

# Implementing Inter-Organisational Information Systems for the Integration of Construction Supply Chains

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# **IMPLEMENTING INTER-ORGANISATIONAL INFORMATION SYSTEMS FOR THE INTEGRATION OF CONSTRUCTION SUPPLY CHAINS**

by

Mesut Pala

A dissertation thesis submitted in partial fulfilment of the requirements for the award of the degree Doctor of Engineering (EngD), at Loughborough University

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*June 2018.*



TO MY UNBORN BABY;  
TO SCIENCE;  
TO THE KNOWN UNKNOWN;

**“LIVE AND LET LIVE”**

NEVER GIVE UP  
HOPE DIES  
LAST!





## **Abstract**

Two trends are currently driving the need for supply chain firms to form closely integrated relationships: collaboration and digitisation. One of the ways to achieve digitisation of supply chain operations is to implement Inter-Organisational Information Systems (IOIS) with selected supply chain partners for a much more efficient, streamlined and orchestrated supply chain operations. Whilst IOIS can be implemented to support various cross-functional business processes (ranging from operational information exchange to pursuing strategic initiatives such as sharing ideas, identifying new market opportunities, and pursuing a continuous improvement approach), in the context of this thesis, the purpose of IOIS implementation is to facilitate the inter-firm procurement-related operations with downstream supply chain firms.

The study undertaken in this research project was initiated in response to an industry requirement to investigate the implementation of IOIS against a backdrop of improved Supply Chain Management and integration practices by large contractor organisations. A case study research strategy was adopted to investigate the IOIS project related, IOIS (system) related issues encountered in ex-ante and ex-post implementation stages of the IOIS. The study concludes that it is the non-technical factors that are critical to the successful delivery of IOIS projects and provides a guideline on IOIS implementation by large contractor organisations. The findings of this research project have been published in a number of peer-reviewed papers.

## **Key Words**

Construction Supply Chain Management; Inter-Organisational Information Systems; Implementation; Integration;

## Used Acronyms / Abbreviations

<b>3D</b>	Three-Dimensional	<b>ICT</b>	Information and Communication Technology
<b>AEC</b>	Architecture Engineering and Construction	<b>IFC</b>	Industry Foundation Class
<b>API</b>	Application Programming Interface	<b>INA</b>	Industrial Network Approach
<b>APL</b>	Advanced Planning and Logistics (System)	<b>IOIS</b>	Inter-organisational Information System
<b>APSS</b>	Advanced Planning and Scheduling System	<b>IOMS</b>	Inter-organisational Middleware System
<b>B2B</b>	Business-to-Business	<b>IPD</b>	Integrated Project Delivery
<b>BIM</b>	Building Information Modelling	<b>IS</b>	Information System
<b>BO</b>	Blanket Order	<b>IT</b>	Information Technology
<b>BPMF</b>	Business Process Management Framework	<b>ITIL</b>	Information Technology Information Library
<b>BSI</b>	British Standards Institution	<b>ITT</b>	Invitation to Tender
<b>BU</b>	Business Unit	<b>JIT</b>	Just-in-Time
<b>CAS</b>	Costing and Account Management System	<b>JV</b>	Joint Venture
<b>CDE</b>	Common Data Environment	<b>KPI</b>	Key Performance Indicator
<b>CICE</b>	Centre for Innovative and Collaborative Engineering	<b>LTSP</b>	Long-term Strategic Partnership
<b>CO</b>	Call-Off Order	<b>NAO</b>	National Audit Office
<b>CPC</b>	Construction Product Catalogue	<b>OEM</b>	Original Equipment Manufacturer
<b>CRM</b>	Customer Relationship Management	<b>OGC</b>	Office of Government Commerce
<b>cSaaS</b>	Collaborative Software-as-a-Service	<b>OMS</b>	Order Management System
<b>cSCM</b>	Construction Supply Chain Management	<b>ONS</b>	Office of National Statistics
<b>cSRM</b>	Construction Supplier Relationship Management	<b>PDF</b>	Portable Document Format
<b>EAIF</b>	Enterprise Architecture Implementation Framework	<b>PE</b>	Project Extranet
<b>e-Business</b>	Electronic Business	<b>PFI</b>	Private Finance Initiative
<b>eCIX</b>	Electronic Commercial Information Exchange	<b>PMS</b>	Project Management System
<b>e-Ccommerce</b>	Electronic Commerce	<b>PMF</b>	Project Management Framework
<b>EDI</b>	Electronic Data Interchange	<b>PPP</b>	Public-Private Partnership
<b>EDIFACT</b>	Electronic Data Interchange for Administration, Commerce and Transport	<b>PQQ</b>	Pre-qualification Questionnaire
<b>EIS</b>	Enterprise Information System	<b>RE</b>	Research Engineer
<b>e-Marketplace</b>	Electronic Marketplace	<b>RICS</b>	Royal Institute of Chartered Surveyors
<b>EngD</b>	Engineering Doctorate	<b>RFI</b>	Request for Information
<b>e-Procurement</b>	Electronic Procurement	<b>RFQ</b>	Request for Quote
<b>ERP</b>	Enterprise Resource Planning	<b>SaaS</b>	Software-as-a-Service
<b>ESP</b>	Exchange Service Provider	<b>SCI</b>	Supply Chain Integration
<b>ESPIO</b>	Economic, Social Psychological, Inter-personal, Organisational – <i>trust</i>	<b>SCIS</b>	Supply Chain Information System
<b>e-Trading</b>	Electronic Trading	<b>SCM</b>	Supply Chain Management
<b>FM</b>	Facilities Management	<b>SCOR</b>	Supply Chain Operations Reference Model
<b>GDP</b>	Gross Domestic Product	<b>SfFC</b>	Strategic Forum for Construction
<b>GRN</b>	Goods Receipt Note	<b>SOAP</b>	Simple Object Access Protocol
<b>GT</b>	Grounded Theory	<b>SME</b>	Small and Medium Enterprise
<b>GUI</b>	Graphical User Interface	<b>SRM</b>	Supplier Relationship Management
<b>HP</b>	Hub Provider	<b>SMF</b>	Service Management Framework
		<b>STEP</b>	Standard for the Exchange of Product Model Data Technology Acceptance Model
		<b>TAM</b>	Transaction Cost Economics
		<b>TCE</b>	Theory of Planned Behaviour
		<b>TPB</b>	

<b>TRA</b>	Theory of Reasoned Action	<b>WPMS</b>	Web-based Project Management
<b>UK</b>	United Kingdom		System
<b>UTAUT</b>	Unified Theory of Acceptance and Use of Technology	<b>XML</b>	eXtensible Mark-up Language
<b>VAN</b>	Value Added Network		

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## Glossary of Terms

<b>Cross-firm</b>	Related to a process or activity where two firms meet.
<b>Cross-functional</b>	Related to a process or activity that involves bringing together of functional individuals, teams or departments in two different organisations.
<b>e-Business</b>	Electronic conduct of business operations.
<b>e-Commerce</b>	Any transaction for the sale or purchase of goods and services conducted over computer networks by methods specifically designed for the purpose of receiving or placing of orders (OECD 2013).
<b>eCIX</b>	Electronic Exchange of Commercial Information- Seamless exchange of different types of transactional information (including, but not limited to, product and pricing information, order, delivery and invoice data) amongst businesses and their back-end ERP systems.
<b>EDI</b>	Electronic Data Interchange- A set of standards to link two or more legacy systems for the transfer of electronic data/document.
<b>e-Procurement</b>	The use of ICT to conduct purchasing and sourcing activities (including identification of need, negotiation, contracting and settlement) between buyer and suppliers.
<b>e-Trading</b>	Web-based technologies that facilitate the B2B commercial exchange between buyer and supplier.
<b>Implementation</b>	“The process of putting a decision or plan into effect; execution” (Oxford Dictionary 2017)
<b>Information Systems</b>	“Combination of information, processes (work practices), people and information technology which are organised to achieve business objectives” (Alshawi and Aouad 1995 p. 252).
<b>Inter-firm</b>	A process or activity that occurs <i>between</i> or <i>among</i> two or more firms.
<b>Interoperability</b>	“The ability of two or more systems or components to exchange information and to use the information that has been exchanged” (IEEE 1990)
<b>Intra-firm</b>	A process or activity that occurs within the boundaries of a firm.
<b>IOIS</b>	Inter-Organisational Information Systems-, are inter-connected enterprise information systems which are linked through an intermediary service provider, a middleware messaging system or software agents, to facilitate boundary spanning business and project related activities.
<b>SCM</b>	Supply Chain Management- Management of a network of relationships within a firm and between interdependent organizations and business units consisting of material suppliers, purchasing, production facilities, logistics, marketing, and related systems that facilitate the forward and reverse flow of materials, services, finances and information from the original producer to final customer with the benefits of adding value, maximizing profitability through efficiencies, and achieving customer satisfaction.
<b>cSCM</b>	The process of strategic management of information flow, activities, tasks, and processes, involving various networks of organisations and linkages (upstream and downstream) involved in the delivery of quality construction products and services through the firms and to the customer, in an efficient manner.
<b>SRM</b>	Supplier Relationship Management- A company-wide business strategy to manage its interconnected, dynamic and multi-dimensional interactions through its various resources within the firm and at the interface with other businesses so that it facilitates development of better relationships throughout its upstream and downstream supply chains.
<b>Transaction</b>	An instance of buying or selling something; that is, a commodity, product or service.

## List of Papers

The following papers, included in the appendices, have been produced during the course of the research in partial fulfilment of the award requirements of the Engineering Doctorate programme.

### Paper 1 (See Appendix B)

Pala, M., Edum-Fotwe, F. T., Ruikar, K. D., Peters, C., and Doughty, N. (2012). “Achieving Effective Project Delivery Through Improved Supplier Relationship Management.” *Working Paper Proceedings. Engineering Project Organisations Conference*, A. Javernick-Will and A. Mahalingham, eds., EPOS, Rheden, Netherlands, 1–12.

### Paper 2 (See Appendix C)

Pala, M., Edum-Fotwe, F. T., Ruikar, K. D., Peters, C., and Doughty, N. (2012). “Improving Supplier Relationship Management Within the AEC Sector.” *Association of Researchers in Construction Management (ARCOM)*, S. Smith, ed., ARCOM, Edinburgh, 707–717.

### Paper 3 (See Appendix D)

Pala, M., Edum-Fotwe, F. T., Ruikar, K. D., Doughty, N., and Peters, C. (2014). “Contractor practices for managing extended supply chain tiers.” *Supply Chain Management: An International Journal*, 19(1), 31–45.

### Paper 4 (See Appendix E)

Pala, M., Edum-Fotwe, F. T., Ruikar, K., Peters, C., and Doughty, N. (2016). “Implementing commercial information exchange: a construction supply chain case study.” *Construction Management and Economics*, 34, 1–21.

### Paper 5 (See Appendix F)

Pala, M., Edum-Fotwe, F. T., Ruikar, K., Peters, C., and Doughty, N. (submitted). “Post-Implementation Analysis of a B2B e-Marketplace.” Under Review. *Submitted for publication in Journal of Information Technology in Construction journal. December 2017.*

## Chapter 1: Introduction

The purpose of this chapter is to provide background into the research. The chapter begins with a summary of the general subject domain (Architecture, Engineering and Construction, or the AEC industry) and the industrial sponsor, before setting out the context of the research and the justification for conducting the research. The chapter also presents the aim and objectives of the research, lists the academic publications and describes the remaining structure of the thesis.

### 1.1 The General Subject Domain

The AEC industry forms the backbone of many national economies as it accounts for a large proportion of activities in the macroeconomic market. The UK AEC industry is one of the biggest in Europe in terms of turnover, employment and number of firms in the industry (FIEC 2015). The UK national data shows that the industry adds 6% to the GDP with an output of about £90 billion from construction output<sup>1</sup> of which £2.5 billion<sup>2</sup> is from export earnings (ONS 2015). There are around 262,000 businesses<sup>3</sup> (of which around 98% are SMEs) employing over 2 million people which equates to about 7% of the working population. Government is the biggest client of the industry with ownership of up-to 40% of all projects (Baldry 2012). The strategic importance of the industry is much bigger when wider economic, environmental and societal impact is taken into consideration. For example it is reported that every £1 spent in construction output generates £2.84 of economic activity in extended supply chains (L.E.K Consulting 2009). Moreover, the importance of the AEC industry for the UK government is also reflected in its spending review for its need of range of construction works which are detailed in National Infrastructure Report (HM Treasury 2011, 2014).

Despite its significance for the national economy, the UK AEC industry suffers from myriad of long-term, multi-dimensional, large-scale and complex problems which have been addressed in various government and NGO reports, recommendations and academic publications (reader is advised to read Langford *et al.*, (2003) for history of government-led reviews on industry problems). Some of the endemic problems that are repeatedly addressed include the following:

- fragmented processes, professions and organisations
- confrontational, adversarial and arms-length relationships
- cost inefficiency and waste
- frequent time-overruns and high rates of defects
- construction complexity and non-transparency of processes
- uncertainty and changes in the design
- lack of cooperation, collaboration and communication between key project actors
- competition and poor profit margins
- lack of investment on research and innovation

Furthermore, in the '*Never Waste a Good Crisis*' report by Constructing Excellence, the pace of change in resolving these problems has been identified as extremely slow (Wolstenholme et al. 2009), adding more pressure to industry at large to improve its image and performance in comparison to other industries such as aerospace and automotive manufacturing industries. Although the latest KPI data shows modest increase in project delivery timelines, cost predictability, and client satisfaction; available benchmark data shows that 55% of all projects are delivered late (Glenigan 2014). The industry profitability, which gives an indication of industry's financial performance in long-term survival was at the lowest point, 2.1% in contrast to 9.9% recorded just before the 2008 financial crisis. The future predictions

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<sup>1</sup> Source: ONS Annual Business Survey data, 2012 results.

<sup>2</sup> Source: ONS UK Trade data, 2015 results. Data is for trade in services for 2014.

<sup>3</sup> Source: ONS Annual Business Survey data, 2013 results.

are quite bleak too following the UK's decision to leave the European Union (see for example a recent industry review by Farmer 2016).

## **1.2 The Industrial Sponsor**

The current research work is conducted as part of an Engineering Doctorate (EngD) degree programme which involved partnership with an industry firm, Asite, and is jointly funded by Loughborough University and EPSRC (Engineering and Physical Sciences Research Council). The EngD degree programme is an alternative to the traditional PhD route where the researcher (called Research Engineer, RE) is involved with a research project which is partly guided by the industrial sponsor. The sponsoring company, Asite Solutions Ltd., is a medium sized software solutions company operating from its head-office in London and regional offices around the world. It was founded after the publication of one of the most influential government construction reports; the Egan Report (Egan 1998), with an aim to serve the communication of information and document management needs of highly fragmented supply chain actors in construction projects. In terms of its business operations, Asite operates in the online 'collaborative Software as a Service' (cSaaS) market providing solutions predominantly for the Architectural, Engineering, Construction, and Facilities Management sectors (collectively referred to as AEC/FM). It offers the cSaaS in the 'Cloud' where users can access the services at any time and from anywhere in the world. The project data is stored in a secure common data environment (CDE) which supports hundreds of file extensions including information-rich 3D Building Information Modelling files. Asite effectively integrates the supply chain firms who are dispersed across time and space and enable them to collaborate and manage the delivery of AEC/FM operations in a timely, accurate and cost-effective manner.

The EngD programme is tailored to the needs of the industry as well as to the commercial interests of the sponsoring company. The research is influenced by both company specific and industry defined problems. In relation to the latter, the aim of the current study is to explore the implementation of ICT enabled Supply Chain Management (SCM) by industry firms (large contractor firms particularly) and in terms of the company specific goals, the research aims to benefit Asite's operations for a much more streamlined software delivery for the AEC/FM organisations. The EngD programme requires the RE to publish the outcome of the research in at least three academic papers as well as completion of a thesis.

