanding practices from within the same organisation or from other businesses to help improve performance.” The identified steps in a benchmarking process (Handfield and Nichols, 2002: 52) include:

- Identify and understand current processes;
- Form a benchmarking team;
- Determine what to benchmark;
- Identify benchmarking partners;
- Collect data;
- Analyse data and identify performance gaps;
- Take actions to improve, and
- Review results.

The whole supply chain is advised to improve the management of its processes in particular with regard to the sharing of information. Measurement and understanding of the supply chain performance will lead to new initiatives that can drive change in the construction process. Peat and McCrea (2009: 4) suggest that all parties involved in the supply chain must look to drive change through all areas of the chain by:

- The education process;
- A cultural change;
- An understanding that all parties will benefit and profit from the process;
- An open and shared approach to the dissection of the associated benefits of improved supply chain performance;
- An attitude of ‘if you’re in, you win’, and
- Where possible, freezing expectations but including change where necessary through joint agreement through the use of contingency plans.

A previous work that focused on the performance of the South African construction industry, the Department of Public Works cited the following as constraints to improved performance in the South African construction industry (Republic of South Africa, 1999 cited by Smallwood, 2002: 4):

- Unregulated labour-only subcontractors;
- The lack of best practice standards;
- The divide between design and construction, which has consequences for H&S, productivity, and quality;
- The adversarial relationships between principal contractors and subcontractors, and between workers;
- The lack of an agency capable of coordinating the development and implementation of measures to promote best practice, and
- Poor control measures to assure compliance with rules and regulations.

A quick glance at the aforementioned constraints will indicate that there is no significant departure from the constraints facing the UK construction industry and other advanced industries elsewhere in the world. An in-depth study of the research work done by
Smallwood (2002: 3) and Shakantu et al. (2007: 100), indicate that the South African construction industry is still grappling with the same set of constraints. That is why the Department of Public Works (Republic of South Africa, 1999 cited by Smallwood, 2002: 5) rightly cites the integration of design and construction processes as one of the key approaches towards enhancing construction industry performance. The seminal work by Smallwood (2002: 10) concluded by suggesting that the potential exist to improve the performance of the construction industry performance relative to a range of indicators - labour productivity, worker training, number of accidents, rework, and profitability predominate. He also recommends that the non-traditional project parameters such as H&S, and the environment should be afforded status equal to that afforded to cost, quality, and time, and the construction industry should endeavour to integrate design and construction; use appropriate procurement systems and contract documentation; engender a partnering approach; implement quality management systems and improvement processes; implement information technology in a pervasive manner; benchmark all performance areas; increase the amount of research and development, and realise 100% education and training.

All these possible remedies are applicable anywhere in the world and result from highly developed countries, which indicate that if properly implemented, they can engender a culture of continuous improvement in the construction process. To summarise, what is clear from the cited literature is that there are significant areas which the industry can address to improve both its effectiveness and efficiency. It is instructive to note that in terms of the construction industry, effectiveness deals with the project management initiatives while efficiency rightly concerns logistics involved in the process. Effectiveness and efficiency gains will both allow projects to be delivered faster and will also improve profitability for all members of the construction supply chain. Conclusively, Childerhouse et al. (2003: 287) affirm that in order to achieve effectiveness and efficiency in construction a more integrated and customised approach to the adoption of lean principles is essential and requires fundamental changes in relationships, and the management thereof, between clients, contractors, and subcontractors.

This particular research looks at the concept of continuous improvement in the South African construction industry through its supply chains. Performance improvement in a process can lead to the sustainability of such a process. This brief literature review concludes with a snapshot of the experience of supply chain members in the construction of Terminal Five at Heathrow airport in London. It was well reported that the introduction of innovation and improvement in the processes was responsible for the successful delivery of this major project with its attendant complexities.
2.10 THE HEATHROW TERMINAL 5: DELIVERY STRATEGY

2.10.1. A case history

The Heathrow Terminal 5 delivery strategy serves as an ideal example whereby supply chain management brought about a favourable outcome. The project team were fully integrated. Wolstenholme et al. (2008: 10) say that “the success of the five-year construction phase of Terminal 5 at London’s Heathrow airport was dependent on putting into effect the principles of a unique form of contract, called the Terminal 5 agreement. The GBP4.3 billion scheme required the client to lead in areas that were typically the traditional domain of suppliers or contractor organisations, resulting in novel methods and relationships. From the early stages it was recognised that the project had to be delivered differently to the norm if it was to achieve its desired objectives. This resulted in the phrase that all those involved in the delivery of the T5 were part of ‘history in the making.’

The Terminal 5 (T5) project at Heathrow airport in west London represented not only an unprecedented and massive expansion of the world’s busiest international airport, but also a risk to the viability of BAA, the owner and client body. Success would be measured against achieving all four of the targets, namely, H&S, time, cost, and quality. The risk of failure relative to any of the targets was sufficient to demand that the delivery strategy had to be different.

The UK construction industry in the mid-1990s could not be relied upon alone to meet the aspirations of clients and thus manage the risks the project presented. ‘Doing it differently’ soon became a conscious theme of the delivery strategy to bring all parties together with a common commitment that all four targets were to be achieved. This was not negotiable.

By any measure, H&S was an absolute requirement, owing to morals, lost time, or reputation. The timely delivery of the facility at Heathrow was essential if significant overcrowding owing to the steady increase in air travel was to be avoided. It was critical that the delivery team achieved its target of a five-year construction programme followed by six months of operational trials leading up to the opening on 27 March 2008. The risk of cost overrun was perhaps more critical than other projects. Infrastructure projects of this scale often have recourse to the public sector purse if cost escalation occurs, but this was not an option. The regulator also set milestones for the construction phase which, if not achieved, would result in the freezing of the agreed phased increases.

When the decision was made to proceed in March 2002, BAA set the budget at GBP 4.3 billion, which was equivalent to approximately two-thirds of its capital value. By most
standards this was a bold decision. In addition, BAA had by this time already spent some GBP 540 million.

The fourth target of quality manifests itself in many ways, from the cost of rework and failure to achieve an integrated and functioning system to the very subjective customer experience or the form and quality of the built environment.

**2.10.2. The T5 agreement**

Understanding the challenges presented was informed by learning from experience elsewhere, including the Heathrow Express development, and taking into account the pressure for industry reform originating from the government (in the form of the Latham, the Egan reports and the Housing Grants Construction and Regeneration Act), from clients and contractors and also, BAA was to learn, from the insurance market. These lessons led to a clear determination of the project execution principles—the principles that would apply to the delivery of T5 as a programme—and, from these, the commercial principles were derived. These were explicitly designed to work with and underpin the execution principles. The totality of these together with a clear statement of behavioural, cultural and organisational expectations created the legal framework which is the ‘T5 agreement’.

**2.10.3. Background**

In order to understand the T5 agreement, it is important to understand the issues that faced BAA in the early-to mid-1990s. The first major issue lay in the scale of T5 as a GBP 4.3 billion project. BAA itself had not before undertaken projects on such a scale, nor previously integrated assets into existing business on this scale. Secondly, BAA realised that the industry’s experience of projects on such a large scale was intermittent. Equally significant was the consideration of T5 as a business proposition, which is no doubt true of all projects. Set in the context of a very challenging budget and programme, it was clear that T5 needed to be thought about in a different way. The magnitude and timeframes of T5 meant, however, that these risks had to be implicitly understood and addressed in the agreement. The conclusion reached was that BAA needed an agreement that could enable the project teams to be very flexible in its approach.

On the basis of its research into projects in excess of GBP 1 billion, and its own experiences at Heathrow Express and elsewhere, BAA had learned that processes and organisation needed to be designed to expose and manage risk, to promote and motivate success and opportunity and to address the behaviours required in all of the key relationships. BAA’s thinking about contracting had thus evolved over time from the traditional transactional
approach to a more relational approach. This required a change of mind-set, and this is reflected in the T5 agreement.

2.10.4. Principles

The T5 agreement is fundamentally built around three simply stated success themes:

- Do what you are doing well and do it better;
- Understand ‘how’ you will deliver as well as ‘what’ you need to do - this means addressing organisational development as well as technical development, and
- Continually work on the relationships including those that are inward-facing / inside the project and those that are outward-facing / outside the project.

It was also clear that in order to achieve the required changes, a culture needed to be created in which teams could actively promote and pursue opportunities. In the T5 context this meant creating a culture in which people were encouraged to:

- Seek out, capture and exploit the best practices of others;
- Remove the barriers and inhibitors to doing things differently;
- Stimulate and support good ideas, and
- Leverage the commercial incentives to perform exceptionally.

All of this needed to be underpinned by organisational development, as understanding the need for organisational changes could lead to changes in the way that teams and organisations behave. In turn, that meant empowering leaders; creating integrated teams who would work to common agendas based on co-operative relationships; and incentivising people to solve problems together and act on learning, rather than allocating blame or exploiting the failure or difficulties of others for commercial advantage.

The commercial principles were then designed to link directly to and underpin the execution principles. As most of the effort was to be directed at making things work, people would be rewarded for working at being successful. The commercial arrangements would remain fair and balanced; norms and performance measurement would be used to demonstrate the best commercial deal, and predictability could be insufficient to meet their targets.