## **1.3 The Research Context**

Organisations do not exist in isolation, and its activities are influenced to a greater or lesser extent by the actions of other organisations that make up its supply chain. In the AEC industry a significant proportion of construction projects are subcontracted to supply chain firms (EC Harris 2013). Holti *et al.*, (2000) stated that in a typical construction project 80% of the project cost is associated with products and services which are provided by the supply chains. Through simulating the effects of supply chain delays in a large scale building project, Hatmoko (2008) demonstrated that material flows by downstream supply firms can add as much as 67 days to project's timeline (around 20% of the project's duration). Elsewhere in the literature, there is a strong correlation between relationship characteristics of supply chain firms and, project and supplier performance. For example, based on an archival analysis of contractor-subcontractor relationships, Autry and Golicic (2010) found a strong link between the relationship strength and subcontractor performance. In a similar vein, findings from a UK-wide questionnaire survey study by Meng (2012) shows that deterioration of supply chain relationships are a major factor of poor project performance (that is, with respect to the cost overruns and time delays). Recognising the vital importance of suppliers and subcontractors on construction projects, many studies highlight the significance of the need to pursue tighter collaborative and integrative practices with key/strategic supply chain firms to minimise defects (Karim et al.

2006), to improve productivity (Fulford and Standing 2014; Loosemore 2014), to mitigate on-site problems (Thunberg et al. 2017), to co-involve early in the decision making process, to generate innovations, competitive advantage (Bresnen 2009; Broft et al. 2016), to achieve time, cost, and performance savings in the long-run (Autry and Golicic 2010; Bankvall et al. 2010; Doloi 2013; Fulford and Standing 2014; Gosling et al. 2015b; a; Karim et al. 2006; King and Pitt 2009; Martinsuo and Ahola 2010; Matthews et al. 2000; Meng 2012) and, to reduce risks involved in the delivery of the project (Aloini et al. 2012).

Against this backdrop, enabled by the ubiquitous advancements in Information Communication Technologies (ICT) in the last 20-30 years, the *modus operandi* of supply chain operations has been subject to a significant reform. It has, for instance, led to transformation of many business relationships to let them become ‘extended virtual enterprises’ (Dyer 2000) or ‘e-supply chains’ (Akyuz and Rehan 2009). Evidence of this can easily be found in aerospace and automotive manufacturing, and, retail and finance industries and in exploring in detail the digitisation of their supply chain interactions and processes (Bughin et al. 2017). It is envisioned that the proliferation of this extensive digital connectivity—also regarded by some as ‘connection beyond transaction’—will not only improve supply chains as a whole but also have a significant impact across the business ecosystems<sup>4</sup> giving rise to a new concept labelled as ‘Industry 4.0’ (Bharadwaj et al. 2013; Roblek et al. 2016).

Similarly, within the AEC industry, organisations are encouraged to transcend the boundaries of their Enterprise Information Systems (EIS) by functionally and collaboratively integrating with that of their supply chain firms. By adopting Inter-Organisational Information Systems (IOIS)—described as Information Systems (IS) that facilitate boundary spanning business and construction project related activities—it is anticipated that AEC firms would achieve more synchronous and streamlined cross-firm supply chain operations, and benefit from reduction in waste, increase in productivity, and efficiencies in supply chain operations (Fulford and Standing 2014). A prominent feature of the IOIS is its ability to facilitate inter-operation of data between back-end systems. Although, the IOIS serve a wide range of needs, the scope of the IOIS referred to in this study is primarily centred on the inter-firm procurement activities which is considered as an essential component of the supply chain operations.

Despite its significant role in integration of supply chains, AEC organisations have failed to adopt and implement IOIS with their supply chains. It is well known fact that construction industry is well-behind in terms of digitization of its inter-organisational processes and, companies fail to take advantage of the leverage that inter-organisational technologies provide for them (Rajat et al. 2016). With respect to the IOIS, although the scope and definitions differ from one another, a number of reports and studies document the poor levels of adoption by the AEC firms. For example, a relatively recent report prepared for the European Commission shows that ICT facilitated commercial data/information exchange (such as Electronic Data Interchange/Web-EDI and XML web services which fall under IOIS) in the AEC industry is quite low; just below 10% of the 138 responses from 11 countries surveyed (European Commission 2013). At the national (UK) level, the ONS survey data of businesses estimates that a mere 1.2% of the £376bn of e-commerce use (Business-to-Business transactions carried over EDI) is represented by the construction sector (ONS 2015). Similar findings reverberate in a study by Eadie *et al.* (2011) who investigated the e-procurement adoption by upstream supply chain firms and found that the rate of electronic conduct of procurement operations was 17% (135) out of 795 firms surveyed. It is worth acknowledging, however, the disproportionate rate of adoption (which is common in all three reports) amongst the businesses surveyed where large organisations appear to lead the adoption and use of IOIS.

<sup>4</sup> “Ecosystems are dynamic and co-evolving communities of diverse actors who create and capture new value through increasingly sophisticated models of both collaboration and competition” (Kelly 2015)

Besides the techno-phobic culture of the industry firms, it is believed that the reasons for low levels of IOIS implementation has deep rooted factors within the structure and formation of the AEC supply chains. For example, Cox *et al.*, (2006) explains that prevailing relationship characteristics (infrequent, one-off and short-term) in the industry often prevent AEC firms from investing in their relationships. Thus, firms do not see the benefits of developing inter-organisational technologies with their supply chains. Nevertheless, with the increased focus on building long-term strategic partnerships, and at the same time, with the advent and proliferation of technological solutions (such as Cloud-computing), it has become necessary for contractor firms to align their internal (ICT) resources and capabilities with that of supply chain firms to be able to fully leverage the benefits and opportunities of closer integrative relationships. The context of this study is, therefore, rooted in the idea of supply chain integration through implementing inter-linked EIS (through third-party technology solutions providers) with an aim to increase effectiveness and efficiency of inter-firm interactions and thereby contributing to the development of supply chains with sustained and competitive relational advantage.

## **1.4 Need for the Research**

Although the cross-fertilisation of IS and SCM research has been a dynamic field of inquiry- in particular within the context of manufacturing and retail firms, prior research focusing on ICT-enabled SCM from the perspective of AEC firms has not received sufficient attention. In addition, although the IOIS have been in existence for a very long time (for example in the form of EDI), the web-enabled integrative IOIS is a relatively new phenomenon for the AEC firms. The web-enabled integrative IOIS is considered a technological innovation because it enables seamless inter-operation of data with an added flexibility to connect-and-transact with key/strategic supply chain firms. However, there is currently very limited knowledge base on sophisticated IOIS implementation and development projects (Xu 2015). Furthermore, clear guidance is lacking in setting a direction for executive management or those responsible for implementing IOIS, specifically within construction organisations' context. One of the main inhibitors of IS/IT implementation by construction organisations is the lack of know-how or mechanisms on how to best implement and introduce IS/IT innovations in construction context (Alshawi et al. 2010a). Therefore, an understanding of how to achieve better deployment of IOIS is required for AEC firms, particularly for the contractor organisations. Such an understanding can help managers facilitate delivery of IOIS implementation and thus achieve successful implementation.

In addition, having a better understanding of how to best implement IOIS in the context of AEC supply chains will provide the following benefits in research and practice.

1. Contribution towards closing the gap between theoretical and practical issues around IOIS implementation.
2. Contribution towards increasing the awareness on the importance and significance of systems integration approaches between supply chain partners.
3. Higher success rate in implementation, adoption and acceptance of IOIS internally within the organisation and externally with supply chain partners.

## **1.5 Research Scope**

The scope of the research is reduced in terms of organisation sector and size to embrace only the large UK contractor firms. The choice of the large contractor firms is made since they represent a significant percentage of the customer base of the research sponsor. Furthermore, a decision had to be made to unite two broad fields of enquiry (ICT and cSCM) within one area: Inter-Organisational Information Systems. The IOIS covers a wide spectrum of technologies, business functions and supply chain processes, however the focus of this research is on IOIS to

facilitate the procurement operations between large contractor firms and their downstream supply chain firms. The research adopts SCM as the theoretical framework to implementing IOIS within construction organisations' environment. In this regard, the research is concentrated on the question of 'how' to implement IOIS within SCM context, rather than 'what' aspect of the IOIS implementation which is specifically concerned with the development of new IOIS.

## **1.6 Aim and Objectives**

The primary aim of the research was to investigate the cSCM for better integration of construction supply chains through IOIS implementation. In order to effectively achieve the overarching research aim, three objectives have been pursued. Each objective was further broken into smaller, more manageable tasks (and sub-tasks) as the research evolved. Section 3.4 provides the details of the research development process.

### **1.6.1 Identify the current practices and challenges for ICT-enabled Supply Chain Management by contractor organisations**

The first objective sought to understand the ICT-enabled SCM from the perspective of large contractor firms. More specifically, the first objective was concerned with the adoption and use of ICT in construction supply chain context with a particular emphasis on (i) the ICT-enabled SCM practices by large contractor firms, and (ii) functionalities offered by the current technology solutions providers for inter-firm technological integration and management of construction supply chains. Following three tasks were set out for this objective.

- Review the state-of-the-art on construction-specific SCM and SRM.
- Explore and identify the current practices and challenges for ICT-enabled SCM technologies by contractor organisations.
- Explore the current AEC-specific Software-As-A-Service solutions that facilitate the collaboration and management of construction supply chains.

### **1.6.2 Examine the main challenges and barriers in Inter-Organisational Information Systems (IOIS) implementation projects and identify the key factors for successful implementation**

The second objective was concerned with the IOIS implementation by large contractor firms. The purpose of the second objective was to investigate the various factors that play a key role in delivery of IOIS implementation projects. The following two key tasks were pursued in order to satisfy this objective.

- Examine the main challenges and barriers during supplier on-boarding phase of an IOIS implementation project.
- Examine the post-implementation challenges; the user adoption and on-going use of a private B2B e-Marketplace system.

### **1.6.3 Develop a guideline for IOIS implementation by contractor organisations**

The third objective is concerned with the development of a guideline to support the IOIS implementation by main contractors. The main task for this objective was set as following.

- Synthesize the previous work and develop a strategic guideline for contractor firms seeking integration with supply chain firms.

Figure 1:1 provides an overview of the research tasks along with its relationship with major EngD deliverables and research outputs, and Table 1:1 provides synopsis of the academic papers published as part of this research.

## 1.7 Structure of the Thesis

The remainder of the thesis is structured as follows.

- **Chapter One-** presents the review of literature on construction specific supply chain management and inter-organisational information systems. The purpose of the Chapter One is to provide an overview of layer and concepts paramount to the framework of the current study.
- **Chapter Two-** provides state-of-the-art literature on cSCM and the IOIS, and presents the knowledge gaps that exist in the surveyed literature.
- **Chapter Three-** reviews the methodological issues surrounding the conduct of the research and outlines the adopted approach along with justification for the chosen methods for each research objective.
- **Chapter Four-** presents the research undertaken and the findings from the research.
- **Chapter Five-** outlines the key findings and implications of the EngD study, the contribution to knowledge/practice, critical evaluation of the research as well as suggestions for future research.

## 1.8 Summary

This chapter presented the introductory elements of the study. The main focus of the chapter was to provide a precis of the general subject domain, the research sponsor, a justification for carrying out the research as well as the aim and objectives of the research. The next chapter presents the review of literature on cSCM, SCI and IOIS implementation.



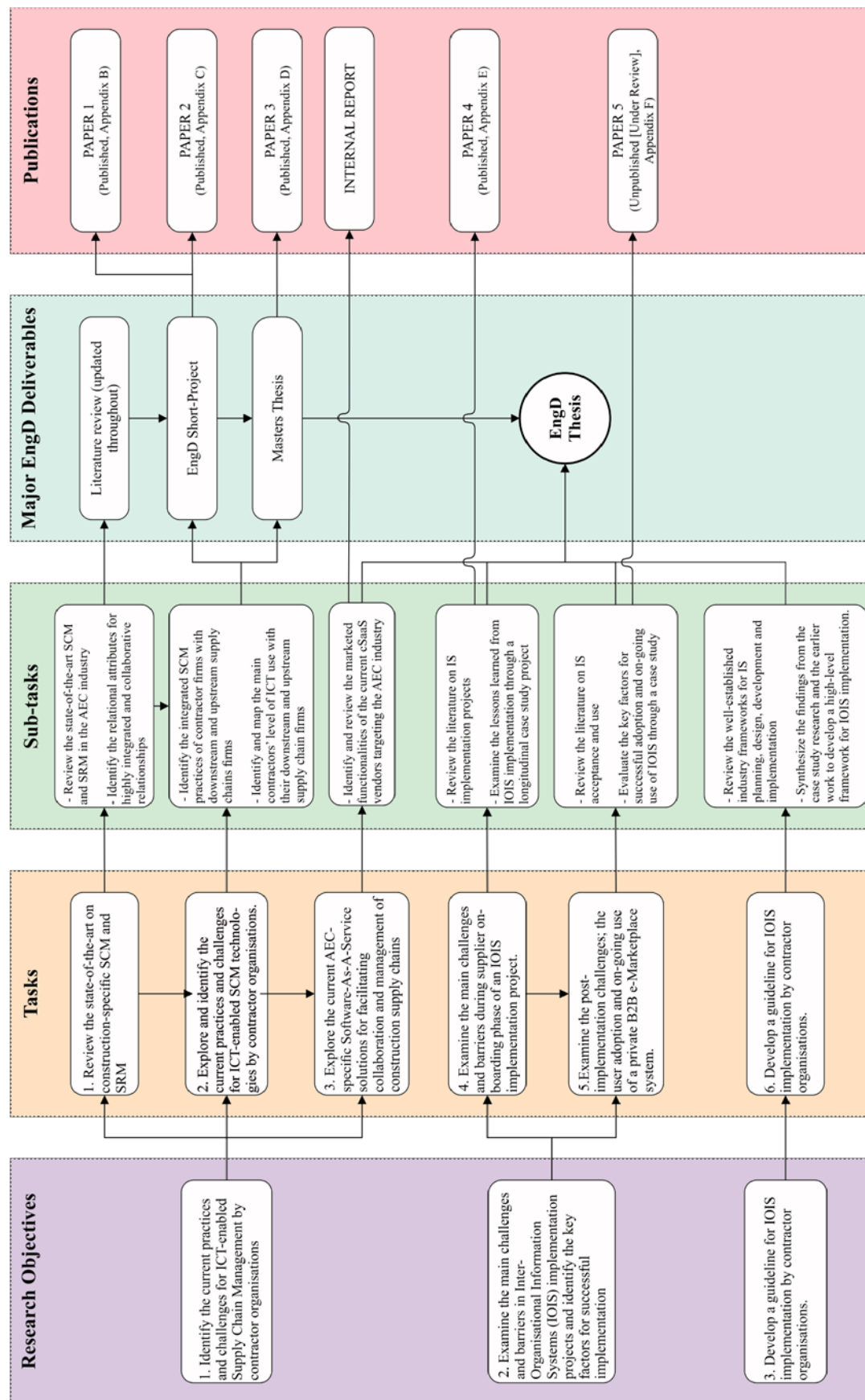


Figure 1:1 Research map linking the research objectives to EngD deliverables.

Table 1:1 Synopsis of academic papers.

<i>Paper ID / Title</i>	<i>Conference / Journal</i>	<i>Status</i>	<i>Description</i>
<b>Paper 1, Appendix B</b> <i>Achieving Effective Project Delivery Through Improved Supplier Relationship Management</i>	<b>Conference</b> <i>Engineering Project Organisations Conference (EPOC)</i>	Published (2012)	This paper is result of the study completed in the first year of the EngD programme. Drawing on literature on Supply Chain Management and Industrial Network Approach, the paper identifies and maps four types of relationships within the AEC supply chains. The paper discusses the management approaches required for different relationship types and its main constituents (people, process and technologies).
<b>Paper 2, Appendix C</b> <i>Improving Supplier Relationship Management Within the AEC Sector</i>	<b>Conference</b> <i>Association of Researchers in Construction Management (ARCOM)</i>	Published (2012)	This paper builds upon detailed literature review on Supplier Relationship Management and presents a conceptual model on trust aspect of relationships. The paper suggests a holistic approach to development of trust in relationships by incorporating five key constructs (economic, social, psychological, inter-personal and organisational) within its scope.
<b>Paper 3, Appendix D</b> <i>Contractor practices for managing extended supply chain tiers</i>	<b>Journal</b> <i>Supply Chain Management: An International Journal</i>	Published (2014)	This paper is continuation from Paper 1 which explores the people/process/technology dimension of the industry relationships from the perspective of large UK contractor firms. The paper reports on a questionnaire survey which explored how large contractor firms manage their relationships with firms in their extended upstream and downstream supply chains.
<b>Paper 4, Appendix E</b> <i>Implementing commercial information exchange: a construction supply chain case study</i>	<b>Journal</b> <i>Construction Management and Economics</i>	Published (2016)	This paper reports on a case study supplier on-boarding process of an Inter-Organisational Information Systems implementation project between a large UK contractor firm and ten of its downstream supply chain firms. The paper identifies the main challenges and barriers that crop up during the early phases of an IOIS implementation project and suggests critical success factors for its successful delivery.
<b>Paper 5, Appendix F</b> <i>Post-Implementation Analysis of a B2B e-Marketplace</i>	<b>Journal</b> <i>ITCON (Journal of Information Technology in Construction)</i>	Under Review (submitted Dec2017)	This paper further explores the case study IOIS implementation project to report on the challenges and barriers to IOIS implementation which surfaced during the ex-post stage. The study sheds light on the system related issues that hinder the successful uptake of IOIS and provides a list of key success/failure factors in IOIS implementation. The paper also provides a review of studies on B2B e-Marketplace systems and background into theories on IS adoption.