It also required that BAA would be able to understand its costs fully. Key principles therefore was total cost transparency, with open access to information on value and waste - not just the numbers - and then planning to decide which costs were of value, by:

- Incentivising the use of directly employed resources;
- Pre-planning risk responses and agreeing accountabilities before work started;
- Examining costs, and then challenging and planning to avoid spending on wasteful activities;
- Measuring progress and performance, and
- Incentivising exceptional performance by pre-planning for exceptional performance, and sharing the benefits.

2.10.5. Integrated project teams

The T5 delivery strategy centred on the concept of the project being composed of a series of products delivered by integrated teams, comprising a fully integrated supply chain in which BAA itself took a proactive leadership role.

Teams were not formed conventionally, that is not by company or discipline, but were assembled around ‘customer products’. At T5 the teams were to be made up of individuals identified as having the right skill sets for the activity in hand, irrespective of who employed them. It was envisioned as a ‘virtual’ organisation, integrated at several levels and rationalising skills from across consultants, contractors and suppliers, including necessary BAA skills, and integrating the client development team in delivering solutions. With hindsight it can be seen that this was difficult to achieve consistently.

There were many project teams where the integration was successfully achieved, however, as demonstrated by the manner in which they managed unforeseen events in line with the projects’ objectives rather than enhancing the financial position of an individual company.

2.10.6. All risk on client

A much-heralded concept is that, at T5, BAA held all the risk all the time. To understand this concept, especially as it was used to underpin the commercial strategy for the T5 agreement, it is important to distinguish risk, in the sense of the potential for harm or opportunity, and liability, in the sense of who pays when things go wrong. The word ‘risk’ is commonly used as a catch-all, and the phrase ‘risk transfer’ is often used in the context of contracting with a supply chain. The common use of the language of risk transfer does not, overtly, make that necessary distinction between the risk of harm occurring to a party and liability of another to pay for it. The T5 agreement explicitly does so.

In an environment where suppliers were providing individuals to work in integrated teams alongside individuals from other suppliers (the virtual company), and where those teams were to be led by BAA staff or individuals from different suppliers, the notion that risk can be
transferred to any given supplier is nonsensical. In that context, expecting suppliers to price risk would also be commercially meaningless and could not be said to represent value for money as it would be impossible to hold an individual supplier to account.

2.10.7. Shared liabilities

Under the T5 commercial strategy, the liability (as distinct from the risks) of the suppliers and BAA was to be shared on a strict no-fault basis. For suppliers, this liability was capped (with some exceptions) by the amount of the available incentive fund. Clearly this would not be sufficient to cover the consequences of all the potential risks and BAA therefore took out employer-controlled insurance programmes to address major or catastrophic risks on a project-wide basis covering the whole of the supply chain. These insurances were construction all risks, third-party liability, and a first, project professional indemnity insurance. This was also bought wherever possible on a no-fault basis so that legal liability was not an issue to be determined prior to the policy responding.

First-tier suppliers were therefore paid actual costs (a defined term in the contract and defined against an agreed cost model) and a fair, agreed, ring-fenced profit. The suppliers’ contractual liability would be a predetermined share (without proof of fault) of the financial consequences of any risk that occurred (risk in this context included defects and non performance). This liability was capped by the amount of the incentive fund except for certain specified indemnified and insured risks.

Under the exceptions, legal liability was, in theory, unlimited. They were however, with the exception of employer liability insurance, insured under the insurances taken out by BAA. Those insurances were for sums far greater (because they were taking account of the totality of the project) than would have been contemplated by any given contractor contemplating insurance for its own defined piece of work. One area in which liability was clearly transferred to suppliers was in the area of the insurance of excesses. In the event of a claim, these were shared among all members of the relevant team or teams (including BAA) in pre-agreed proportions and elements of them were payable from the built-up incentive funds. If there was no incentive fund or insufficient fund available, then the excesses fell wholly to the members of the relevant team.

It can therefore be seen that the incentive fund was a key part of the commercial strategy. Suppliers had had no opportunity to price risks or liability and the incentive fund was therefore their only opportunity to improve on the margins that were represented by the ring-fenced profit arrangements.
The delivery and commercial strategies were therefore designed in combination to change the focus of the contract to management. This was to ensure that the project teams’ focus was on managing the cause up front and not the effect (in terms of claims and counter claims) after the event.

2.10.8. Cultural commitment

Unusually for a contract, the T5 agreement also addressed the cultural requirements that were believed were a prerequisite for the successful delivery of the project. This was the third limb of the arrangement. BAA accepted that in strict legal terms it is difficult to enforce such provisions and aspirations. These issues were, however, sufficiently important that, in BAA’s views, and they needed to be expressly dealt with within the contractual terms. The contract therefore explicitly requires individual and firms to be aware of and focus on partnering, trust and cooperation, and being seen to do what they say.

2.10.9. Procurement

Approximately 75% of the GBP 4.3 billion project cost was procured via the T5 agreement in contract with its 80 first-tier suppliers. The remaining value was associated with works being procured or liabilities incurred via a variety of forms of contract appropriate to the party involved, for example Thames Water, Highways Agency, London Underground, Network Rail, Heathrow Airport Ltd. A BAA version of the NEC Engineering and Construction Contract was the only recommended form for the thousands of second-tier contracts in the supply chain.

BAA also used various NEC contracts—particularly the Professional Services Contract—for around 150 direct relationships with consultants and other suppliers, representing approximately 10% of total project cost.

2.10.10. Industrial relations and employment

While the responsibility for good industrial relations and fair employment policy is between the employer and the employee and their representative organisation, the consequence of a poor relationship is felt directly by the client body.

The risk that a member of the supply chain would adopt different terms in their respective employment contracts, which might possibly result in unstable industrial or employee relations led BAA to formulate the T5 industrial relations policy and the T5 employment policy. At T5 BAA entered into contract with 80 first-tier suppliers individually, but under identical terms in the form of the T5 agreement. The T5 industrial relations policy was incorporated in the T5 agreement and was thus contractually binding.
The policy required the suppliers to ensure every construction operative is directly employed; provide transparency and alignment for operative pay; ensure any bonus arrangement to have a measurable basis, and operate within the framework of national agreements and thus employ individuals with one of the four recognised national agreements accepted on the project.

The T5 programme was nominated as a ‘designated’ project under the scope of the UK construction industry’s major projects agreement (http://www.mpaforum.org.uk/).

BAA, the suppliers’ managers and the representatives of the trade unions met frequently to ensure the fair application of the policy and that any issues were identified and resolved.

The T5 employment policy provided practical advice and standards on all aspects of employment of construction operatives including:

- Recruitment, covering use of a common recruitment database, interview and application process, establishing ‘right to work in the UK’ in accordance with the Asylum and Immigration Act 1996, security screening and verification of competency and skills including a minimum period of experience in the construction industry;

- During employment to ensure that employees were inducted and properly trained, possessed nationally accredited skills certification or the Construction Skills Certification Scheme (CSCS) H&S test, completion of a health questionnaire or in safety-critical roles to be seen on site by an occupational health nurse;

- While on site all personnel were to comply with the policies regarding drugs and alcohol, H&S, and other site rules;

- The employer to comply with a no-poaching policy, to have proper procedures for managing grievances and disciplinary issues, when employing individuals from abroad to ensure compliance with work-permit requirements and, for non-English speaking personnel, specific requirements to ensure the individual understands the training and the task;

- Pay, reward for productivity, resignation, dismissal, end of contract and redundancy, and

- Assurance as well as the requirement for the first-tier suppliers to audit their subcontractors to ensure compliance to both policies.

In over five years of construction activity there were only six days of industrial action contained within specific parts of the works, which had no impact on the overall programme.
2.10.11. Commitment to people

BAA recognised that it had to lead on the application of the processes to achieve the cultural change which was implicit in the delivery strategy and expressed in the T5 agreement.

The introduction of an H&S initiative known as the ‘incident and injury free’ programme, required a cultural change to enable each individual to recognise that there is no acceptable level of accidents. BAA led by mobilising all personnel, staff and operatives from all participating organisations, from managing director level down to commit to the belief in the possibility of a programme that was incident and injury free. This initiative was supported by poster campaigns to encourage individuals to take personal responsibility for their actions.

The achievements of individual team milestones were celebrated and supported by an award scheme, ranging from a regular GBP 5,000 team award down to GBP 25 spot awards for exceptional performance or initiatives. Communications of the expected behaviours as well as news of the project were published monthly in an extremely effective site newspaper.

This case history describes the delivery strategy used on Heathrow Airport Terminal 5. The Heathrow Terminal 5 is a multi billion pounds projects involving both building and civil engineering works. The construction phase involved 80 first-tier suppliers in the form of main contractors and a plethora of second-tier suppliers in the form of subcontractors. According to Wolstenholme et al. (2008: 12) the ‘virtual organisation’ comprises staff members of the supply chain that are best suited for a particular deliverable regardless of their primary employer within the supply chain.