## Chapter 2: Review of Related Literature

### 2.1 Introduction

This chapter presents the state-of-the-art literature on construction Supply Chain Management (cSCM) and Inter-Organisational Information Systems (IOIS). The chapter begins with a summary of SCM, and then tries to explore how cSCM has been operationally defined and represented within the literature. The concept that underpins the cSCM, that is Supply Chain Integration (SCI), is presented in Section 2.4. Based on synthesis of available literature, the key components of SCI are provided along with the drivers and barriers to its implementation by large contractor firms operating in the AEC industry. The following section presents an overview of different implementation approaches, the benefits and the advantages gained from IOIS implementation and the key challenges that hinder the development and implementation of IOIS projects. The last section outlines the key research gaps that exist in the literature to further reinforce the need for the study.

### 2.2 Supply Chain Management

The management of the supply chains is a relatively new concept which has appeared in study and practice during the early 1980s. Supply Chain Management (SCM hereafter) is bred and flourished from the operations and logistics management context in automotive manufacturing industry (Oliver and Webber 1982; Womack et al. 1990). In the literature, the work of Oliver and Weber (1982) is usually credited for introducing the terminology but the concept gained greater interest after the publication of “*The Machine That Changed the World*” by Womack *et al.*, (1990). The principal concern of the Oliver and Weber’s study was the strategic logistics management (i.e.: physical distribution and transport) whereas Womack *et al.* have introduced the lean concept to automotive industry supply chains. Today, both the theoretical and practical application of the SCM concept have expanded to include many other functions and inter-organisational activities within its scope such as marketing, sales, production, purchasing and operations management (Burgess et al. 2006; Harland 1996; Tan 2001).

The variety of perspectives to SCM has been problematic for its theoretical and practical development. Previous studies which review the generic SCM body of knowledge show that there is neither a universally agreed definition or a consensus on the scope and essence of SCM (Naslund and Williamson 2010). For example, in their work of reviewing literature on SCM, Stock and Boyer (2009) identified 173 unique SCM definitions adopted in the extant literature. Although the lack of definitional consensus leads to dimensionally scattered line of inquiry (which further hinder the development of SCM under a unified discipline), on the other hand a consolidated definition unnecessarily restricts the subject into a narrowly defined field of inquiry (Chicksand et al. 2012). Hence, many scholars argue that it may not be necessary to develop a single-unified SCM definition or theory since the concept entails range of multi-disciplinary activities, functions and processes within its scope (Fawcett et al. 2008; Halldorsson et al. 2007). Similarly, a pluralist perspective in the studies and practice of SCM is both advocated and preferred as it provides a rich and lively debate on the subject field. Thus, without going further into debate surrounding the SCM definitions and theory, the current study adopts the definition suggested by Stock and Boyer (2009 p. 79) who termed SCM as “*the management of a network of relationships within a firm and between interdependent organizations and business units consisting of material suppliers, purchasing, production facilities, logistics, marketing, and related systems that facilitate the forward and reverse flow of materials, services, finances and information from the original producer to final customer with the benefits of adding value, maximizing profitability through efficiencies, and achieving customer satisfaction.*”

In the manufacturing context, the concept of 'supply chain' generally refers to a network of organisations which are bridged together by upstream and downstream flows of materials, goods, products, services, finances and information from suppliers to ultimate customer (Mentzer et al. 2001). One of the early conceptual frameworks offered by Harland (1996) is often taken as a frame of reference to outline the boundaries of management at four levels: (i) internal (ii) dyadic, (iii) extended, or (iv) network of supply chains. The internal level is regarded as a priori activity where the intra-firm business functions and processes are integrated to enable external integration with suppliers. At the dyadic level the management activities are concerned with the firm-firm interactions which span one level beyond the immediate supply chain hierarchy; that is, immediate supplier. At the next level, the focus of SCM extends to include supplier(s) of the immediate supplier. The third level deals with the compilation and management of all supply chain firms involved at different stages from source to manufacture and on to delivery of the products/goods/services to the end customer. This categorisation implies that the focus and the application of SCM can greatly vary depending on the level and the number of organisations involved in the supply chain.

The underlying principle in SCM implementation is to improve the long-term performance of the firm-firm relationships through alignment and integration. In its simplest terms, the pursuit of SCM requires identification of (i) the key supply chain members, (ii) the key processes to inter-link, and (iii) the level of management and integration required for each interface (Lambert and Cooper 2000). Given the diversity in priorities (e.g.: cost reduction, client satisfaction, increase in added-value, responsiveness, agility, innovation and so on), the implementation of SCM entails a complex set of environmental conditions, tools, processes and methods which must be uniquely aligned with each supply chain (Kotzab et al. 2011). As a result, there are a plethora of methodological approaches (both conceptual and applied) on how to execute SCM; for example, supplier segmentation, strategic purchasing, supplier development, supply-base reduction to name a few. Due to space limitations they are not covered here but for an overview of some of the in-use SCM frameworks the reader is referred to the work of Naslund and Williamson (2010).

### **2.3 Construction Supply Chain Management (cSCM)**

Although definitional consensus is yet to emerge in the literature, this study adopts one of the earlier definitions suggested by Akintoye *et al.*, (2000) who described the notion of construction specific SCM (cSCM) as the "*process of strategic management of information flow, activities, tasks and processes, involving various networks of organisations and linkages (upstream and downstream) involved in the delivery of quality construction products and services through the firms and to the customer, in an efficient manner*". Similar to manufacturing context, the ultimate aim in cSCM is to improve the construction performance (in terms of project delivery timeline, quality and cost) by extending the traditional inter-organisational activities to a broader network of organisations and stakeholders (including building end-users) (Xue et al. 2007). It is worth noting at this point that this study is primarily concerned with cSCM from the point of main contractors and focus specifically on downstream supply chain firms which include suppliers, subcontractors and specialist contractors. The study uses the terms suppliers and subcontractors interchangeably to refer to any firm which provide materials, equipment and/or specialist services, for and on behalf of main contractors in construction projects.

In examination of the cSCM from main contractors' perspective King and Pitt (2009) distinguished two types of supply chains: the project-specific supply chains and organisational supply chains. Project-specific supply chains form in direct response to a specific client requirement whilst the latter relates to the main contractors' organisational supply chain (King and Pitt 2009). These two groups can be further classified in terms of three key functions; those that deliver production related materials that get incorporated in to the final product labelled as

primary supply chains; those that provide equipment, expertise and materials that facilitate construction, called the support chains, and the third; those that provide subcontract labour (human resource supply chain) (Cox and Ireland 2002; Muya et al. 1999). In reality, however, the boundary and the interrelationships between these supply chains is extremely fuzzy due to commercial complexity associated with the markets, products/services, and projects in which AEC supply chain firms operate (London 2008).

When viewed from a construction project angle, the number of supply chain firms involved in the delivery of a construction project will depend on the characteristics of the project defined by size, complexity, duration, procurement method and so on. Due to their level of stake in the project the responsibility of coordination and management of the project supply chains usually rests with the main contractors (Jones and Saad 2003; Morledge et al. 2009). Therefore, as well as bringing their own supply chains into the project, main contractors are also tasked with orchestrating the project supply chains (Vrijhoef 2011). Figure 2:1 provides an illustration of the myriad of interactions between project participants, teams and organisations at various stages of a project. This is intended to be a rather simple illustration to give a snapshot of the tier one supply chain firms' involvement in construction projects. For a detailed model of the extended network of supply chains the reader is referred to the work of London (2008) which provides an elaborate view of the structural and behavioural characteristics of construction supply chains from industrial economics perspective.

It is a well-known fact that the AEC industry is highly fragmented and supply chains operate in a loosely-coupled fashion (Dubois and Gadde 2002). The duration of the relationships are largely determined by the project's lifespan where supply chains normally disband when the project is completed (Segerstedt and Olofsson 2010). Given that every construction project is unique, not only that the supply chains are reconfigured at every project but the activities they are tasked with, such as design, source, supply, install, and manage, is specific for each project (London 2008). This effectively requires every supply chain process to be considered within its own specific context. Furthermore, the intensity of the supply chain firms' involvement is highest during the construction phase where, as can be seen from the Figure 2:1, majority of the firms (including sub-subcontractors and sub-suppliers) are converging at this stage to deliver the build (Azambuja and O'Brien 2009). It is also worth mentioning that the nature of activities are defined by the stages in the project and a supply chain firm can have multiple and concurrent interfaces as project progresses (Azambuja and O'Brien 2009; Gosling et al. 2015b). It is these underlying circumstances (that is, temporary, one-off, project specific, irregular and disjointed interactions) which the literature highlights as the primary impediment towards streamlined and efficient supply chain operations, also which the concept of cSCM attempts to address and overcome.

With respect to the implementation of cSCM by main contractors, there are two notable approaches mentioned in the literature: operational and strategic. Much of the cSCM research and practice tend to focus on day-to-day issues related operational aspects of the supply chains and primarily deal with flow of information, goods, and services along the supply chains to the construction site. According to Vrijhoef and Koskela (2000) the operational cSCM is concerned with: (i) the interface between the supply chain and construction site; (ii) reducing costs related to logistics, lead-time and inventory on specific project supply chains; (iii) transferring activities from the site to earlier stages of the supply chain; and, (iv) integrated management of the supply chain with emphasis on improvement of supply chain and the site production. Lastly, they add that there is also the fifth role of cSCM which is concerned with the management of the supply chains by facility or real estate owners in ex-post stage of construction projects. An important point to note here is that these activities are not mutually exclusive, but are often implemented conjointly (Vrijhoef and Koskela 2000). Recently, the Just-in-Time, Lean Construction, and other logistics management tools and practices have

become popular approaches in operationalising cSCM. In brief, the key objective of these methods is to reduce the unnecessary ‘waste’ in production and logistical processes at the inter-firm and cross-firm interfaces.

The strategic dimension of cSCM, on the other hand, is generally concerned with the contextual circumstances that govern the structure, formation and control in supply chain tiers. There are many competing and contested views on strategic cSCM which attempt to explain the level of control that can be exercised on construction supply chains. One of the prominent views; the power perspective, which has its roots in Transaction Cost Economics (TCE) theory, suggests that the influence of a large contractor firm over its supply chain is bounded by the relationship it has with the supplier firm in the immediate tier (Cox and Ireland 2002; Ireland 2004). The power perspective explains that the degree of management that can be exercised on construction supply chains is determined by the main contractors’ power position (Cox and Ireland 2006). Much of the power and dominance is derived from and contingent upon longevity, frequency and continuity of the exchange/relationship, the number of suppliers in the market, the number of available alternative buyers, the extent of supplier switching costs for the buyer, the extent to which product/service is commoditised, the extent to which product/service standardised, the buyer search cost, and the level of information asymmetry advantage that buyer firm has over suppliers (Cox and Ireland 2002). As per the power perspective, a contractor firm cannot possess necessary dominance in every supply chain and it needs to implement different integration and collaboration strategies relative to its power position in the supply chain (Cox and Ireland 2006).

The review of literature also reveals that in addition to the main contractor-supplier hierarchy, upstream clients can have an (direct and indirect) influence on main contractors to form a much more aligned supply chain interactions in the downstream tiers (Love et al. 2004). Many studies point out that client-driven cSCM can be initiated through PFI and prime contracting routes which, compared with the traditional project delivery timelines, stretch over a long-term (Beach et al. 2005; Briscoe and Dainty 2005; Green et al. 2005). For example, Male (2003) argued that in projects procured under single-responsibility (for instance PFI,

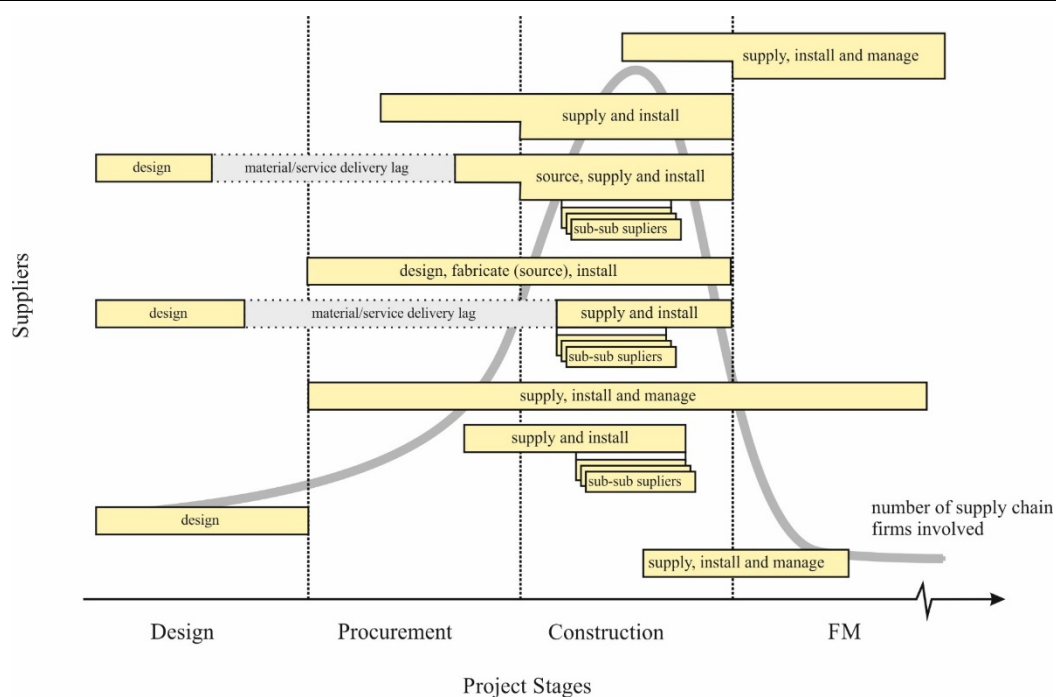


Figure 2:1 Supply chain firms' involvement in construction project delivery.

Turnkey, Prime Contracting and Design and Build) main contractors have greater potential to align and integrate with their project and organisational supply chains as risk/uncertainty over project variables (such as time and cost) is reduced. In this respect contractors are enticed to commit long-term contractual agreements with their supply chains and focus on relationship building to improve the inter-organisational operations. The RICS survey of contracts show that the uptake and adoption of such agreements have increased over the years, however the number and value of long-term relational contracting arrangements (such as partnering) are very low in comparison with the traditional forms of procurement (RICS 2010). A recent initiative by UK governments aims to stimulate the uptake of long-term engagements between the downstream supply chain tiers by increasing the visibility and certainty of the future construction projects through the National Infrastructure Plan publications (HM Treasury 2011, 2014) and Government Construction Strategy reports (Cabinet Office 2011).

At this point it would be beneficial to cite the several important criticisms that cSCM face in theory and practice. While many see considerable potential in applying the SCM concept to construction, discerning voices in the literature point out that cSCM heavily resonates with the latest ‘faddish’ management thinking and aspirational practices which are far beyond realisation. For example, authors including Green *et al.* (2005), Fernie and Thorpe (2007), and Fernie and Tennant (2013) questioned the attempts (both in theory and practice) to emulate the SCM practices in other industries without taking into account the unique context in which construction supply chains operate. In addition to this, through the studies of the perceptions of supply chain professionals, their findings revealed that cSCM is an esoteric term where there is great deal of confusion surrounding its definition; how it should be implemented; and, with whom it should be implemented. Hence, cSCM is viewed as a nascent theory which lacks proper implementation by AEC organisations.