The project was not only contractually driven in the form of the T5 agreement, NEC suites of contracts, and bespoke contract forms, but it also adopts a collaborative working relationship in the supply chains. Because it was critical that the delivery team achieved its target of a five-year construction programme, a different strategy was therefore utilised. The T5 delivery outcome showcases the benefits of innovation and performance improvement in the construction process. There was also a strategic emphasis on the relationships between the client, consultants, contractors and subcontractors. Several innovative concepts were used to encourage the spirit of partnering in the supply chain. From the T5 agreements, to the clients absorbing almost all the risks and the contractors having ring fenced profit margins agreed up-front and subcontractors utilising the same industrial relations and employment mechanism, the T5 was truly a ‘history in the making’ in evolving new ways of capital project delivery.

The attributes of collaboration and partnering were evident in the construction process. Barriers and inhibitors to innovation were removed and adoption of best practices was
encouraged. It can also be assumed that the transfer of knowledge and expertise took place in the integrated project team. The supply chain structure was such that the potential for adversarial relationships within the project teams were strongly mitigated because similar contractual documentation and communication system was deployed for use. The supply chains were totally focused on the project outcome. It was even stated in the paper that leaders were empowered to create integrated teams who would work to common agendas based on cooperative relationships.

The business case of T5 and the leadership role taken by BAA made it imperative that all supply chain members understood the simple fact that failure or cost overrun was not an option because of the possibility of tax payers bearing the losses. This case history demonstrates the ability of integrated supply chain management and innovation to realise a favourable project outcome on a major construction project.
3.0 METHODOLOGY

3.1 RESEARCH METHOD

The descriptive method was used in this research. The descriptive survey method (Leedy and Ormond, 2005: 179) is employed to process the data obtained through observation. They suggest that this type of research involves either identifying the characteristics of an observed phenomenon or exploring possible correlations among two or more phenomena. In every case, descriptive research examines a situation as it is. It does not involve changing or modifying the situation under investigation, nor does it intend to determine cause-and-effect relationships. Agresti and Franklin (2007: 11) define descriptive statistics as methods for summarizing data. The summaries usually consist of graphs and numbers such as averages and percentages. They also identify three reasons for the use of statistical methods of data analysis. These reasons are:

- Design, which refers to planning how to obtain data;
- Description, which means exploring and summarizing patterns in data, and
- Inference, which means making decisions or predictions based on the obtained data.

Therefore, statistical methods provide ways and means to measure and understand variability. A variable is thus any uniqueness that is recorded for subjects in a study. The data values observed for a variable are referred to as the observations. The analysis of data directly depends on the type of variable observed. In terms of this research, the variables are quantitative in nature and discrete.

3.2 DATA COLLECTION

The secondary data used in this research was obtained from various hard copy and online sources, inter alia, journal and conference papers, articles, books, reports, and theses. The search for information was undertaken in the Nelson Mandela Metropolitan University library and computer laboratories, where the following databases were accessed:

- EBSCO;
- Emerald Insight online;
- Business periodicals index;
- Social Sciences Index, and
- NMMU’s own database.

The primary data used in the study was acquired through the administration of a structured questionnaire. The administration of the questionnaire was expedited in the following phases:

- A postal survey using the questionnaire (Appendix 1) was posted to the members of the sample frame with an accompanying introductory letter dated 25 May 2009;
A reminder e-mail was sent to the firms, which did not return the questionnaire by the 22 June 2009;

A further telephonic reminder was made to the firms, which did not return the questionnaire by the 30 June 2009 and the questionnaire was administered electronically to the respondents, and

Owing to the low response rate, a further reminder was sent to the firms, which did not return the questionnaire. Four e-mail reminders were sent between 1st of July and 17th of July 2009.

3.3 QUESTIONNAIRE DESIGN

The questionnaire was intended to serve as a comprehensive source of data. The questionnaire design was based not only on findings in the literature review, but also on the perceptions of the contractors in South Africa.

The questionnaire consisted of three sections:

- Section 1 consisted of questions about the respondent’s demographic background;
- Section 2 addressed the state of the construction process in South Africa relative to supply chain management. The extent of relationship problems as well as familiarity with innovative processes such as collaborative working was assessed. The section ended with questions relative to the use of supply chain management as a management tool, and
- Section 3 addressed the research hypotheses. Known construction industry key performance indicators were used to solicit responses to the effect of proactive supply chain management on an attempt to address the prevalence of adversarial relationships in construction, elimination of fragmentation, as well as the improvement of information sharing and reliability with the supply chain.

3.4 THE POPULATION

The population is the set of all the subjects of interest (Agresti and Franklin, 2007: 10). The population was comprised of general contractors who are members of the Master Builders South Africa (MBSA).

The population of general contractors is heterogeneous in nature and varies in terms of revenue; number of employees; types of work undertaken; technological level of work; education; experience; competence, and professionalism of management.

3.5 SAMPLE FRAME

A sample is the subset of the population for whom data exists (Agresti and Franklin, 2007: 10). The sample frame was identified through the regional affiliates of MBSA. Regional
affiliates include the East Cape Master Builders Association, Free State Master Builders Association, Gauteng Master Builders Association, Kwa-Zulu Natal Master Builders Association, West Boland Master Builders Association, and Western Cape Master Builders Association. With the exception of Western Cape Master Builders Association, the entire membership list was available online at the time of the survey.

### 3.6 SAMPLE SIZE

The systematic random sampling method was adopted, using MS Excel for the generation of random numbers. The sample size comprised of 108 construction firms in total and its distribution is presented in Table 3.1.

<table>
<thead>
<tr>
<th>Association</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>East Cape Master Builders Association</td>
<td>21</td>
</tr>
<tr>
<td>Free State Master Builders Association</td>
<td>4</td>
</tr>
<tr>
<td>Gauteng Master Builders Association</td>
<td>29</td>
</tr>
<tr>
<td>Kwa-Zulu Natal Masters Builder Association</td>
<td>19</td>
</tr>
<tr>
<td>West Boland Master Builders Association</td>
<td>13</td>
</tr>
<tr>
<td>Western Cape Master Builders Association</td>
<td>22</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>108</strong></td>
</tr>
</tbody>
</table>

### 3.7 ANALYSIS OF THE DATA

The Statistica (version 9.0) statistical analysis software package was used by the NMMU Unit for Statistical Support to generate the descriptive and inferential statistics.

The Microsoft Excel Ranking function was used to compute the rank of mean scores of responses. This was based on the percentage responses to the 5-point likert type-scale. The survey required respondents to indicate their opinions on how strongly they agree or disagree with the statements and / or questions, ranging from strongly agree to strongly disagree with an option to tick the unsure option in case the respondents were not familiar with the questions.

The ranking enabled the importance of individual statements, problems, parameters and key performance indicators to be evaluated relative to each other.

The $p$ value, which is the level of significance for the test was 5%. The $p$ value is the probability that the test statistics equal the observed value or a value even more extreme (Agresti and Franklin, 2007: 371). It is calculated by presuming that the null hypothesis $H_0$ is true. In plain English, the $p$ value is a tail probability beyond the observed test statistics.
value. Smaller $p$ values provide stronger evidence against the null hypothesis. The Unit for Statistical Support affirmed that the value is appropriate for the research analysis. In addition, the tests for association and independence were conducted at 5% levels of significance.

### 3.7.1 Tests for Association

An association exists between two variables if a particular value for one variable is more likely to occur with certain values of the other variable. In other words, when there is an association, the likelihood of a particular value for one variable depends on the value of the other variable (Agresti and Franklin, 2007: 90).

According to Agresti and Franklin (2007: 546), the inferential parts of regression use the tools of confidence intervals and significance tests. They provide inference about the regression equation and correlation and $r$-squared in the population. Therefore, the Spearman rank order test was used to test for the nature and extent of association between two variables.

The value of the $r$ ranges from $-1$ to $+1$, with $+1$ indicating a perfect positive relationship, $-1$ indicating a perfect negative relationship and $0$ indicating perfect independence. Analysing the strength of association reveals whether the association is an important one or if it is statistically significant, but weak and unimportant in practical terms.

### 3.7.2 Independence versus Dependence

Two categorical variables are independent if the population conditional distributions for one of them are identical at each category of the other. The variables are dependent or associated if the conditional distributions are not identical (Agresti and Franklin, 2007: 488). Two categorical variables can be classified as either independent or dependent through a significance test. The hypotheses for the test are:

- $H_0$: The two variables are independent and
- $H_a$: The two variables are dependent (associated).

The test statistics for the test of independence summarizes how close the observed cell counts fall to the expected cell counts. Symbolized by $X^2$, it is called the chi-squared statistic, taking the name of its sampling distribution. It is the oldest statistics test in use and it was introduced by the British statistician Karl Pearson in 1900 (Agresti and Franklin, 2007: 492).
4.0 RESULTS

4.1 RESPONSE TO QUESTIONNAIRE

Out of the 108 questionnaires posted, 13 were returned after 9 weeks of initial postage. 8 questionnaires were returned to sender presumably due to change in organisation addresses. Furthermore, no reasons were given for the 79 questionnaires that were not returned. While through telephonic conversation, 8 respondents registered their disinterest in the survey and they gave different reasons such as:

- Refusal of the university to grant admission to a son resulted in apathy towards all activities concerning the university;
- Failure to see the benefit of the survey to company business, and
- Though, a member of a Master Builders Association, some firms are not directly involved in construction.

Figure 4.1 Response to questionnaire

The geographical spread of the survey is indicated in Table 4.1 and the differences between sent and received questionnaires is indicated in Figure 4.2. The table indicates the number of questionnaires sent to individual MBSA affiliated associations and the response rates.
### Table 4.1 Spread of response

<table>
<thead>
<tr>
<th>Association</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>East Cape Master Builders Association</td>
<td>4</td>
</tr>
<tr>
<td>Free State Master Builders Association</td>
<td>0</td>
</tr>
<tr>
<td>Gauteng Master Builders Association</td>
<td>4</td>
</tr>
<tr>
<td>Kwa-Zulu Natal Master Builders Association</td>
<td>3</td>
</tr>
<tr>
<td>Western Boland Master Builders Association</td>
<td>0</td>
</tr>
<tr>
<td>Western Cape Master Builders Association</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>13</strong></td>
</tr>
</tbody>
</table>

![Figure 4.2 Comparison of response to sent questionnaires](image)

#### 4.2 RESPONSE RATE

The low response rate was anticipated and in order to mitigate this, the following procedures were followed:

- The respondents were assured of confidentiality of their responses;
- The covering letter made an unselfish appeal to the respondents;
- The length of the questionnaire was kept to a minimum three page;
A reminder e-mail was sent after four weeks of sending the questionnaires; a reminder phone call was made after one week of sending the reminder e-mail, and a reminder e-mail was sent every Friday for three weeks to encourage the respondents to work on the questionnaire during the rest period on weekends.

4.3 SECTION 1: DEMOGRAPHIC DATA

This section of the questionnaire requested demographic information from the respondents.

Question 1: What kind of organization do you work for?

The result indicates that 85% of the respondents work for main contractors while 15% worked for subcontractors.

Figure 4.3 Respondents' type of organisation

Question 2: What kind of projects does your organisation undertake?

The results show that 46% of the respondents undertake civil engineering construction projects while 54% undertake building construction projects (Figure 4.4).
Question 3: Please indicate the number of years your organisation has been in operation in the box provided below?

Most of the respondents have been in the industry for less than 25 years. The results indicate that 46% have been in the industry for less than 25 years, 8% between 26 and 50 years, 15% between 51 and 75 years, and 31% have been around for over 76 years.
**Question 4: Please indicate the approximate number of employees in your organisation in the box provided below?**

The results indicate that 31% of organisations employ 1-100 employees, 31% 101 to 500, 8% between 501 and 1,000, and 31% in excess of 1,001.

![Figure 4.6 Number of employees employed by respondents’ organisations](image)

**Question 5: Please indicate your organisation’s annual turnover for the year 2008 and the number of projects your organisation undertook in 2008 in the boxes provided below?**

The results reveal that 8% of the respondents have a turnover of less than R1 million, 31% between R2 and R100 million, 23% between R100 and R1 billion, while 31% in excess of R1 billion (Figure 4.7).

In addition, 8% of the respondents executed between 1 and 5 projects in the past year, 42% between 6 and 10 projects, and 25% between 11 and 15 projects. However, 25% of the respondents failed to provide information concerning the number of projects executed by their firms (Figure 4.8).
Figure 4.7 Annual turnover of respondents’ organisations

Figure 4.8 Number of projects undertaken by respondents’ organisation

**Question 6: Please indicate your gender?**

Males predominate in terms of the gender of the respondents, with only 8% accounting for the female gender (Figure 4.9).
**Question 7: Please state your age in the box provided below?**

The age distribution of the respondents is indicated in Figure 4.10. It can be seen that 62% of the respondents are relatively young. Their age ranges between 25-35 years, while 15% of the respondents are between 36-45 years of age. The older respondents, 15% are between 46-55 years and 8% between 56-65.

**Question 8: Please indicate the length of your experience in the construction industry in the box provided below?**
New entrants into the industry constitute 62% of the respondents (1-10 years). The more experienced cohorts accounted for 8% and 31% of the respondents respectively (Figure 4.11).

**Figure 4.11 Respondents years of construction experience**

**Question 9: Please indicate the highest formal qualification you hold?**

There was no respondent that had a College / High school certificate as his highest qualification (Figure 4.12).

**Figure 4.12 Qualifications of respondents**
Diploma holders constitute 24% of the respondents, while first degree and postgraduate qualification holders account for 76% of the respondents.

**Question 10: Please indicate your status in your organisation?**

Figure 4.13 reveals that most of the respondents were site management (42%), followed by middle management (33%), and corporate executives (25%).

Figure 4.13 Management level of respondents

**4.4 SECTION 2: THE CONSTRUCTION PROCESS STATUS QUO**

This section seeks to assess the state of the construction industry in terms of processes and improvements therein.

**Question 11: Please indicate if your organisation considers supply chain management important for project success?**

The majority of the respondents replied in the affirmative (70%). 15% were unsure, while 15% responded that their organisations do not consider management of the supply chain important for project success (Figure 4.14).
Question 12: Please indicate if your organisation has been involved in collaborative working arrangements in the last 10 years.

The results indicate a 69% level of affirmative response, and 23% negative, 8% were unsure (Figure 4.15).

Figure 4.14 Importance of supply chain management

Figure 4.15 Involvement in collaborative working arrangements

Question 13: On a scale of 1 (strongly disagree) to 5 (strongly agree), please indicate the extent of your agreement with the under listed relationship problems in the construction process (Please note the unsure option)?
The proper interpretation is reflected in the table below through ranking. The responses were ranked using the mean score of individual problems. Table 4.2 indicates that short-term objectives and price oriented approach achieved the highest mean score. Poor use of modularisation in order to reduce construction time is ranked 2\textsuperscript{nd}. Adversarial relationships is ranked 8\textsuperscript{th}, which indicate that though it is present in the construction process, it is not endemic.

\textbf{Table 4.2 Relationship problems}

<table>
<thead>
<tr>
<th>Problems</th>
<th>Mean</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adversarial relationships are endemic in the construction process</td>
<td>3.00</td>
<td>8</td>
</tr>
<tr>
<td>The construction supply chain is fragmented</td>
<td>3.23</td>
<td>6</td>
</tr>
<tr>
<td>Presence of contractual and competency distrust in the supply chain</td>
<td>2.92</td>
<td>10</td>
</tr>
<tr>
<td>Disproportionate assessment and allocation of construction project risks</td>
<td>3.23</td>
<td>5</td>
</tr>
<tr>
<td>Significant numbers of irregular clients of the industry</td>
<td>3.31</td>
<td>3</td>
</tr>
<tr>
<td>Uneven level of commitment of project parties</td>
<td>3.00</td>
<td>7</td>
</tr>
<tr>
<td>Short term objectives and price oriented approach persists in the industry</td>
<td>3.92</td>
<td>1</td>
</tr>
<tr>
<td>Poor use of modularisation in order to reduce construction time</td>
<td>3.46</td>
<td>2</td>
</tr>
<tr>
<td>Presence of inefficient and ineffective problem solving mechanism</td>
<td>3.00</td>
<td>9</td>
</tr>
<tr>
<td>Strict and inflexible adherence to contents of construction contract data</td>
<td>3.31</td>
<td>4</td>
</tr>
</tbody>
</table>

\textbf{Question 14: On a scale of 1 (strongly disagree) to 5 (strongly agree), please indicate your view of collaborative working in the construction process (Please note the unsure option)?}

Table 4.3 indicate that long-term relationships can persuade subcontractors to focus on value instead of profit.
Table 4.3 Statements relative to collaboration

<table>
<thead>
<tr>
<th>Statements</th>
<th>Mean</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of partners with appropriate collaborative skills</td>
<td>3.69</td>
<td>10</td>
</tr>
<tr>
<td>Collaboration can simplify the construction process</td>
<td>4.23</td>
<td>2</td>
</tr>
<tr>
<td>Knowledge sharing and transfer is possible in a collaborative working environment</td>
<td>4.38</td>
<td>1</td>
</tr>
<tr>
<td>Common project goals and objectives can be negotiated in an agreeable manner</td>
<td>4.00</td>
<td>7</td>
</tr>
<tr>
<td>Collaborative procurement methods can promote innovation and improvements on major projects</td>
<td>4.00</td>
<td>8</td>
</tr>
<tr>
<td>Long-term and stable relationships can persuade subcontractors to focus on value instead of profit</td>
<td>4.23</td>
<td>3</td>
</tr>
<tr>
<td>Collaborative working can lead to a better quality service</td>
<td>4.23</td>
<td>6</td>
</tr>
<tr>
<td>Closer relationships can break down barriers such as culture</td>
<td>4.23</td>
<td>4</td>
</tr>
<tr>
<td>Consistent workload is beneficiary to long term relationships</td>
<td>4.23</td>
<td>5</td>
</tr>
<tr>
<td>Avoidable communication problems can be mitigated through collaboration</td>
<td>3.85</td>
<td>9</td>
</tr>
</tbody>
</table>

Given that the mean scores are > 3.00, the respondents can be deemed to agree as opposed to disagree with the statements, which in turn indicates the respondents suggestion that collaboration can simplify the construction process, as well as knowledge sharing and transfer being possible in a collaborative environment.