Another conclusion drawn out from the above-mentioned studies is that there is a large gap between cSCM thinking and practice. Indeed, across the extant literature cSCM is commonly advocated and reported in the form of project based *dyadic arrangements*; that is partnering, collaborative and other similar relational contracting strategies (Pryke 2009). Although these strategies are useful in cSCM implementation they have minimal impact on the configuration and management of tiers beyond the immediate supplier (Mason 2007). Consequently, the current application and practice of the cSCM falls short of the intended vision and strategy behind SCM concept which is concerned with the transformation of the entire supply chain. In cases where cSCM is driven by client demand, many studies (Akintoye *et al.* 2000; Morledge *et al.* 2009; Skitmore and Smyth 2007) and industry-wide surveys and reports (EC Harris 2013) point out that the depth of engagement tends to be no more than the first tier sub-contractors. In support of these findings, Smyth (2010) revealed that even in client-driven conditions where cSCM is initiated and promoted through so-called demonstration projects, there is insufficient evidence of corporate adoption and implementation of cSCM beyond those project-specific initiatives.

## **2.4 Supply Chain Integration**

It is widely recognised that one of the building blocks of cSCM is the degree of integration between the supply chain firms (Bankvall *et al.* 2010; Kannan and Tan 2010; Vrijhoef 2011). Supply Chain Integration (SCI) takes place at a variety of contextual conditions, levels and intensities; hence it is defined, operationalized, and measured in many different ways (Betts *et al.* 1995; Eriksson 2015; van der Vaart and van Donk 2008; Vrijhoef 2011). In its simplest form, integration encompass coordination of material, information and financial flows within an organisation and at the interface with external supply firms. The literature also conceptualise integration from a broader organisational perspective to reveal its distinct yet overly complex features in AEC supply chain context (for example, in the form of partnering, integrated project

delivery and strategic alliancing) (Lahdenperä 2012). The focus of the current study is on firm-to-firm integration which is usually depicted along the continuum of loose co-operation (operational integration) to a higher level of inter-organisational alignment (strategic partnership) involving greater optimisation and synchronisation of supply chain operations between two or more firms.

The core dimensions of SCI can be described as actor, process and technology integration (Goulding and Lou 2013). Based on review of literature, these three inter-related and inter-dependent components are further broken down into six elements illustrated in Figure 2:2. It is generally accepted that these six constituents are crucial in any type of integration implementation; be it project, organisational or industry level (Betts et al. 1995).

The term 'actor' refers to individuals who participate in range of activities (or functions) in construction projects and organisations. The major task in actor integration is to strengthen and support the work/role related activities of individuals during design and construction phase of a project. However, there is also the social dimension of actor integration which plays a critical role in bringing together and functioning of inter-firm interactions. Chinowsky *et al.*, (2008) referred to these two components in actor integration as the 'mechanics' and 'dynamics' of actor integration. The objective in the former is to integrate the ideas, knowledge and perspectives of the actors for the successful execution of a project or organisational activity (Chinowsky et al. 2008; Pryke 2005). The social aspect of actor integration is regarded as one of the most important factors in team bonding in project environments. As reported by Chinowsky *et al.*, (2008) social connectivity is the key motivator for building formal and informal relationships in intra and inter-firm networks. Although there has been a number of studies about inter-personal relationships between project participants, social integration of actors across supply networks remains a largely uncharted territory in the construction research domain (Pryke 2005).

In terms of process integration there are two contexts where firms become inter-connected. On the one hand, integration may concern functional processes across organisational boundaries such as flow of goods, planning and control, and organisation and information flow (van der Vaart and van Donk 2008). On the other hand, process integration may refer to the integrated, interdependent, and concurrent chain of processes in the design and construction interface of a project where individuals, teams and firms collaborate to eliminate inefficiencies, reduce lead times, and improve quality and cost (Evbuomwan and Anumba 1998; Shelbourn et al. 2006). The former emphasises the physical, temporal, and economic elements of business interaction. In this respect, the integration enhances automation of certain supply chain activities wherein the quality and timely sharing of information with the supply chain firms (especially the lower supply chain tiers) is one of the key facets of integration (Titus and Bröchner 2005). The latter type is mostly concerned with the behavioural, communicational and collaborative processes in design, construction and facilities management phase of a project to enable a more effective and efficient interaction between an array of disciplines and supply chain firms (Evbuomwan and Anumba 1998; Morash and Clinton 1998; Owen et al. 2010; Shelbourn et al. 2006). Drawing a distinction between these two types of process integration is important because of the differences in integration goals and operationalisation across multiple projects.

Technology has a critical attribute in terms of providing the infrastructure and the tools for closely knitted supply chain interactions (Benton and McHenry 2010; McCreia and Peat 2009). There is a unanimous agreement in the literature that the efforts to integrate without considering the technology dimension will fail to deliver the aspired benefits of SCI (Gunasekaran and Ngai 2004; Power 2005; van der Vaart and van Donk 2008; Xu 2015). A key criterion in technology integration is to make use of both intra-firm and inter-firm technological capabilities (Xu 2015). The intra-firm technological integration is required for



effective and efficient conduct of in-house business operations whereas the latter is needed for facilitating the automation, co-ordination, and collaboration of cross-organisational work processes (Gunasekaran and Ngai 2004). Prior literature mention a wide range of inter and intra-firm systems and technologies including: Building Information Modelling (BIM) for generation of an ‘intelligent’ building model; Project Extranets for collaborating on a common platform; Integrated Databases for storage, transfer and retrieval of information; Electronic Data Interchange systems and ERP technologies to automate a wide range of inter-enterprise operations such as ordering, payments, invoicing logistics, inventory, planning and scheduling operations. Literature does not, however, make a clear distinction on the extent of use of inter-firm technologies in supply chain integration context; that is, their extent of use by contractors with the suppliers in downstream tiers.

The literature is abundant with studies that provide a long list of benefits of the SCI practices— most notable being the partnering and collaborative arrangements. Although the majority of the claims are yet to be fully supported by empirical evidence, some of the key benefits and advantages of SCI as a primary expected outcome include the following:

- achieving significant operational efficiencies through streamlining operations within vertical business functions or horizontally across the entire construction project (Bankvall et al. 2010; Eriksson 2010; Gosling et al. 2015a).
- competitive advantage which can be difficult to imitate by competitors; for example competition through superior value rather than lower margins (Benton and McHenry 2010; Holt et al. 1999).
- integrating with suppliers (especially the primary supply chain firms which deliver production related materials) can reduce information lag and maximise the efficiency of conducting activities as well as minimising inventories and cycle times (Benton and McHenry 2010).
- minimise both transaction and production related costs (Benton and McHenry 2010).
- it can foster early engagement, innovation, client satisfaction, long-term relationships, and mutual trust which can lead to profitable outcome for all (Akintoye et al. 2003; Mosey n.d.).
- it can provide a better guard against organisational and project related risks (Aloini et al. 2012).

The execution of SCI does not come without problems too. Akin to the challenges posed by the inherent structure of the industry, there are several difficulties encountered by each party

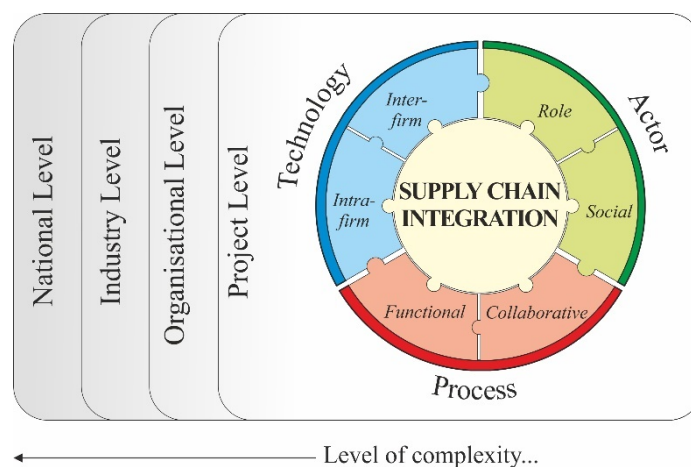


Figure 2:2 The main constituents of Supply Chain Integration (SCI).

involved in the integration process (see, for example, the SfFC (2007) report for the case studies). Some of the challenges cited by main contractors include lack of trust, lack of collaborative experience and business fit, fear of being in locked-in relationships, reduced competition, high switching-costs between suppliers and increased dependency (Akintoye and Main 2007; Briscoe and Dainty 2005; Broft et al. 2016; Cox and Ireland 2006; Fulford and Standing 2014). Suppliers on the other hand, commonly blame main contractors for lack of trust, unfair treatment during supplier selection, evaluation, payments and disputes, lack of transparency and visibility of information (Broft et al. 2016; Dainty et al. 2001; EC Harris 2013; White and Marasini 2014), cost-driven agendas (Wood and Ellis 2005) and, prevailing adversarial conditions (for example focus on reducing cost rather than inefficiencies) associated with some integrated practices (such as strategic partnering arrangements) (Business Vantage 2009; Fulford and Standing 2014; Humphreys et al. 2003; Mason 2007; Meng 2013). Moreover, it is argued that while integration creates a strong bond between a contractor and supplier firm, the adaptations and routines that a firm develops for a particular relationship can have a serious impact on its relationship with other firms (Ford et al. 2003). London (2008) point to the fact that suppliers in the AEC industry have many materials/services and customers, and will seldom be part of just one supply chain. In this regard, some integration activities can undermine suppliers' flexibility to align and coordinate with other buyers (contractors), leading to conflict of interest in doing business with a wider buyer/customer base.

## 2.5 Inter-Organisational Information Systems to Support SCI

The importance of ICT in SCI is widely acknowledged in the literature (Fulford and Standing 2014; Näslund and Hulthen 2012). Figure 2:3a illustrates where the Inter-Organisational Information Systems (IOIS) sits in relation to the broader subject area (Information Systems, or IS). Although the intersection where IOIS emerge is a relatively narrow field, it's application both in research and practice, comprise of diverse set of applications, systems and technologies. See, for example, the studies by Boddy *et al.*, (2007) and Rezgui *et al.*, (2011) which provide an excellent overview of the research on computer integrated construction.

The current study describes IOIS as an environment which mediates the inter-connection between enterprise information systems to facilitate boundary spanning business (and construction project related) activities. This definition of IOIS is by purpose broad as there are many cross-firm interfaces which firms need to ensure that adequate ICT-enabled mechanisms are in place for efficient SCI (Näslund and Hulthen 2012). Whilst recognising the fact that single interface integration is not enough to constitute to a tightly connected relationship, this study mainly focus on IOIS implementation relative to the procurement function which plays a key role in supply chain relationships (Fulford and Standing 2014; Wagner and Essig 2006). The core objectives of IOIS in procurement operations is to enable co-ordination, collaboration, commerce and automation of commercial interactions between a buyer firm and its suppliers (Figure 2:3b). When referring to an IOIS the following key characteristics distinguish them from other types of systems.

1. They involve highly secure, real-time integration and automation of cross-organisational business processes, data, applications and systems.
2. They are developed on co-operative terms with multitude of downstream (and/or upstream) supply chain firms.
3. They allow interoperability of data between back-end systems without manually manipulating, re-entering or re-processing data.
4. They involve working with IT/IS solution providers; that is third parties such as middleware service providers (for example VANs, Hubs, e-Marketplaces and so on, which provide the necessary intermediary infrastructure and related services for

planning, design, development and maintenance of the IOIS), in the process of linking supply chain firms.

Owing to their sophisticated design and development, the implementation of IOIS also entail the following pursuits.

1. Re-engineering of the business processes (both internal and external) to achieve alignment, and thereby performance improvements in operational and business activities.
2. Re-alignment of the IS/IT strategies and resources between the supply chain firms.

Amongst the some of the key operational drivers for IOIS adoption and utilisation are as follows.

1. Despite the rapid advances and emergence of ICT, there is still high levels of interoperability between different systems which, over the years culminated islands of technology within and between the AEC firms (Kang et al. 2012a; McGraw-Hill Construction 2007; Obonyo 2004; Rezgui et al. 2011; Tatari and Skibniewski 2011). Most Enterprise Information Systems (EIS) in the AEC industry work in isolated fashion where firms have to reprocess the information manually in their back-end systems, leading to loss, distortion, and duplication of data across systems (Tatari et al. 2007). The integrative power of IOIS enables organisations to bridge the gap between heterogeneous EIS; most notable being ERP (Enterprise Resource Planning) systems (Xu 2015), and therefore enable much more streamlined and synchronous inter-firm interactions (for instance voluminous and complex financial information flows between the trading parties) (Walker et al. 2008).
2. Since most EIS systems cannot—or are not designed to, work across organisational boundaries, current solutions such as legacy ERP systems are insufficient for an extended enterprise functionality (Akkermans et al. 2003; Näslund and Hulthen 2012; Shi and Halpin 2003). Although business transactions can be supported by some ERP systems, major SCM processes requires coordination by IOIS (Gunasekaran and Ngai 2004; Nøkkentved 2007; Themistocleous et al. 2004; Vaidyanathan 2009; Xu 2015).

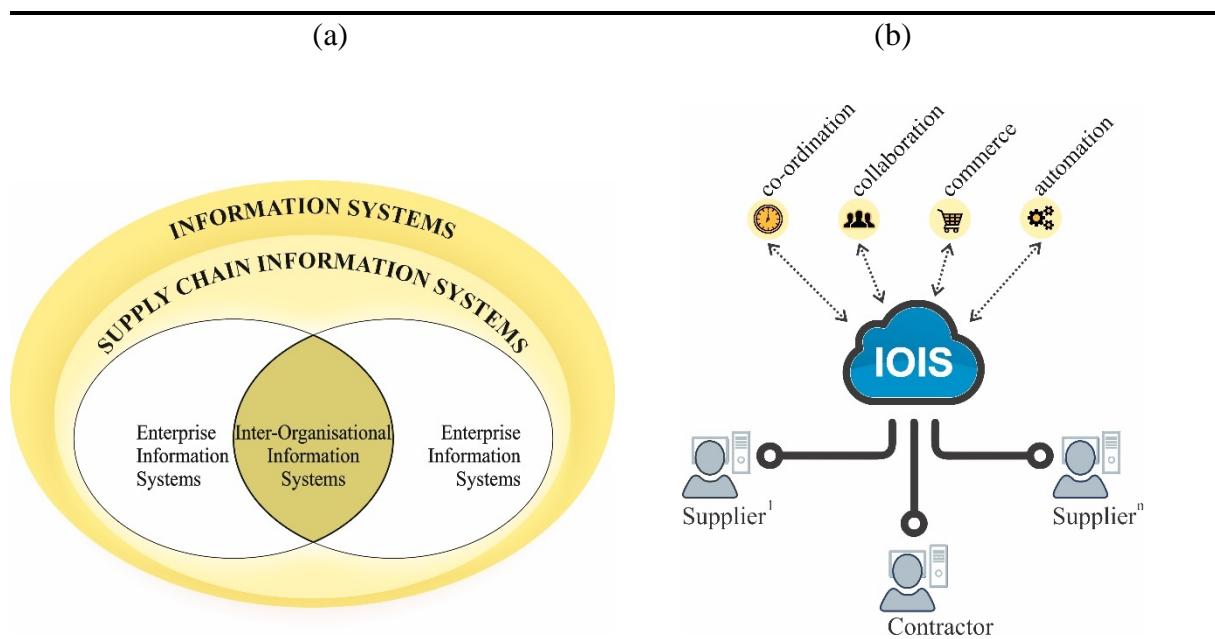


Figure 2:3 (a) A frame of reference for IOIS domain (b) Simplified view of IOIS elements.

3. Prior research stress the importance of combined use of supply chain firms' IS/IT capabilities to encourage deeper levels of integration as well as to complement and enhance the bilateral relationships (Rai et al. 2006, 2009, 2012; Rajaguru and Matanda 2013; Venkatraman 1994). Supply chain visibility, sharing strategic data/forecast, collaborative planning, forecasting, and replenishment, vendor managed inventory, and logistics are some of the prime examples that could be exploited during IOIS implementation to support SCM and thereby enable closer integration between the supply chain partners (Fulford and Standing 2014; Nøkkentved 2007; Wang and Archer 2007; Xue et al. 2007).