**Question 15:** On a scale of 1 (strongly disagree) to 5 (strongly agree), please indicate your view on the use of supply chain management as a management tool in construction (Please note the unsure option)?

Ranking the responses indicates that early involvement of supply chain partners is considered crucial to the attainment of project goals.
Table 4.4 Supply chain management as a tool

<table>
<thead>
<tr>
<th>Statements</th>
<th>Mean</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong leadership in coordinating interfaces is essential for successful supply chain management</td>
<td>4.15</td>
<td>2</td>
</tr>
<tr>
<td>Early involvement of supply chain partners is key to achieving target objectives</td>
<td>4.23</td>
<td>1</td>
</tr>
<tr>
<td>Open book accounting practice between the supply chain partners is seldom used in project execution</td>
<td>3.38</td>
<td>6</td>
</tr>
<tr>
<td>Recurrent poor creation of value in the process by supply chain partners</td>
<td>3.23</td>
<td>9</td>
</tr>
<tr>
<td>Supply chain management based on collaboration can reduce overall project cost</td>
<td>3.62</td>
<td>4</td>
</tr>
<tr>
<td>Appropriate deployment of ICT can improve information sharing among supply chain partners</td>
<td>3.38</td>
<td>7</td>
</tr>
<tr>
<td>Improper use of power to influence decisions by the focal firm in the supply chain</td>
<td>3.00</td>
<td>10</td>
</tr>
<tr>
<td>Poor use of management tools such as lean construction to eliminate waste in the process</td>
<td>3.46</td>
<td>5</td>
</tr>
<tr>
<td>Open exchange of data and information is a driver of construction supply chain management</td>
<td>4.08</td>
<td>3</td>
</tr>
<tr>
<td>Poor adoption of best practices such as partnering and supply chain management in the industry</td>
<td>3.23</td>
<td>8</td>
</tr>
</tbody>
</table>

4.5 SECTION 3: EFFECT OF SUPPLY CHAIN MANAGEMENT ON PROJECTS

The questions in this section sought to secure feedback on the effect of proactive management of supply chains involved in project execution.

*Question 16: Using the under listed key performance indicators, on a scale of 1 (very poor) to 5 (very good), please indicate the effect of proactive supply chain*
**management as a tool to reduce adversarial relationships in construction (Please note the unsure option)?**

Key performance indicators were used in assessing the hypotheses because they are mostly used in assessing project performance.

Table 4.5 Mitigation of adversarial relationships

<table>
<thead>
<tr>
<th>KPI</th>
<th>Mean</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site productivity</td>
<td>4.15</td>
<td>1</td>
</tr>
<tr>
<td>Cost predictability</td>
<td>4.00</td>
<td>2</td>
</tr>
<tr>
<td>Time predictability</td>
<td>4.00</td>
<td>3</td>
</tr>
<tr>
<td>Occupational health and safety</td>
<td>3.77</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 4.6 Correlations for adversarial relationships variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Q16.1</th>
<th>Q16.2</th>
<th>Q16.3</th>
<th>Q16.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q16.1</td>
<td>1.000</td>
<td>0.894</td>
<td>0.504</td>
<td>0.711</td>
</tr>
<tr>
<td>Q16.2</td>
<td>0.894</td>
<td>1.000</td>
<td>0.563</td>
<td>0.795</td>
</tr>
<tr>
<td>Q16.3</td>
<td>0.504</td>
<td>0.563</td>
<td>1.000</td>
<td>0.443</td>
</tr>
<tr>
<td>Q16.4</td>
<td>0.711</td>
<td>0.795</td>
<td>0.443</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Cronbach alpha: .884146, standardized alpha: .882109, and average inter-item corr.: .689739

Based on the Cronbach alpha (.884146), standardized alpha (.882109), and the average inter-item correction (.689739), Table 4.6 indicate that the variables are strongly correlated (associated), and site productivity is ranked the number one in Table 4.5.

Due to the limited number of responses to the survey, both parametric and non-parametric statistical analyses are used to test the hypotheses. The parametric is the preferred method while the non-parametric method is used to confirm the result.

The null hypothesis is $H_0: \mu = \mu_0 = 3$

The two-sided alternative hypothesis is $H_1: \mu \neq \mu_1$ (3)

The null hypothesis is a statement that the parameter takes a particular value. The alternative hypothesis states that the parameter falls in some alternative range of values. Therefore, the value in the null hypothesis usually represents no effect, while the value in the
alternative hypothesis then represents an effect of some type (Agresti and Franklin, 2007: 369).

Table 4.7 Parametric test

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dv.</th>
<th>N</th>
<th>Ref. Constant</th>
<th>t-value</th>
<th>df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q16.1</td>
<td>4.0</td>
<td>0.9</td>
<td>13</td>
<td>3</td>
<td>3.95</td>
<td>12</td>
<td>0.0019</td>
</tr>
<tr>
<td>Q16.2</td>
<td>4.0</td>
<td>0.8</td>
<td>13</td>
<td>3</td>
<td>4.42</td>
<td>12</td>
<td>0.0008</td>
</tr>
<tr>
<td>Q16.3</td>
<td>3.8</td>
<td>0.7</td>
<td>13</td>
<td>3</td>
<td>3.83</td>
<td>12</td>
<td>0.0024</td>
</tr>
<tr>
<td>Q16.4</td>
<td>4.2</td>
<td>0.9</td>
<td>13</td>
<td>3</td>
<td>4.63</td>
<td>12</td>
<td>0.0006</td>
</tr>
</tbody>
</table>

Table 4.8 Non-parametric test

<table>
<thead>
<tr>
<th>Pair of Variable</th>
<th>Valid N</th>
<th>T</th>
<th>Z</th>
<th>p-level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q16.1 &amp; Three</td>
<td>13</td>
<td>0.00</td>
<td>2.52</td>
<td>0.0117</td>
</tr>
<tr>
<td>Q16.2 &amp; Three</td>
<td>13</td>
<td>0.00</td>
<td>2.67</td>
<td>0.0077</td>
</tr>
<tr>
<td>Q16.3 &amp; Three</td>
<td>13</td>
<td>0.00</td>
<td>2.52</td>
<td>0.0117</td>
</tr>
<tr>
<td>Q16.4 &amp; Three</td>
<td>13</td>
<td>0.00</td>
<td>2.67</td>
<td>0.0077</td>
</tr>
</tbody>
</table>

The $p$ value indicates that the null hypotheses cannot be accepted. The alternative hypothesis applied to each variable can be accepted. For each of the variables tested at 5% significance test level, the $p$ value is less than 0.05.

**Question 17:** Using the under listed key performance indicators, on a scale of 1 (very poor) to 5 (very good) please indicate the effect of proactive supply chain management as a tool to eliminate fragmentation in the construction process (please note the unsure option)?

The mean score for the key performance indicators used to assess the elimination of fragmentation is shown on Table 4.9. Value for the client is ranked 1$st$ in Table 4.9. Contractor’s satisfaction is ranked 2$nd$, while innovation and improvement as well as magnitude of defects and rework are ranked 4$th$ and 3$rd$ respectively.

Table 4.9 Elimination of fragmentation

<table>
<thead>
<tr>
<th>KPI</th>
<th>Mean</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value for the client</td>
<td>4.23</td>
<td>1</td>
</tr>
<tr>
<td>Contractor’s satisfaction</td>
<td>3.92</td>
<td>2</td>
</tr>
<tr>
<td>Magnitude of defects and rework</td>
<td>3.69</td>
<td>3</td>
</tr>
<tr>
<td>Innovation and improvement</td>
<td>3.69</td>
<td>4</td>
</tr>
</tbody>
</table>
Table 4.10 Correlations for fragmentation variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Q17.1</th>
<th>Q17.2</th>
<th>Q17.3</th>
<th>Q17.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q17.1</td>
<td>1.000</td>
<td>0.822</td>
<td>0.523</td>
<td>0.248</td>
</tr>
<tr>
<td>Q17.2</td>
<td>0.822</td>
<td>1.000</td>
<td>0.685</td>
<td>0.343</td>
</tr>
<tr>
<td>Q17.3</td>
<td>0.523</td>
<td>0.685</td>
<td>1.000</td>
<td>0.354</td>
</tr>
<tr>
<td>Q17.4</td>
<td>0.248</td>
<td>0.343</td>
<td>0.354</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Cronbach alpha: .754023, standardized alpha: .797241, and average inter-item corr.: .532457

The correlation table reveals that the variables are associated. The results of the parametric and non-parametric statistical analysis, is indicated in Table 4.11 and 4.12.

Table 4.11 Parametric test

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dv.</th>
<th>N</th>
<th>Ref. Constant</th>
<th>t-value</th>
<th>Df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q17.1</td>
<td>4.2</td>
<td>0.8</td>
<td>13</td>
<td>3</td>
<td>5.33</td>
<td>12</td>
<td>0.0002</td>
</tr>
<tr>
<td>Q17.2</td>
<td>3.9</td>
<td>0.8</td>
<td>13</td>
<td>3</td>
<td>4.38</td>
<td>12</td>
<td>0.0009</td>
</tr>
<tr>
<td>Q17.3</td>
<td>3.7</td>
<td>0.8</td>
<td>13</td>
<td>3</td>
<td>3.32</td>
<td>12</td>
<td>0.0061</td>
</tr>
<tr>
<td>Q17.4</td>
<td>3.7</td>
<td>1.2</td>
<td>13</td>
<td>3</td>
<td>2.11</td>
<td>12</td>
<td>0.0564</td>
</tr>
</tbody>
</table>

Table 4.12 Non-parametric tests

<table>
<thead>
<tr>
<th>Pair of Variable</th>
<th>Valid N</th>
<th>T</th>
<th>Z</th>
<th>p-level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q17.1 &amp; Three</td>
<td>13</td>
<td>0.00</td>
<td>2.80</td>
<td>0.0051</td>
</tr>
<tr>
<td>Q17.2 &amp; Three</td>
<td>13</td>
<td>0.00</td>
<td>2.67</td>
<td>0.0077</td>
</tr>
<tr>
<td>Q17.3 &amp; Three</td>
<td>13</td>
<td>0.00</td>
<td>2.37</td>
<td>0.0180</td>
</tr>
<tr>
<td>Q17.4 &amp; Three</td>
<td>13</td>
<td>6.00</td>
<td>1.68</td>
<td>0.0929</td>
</tr>
</tbody>
</table>

Both tests indicate the same conclusion. The null hypothesis (3) cannot be accepted for Q17.1, Q17.2, and Q17.3. The alternative hypothesis cannot be accepted for Q17.4 yet the result does not indicate support for the null hypothesis.

**Question 18:** Using the under listed key performance indicators, on a scale of 1 (very poor) to 5 (very good), please indicate the effect of proactive supply chain management as a tool to improve information sharing in the construction process (Please note the unsure option)?
Table 4.13 Improvement of information sharing

<table>
<thead>
<tr>
<th>KPI</th>
<th>Mean</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effectiveness of communication systems</td>
<td>3.92</td>
<td>1</td>
</tr>
<tr>
<td>Magnitude and frequency of contractual claims</td>
<td>3.54</td>
<td>2</td>
</tr>
<tr>
<td>Reduction of paperwork and request for information documents</td>
<td>3.23</td>
<td>3</td>
</tr>
<tr>
<td>Magnitude and frequency of contractual disputes</td>
<td>3.15</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 4.14 Correlations for information sharing variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Q18.1</th>
<th>Q18.2</th>
<th>Q18.3</th>
<th>Q18.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q18.1</td>
<td>1.000</td>
<td>0.359</td>
<td>0.015</td>
<td>0.287</td>
</tr>
<tr>
<td>Q18.2</td>
<td>0.359</td>
<td>1.000</td>
<td>0.650</td>
<td>0.294</td>
</tr>
<tr>
<td>Q18.3</td>
<td>0.015</td>
<td>0.650</td>
<td>1.000</td>
<td>0.740</td>
</tr>
<tr>
<td>Q18.4</td>
<td>0.287</td>
<td>0.294</td>
<td>0.740</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Cronbach alpha: .725861, standardized alpha: .719510, and average inter-item corr.: .423778

Table 4.14 indicates that the variables are fairly correlated. That is their association is not strong. The \( p \) value for the tests (Tables 4.15 and 4.16) indicates that only variables Q18.1 and Q18.2 alternative hypotheses can be accepted with certainty. The rest variable in the group produce \( p \) values that are equal / more than 0.05, which means their mean score is not statistically significant in relation to the null hypothesis (3).

Table 4.15 Parametric test

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dv.</th>
<th>N</th>
<th>Ref. Constant</th>
<th>t-value</th>
<th>Df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q18.1</td>
<td>3.9</td>
<td>0.8</td>
<td>13</td>
<td>3</td>
<td>4.38</td>
<td>12</td>
<td>0.0009</td>
</tr>
<tr>
<td>Q18.2</td>
<td>3.5</td>
<td>0.8</td>
<td>13</td>
<td>3</td>
<td>2.50</td>
<td>12</td>
<td>0.0279</td>
</tr>
<tr>
<td>Q18.3</td>
<td>3.2</td>
<td>1.1</td>
<td>13</td>
<td>3</td>
<td>0.49</td>
<td>12</td>
<td>0.6364</td>
</tr>
<tr>
<td>Q18.4</td>
<td>3.2</td>
<td>1.2</td>
<td>13</td>
<td>3</td>
<td>0.67</td>
<td>12</td>
<td>0.5133</td>
</tr>
</tbody>
</table>
Table 4.16 Non-parametric test

<table>
<thead>
<tr>
<th>Pair of Variable</th>
<th>Valid N</th>
<th>T</th>
<th>Z</th>
<th>p-level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q18.1 &amp; Three</td>
<td>13</td>
<td>0.00</td>
<td>2.67</td>
<td>0.0077</td>
</tr>
<tr>
<td>Q18.2 &amp; Three</td>
<td>13</td>
<td>0.00</td>
<td>2.02</td>
<td>0.0431</td>
</tr>
<tr>
<td>Q18.3 &amp; Three</td>
<td>13</td>
<td>11.00</td>
<td>0.51</td>
<td>0.6121</td>
</tr>
<tr>
<td>Q18.4 &amp; Three</td>
<td>13</td>
<td>11.00</td>
<td>0.51</td>
<td>0.6121</td>
</tr>
</tbody>
</table>

**Question 19:** Using the under listed key performance indicators, on a scale of 1 (very poor) to 5 (very good,) please indicate the effect of proactive supply chain management as a tool to improve reliability between project partners (Please note the unsure option)?

The ranking table shown below indicates that top management commitment and trust between project partners are ranked 1st and 2nd respectively. This means the respondents view these key performance indicators relevant to the improvement of reliability in the construction supply chain.

Table 4.17 Improvement of reliability

<table>
<thead>
<tr>
<th>KPI</th>
<th>Mean</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top management commitment</td>
<td>4.23</td>
<td>1</td>
</tr>
<tr>
<td>Trust between project partners</td>
<td>4.08</td>
<td>2</td>
</tr>
<tr>
<td>Frequency of team building workshops</td>
<td>3.46</td>
<td>3</td>
</tr>
<tr>
<td>Frequency of arbitrations and law suits</td>
<td>3.15</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 4.18 Correlations for reliability variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Correlations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Q19.1</td>
</tr>
<tr>
<td>Q19.1</td>
<td>1.000</td>
</tr>
<tr>
<td>Q19.2</td>
<td>0.902</td>
</tr>
<tr>
<td>Q19.3</td>
<td>0.119</td>
</tr>
<tr>
<td>Q19.4</td>
<td>0.067</td>
</tr>
</tbody>
</table>

Cronbach alpha: .533333, standardized alpha: .518643, average inter-item corr.: .300433

The data indicates a weak correlation among the variables in Q19 (Table 4.18).
Table 4.19 Parametric test

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dv.</th>
<th>N</th>
<th>Ref. Constant</th>
<th>t-value</th>
<th>Df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q19.1</td>
<td>4.1</td>
<td>0.9</td>
<td>13</td>
<td>3</td>
<td>4.50</td>
<td>12</td>
<td>0.0007</td>
</tr>
<tr>
<td>Q19.2</td>
<td>4.2</td>
<td>0.7</td>
<td>13</td>
<td>3</td>
<td>6.12</td>
<td>12</td>
<td>0.0001</td>
</tr>
<tr>
<td>Q19.3</td>
<td>3.2</td>
<td>0.7</td>
<td>13</td>
<td>3</td>
<td>0.81</td>
<td>12</td>
<td>0.4363</td>
</tr>
<tr>
<td>Q19.4</td>
<td>3.5</td>
<td>0.8</td>
<td>13</td>
<td>3</td>
<td>2.14</td>
<td>12</td>
<td>0.0532</td>
</tr>
</tbody>
</table>

Table 4.20 Non-parametric test

<table>
<thead>
<tr>
<th>Pair of Variable</th>
<th>Valid N</th>
<th>T</th>
<th>Z</th>
<th>p-level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q19.1 &amp; Three</td>
<td>13</td>
<td>0.00</td>
<td>2.67</td>
<td>0.0077</td>
</tr>
<tr>
<td>Q19.2 &amp; Three</td>
<td>13</td>
<td>0.00</td>
<td>2.93</td>
<td>0.0033</td>
</tr>
<tr>
<td>Q19.3 &amp; Three</td>
<td>13</td>
<td>7.00</td>
<td>0.73</td>
<td>0.4631</td>
</tr>
<tr>
<td>Q19.4 &amp; Three</td>
<td>13</td>
<td>0.00</td>
<td>1.83</td>
<td>0.0679</td>
</tr>
</tbody>
</table>

The parametric test (Table 4.19) indicates $p$ values that favour the acceptance of the alternative hypothesis for Q19.1 and Q19.2. The non parametric tests (Table 4.20) also confirm the same result. It can be inferred that the $p$ values for Q19.4 and Q19.3 indicate that the mean score for these variables are not statistically significant.