Drawing on Transaction Cost Economics (TCE) and Resource Based View (RBV) theories several important drivers are believed to promote the uptake of IOIS. First, the TCE sees IOIS as a strategic mechanism to manage the coordination costs with suppliers. Accordingly, IOIS allows firms to effectively reduce uncertainty in the transaction costs by substituting, for example, the traditional procurement process with a highly automated end-to-end IOIS (da Silveira and Cagliano 2006; Wang and Wei 2007). Second, as with the adoption and development of IS/IT, the implementation of IOIS brings competitive advantage to organisations through improvements in operational efficiencies (da Silveira and Cagliano 2006), which in turn, under the appropriate conditions, lead to better organisation-level performance against the market forces (Porter 2008). Third, complementary to the RBV and market forces theory, through the IOIS implementation organisations can gain access to or exploit the resources and capabilities of their business partners to create competitive advantage that would be difficult to imitate by competitors (Fawcett et al. 2011). However it is worth noting that whilst IOIS can provide effective means to more streamlined inter-firm interactions, it is the innovation in process improvement and management, along with IS/IT, as enabler, within which competitive advantage can be achieved (Davenport 1993, 2005). Thus, the benefits of IOIS could be further enhanced when it is aligned with appropriate Business Process Re-engineering strategies. In addition to the TCE and RBV theories, number of external factors can motivate an organisation's decision to adopt inter-organisational linkages. For example, as shown by Teo *et al.*, (2003), rather than based on a purely internal strategic decision, firms are also influenced by isomorphic external pressures (normative, coercive, and mimetic) from competitors, trading partners, customers, and/or public and private institutions to adopt and use IOIS.

### 2.5.1 IOIS Implementation Approaches

There are many options for firms wishing to implement IOIS however due to space limitations only Value-Added Network providers (VANs), e-Marketplaces and Web-based Project Management Systems (WPMS) will be covered. IOIS can be initiated with the use of VANs which are essentially intermediary technology vendors responsible for translation, conversion and communication of commercial documents between two or more firms. The prime objective of VANs is to facilitate functional integration (the exchange of commercial documents more specifically) through EDI (Electronic Data Interchange). By using VANs, firms eliminate the need for hardware, software and/or communication needs, and thereby capitalise on EDI technology (Wagner and Essig 2006). Despite its long history, however, the reported usage of EDI (and thereby the VANs) is scanty within the AEC industry with builders' merchants and large contractor firms being the most notable adopters (Samuelson and Björk 2013). McCrea and Peat (2009) and Kong *et al.*, (2004) reasoned the initial cost of setup and complexity of standards for the low levels of EDI adoption, whilst Lewis (1998) showed that unwillingness to change, lack of awareness and lack of clear business case with little apparent benefits from its application deferred AEC firms' decision to invest in the technology.

The developments Internet technologies in the last 10-15 years gave rise to another form of IOIS called e-Marketplace systems which are described as environments dedicated to facilitating the inter-firm sourcing and purchasing activities (Kaplan and Sawhney 2000; Standing et al. 2006). There is a lot of confusion about the roles and functions of current e-Marketplace systems (Balocco et al. 2010), however some of the notable examples of e-Marketplace service providers include Oracle<sup>5</sup>, SAP Ariba<sup>6</sup> (which are multi-industry service providers) and Coins<sup>7</sup> (which focus on AEC industry specifically). Balocco *et al.*, (2010) stated that the scope of the functionalities offered in some systems can be extended beyond transactional exchange to also cater for supplier matching, auctioning, collaboration, collaborative planning, forecasting and replenishment, logistics and so on. A recent desk study by Ibem and Laryea (2014) point out to evolution towards intelligent web-based (e-Marketplace) systems in execution of construction procurement activities. However, they also noted the lack of end-to-end integration capabilities of these systems which fail to ‘promote individual performance of construction procurement tasks’ (Ibem and Laryea 2014).

There are myriad of AEC-specific WPMS that enable actor and process integration in construction projects (Alshawhi and Ingirige 2003; Nitithamyong and Skibniewski 2004). Numerous functionally overlapping technologies (and terminologies) exist in the literature with reference to the same phenomenon, for example; Electronic Document Management Systems (Samuelson and Björk 2013), Online Collaboration and Project Management systems (Becerik and Pollalis 2006), Project Extranets (Wilkinson 2005) and WPMS (Nitithamyong and Skibniewski 2004). This study uses the term WPMS throughout to refer to the same. In addition to their core functionality of project documentation and drawing management, and collaboration, WPMS can also facilitate the systematic sourcing; which typically include organization, planning and management of tenders and contracts for production-related materials, goods and services (Alshawhi and Ingirige 2003; Nitithamyong and Skibniewski 2004). According to a survey by Eadie and Perera (2016) many of the procurement and sourcing operations are now being conducted on these platforms. Ren *et al.*, (2008) argued that a major limitation of the WPMS is that they are primarily designed to facilitate the business and workflow processes for strategic sourcing needs of firms (or projects) rather than support the inter-firm operational activities related to buying and selling.

In addition to above, recently AEC firms have been exploring service-oriented Cloud-computing model to outsource their (actor, process and technological) integration needs (Underwood and Khosrowshahi 2012). The ‘Cloud’ metaphor refers to the computing architecture which comprise of platform and infrastructure to support the delivery and use of software on the web (Mell and Grance 2011). The IT industry is already seeing a prolific trend to move away from stand-alone, locally deployed software solutions to services based on the Cloud-computing concept. According to a survey by Underwood and Khosrowshahi (2012) AEC firms are actively considering these new approaches in their operations. The Cloud-based Software-As-a-Service (SaaS) is an evolutionary software delivery model whereby companies buy subscription licences to use the software online via a web-browser rather than locally deploying on premises (Wilkinson 2005). SaaS has several significant advantages over traditional software delivery methods which include: (i) rapid deployment- it does not require any forefront development meaning that deployment is a matter of user training and migration from previous/existing system, (ii) scalability- subscription based use means companies only pay for the features they use and how much they use (e.g.: based on no of users), and (iii) cost-efficiency- it does not require capital expenditure or consume any resource regarding

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<sup>5</sup> Available on: <http://www.Oracle.com>, Last Accessed: 24/05/2018

<sup>6</sup> Available on: <http://www.Ariba.com>, Last Accessed: 24/05/2018

<sup>7</sup> Available on: <http://www.Coins-Global.com>, Last Accessed: 24/05/2018

development and version upgrade which is undertaken by the SaaS vendor (Dubey and Wagle 2007; Wilkinson 2005).

The review of the state-of-the-art literature does not define a commonly agreed typology of IOIS (Hadaya and Pellerin 2010; Saeed et al. 2011). Many of the above IOIS exhibit high levels of overlapping, multi-functional and dynamic features which makes it very difficult to separate between the different conceptualisations referred to in the literature, and the arrangements adopted in practice (Saeed et al. 2011; Standing et al. 2010). Added to this complexity—since each system generate and offer different types of benefit and advantages—there is multitude of governance structures, formation and mode of interaction as firms choose to adopt many of these technologies simultaneously with their supply chain firms (Lyytinen and Damsgaard 2011). In addition, terms such as e-trading, e-commerce or e-procurement systems are used synonymously with the IOIS (Chaffey 2009; Walker et al. 2008) which not only shows a lack of coherent conceptualisation of IOIS in the literature (Standing et al. 2010) but also implies a fragmented adhocracy in IOIS implementation (Hadaya and Pellerin 2010).

## 2.5.2 Systems Integration Approaches

As indicated earlier, a key aspect of IOIS is systems integration to enable end-to-end flow of data/information (Xu 2015). Review of literature warns that without the systems integration, firms would fail to achieve the full potential of IOIS implementation and use (Dai and Kauffman 2002; Saeed et al. 2011). Much of the knowledge base on systems integration resides within the Enterprise Application Integration (EAI) or Enterprise Integration (EI) domains which hosts majority of the work in relation to the information integration strategies, processes, and systems (Schmidt et al. 2010; Xu 2015). In a comprehensive review of studies on systems integration, Shen *et al.* (2010), Rezgui *et al.*, (2011) and Xue *et al.*, (2012) point to an array of systems, technologies, standards and tools utilised for different functional and collaborative systems integration. For the brevity of the discussion, this section describes systems integration at data, process and application levels, but for an in-depth coverage of the subject the reader can refer to Xu (2015).

Data oriented integration is the first step towards systems integration. A common data model which allows enterprise or inter-enterprise applications to re-use data/information is the prime objective in data integration. However, this is rarely the case within an organisation's EIS environment, let alone in inter-firm supply chain context (Shen et al. 2010). In addition to the common data model there is also the need for process interoperability to cope with the semantic discrepancies that exist between different data sources. There exists plethora of data exchange standards (including IFC, EDI, STEP, XML and XML variants) as well as process interoperability frameworks (such as Tradacoms, BASDA, EDIFACT, and RosettaNet) which all seek to provide guidelines for the exchange of data in relation to procurement activities. At the application level, the integration is aimed at data/information exchange between stand-alone ERP applications and legacy systems, so it encapsulates the elements of both data and process integration. Semantic Web-Services, Application Programming Interface (API), Simple Object Access Protocol (SOAP) are some of the technologies used at application level integration (Akyuz and Rehan 2009). Samtani (2002) argued that it is a relatively straightforward task to interlink two applications which are designed to work with one another, however problems arise when the proprietary systems are customised or be-spoke systems are used, which then makes the integration a daunting task. See, for example, Aouad and Arayici (2010) for case studies in computer integrated construction technologies.

Within the AEC context, there have been many attempts to solve the obstacles in systems integration (see Shen *et al.*, 2010 for the examples), however the issues with interoperability, lack of standardisation, lack of a global actor and legal framework to enforce and regulate the use of standards, as well as the lack of IS/IT strategy and lack of internal

integration maturity are some of the reasons cited for poor levels of systems integration in the AEC industry (Aouad and Arayici 2010; Grilo and Jardim-Goncalves 2013; Jung and Gibson 1999; Rezgui et al. 2011; Rezgui and Zarli 2006; Shen et al. 2010; Tatari and Skibniewski 2011).

### **2.5.3 Benefits and Advantages of IOIS**

Bakis *et al.*, (2006) note that the benefits and advantages derived from IS utilisation can manifest itself in many ways (for example economic, technological, individual and organisational levels). The operational benefits will be the focus here since it is one of the main outcomes of IOIS implementation (as per the TCE and RBV theories). As far as SCI processes are concerned, studies by Rai *et al* (2006, 2012) show that IT and process integration capabilities lead to increased efficiency and enhanced supply chain performance. More specifically, it is widely acknowledged that the use of cross-organisational IS to facilitate commercial interactions enables vast amount of efficiencies to be gained from real-time and efficient transmission of transactional data (Gunasekaran and Ngai 2004; Tatari and Skibniewski 2011). It is anticipated that by orchestrating the inter-firm commercial activities firms would achieve higher levels of productivity and save significant resources (time and cost) throughout the business (Fulford and Standing 2014; Hashim et al. 2013; Schnitzler and Österlund 2015; Walker et al. 2008). It is worth to recognise however, while the generic IS literature provide ample results on benefits and value gains from IOIS implementation, in the AEC domain, most claims are yet to be supported with empirical evidence.

Studies that report on savings achieved from implementing integrated IOIS is generally limited to EDI or e-Hubs. As far as e-Marketplace implementation is concerned, Alarcón *et al.*, (2009) conducted a questionnaire survey among a specific e-Marketplace users in Chilean construction industry and reported benefits of increased process transparency, reduced process cycle time, reduced upstream variability, and reduced inventories and waste of materials. On the other hand, Cole (2008) provides several anecdotal examples from e-Hubs to demonstrate the operational savings from automated exchange of high volume transactional documents (e.g.: Blanket Orders, Purchase Orders, Invoices, Advanced Shipping Notes, Goods Received Notes, Credit Notes and eCatalogues). Similarly, drawing on cases of successful implementation by some industry firms, it has been also claimed that procurement process related costs can be reduced up to 60% (Asite 2015) and savings from £2 to £7 per document can be achieved as a result of accurate and timely order/invoice exchange (Cole 2008). Meanwhile in the public sector, adopting a similar approach (i.e.: just switching from paper to e-invoicing) is expected to save the UK public sector and its suppliers minimum of £2billion per annum (McPartland 2014).

On the other hand, in terms of ROI (Return-on-Investment), Balocco *et al.*, (2010) point out that one of the key advantages of IOIS implementation is that the organisation that leads the IOIS deployment can benefit significantly from economies of scale. Although this claim is not supported by empirical evidence, it has been suggested that the value and benefits derived from IOIS increases exponentially with the number of suppliers added whilst the cost of implementation rises only linearly (Balocco et al. 2010; Dai and Kauffman 2002; Iskandar et al. 2001).

### **2.5.4 Key Issues in Implementation of Integrated IOIS Projects**

In spite of the substantial amount of investments on IS development projects, a significant proportion of IS projects fail to achieve their intended business objectives (Alshawhi 2007). Like many IS projects, the challenges associated with IOIS implementation are multi-tiered (that is, relates to end-user, project, organisation and industry level problems), and multi-faceted (concerns process, financial, legal, and technology related factors). The literature on generic

and AEC-specific IS/IT implementation is abundant with studies that provide a long list of success/failure factors (the reader is referred to Hughes et al. 2017 who provide a comprehensive coverage of the issues reported in the IS literature). Within the AEC-specific domain, Lu *et al.*, (2014) recently conducted an extensive survey of literature and consolidated the results in previous studies into following six areas of concern (also relevant to IOIS projects).

1. *End-User related*: knowledge, skills, acceptance and resistance to change.
2. *Organisational*: top-management support, organisational characteristics, training and technical support.
3. *Technology related*: the ease of use, reliability, compatibility and extendibility of the technology as well as the information security.
4. *Construction project*: the characteristics of construction projects defined by the structure, type, duration, location and project specification.
5. *External pressures*: for instance, the government regulations, competitive forces and so on, which are outside the direct control of the organisation.
6. Inclusion of wider criteria in ICT investment *evaluation and strategic planning* decisions.

Akin to above, there are few distinct challenges posed by the complexities in planning, design, development and implementation of integrated IOIS projects (Denolf et al. 2015; Jrad and Sundaram 2015a; b, 2016; Kauremaa and Tanskanen 2016; Modol 2006; Schubert and Legner 2011). Based on the review of state-of-the-art literature, these are grouped into three categories.

**Technical Challenges**— IOIS are intrinsically more risky than traditional internal IS/IT projects given that its planning, design, development, use and maintenance stretch from intra-firm to inter-firm boundaries of the organisations involved. As far as the technical development is concerned, much of the implementation challenges arise due to the inherent complexities associated with systems integration, that is, the software development tasks such as mapping, transformation, and translation of data between heterogeneous systems (Samtani 2002). Whilst systems incompatibility can be partially overcome by adopting and agreeing on common data exchange standards and protocols, it is argued that complications arise because in many cases ERP systems are not designed, or designed with an intent, to work across organizational boundaries (Lorbiecki 2013; Themistocleous et al. 2004). Hence the need for additional development tasks to enable interoperation of data across disparate systems (Themistocleous et al. 2004). Denolf *et al.*, (2015) point out that the technical complexity can be highly influenced by the existing technical infrastructure (e.g.: the interfacing capabilities of the legacy systems), concerns over security, reliability, and efficiency of data/information exchange, emphasising consideration of a broader scope of technical issues during IOIS implementation projects. Further technical issues crop-up during the later stages of the IOIS projects due to the need to update systems and processes (Jrad and Sundaram 2016). Moreover, akin to the software component, the way the data (or information) is structured, stored, and managed is different from one system to another. For example, Martínez-Rojas *et al.*, (Martínez-Rojas et al. 2015) and Obonyo (2004) note that much of the product/catalogue data held by construction organisations and their suppliers are unstructured and stored in multiple databases which consequently create an additional layer of challenge to solve in systems integration.

**Organisational and Management Challenges**— It emerges from discussion in many IOIS studies that most challenges in IOIS implementation are concerned with organisational and management issues rather than with technical issues (Jrad and Sundaram 2015a; Robey et al. 2008). In their review of studies published between 1990 and 2003, Robey *et al.*, (2008) point



to a number of key concerns reported in the literature which are a combination of organisational culture, user acceptance/rejection, change management, and business process re-engineering issues, as well as lack of senior management support/commitment in the implementation process. In addition, the project management dimension can also influence the success/failure of IOIS implementation (Denolf et al. 2015; Koh et al. 2011). Lessons learned from historical IS development projects reveal a number of factors which include; underestimated/unrealistic timelines, weak requirements definition, lack of participation of system users in systems development, poor functioning of the project team and lack of skills, knowledge and experience in managing IOIS project development (Denolf et al. 2015; Koh et al. 2011; McLeod and MacDonell 2011). A relatively recent study by Hekkala and Urquhart (2012) shows that potential conflict in terms of power relations between the project participants also play a key role in complex IOIS development projects.