4.6 VALIDITY AND RELIABILITY OF RESULTS

The response rate relative to the study is not high, but it is acceptable for this level of study. Given the quantitative and objective nature of the study, reliability and validity of the findings can be assumed. Essentially, validity entails the question “does the measurement process, assessment or project actually measure what it was intended to measure?” Therefore, the study can be said to meet the criteria relative to validity and reliability. For instance, a four page questionnaire that consists of three sections that reflects general industry issues / problems and the research hypotheses was used for the investigation. In addition, internal validity relative to the study results are legitimate because the sample size generation procedure, data collection, and analysis performed were consistent with standard procedures adopted in quantitative research methodology.

Specifically, the sample size was generated through systematic sampling method, all the data collected in the same manner, and the analysis of the data was consistently controlled. In terms of external validity, the results are transferable to similar population that include contractors and subcontractors. In a nutshell, high level of validity can be assumed achieved in this study since the study was properly designed and strict protocol execution was observed throughout the study.
5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 GENERAL CONCLUSIONS

The South African construction industry is arguably the most advanced in sub-Saharan Africa. The research has further highlighted the fact that the performance-related issues in the South African construction industry are similar to the ones in the UK and the USA. The majority of the organisations that responded to the survey affirm the importance of supply chain management. They concur that supply chain management is vital for project success. Their assertion is based on experiences gathered on construction projects executed within the borders of the Republic of South Africa. In the last decade, most of the firms have been involved in one form of collaborative working or the other. This form of working gave credence to their perceptions concerning supply chain management. Though, they agree that adversarial relationships are present in the industry, their opinion is that it is not endemic. This is a notable departure from the norm in the last 2 decades whereby traditional forms of contracting was the only form used in the industry.

However, short term objectives and a price oriented approach persist in the industry. It is a problem that is uppermost in the mind of the respondents and it seems to have dominance in all sub sectors of the industry. The number of irregular clients of the industry is also a huge concern. This makes long term relationships difficult and necessitates short term view of project objectives. A relationship problem in the construction process that is equally high on the ranking scale is fragmentation. The research indicates that the construction supply chain is fragmented. Not only fragmented, but also there is strict and inflexible adherence to contents of construction contract data as well as poor use of modularisation in order to reduce construction time.

In addition, poor risk management competency can be found in the industry. This is coupled with the fact that contractual and competency distrust in the supply chain play a marginal role among the relationship problems in construction. Inefficient and ineffective problem solving mechanisms, especially between contractors and subcontractors was also highlighted as a problem. However, the most pressing issue to deal with right away seems to be the reduction of the prevalence of short term objectives and price oriented approach of supply chain members.

Knowledge has been said to be synonymous to power. Knowledge sharing and transfer is possible in a collaborative working environment in the South African construction industry. Collaboration can simplify the construction process by removing bottlenecks occasioned by individual perceptions and attitude. The quality of service between suppliers, subcontractors
and contractors can be improved as well as the quality of service delivered to clients and other project stakeholders. Closer relationships have the potential to break down barriers such as organisational and individual cultures. Given the labour intensive nature of some major construction projects whereby a personnel head count can reach a thousand at any given time, collaboration can support the flow of materials and information. Further, a consistent workload is beneficiary to long term relationships. A subcontractor that is sure of consistent work with a major contractor for a long time may align its project goals with that of its clients. This is particularly true for subcontractors dealing with formwork or earth works because their services will always be sought at the inception of new construction projects. Long term and stable relationships can therefore persuade subcontractors to focus on value rather than profit.

Contractors can also adopt collaborative procurement methods to promote innovation and creativity on construction projects. The procurement method may facilitate the negotiation of common project goals and objectives in an agreeable manner. Collaboration can also mitigate avoidable communication problems as well as logistics related issues. The construction industry is not in lack of partners with appropriate collaborative skills, but the will and mechanism to engender a collaborative working environment is what needs to be improved up on.

Contemporary management tools have sought the improvement of processes in organisations. Similarly, supply chain management can engender a culture of continuous improvement in construction. Early involvement of supply chain partners is a key to achieve continuous improvement. Stated target objectives are formulated by the supply team with everyone having an input. Strong leadership in coordinating interfaces and open exchange of data and information is a driver of successful supply chain management. The overall project cost can be impacted positively through collaboration based supply chain management.

There is poor uptake of lean construction as a management tool to eliminate waste in the construction process. Waste in construction can be people related or process related. The intent of lean construction is to identify potential waste through mapping and then redesign the process. Open book accounting is still a mirage, but there seems to be an improvement in this area through transparency. The penetration of information technology in the industry is still weak. It can be assumed that the reason is cost related. Apart from the major construction contractors’ deployment of up to date ICT by firms might be hindered by availability of capital. Capital is a resource that is quite scarce during an economic recession. Value creation and use of power in the industry to influence decisions is appropriate.
5.2 CONCLUSIONS RELATIVE TO HYPOTHESES

5.2.1 Hypothesis 1: *Adversarial relationships among subcontractors result in poor project performance.*

Site productivity is a very good key performance indicator that shows the effect of proactive supply chain management as a tool to reduce adversarial relationships in construction. Time and cost predictability is also a good way of knowing the effectiveness of supply chain management to reduce adversarial relationships on construction sites. Occupational health and safety can be used effectively in supply chain management approaches to realise improvement. All these key performance indicators reveal that proactive supply chain management has an effect on adversarial relationships. It can be used in the reduction of negative relationships between project teams and supply teams.

Adversarial relationships among subcontractors result in poor project performance. Site productivity, time predictability, cost predictability and occupational health and safety are key performance indicators that show if project performance is poor or good. The strong correlations of these key performance indicators reveal that they are strongly associated and effective indicators of the state of relationships within a construction supply chain. That is a positive or optimistic site productivity, time predictability, cost predictability and occupational health and safety may suggest little or non existence of adversarial relationships in a supply chain. While a negative measure of these key performance indicators may suggest the reverse.

5.2.2 Hypothesis 2: *Integration of the supply chain eliminates waste and adds value to the process.*

Fragmentation is present in today’s construction industry. The tendency to move toward horizontal integration rather than vertical integration in favour of reduction of overhead cost has engendered fragmentation in the industry. However, the quest for the creation of optimum value for clients can eliminate fragmentation in the construction process. The satisfaction of contractors through quality service received from subcontractors can also eliminate fragmentation. Similarly, a culture of innovation and improvement in organisations has an effect on the elimination of fragmentation through supply chain management. Though, effect of magnitude of defects and rework cannot be ascertained, it also impacts the supply chain.

The opposite of fragmentation is integration. The key performance indicators of value for client, contractor’s satisfaction, and innovation and improvement suggest that they are not only effective in measuring the level of integration in the supply chain, but can also eliminate or reduce fragmentation in the construction process.
5.2.3 Hypothesis 3: **Project delivery outcomes suffer when open and defined communication links are absent in the supply chain.**

The effectiveness of communication systems such as ICT has been shown to have an effect on proactive supply chain management as a tool to improve information sharing in the construction process. The research also indicates that the magnitude and frequency of contractual claims can indicate the performance of supply chain management when deployed to improve information sharing in construction. Magnitude and frequency of contractual disputes as well as a reduction of paperwork and request for information documents are poor indicators of the state of information sharing in the supply chain.

Therefore, the effectiveness of communication systems as well as the magnitude and frequency of contractual claims can impact project delivery outcomes either positively or negatively. When these key performance indicators are positive then it is a plus for project delivery outcomes while the reverse is the case when the key performance indicators are in red.

5.2.4 Hypothesis 4: **Alignment of project goals is difficult without mutual trust in the supply chain.**

The effectiveness of top management commitment in engendering trust within the supply chain is well documented in this research work. The investigation revealed that top management commitment and trust between project partners has an effect on the improvement of reliability within the supply chain. Frequency of arbitrations, law suits and team building workshops has no strong effect on improving reliability according to the research result. Team building workshops have an effect, but the depth of the effect cannot be ascertained.

In addition, mutual trust in the supply chain can deepen where top management is committed and the project teams are open-minded about individual competencies.

5.3 **RECOMMENDATIONS**

Having stated that the non integration of the construction supply chain hinders the creation and improvement of value for money in the construction process as the research problem statement and that the research was conducted on the strength of the statement, the recommendations will address issues related thereto. Specifically the recommendations are anchored on collaboration and supply chain management. The recommendations include:

- Ensuring the early involvement of key project team members that have expert knowledge so that an appropriate level of client satisfaction and value can be defined;
• Establishing of subcontractor and supplier relationships by selecting teams based on value rather than lowest price;
• Integrating pre-construction and construction activities and adopting common processes such as ICT;
• Managing the project parameters of cost, schedule, quality, and H&S in unison;
• Working together as a team to agree mutual goals and devise dispute resolution mechanisms;
• Developing and monitoring continuous improvement programmes;
• Developing and implementing sound risk management processes;
• Dealing with risks and rewards equitably by using modern commercial arrangements such as collaborative contract forms, target cost and open book accounting;
• Using non-adversarial forms of contract and ensuring that contractual relationships are appropriate for expected project objectives;
• Using cost-plus and design and build forms on contract and deemphasising the use of management contracting as well as traditional forms of contracting;
• Encouraging negotiated contracts instead of competition;
• Mobilising and developing people in order to ensure employee satisfaction through integrated teams, and
• Adopt Latham / Egan collaborative working principles.