**Supply Chain Related Challenges**— Experiences in other industries on implementing EDI, e-Marketplaces or B2B integration technologies also indicate that a significant proportion of challenges stem from institutional context; or in other words, the dynamics that govern the inter-relationship between supply-chain firms. The following are commonly cited within the reviewed state-of-the-art literature as key factors which can determine the fate of IOIS projects.

1. *Trust and commitment in the relationship:* IOIS are considered as long-term solutions which are an add-on to existing trust-based relationships (Saeed et al. 2011). In this regard, the degree of trust and commitment between firms is considered as a prerequisite for the success of IOIS projects (Denolf et al. 2015; Koh et al. 2011).
2. *Lack of strategic alignment of business and IS strategies:* it is not only feasible to design and build a technically sophisticated IOIS, but also to formulate business strategies that complement and support these systems. IOIS implementation are bound to fail, at least in the long-term, if a firm's strategic IS objectives are not in alignment with that of its supply chain partners, or vice versa (Denolf et al. 2015; Rajaguru and Matanda 2013).
3. *Lack of knowledge and expertise in building extended enterprise functionality:* Not all supply chain partners would be equal in terms of IS/IT capabilities/resources. Some supply chain firms (SMEs in particular) would not have even considered building an extended enterprise functionality with their buyers due to the financial constraints (Harland et al. 2007).
4. *Incongruences in relationship priorities:* for example, some supply chain firms would want to build on strategic aspects of their relationships whereas some would prefer improving operational elements of their interaction (Koh et al. 2011).
5. *Incompatibility of organisational culture, values, beliefs and norms:* the differences in 'soft' attributes of relationships can have an influence on decisions to integrate with one another (Koh et al. 2011; Rajaguru and Matanda 2013).
6. *Relationship change management:* the implementation of IOIS with supply chain firms represent both, a control mechanism and relationship building mechanism for the firm leading the implementation (i.e.: main contractors). In relation to the former, the adoption of IOIS can be regarded as a departure from market-based relationship to a more hierarchical mechanism for governance of the supply chain relationships. With respect to the relationship building mechanism, by eliminating the non-value adding operations, the IOIS enables the principle firm (that is, main contractors) to concentrate on key aspects of their interaction and relationship with downstream firms. In this regard, the decision to adopt IOIS will inevitably influence the structure, conduct and performance in the relationship. Appropriate change management strategy is, therefore, considered as one of the critical elements during the transformation of the relationships (Koh et al. 2011).

7. *Potential of asymmetric use of IOIS (or decreased information asymmetry)* where one of the parties gains advantage over the other through more transparent or better information sharing; for instance in collaborative planning, forecasting, and replenishment systems (Cho et al. 2017; Schmidt et al. 2010).

Evident from the literature review findings, the integrated IOIS projects present major challenges for organisations with the implementation process. The primary cause of the complexity stems from the multiplicity and diversity of factors associated with the planning, design, development and use of the IOIS. Despite its crucial role in seamless supply chain operations few researchers have engaged with end-to-end IOIS implementation within the context of AEC sector firms. Next section describes some of the research gaps highly relevant for this study.

## 2.6 Gaps in the Literature

It is highly emphasized in the literature that inter-organisational relations need close attention before adopting, implementing and sustaining cSCM (Pryke 2009). Despite its significance, however, there exists lack of systematic studies on relationship-centric approach to cSCM (Vrijhoef 2011). What research interest exists is mostly focused on specific relationship types, partnering and collaborative relationships, and lacks consideration of different relational elements (for example IOIS) that play a key role in supply chain interactions. Section 2.4 outlined that integration with key suppliers require three essential elements within its scope: actor, process and technological integration. Although the reviewed literature repeatedly address and highlight the importance of inter-firm collaborative and integrative relationships in all three dimensions of integration; both, the study and practice of cSCM, largely focus on upstream firms—between large contractors and clients, architects, designers—neglecting the firms in downstream supply chain tiers (London 2008; Meng 2013). Contractor organisations are involved with myriad of suppliers however the tools, technologies and processes adopted in practice to facilitate integration are not well-researched from SCM perspective.

With respect to IOIS implementation, existing research largely focus on WPMS (and less so on EDI). The WPMS are commonly used to manage project documentation and information between range of project stakeholders through a web-based platform (Adriaanse et al. 2010). The latter form (EDI) is primarily adopted for the exchange of financial data/information with a certain segment of supplier base (predominantly builder's merchants) (Alshawhi 2007; Samuelson and Björk 2013). Whilst WPMS facilitate collaboration, coordination and project management between the supply chain firms, it generally lacks back-end systems integration, which consequently creates silos of information residing in multiple systems. The latter type (EDI) is also restricted to the financial data exchange and therefore lacks the ability to facilitate cross-functional process integration: for example, complex inter-firm procurement processes from procure-to-pay (McCrea and Peat 2009). There is also a third type of IOIS, that is, Building Information Modelling— or BIM, which embrace a wide range of tools, technologies and processes within its scope to bring together a data rich 'intelligent' model in a common data environment (Martínez-Rojas et al. 2015). Although BIM as an IOIS offer interesting opportunities (Grilo and Jardim-Goncalves 2011), its implementation is mostly project-centric and limited to certain disciplines (design management) and project stages (building design and pre-construction) (Eadie et al. 2013).

It follows from the literature review that there is insufficient understanding of how to approach highly integrated IOIS implementation (Jrad and Sundaram 2015a; Kauremaa and Tanskanen 2016; Standing et al. 2010). As indicated above, there are abundance of studies which investigate the *use* and *adoption* of WPMS (Adriaanse et al. 2010; Arnold and Javernick-Will 2013; Becerik and Pollalis 2006; Erdogan et al. 2008, 2014; Hjelt and Björk 2007; Lee and Yu 2012; Nitithamyong and Skibniewski 2006, 2011; Peansupap and Walker 2006; Ruikar

et al. 2005; Samuelson and Björk 2013; Sargent et al. 2012; Wong 2007; Wong and Lam 2010), BIM (Aouad and Arayici 2010; Eadie et al. 2013; Hartmann et al. 2012; Jung and Joo 2011; Ozorhon and Karahan 2016; Papadonikolaki and Wamelink 2017; Won et al. 2013) and intra-firm ERP systems implementation (Chung et al. 2008, 2009; Kwak et al. 2012; Ozorhon and Cinar 2015; Tatari et al. 2008; Tatari and Skibniewski 2011; Yang et al. 2007) where the subject matter of these studies is documenting the best practices and critical success factors, innovation diffusion, e-readiness or change management. On the other hand, there are plethora of studies that look into IS/IT development by AEC organisations however they primarily deal with organisational strategies concerning *intra-firm technology implementation* (Alshawhi et al. 2010b; Henderson and Ruikar 2010; Jung and Gibson 1999). As unveiled in Section 2.5, the management of an integrated IOIS is quite different from in-house IS development projects. Moreover, studies that investigate the technology implementation from supply chain context is generally limited to EDI (Lewis 1998; Schnitzler and Österlund 2015). EDI is adopted with a certain number and type of suppliers and, therefore, its implementation is not comprehensive enough to deal with complexities that characterise IOIS implementation with multitude of supply chain firms.

Furthermore, research which offers practical guidance for AEC firms venturing into the world of integrated IOIS—especially in the era of advanced technological solutions such as Cloud-computing—are at best very few. A relatively recent study by Hadaya and Pellerin (2010) is one of the few that explore the determinants of IOIS use and adoption to support the inter-organisational transactional and collaborative processes with supply chain firms. Their findings (based on 67 responses to a questionnaire survey received from construction firms in Canada) reveal a number of relational (supply chain relationship characteristics) and organisational factors (such as readiness and firm size) that influence the use and adoption web-based IOIS. Another more recent example, is the work of Papadonikolaki (2016), who focused on BIM-enabled supply chain partnerships. While such studies provide beneficial guidance for deploying IOIS projects in supply chain context, more work is needed to broaden our knowledge of IOIS implementation projects' lifecycle.

Akin to implementation management, it is worth noting that there is also a need to study the state-of-the-art in IOIS since procurement technologies have been subject to significant evolution in the last 10 years or so (Ibem and Laryea 2014). Although the prior research has conceptualised or reported a range of integrated WPMS (see, for example, Alshawhi and Ingirige 2003; Grilo and Jardim-Goncalves 2013; Liu et al. 2003; Ren et al. 2012; Zhu and Augenbroe 2006), it seems there is insufficient clarity about the interfacing capabilities of the current service providers/platforms with back-end ERP systems to support the inter-firm procurement operations. In this regard, there is a need to delineate the current integration capabilities of construction project management and collaboration systems with external systems. As far as the ERP integration is concerned a number of exploratory studies exist which point out to the low levels of both, internal and external integration of construction enterprise information systems (Kang et al. 2012b; Tatari et al. 2007). In an industry whitepaper by IFS, an ERP solutions provider, it has been pointed out that only a small percentage of engineer-to-manufacture firms (including contractors) utilise the full integration capability of their ERP and project management systems (Lorbiecki 2013). On the other hand, several research studies (Alshawhi and Ingirige 2003; Becerik and Pollalis 2006; Charalambous et al. 2012; Liu et al. 2011; Nitithamyong and Skibniewski 2004; Wilkinson 2005) and industry reports (NCCTP 2006) provide a snap-shot of the high-level functionalities of WPMS. It should be noted that there is a constant need to evaluate state-of-the-art in order to assess the gap between theory and practice. In a study of marketed functionalities of WPMS providers Liu *et al.*, (2011) have analysed fourteen vendors however their study did not report any integrative features that allow inter-connection with the back-end ERP systems.

## **2.7 Summary**

The review of literature presented in this section has attempted to bring together the state-of-the-art in cSCM and IOIS which underpins this study. In terms of its adoption and adaptation to construction context, review of prior literature indicates that AEC industry is plagued with many challenges to adequately implement SCM. Nevertheless, integration is regarded by most as a key component of cSCM which must be pursued with strategic or key supply chain firms to realise the benefits of, and opportunities provided by closer engagement with supply chain partners. SCI requires incorporation of the IOIS into the business relationships to facilitate the inter-link between actor, process and technology integration. However, multitude of technical, management and supply chain related issues that have been reported in the literature suggests there is more work needed for developing normative recommendations for industry practitioners as to what, why, when and how to approach IOIS implementation. The next chapter presents the methodology adopted for conducting the research.

## **Chapter 3: Research Methodology**

### **3.1 Introduction**

Research methodology provides the blueprint of a scientific investigation. This chapter presents a precis of the methodological approaches and the reasoning behind their selection.

### **3.2 Philosophical Considerations**

The philosophical standpoint of a research determines many facets of the research including the process by which the research is conducted. According to Blaxter *et al.*, (2006) research philosophies provide guidance on choosing the most appropriate method for the research; and, help to identify and clarify the constraints in research design to enable an informed decision making. The philosophical views of a research relate to the researcher's assumptions about the nature of reality (ontology) and beliefs about how one might discover knowledge (epistemology).

#### **3.2.1 Ontology**

Ontology is the belief or assumptions of a researcher which s/he is knowingly or unknowingly is subscribed to. By adopting one of the perspectives in a continuum of *realist* and *relativist* spectrum, the research is influenced by the choice which the researcher makes about the nature of the reality and the methods s/he employs to investigate the research problem (Stahl 2008). In the realist approach the researcher holds the belief that there is a reality which exists independently of the observer (or the researcher's cognition). By contrast, in relativist approach the researcher assumes that there is no true reality which exists independently of perception, therefore the study is based on researcher's subjective perceptions of the physical and social world (Bryman and Bell 2007).

The above perspectives (realist and relativist assumptions) sit at the opposite ends of the spectrum but there are many variants of each which reflect a different strand in logic of thinking about the nature and reality (Stahl 2008). For example a compromise between the two purist views is the critical realist perspective which recognises that there is a reality independent of our perception but as the researcher interacts with the reality the perception of reality is adulterated (Easterby-Smith et al. 1991). A particular assumption in critical realist approach is that the phenomenon under study is not orderly or stable, and constantly undergoing change (Stahl 2008). This assumption suggests that our ability to know the reality with certainty is limited as nature and reality is shaped by our experience and exposure, and vice versa. The ontological base of this thesis holds to this latter perspective and adopts the view that there are multiple realities. It assumes that the objective reality is constructed through the researcher's cognition, and therefore all knowledge is local, provisional and context-dependent.

#### **3.2.2 Epistemology**

Another domain which underpins the research is the question of how the researcher comes to acquire knowledge (Cornford and Smithson 2006). There are two mainstream schools of thought on epistemological arguments: positivism and phenomenology. The positivist view rejects the meta-physical facts and only recognises objects which can be measured and observed. In contrast to this, the phenomenological (interpretivists) paradigm argues that reality is constructed through the subjective meanings and understandings of the researcher. The key features of these two primary research approaches entail the principles shown in Table 3:1.

The interpretivist approach involves in-depth investigation and analysis of the phenomena under study from a non-deterministic perspective. The main weakness of interpretivist approach is that findings emerge through the researcher's interpretation of the reality therefore there could be multiple realities which may be valid in its own context and

condition. The positivist approach, by contrast, aim for replicability and generalisability through formulation of hypotheses, models or causal relationship among constructs, and use quantitative methods to test and validate the theories and hypotheses. One of the main shortcomings of the positivist approach is that it tends to be highly descriptive so it is not appropriate for studies which seek to gain insights and knowledge into the meaning of outcomes.

Although the positivist proposition has dominated the IS research, the interpretivist approach has received considerable attention in Europe and worldwide (Chen and Hirschheim 2004). However strict adherence to a single epistemological position have abated over the years since seeing the positivism and phenomenology as two complementary perspectives is regarded more useful than constraining the research into a narrow paradigm (Orlikowski and Baroudi 1991; Stahl 2008). In fact, Sidorova *et al.*, (2013) claimed that many IS research has drawn theories from a number of established disciplines including organisation theory, sociology, economics, psychology, management, and decision making, which consequently resulted in the boundaries between the positivist and interpretivist perspectives to fade away. Application of mixed-methods approach is acknowledged as both feasible and desirable to deal effectively with the full richness of the context in which IS are designed, developed, implemented and used. Following the advice of Mingers (2001), Davis (2000), Venkatesh *et al.*, (2013) and Davison and Martinsons (2015) among many others, most researchers nowadays tend to adopt a multi-methodological (pluralist and pragmatist) approach to IS research.

### 3.3 Methodological Considerations

Research into methodological issues begins with evaluation of the most appropriate methods and techniques for the research. The evaluation can be conducted from a number of dimensions or lenses which Saunders *et al.*, (2007) referred to as the layers of a ‘research onion’. These layers are quite significant in devising an overall research strategy and, it is concerned with the paradigmatic assumptions, the process of research design, and the method of collecting data (Saunders et al. 2007). Below is a brief discussion on the methodological considerations taken into account in business management and IS research.

Table 3:1 A comparison of the Positivist and Phenomenological schools of thought (adapted from Easterby-Smith et al. 1991)

	<i>Positivism</i>	<i>Phenomenology</i>
<b>Beliefs</b>	<ul style="list-style-type: none"> <li>Observer is independent and objective from objects of research</li> <li>Science is value-free</li> </ul>	<ul style="list-style-type: none"> <li>Observer is subjective and part of what he observes</li> <li>Science is driven by human interests</li> </ul>
<b>Aims of Researcher</b>	<ul style="list-style-type: none"> <li>Describe casual explanations and fundamental laws</li> <li>Look for the average</li> <li>Theory verification by formulating hypothesis and testing them.</li> <li>Reduce phenomena to simple parts through reductionism</li> </ul>	<ul style="list-style-type: none"> <li>Try to understand what is happening</li> <li>Look for the specific and detailed descriptions.</li> <li>Theory generation through induction from data</li> <li>Look at the totality of each situation</li> </ul>
<b>Methods</b>	<ul style="list-style-type: none"> <li>Quantitative approaches that use statistics, experiments and questionnaires</li> <li>Large samples</li> </ul>	<ul style="list-style-type: none"> <li>Multiple methods used to establish different view of the phenomena</li> <li>Small samples investigated/collected in detail or over time</li> </ul>

### 3.3.1 Paradigms

Drawing on the seminal work of Kuhn (1970) the concept of paradigm is commonly defined as the set of beliefs, values and assumptions that a community of scientists have in common. Typically, it consists of the ontological, epistemological, human, and methodological standpoints of research (Bryman and Bell 2007). The research on IS can be framed around two complementary but distinct paradigms: behavioural science and design science (Hevner et al. 2004). Research that belongs to the former paradigm seeks to predict or explain human and organisational behaviour in terms of IS's use or intention to use, perceived usefulness, net benefits, service and information quality, whereas the design-science research focuses on creating new, purposeful and innovative IS artefacts that intends to solve identified organisational problems (Hevner et al. 2004). Compared with other established disciplines IS is a relatively new field of research so it has not gained a significant maturity in terms of building a common ground within these two paradigms (Sidorova et al. 2013). Consequently the paradigmatic orientations (particularly the underlying epistemological standpoint) within both design-science or behavioural science research are not easily defined or distinguished from one another (Sidorova et al. 2013). Furthermore, there has been frequent calls for building IS as a distinguished discipline of its own rather than a convenient meeting point for variety of fields or disciplines (Benbasat and Zmud 2003). However, many prominent scholars oppose to the idea of forcing IS field into a single paradigmatic field of inquiry on the basis that more fruitful results would be produced at the coalescence of two or more fields than in a narrowly defined IS discipline (Cornford and Smithson 2006; Davis 2000).

### 3.3.2 Research Approaches

Research approach concerns the logic of arriving at a conclusion which can be either deductive or inductive. In the deductive method the researcher usually seeks to explain the causal relationships between variables and starts by developing a priori-theory (or hypothesis) which is empirically tested to confirm or reject the initial theory (Saunders et al. 2007). A reverse process is adopted in the inductive approach where the researcher generates a theory based on observations made. The deductive approach is reductionist and objective in nature, and follows a highly-structured methodology in order to come up with a generalised statement. Inductive approach on the other hand is less concerned with the generalisation and aims to understand the meanings humans attach to phenomena and the context in which events unfold.

### 3.3.3 Research Strategies

There are many approaches to, or designs for, research strategy, which may be carried out in combination or individually depending on the preferences; the resources available; the constraints operating under; and, the particular issues which the study aims to address (Blaxter et al. 2006). The most common approaches used in IS and business management studies are described below.

**Action Research**— The rationale for action research resides in the need to get involved in a real-life situation (for example, policy making, nursing and so on) by co-operating and collaborating with participants under study to identify, develop and act on the outcomes of the research (Oates 2006). It is inherently a participatory process and involves participants to have a voice and influence over any changes (Bryman and Bell 2007). The main issues with action research include problems with identifying who should be involved and in what ways, difficulties in meeting the needs and expectations of everyone involved, challenges with putting action into practice as well as availability of resources (it is a highly time consuming multi-phased inquiry process) (Bryman and Bell 2007).

**Case Study Research**— A case study can be defined as the investigation of a contemporary phenomenon in its real life context (Yin 2014). The case study strategy is most appropriate in situations where the aim is to explore the ‘how’ and ‘why’ questions in-depth (Yin 2014). The case selected for study can be either typical or atypical case, or a test-bed for testing an existing theory (Yin 2014). Case study research produces rich data, as the researcher generally employs a multi-source data collection strategy (both qualitative and quantitative). The main limitation of case study approach is the generalisability or the extrapolation of the findings beyond the case(s) being studied (Oates 2006). There are a number of techniques, however, which can be applied to case study research to increase the internal and external validity of the findings (Yin 2014).

**Ethnographic Research**— is a type of participatory research whereby the researcher immerses into the natural setting of people or events under the study, carrying out observation of activities, behaviours and phenomena (Bryman and Bell 2007). The role and involvement of the researcher can range from complete participant (whereby the researcher is completely involved in a certain situation) to complete detachment (that is, observer is free from involvement in any way) (Bryman and Bell 2007). Ethnographic research is useful in contexts where the interest is to understand the world, in particular the social constructs that shape subjects’ culture, as perceived by the subjects who live in that world. As such, it lends itself to phenomenological perspective in design and conduct of research (Oates 2006).

**Grounded Theory**— There is a lot of controversy surrounding the development of grounded theory (GT) which does not permit a clear understanding on its definition and how to execute it (Oates 2006). In general terms, the idea in GT is to follow a path of discourse (through a combination of deduction and induction) that leads to the emergence of a core theme around which the researcher builds and develops a theory (Saunders et al. 2007). GT offers a flexible research approach and has been applied in many IS studies in the past, albeit predominantly as a qualitative data analysis technique (Urquhart and Fernández 2016). This is considered by some authors as a key misconception in its use and it has been suggested that a good comprehension of the overall method is required (in terms of the methodological assumptions related to its use) in order to facilitate the development of a substantive theory (Birks et al. 2012; Urquhart and Fernández 2016).

**Survey Research**— In survey research the focus of attention is to gather qualitative and/or quantitative data in a standardised and systematic way from a sampled population (Bryman and Bell 2007). Survey research follows a deductive approach where the aim is to make a statistically generalised conclusion about a wider population. Researcher generally looks for patterns (and correlations between variables) in data collected which is analysed using descriptive and inferential statistics techniques (Bryman and Bell 2007). Questionnaire surveys (particularly the online/electronic surveys) are the most popular method in data collection however literature reviews, interviews, documents, and observations are also employed in data collection strategy to complement and/or draw richer insights into the findings (Bryman and Bell 2007).

### **3.3.4 Time Horizons**

Another question asked during research formulation process is whether the research will be longitudinal or cross-sectional. The cross-sectional approach is frequently employed in social science studies to identify the prevalence of a phenomenon, problem, or a situation at a particular point in time (Saunders et al. 2007). Using qualitative and quantitative data (through surveys for example), the aim is to examine the relationships between variables. The



longitudinal design involves the same technique as in cross-sectional design however the procedure is replicated over a period of time to understand how the phenomena changes with time (Saunders et al. 2007). Depending on the length of the research and purpose of the study the time intervals can vary between days and weeks to much longer periods, for example, months and years.

### **3.3.5 Choices**

In focusing on different modes of enquiry, the researcher makes an important decision on different frameworks for the collection and analysis of data (Bryman and Bell 2007). Overall there are three choices (qualitative, quantitative or multi-method) into the research design where, as can be seen from Table 3:2, each employs a different approach in many ways.

#### **3.3.5.1 *Qualitative Methods***

The qualitative research approach is usually associated with the phenomenological (interpretative) school of thought (Kumar 2005). Principle aim of pure qualitative research is to establish the meaning of the phenomenon from individual's opinions, views, qualities and experiences. A number of authors outline the main features of qualitative methods, in particular Fellows and Liu (2008) noted that qualitative research is concerned with collecting and analysing information using multiple methods, mainly in non-numeric forms. Moreover, Blaxter *et al.* (2006) explained that the aim of qualitative approach is to achieve 'depth' rather than 'breadth', hence it tends to be rich in context and scope.

The inherent weakness of qualitative research methods is discussed by Bryman and Bell (2007) who emphasized four main disadvantages of adapting a qualitative approach. Firstly, findings from a qualitative research are often derived from subjective values of the researcher and discourses of views that are seen significant and important to the researcher (or participants). Secondly, it is difficult to replicate the study due to subjectivity and unstructured nature of the qualitative data. Thirdly, because data is generally collected from a small number of participants, it is difficult to generalise the research findings to a larger setting. Finally, due to lack of transparency and deficiencies in data collection and analysis phase, it is very hard to establish how the researcher has arrived to the conclusion. Moreover, several authors (Bryman and Bell 2007; Easterby-Smith et al. 1991; Fellows and Liu 2008; Naoum 2007) stress the difficulty of collection, filtering and organisation of data, which can be a very lengthy process (time and resource consuming).

#### **3.3.5.2 *Quantitative Methods***

Quantitative approach reflects the positivist research paradigm, which is 'value-free', objective in nature (Bryman and Bell 2007). Naoum (2007 p. 38) defined the quantitative methods as "testing a hypothesis or a theory composed of variables, measured with numbers, and analysed with statistical procedures". Quantitative approaches involve gathering of relatively large-scale numerical data, which is analysed (using statistical procedures) and interpreted in order to come to conclusions to test or verify a theory (Bryman and Bell 2007).

One of the advantages of quantitative approach is that it yields precise, reliable, quantified results and findings (Bryman and Bell 2007). In addition to this, quantitative approach leads to generalisation and replication of the study (Fellows and Liu 2008). Concerns on validity and reliability are often termed with qualitative research approaches, as it is difficult to apply conventional standards of validity and reliability to qualitative research data (Bryman and Bell 2007). However, in quantitative research different techniques can be adopted to check the validity, reliability and accuracy of the findings (Fellows and Liu 2008).

Despite the above-mentioned strengths, the quantitative research approach is often criticised for failing to account for researcher's opinions, views, intentions, attitudes and

experiences. In other words, quantitative research fails to distinguish social world from natural world and tends to ignore how people interpret the world around them. Furthermore, Bryman and Bell (2007) argued that this can lead to bias as scientific approach cannot be totally objective, since subjectivity is involved in data input, collection and analysis. Bryman and Bell (2007) further explained that measurement may be flawed, for example it may not be precise and accurate due to parallax (researchers seeing things differently) as well as instrument error and so on.

### 3.3.5.3 *Triangulation (multi-method)*

Flick (2007) described the triangulation as the reflection of the research issue from at least two points. Easterby-Smith *et al.* (1991) distinguished four variants of triangulation. The most used one is data triangulation, which is the use of multiple methods to ‘compensate’ for the weakness of a research method by counterbalancing with strengths of another. Another method is triangulation of theories which involve the use of models from one discipline to look at the issue from a different perspective and explain situations from a multiple perspective. Thirdly, triangulation by researcher is another method which involves a different person to collect data on the same research problem. Finally, the methodological triangulation method involves using both quantitative and qualitative methods for data collection to where, for example ‘objectivity’

Table 3:2 A comparison of the qualitative and quantitative modes of enquiry.

	<i>Qualitative</i>	<i>Quantitative</i>
<b>Paradigm</b>	<ul style="list-style-type: none"> <li>▪ Interpretivist</li> </ul>	<ul style="list-style-type: none"> <li>▪ Positivist</li> </ul>
<b>Aim</b>	<ul style="list-style-type: none"> <li>▪ To establish the meaning of the phenomenon from individual’s opinions, views, qualities and experiences</li> </ul>	<ul style="list-style-type: none"> <li>▪ To test or verify a hypothesis or a theory by gathering of relatively large-scale numerical data which is analysed (using statistical procedures) and interpreted in order to come to reach to a conclusion</li> </ul>
<b>Features</b>	<ul style="list-style-type: none"> <li>▪ Unstructured/semi-structured or open methodology</li> <li>▪ Descriptive</li> <li>▪ Gives ‘depth’</li> </ul>	<ul style="list-style-type: none"> <li>▪ Structured and predetermined methodology</li> <li>▪ Factual and quantifiable</li> <li>▪ Gives ‘breadth’</li> </ul>
<b>Strength</b>	<ul style="list-style-type: none"> <li>▪ Rich in context and scope</li> </ul>	<ul style="list-style-type: none"> <li>▪ Yields precise, reliable, quantified results and findings</li> <li>▪ Leads to generalisation and replication of the study</li> <li>▪ Different techniques can be adopted to check the validity, reliability and accuracy of the findings</li> </ul>
<b>Weaknesses</b>	<ul style="list-style-type: none"> <li>▪ Findings are often derived from subjective values of the researcher and discourses of views that are seen significant and important to the researcher</li> <li>▪ Difficult to replicate due to subjectivity and unstructured nature of the research</li> <li>▪ Difficult to generalise the research findings to a larger setting</li> <li>▪ Can be hard to establish how the researcher has arrived at the conclusion</li> <li>▪ Can take a lot of time to collect, filter and organise data</li> </ul>	<ul style="list-style-type: none"> <li>▪ Fails to distinguish the social world from natural world and ignores how people interpret the world around them</li> <li>▪ Measurement may be flawed, for example, it may not be precise and accurate due to parallax (researchers seeing things differently) or wrong instrument may be chosen to collect data.</li> <li>▪ Problems with the meaning of the questions can render the validity/reliability of data, for example, a respondent may not share the same knowledge and imply something completely different</li> </ul>
<b>Main Data Collection Techniques</b>	<ul style="list-style-type: none"> <li>▪ Open question surveys</li> <li>▪ Semi-structured interviews</li> <li>▪ Participant/process observations,</li> <li>▪ Focus groups</li> </ul>	<ul style="list-style-type: none"> <li>▪ Data that can be quantified, numbers, statistics etc.</li> <li>▪ Factual questions</li> <li>▪ ‘Closed’ questions</li> <li>▪ Structured Interviews</li> </ul>

of the quantitative approach can be balanced with ‘subjectivity’ of qualitative approach to produce a neutral viewpoint. Or alternatively “quantitative methods can be used to study both ‘hard facts’ and human perceptions; likewise qualitative methods can be used and analysed in either objectivist or constructionist way” (Easterby-Smith et al. 1991 p. 134). Fellows and Liu (2008); Bryman and Bell (2007) and; Flick (2007) outlined the following benefits of triangulation.

- Triangulation is generally implemented to limit the bias, increase the consistency and validate the findings by confirming with more confident and accurate data. This means results could either converge, complement each other or diverge.
- While quantitative research gathers hard facts and figures (such as through closed questions in a questionnaire), qualitative research instruments such as semi-structured/unstructured interview can be utilised to collect ‘human’ issues related to the research.
- Possible instruments for triangulation include diaries, archives of a project; and databanks which can save on research time and cost.

### **3.3.6 Data Collection and Analysis Methods**

Data sits at the heart of an evidence based empirical study (Saunders et al. 2007). There are two main sources (primary and secondary) that could be utilised in data collection strategy. The key issues that influence the researchers’ choice include access to data, response rate, time available, methods of analysis and bias. Most widely used tools for collecting data are from primary sources such as interviews and self-completion questionnaires (Fellows and Liu 2008). Advantages and disadvantages of using self-completion questionnaire is discussed by Naoum (2007), who mentioned benefits gained from speed, economy and verified data input as the respondent is not required to provide an answer on the spot. However, its’ main disadvantages are: misunderstanding or wrong interpretation of questions which can lead to inappropriate answers; self-completion questionnaires do not allow opportunity for probing which can lead to bias; problems with accuracy of obtained data; and, problems with response rate where response rate between 20-30% is usually set as a benchmark for questionnaire surveys (Bernard 2000). One way to complement questionnaire surveys is to conduct face-to-face and telephone interviews. By conducting interviews, the researcher can gain further insight into to the phenomenon under study by probing additional questions that otherwise would be difficult to collect through survey questionnaires.

Data collection can be bolstered by collecting further data from secondary data sources to provide a more comprehensive and detailed investigation and analysis. Secondary data sources can include data /information that is held or administered by others, e.g.: organisational records, documents, reports, publications and so on. When collecting secondary data, it is important to consider the reliability (who collects/administers the data), suitability (the objective, scope and nature of the data collected), and the adequacy (the level of accuracy) of the data.

Several statistical and non-statistical methods are suggested by Naoum (2007), however, it is greatly appreciated in the literature reviewed that qualitative and quantitative data will require different instruments and procedures for analysing the data. Analysis of the quantitative data will involve several techniques and procedures to aid accurate interpretation of the data. Once this data is analysed the descriptive representation of the data (bar charts and frequency distribution tables) will illustrate to the reader the patterns and relationships more clearly and in a more digestible way. Some of the most appropriate statistical analysis techniques for this study are non-parametric tests such as the measurement of central tendency (for example, mean, median and mode); and parametric tests such as student’s *t*-distribution. The arithmetic mean is used to find the average of the all values in a set of data; the mode is the most frequently

occurring value whereas the median is computed to find the value located in centrally in a data set. The Chi-square test is another form of non-parametric test where it is used to compare the *observed* and *expected* frequencies in a data set to see if the differences between two or more population of data are significant within the 95% level of confidence (Fellows and Liu 2008). The *t*-distribution on the other hand is a form of parametric test which allows comparison of the differences between two means– that is if the difference between two means is statistically significant if both means were equal in terms of the number of sample (Sapsford and Jupp 1998). The *t*-test is for use with data that is measured on an interval or ratio scale and the value computed at the end reflects the difference within or less than 5% probability of error (Sapsford and Jupp 1998). Another common analysis technique is the standard deviation which is a way of measuring the variation spread around the mean and it is generally used to interpret the data in terms of probability. Normally, a high standard deviation means that data points are far from the mean and small standard deviation indicates that data points are clustered closely around the mean (Sapsford and Jupp 1998).