5.4 FURTHER RESEARCH

It could be said that this research provides vital feedbacks relative to the management of construction projects. Specifically, problems, solutions, and the dynamics between project partners were highlighted. However, research needs to be conducted in order to ascertain the effect of recurring defects and rework on relationships between project partners, and performance expectations of project stakeholders. Furthermore, the depth and frequency of contractual disputes, paperwork, and RFIs needs to be examined properly in order to ascertain their influence and ability to reveal the state of information sharing in the construction supply chain.

Conclusively, the acceptance and the depth of adoption of best practices such as lean construction, modularisation, open book accounting and early contractor involvement in the South African construction industry deserve further investigation.
REFERENCES


25 May 2009

Dear Madam / Sir

Re: The impact of construction supply chain management on value on projects

This survey is part of a research project at MSc level aimed at meeting the requirements for the degree of Masters in the Built Environment with specialisation in Construction Management at the Nelson Mandela Metropolitan University.

The aim of the research work is to assess the level of implementation or rather adoption of best practices such as supply chain management and partnering in South Africa, and to present recommendations that will assure continuous improvement in the construction process.

Kindly complete accompanying questionnaire and return same to:

Department of Construction Management
Nelson Mandela Metropolitan University
PO Box 77000
Port Elizabeth
6031.

Please return either through postal services or facsimile (041) 504 2345 by the 30th of June, 2009.

Attention: Prof John Smallwood / Mr Fidelis Emuze

Should you have any queries please do not hesitate to contact Mr Fidelis Emuze at 0714509442 or per e-mail:
Fidelis.Emuze@nmmu.ac.za

Please note that the confidentiality of your response is assured.

Thanking you in anticipation of your response.

Mr Fidelis Emuze

MSc Built Environment (Construction Management) student

Prof John Smallwood PhD (Construction Management)
A. ORGANISATION
1. What kind of organisation do you work for?
   - Contractor
   - Subcontractor
2. What kind of projects does your organisation undertake?
   - Civil Engineering
   - Building Construction
3. Please indicate the number of years your organisation has been in operation in the box provided below.
   - ………………..years
4. Please indicate the approximate number of employees in your organisation in the box provided below.
   - ………………..No.
5. Please indicate your organisation’s annual turnover for the year 2008 and the number of projects your organisation undertook in 2008 in the boxes provided below.
   - R………………
   - ………………..No.

B. PERSONAL
6. Please indicate your gender.
   - Male
   - Female
7. Please state your age in the box provided below.
   - ………………..years
8. Please indicate the length of your experience in the construction industry in the box provided below.
   - ………………..years
9. Please indicate the highest formal qualification you hold.
   - College/High School
   - Diploma
   - First Degree (BSc)
   - Postgraduate Degree (MSc, PhD)
10. Please indicate your status in your organisation.
    - Corporate Executive (Directors)
    - Middle Management (Construction Managers)
    - Site Management (Agents, Engineers)
SECTION 2: THE CONSTRUCTION PROCESS STATUS QUO

11. Please indicate if your organisation considers supply chain management important for project success.
   - Yes
   - No
   - Unsure

12. Please indicate if your organisation has being involved in collaborative working arrangements in the last 10 years.
   - Yes
   - No
   - Unsure

13. On a scale of 1 (strongly disagree) to 5 (strongly agree), please indicate the extent of your agreement with the under listed relationship problems in the construction process (Please note the unsure option).

Please relate your responses to construction projects in South Africa

<table>
<thead>
<tr>
<th>Problems</th>
<th>Unsure</th>
<th>Strongly disagree…Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.1 Adversarial relationships are endemic in the construction process</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>13.2 The construction supply chain is fragmented</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>13.3 Presence of contractual and competency distrust in the supply chain</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>13.4 Disproportionate assessment and allocation of construction project risks</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>13.5 Significant numbers of irregular clients of the industry</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>13.6 Uneven level of commitment of project parties</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>13.7 Short term objectives and price oriented approach persists in the industry</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>13.8 Poor use of modularisation in order to reduce construction time</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>13.9 Presence of inefficient and ineffective problem solving mechanism</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>13.10 Strict and inflexible adherence to contents of construction contract data</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

14. On a scale of 1 (strongly disagree) to 5 (strongly agree), please indicate your view of collaborative working in the construction process (Please note the unsure option). Please relate your responses to construction projects in South Africa

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Unsure</th>
<th>Strongly disagree…Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.1 Lack of partners with appropriate collaborative skills</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>14.2 Collaboration can simplify the construction process</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>14.3 Knowledge sharing and transfer is possible in a collaborative working environment</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>14.4 Common project goals and objectives can be negotiated in an agreeable manner</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>14.5 Collaborative procurement methods can promote innovation and improvements on major projects</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>14.6 Long-term and stable relationships can persuade subcontractors to focus on value instead of profit</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>14.7 Collaborative working can lead to better quality service</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>14.8 Closer relationships can break down barriers such as culture</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>14.9 Consistent workload is beneficiary to long term relationships</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>14.10 Avoidable communication problems can be mitigated through collaboration</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>
15. On a scale of 1 (strongly disagree) to 5 (strongly agree), please indicate your view on the use of supply chain management as a management tool in construction (Please note the unsure option).

Please relate your responses to construction projects in South Africa

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Unsure</th>
<th>Strongly disagree…Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.1 Strong leadership in coordinating interfaces is essential for successful supply chain management</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>15.2 Early involvement of supply chain partners is key to achieving target objectives</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>15.3 Open book accounting practice between the supply chain partners is seldom used in project execution</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>15.4 Recurrent poor creation of value in the process by supply chain partners</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>15.5 Supply chain management based on collaboration can reduce overall project cost</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>15.6 Appropriate deployment of ICT can improve information sharing among supply chain partners</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>15.7 Improper use of power to influence decisions by the focal firm in the supply chain</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>15.8 Poor use of management tools such as lean construction to eliminate waste in the process</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>15.9 Open exchange of data and information is a driver of construction supply chain management</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>15.10 Poor adoption of best practices such as partnering and supply chain management in the industry</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

SECTION 3: EFFECT OF SUPPLY CHAIN MANAGEMENT ON CONSTRUCTION PROJECTS

16. Using the under listed key performance indicators, on a scale of 1 (very poor) to 5 (very good) please indicate the effect of proactive supply chain management as a tool to reduce adversarial relationships in construction (Please note the unsure option).

<table>
<thead>
<tr>
<th>Factors</th>
<th>Unsure</th>
<th>Very poor………………..Very good</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.1 Time predictability</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>16.2 Cost predictability</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>16.3 Occupational health and safety</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>16.4 Site productivity</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

17. Using the under listed key performance indicators, on a scale of 1 (very poor) to 5 (very good) please indicate the effect of proactive supply chain management as a tool to eliminate fragmentation in the construction process (Please note the unsure option).

<table>
<thead>
<tr>
<th>Factors</th>
<th>Unsure</th>
<th>Very poor………………..Very good</th>
</tr>
</thead>
<tbody>
<tr>
<td>17.1 Value for the client</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>17.2 Contractor’s satisfaction</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>17.3 Innovation and improvement</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>17.4 Magnitude of defects and rework</td>
<td>U</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>
18. Using the under listed key performance indicators, on a scale of 1 (very poor) to 5 (very good) please indicate the effect of proactive supply chain management as a tool to improve information sharing in the construction process (Please note the unsure option).

<table>
<thead>
<tr>
<th>Factors</th>
<th>Unsure</th>
<th>Very poor</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>18.1 Effectiveness of communication systems</td>
<td>U</td>
<td>1 2 3</td>
<td>4</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18.2 Magnitude and frequency of contractual claims</td>
<td>U</td>
<td>1 2 3</td>
<td>4</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18.3 Magnitude and frequency of contractual disputes</td>
<td>U</td>
<td>1 2 3</td>
<td>4</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18.4 Reduction of paperwork and request for information documents</td>
<td>U</td>
<td>1 2 3</td>
<td>4</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

19. Using the under listed key performance indicators, on a scale of 1 (very poor) to 5 (very good) please indicate the effect of proactive supply chain management as a tool to improve reliability between project partners (Please note the unsure option).

<table>
<thead>
<tr>
<th>Factors</th>
<th>Unsure</th>
<th>Very poor</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>19.1 Trust between project partners</td>
<td>U</td>
<td>1 2 3</td>
<td>4</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19.2 Top management commitment</td>
<td>U</td>
<td>1 2 3</td>
<td>4</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19.3 Frequency of arbitrations and law suits</td>
<td>U</td>
<td>1 2 3</td>
<td>4</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19.4 Frequency of team building workshops</td>
<td>U</td>
<td>1 2 3</td>
<td>4</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Although the data you have provided in this questionnaire will be treated in the strictest confidence, it would be appreciated if you would record your details below to facilitate contacting you, in the event a query should arise.

ORGANISATION:  
ADDRESS:  

NAME:  
TELEPHONE:  
MOBILE:  
E-MAIL:  
DATE:  

THANK YOU FOR YOUR CONTRIBUTION TO THIS RESEARCH DIRECTED TOWARDS CONTRIBUTING TO THE IMPROVEMENT OF THE CONSTRUCTION PROCESS IN SOUTH AFRICA.