### **3.4 Adopted Research Methodology**

Research that is directed towards solving practical problems with an aim to inform practice is regarded as applied in nature (Van Aken 2005; Kumar 2005). Considering the research problem stated earlier in Section 1.6 and the nature of EngD the programme, an applied research approach (as opposed to pure research which aims to build scientific theory) is most appropriate for this study. Another methodological question to address at this point is the paradigm the current study belongs to. As opposed to design science research which seeks to design, create and evaluate new IS artefacts (Hevner et al. 2004), this research is primarily concerned with the implementation and management of IS artefacts in the context of AEC organisations, namely main contractors. Thus, the current study is anchored in the behavioural (management) science research paradigm. However, this is not to say that the study is independent of, or isolated from, design science research. Quite the opposite, the study recognises the complementary role of both paradigms to contribute to knowledge on design, development, implementation, evaluation and evolution of purposeful IS artefacts.

The EngD project did not set-out or defined a pre-planned methodology to follow. Rather, the research methodology evolved as the project progressed. As indicated earlier, a multi-methodological approach was deemed appropriate to fulfil the research objectives set out in Section 1.6. The primary aim in this study was set to investigate the cSCM for better integration of construction supply chains through IOIS implementation. This aim is specifically concerned with three objectives where the main emphasis is on (i) exploration of ICT-enabled SCM and SCI technologies, (ii) evaluation of IOIS implementation in a construction supply chain environment and (iii) formulation of a best-practice IOIS implementation framework by contractor organisations. The first research objective is exploratory in nature and it aims to investigate the existing SCM technologies adopted by main contractors to support SCI with firms in dyadic and extended supply tiers. The second objective is explanatory of the factors that play a key role in design, development and use of complex IOIS projects. The core mission of the third objective is to synthesise the findings from the earlier investigation and develop an implementation guideline for effective and efficient delivery of IOIS projects.

Besides the guidance provided by the research sponsor, the research process was carefully aligned with the mandatory EngD programme requirements which included completion of several post-graduate modules; EngD. Short Project Module (undertaken in the second semester); an MSc. Thesis (submitted at the end of the first year of the programme); and a minimum of three scholarly publications in academic conferences and journals (presented in Appendices B-F of this thesis). The academic modules completed in the first year were: Research and Communications, Lean and Agile Manufacturing (Semester 1), Procurement and

Contract Procedures (Semester 2). The RE has also participated in numerous Management and Professional Development training courses, seminars and workshops throughout the EngD programme for enriching personal development as well as to help with dissemination of the study findings and gain industry exposure (see Appendix H for the details).

Next, each research objective is discussed within its own methodological boundaries to justify the decisions made in relation to the conduct of the research.

### 3.4.1 Research Objective 1

The sponsoring company has active interest in developing technological solutions to the cSCM problems experienced by large contractor firms. This is primarily due to large contractor firms being one of the main client base of the sponsoring company and the key users of the platform. However, it is equally important to emphasize that contractor firms are responsible for majority of the scope of work awarded in a construction project, and therefore, they play a key role in integration, coordination and cooperation between the diverse stakeholders involved in the delivery of construction projects. As a result, there is strong demand for exploration of the ICT-enabled cSCM by large contractor firms to manage their project-specific and organisational supply chains. The first research objective aimed to ascertain an up-to-date and extensive understanding of the relationship-centric cSCM tools and technologies adopted by contractor firms and their downstream supply chain partners. The investigation was divided into three tasks where each adopts a different instrument for data collection and analysis.

**Task 1. Relationship-Centric SCM in the AEC Industry.** This study adopts a relationship-centric focus to cSCM which require an understanding of the inter-firm relationships in the AEC industry. As the research objective was exploratory in nature, a combination of desk study and literature review was deemed appropriate for this task. A preliminary report on AEC specific SCM (both as a concept and its practice by main contractors) was presented at the beginning of the thesis (Chapters 1 pp. 1-6, and 2 pp. 9-16). The articles attached in Appendix B and C also provide a summary of the literature studied. A further in-depth exploration of the construction supply chain relationships was required in order to develop a conceptual framework for implementing IOIS projects through relationship-oriented cSCM.

**Task 2. Contractor Practices for ICT-enabled cSCM.** The objective in the second research task involved synthesising the findings drawn from a questionnaire survey for conceptualising a management and integration framework. Survey-based research was considered as an ideal method for identifying the integrative practices adopted by contractor firms. A pre-tested questionnaire survey was sent out the industry practitioners to validate the findings from the literature and probe a variety of ICT tools and technologies reported in the literature. The questionnaire contained questions regarding the use and adoption of ICT tools and technologies to support contractor firms' integration and relationship management with dyadic and extended supply chain firms. The information collected from the questionnaire survey enabled the research to develop a high-level strategic SCI framework which is presented in Appendix D.

**Task 3. Marketed Functionalities of SaaS Providers Facilitating Collaboration and Integration of AEC Supply Chains.** The focus in the third task shifted towards the technological landscape with a specific emphasis on the SaaS technology solution providers which facilitate the inter-firm technological integration between the construction supply chain firms. A total of 78 SaaS vendors, which specifically target the AEC industry as their main client base, were identified. The solutions these firms were marketing were analysed to determine their functional characteristics and to make a cross-comparison of inter-organisational systems and technologies implemented by contractor organisations. A matrix-

style spreadsheet was created to track the state of developments and product features by each vendor. The company websites (including the social media accounts such as Twitter and LinkedIn) were the main source for data collection however influential AEC-technology bloggers (aechbytes.com and extranetevolution.com), and marketing channels such as technology sections of online industry news sites (such as building.co.uk, constructionnews.co.uk and enr.com) were also used for in-depth analysis of the core features. The spreadsheet was kept up-to-date with the developments announced by each vendor to reflect an up-to-date list of the features being developed and marketed to industry firms.

### 3.4.2 Research Objective 2

The second research objective sought to investigate the implementation of the IOIS by main contractors. In this study, the term implementation is taken as a set of activities consisting of three phases: (i) pre-implementation activities such as planning and requirements specification, (ii) implementation which is concerned with the development activities and the actual delivery of the technology, and (iii) post-implementation where the focus turns to adoption and on-going use of the technology until the solution becomes fully diffused into an organisation's core business and IS strategy (Linton 2002).

There are clearly epistemological limits to studying the IOIS implementation due to variations in systems being implemented and the breadth of issues encountered during the management of the implementation process. In this regard, a decision was made to focus the research on Cloud-based private B2B e-Marketplace systems. Another decision in the process of studying IOIS implementation was to adopt two different but complementary perspectives to the nature of inquiry: that is, (i) the evaluation of the IOIS implementation project as the object of assessment and (ii) the evaluation of the IOIS artefact as the object of assessment. Consequently, the second objective was split into two tasks and carried out in two phases to better accommodate these two perspectives. The aim in the first task (Task 4) was to explore the key success/failure factors in an IOIS implementation project whilst the second task (Task 5) was primarily concerned with the IOIS artefact (the evaluation of the use and adoption of a Cloud-based B2B e-Marketplace system).

A case study research strategy was adopted to satisfy the second research objective. Yin (2014) advocated the use of case study to investigate a contemporary phenomenon within its real-life context. The case study research strategy not only makes a good instance of documentation and analysis of rare cases (implementation and use of private B2B e-Marketplace systems by AEC organisations), but it also provides detailed and rich insight into 'how' and 'why' certain outcomes occur in a given context (Yin 2014). This in our case is the critical factors that play a key role during an IOIS implementation which is not commonly reported or investigated in the wider IS research domain, let alone in the AEC context (Jrad and Sundaram 2015a). Another reason for the selection of case study strategy was the availability of the project and the access provided to RE, allowing the empirical investigation to extend over 2 years and the data collection to spread over a 3-year period (see Figure 3:1). Moreover, the case study strategy was also deemed beneficial for improving the future product/service delivery practices at the sponsoring company by identifying the key project and technical impediments that crop-up during multi-firm IS development projects. Prior to empirical investigation, a critical review of the IS development literature was undertaken to identify the common implementation challenges reported in generic and AEC-specific IS literature. Primarily, the review of literature examined the research on WPMS, e-Marketplaces and EDI, which are commonly deployed in supply chain context to support SCI. The main challenges reported in the past literature are categorised into several themes and presented in Chapter 2:2: pp. 16-25, of this thesis.

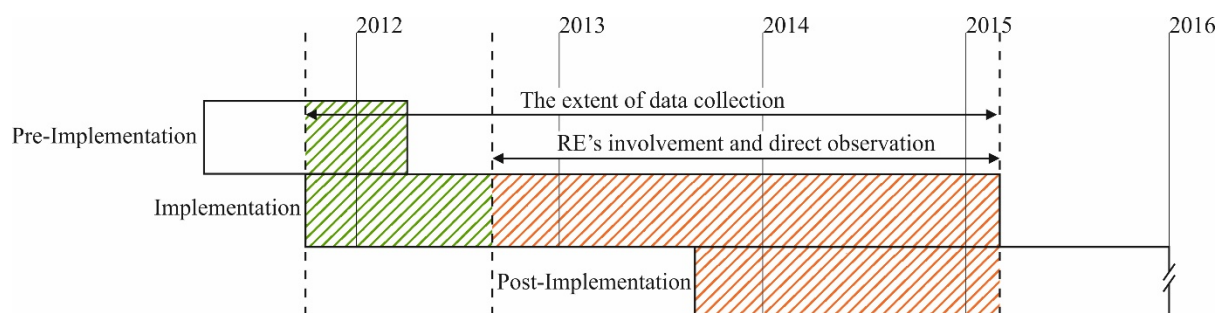


Figure 3:1 The timeline of the data collection process in the case studied (Objective 2).

The IOIS implementation project in the case studied was undertaken for a large contractor firm which is one of the top 20 contractor firms in the United Kingdom (UK) in terms of turnover<sup>8</sup>. The decision to implement IOIS was made at organisational level by the firm's senior level management during early 2011. The sponsoring company was selected in mid-2011 as the technology solution provider to design, develop and implement the system. The development process consisted of three main stages. In the first stage, a procurement system was developed by the sponsoring company which took around 6 months to accomplish. The second stage involved setting up of the link between the contractor firm and the technology vendor. In the third stage, the selected supply chain firms (n=10) were invited/brought into the project to enable a fully automated procurement process. Following a short trial period with one of the business units of the contractor firm, the Cloud-based B2B e-Marketplace system was rolled live across the three business units (construction, facilities management and infrastructure), five specialist subcontracting businesses (Civil Engineering, Custodial, Groundwork Engineering, Interiors and, Mechanical and Electrical) and 42 projects of which five were Joint-Venture projects. Following describes the methodology adopted in relation to each research task.

**Task 4. Lessons Learned During Supplier On-Boarding Phase of an IOIS Implementation Project.** The investigation in Task 4 focused on the supplier integration (supplier on-boarding) stage which was the core task in delivery of the IOIS by the sponsoring company. The direct observation by the RE was carried out over a longitudinal time frame (little over 2 years) beginning from late 2012, and involving ten supplier integration projects. The data gathered from multiple sources were collated in a master spreadsheet for each supplier integration project as shown in Figure 3:2. The data sources include project development logs (the back-end software activities), meeting minutes, and project reports as well as participant-observation data gathered through face-to-face and teleconferencing meetings. In addition, the RE captured information from the email communications for identifying both the technical and project related issues during the supplier integration process. Email is one of the most widely used tools in intra and inter-firm project communication and collaboration. In the current era of work practices, email is well integrated with everyday workplace tasks of project team members who are dispersed across geographies and time zones (Whittaker and Sidner 1996). Another reason for selection of email data was that email documents the accountability and commitment in projects. The information extracted from the past email communications not only provide a lot of insight into the particulars of each integration project but also— perhaps more importantly,

<sup>8</sup> Based on data from: [theconstructionindex.co.uk/](http://theconstructionindex.co.uk/), (Top 100 Construction Companies in 2016)



reveal invaluable information on individual, collective and organisational memories on projects.

### Task 5. Post-implementation Evaluation of IOIS— A case Study of a B2B e-Marketplace.

The research in Task 5 focused on the ex-post implementation stage, covering the first year of going live to identify and analyse the key characteristics of the IOIS which yields the best chance of use and adoption amongst its primary user base. More specifically, there were two questions which the research sought to address: (i) what was the extent of adoption and acceptance, and (ii) what were the challenges that users faced during the on-going use of the system? The study utilised a well-established theoretical model developed in the IS literature; DeLone and McLean Information Systems Success Model by DeLone and McLean (1992), to explore these two questions. Several complementary qualitative and quantitative data sources were utilised for data collection and analysis including; information gathered from technical issue logs, 12-month usage statistics, and two electronic questionnaire surveys (issued to end-users at two different points in time). With regards to the usage analysis, a master register (which contained data relating to system use at multiple levels, for example: individual, project and business unit), was created to analyse the actual usage statistics in the first year of going live with the implementation project.

Yin (2014) advocates the use of four tests in order to strengthen the generalisability and increase the internal and external validity of the findings derived from a case study research. These are shown in Table 3:3 along with the strategies that were employed during the course of investigation. In addition, the RE had adopted the role of a neutral/detached observer in data collection and analysis in order to prevent value-ladenness of the inquiry. Further, the RE had adhered to a transparent and consensual research process (involving close collaboration between the contractor firm and sponsoring company) to enable a non-biased data collection, analysis and refinement of the research findings.

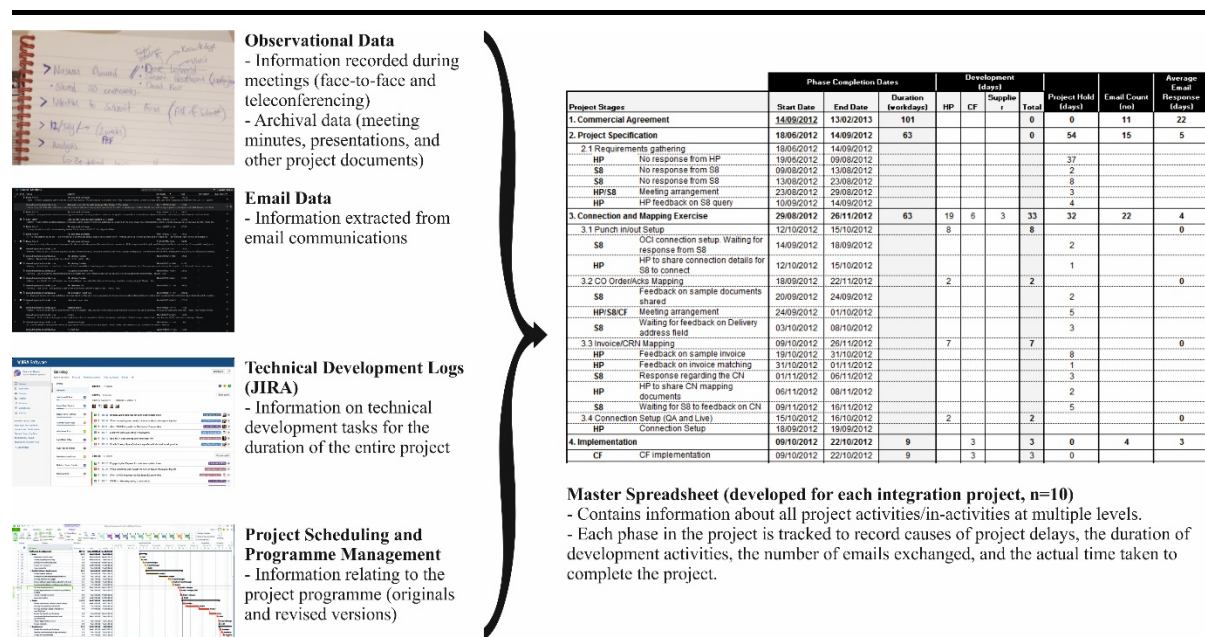


Figure 3:2 Task 4 research protocol for data collection and analysis.



### 3.4.3 Research Objective 3

The third research objective was a solution-oriented mission which was set out with the objective of developing a guideline to help contractor organisations with execution of IOIS implementation. The previous two objectives prepared the ground-work where the findings and implications drawn from the preceding research tasks were used as a guidance in the development of a practice-oriented framework for implementation of the IOIS projects. The process adopted in Objective 3 was guided by the coding principles of the GT (grounded theory) which, according to Birks *et al.*, (2012), has become an increasingly adopted research strategy in the IS research. In order to avoid any misconception on the use of the GT label, it is important to note that, the GT was adopted as a technique for a systematic exploration, analysis and synthesis of previously undertaken tasks rather than to build a new substantive theory.

A three step-process was followed in development of the strategic implementation guideline. First, as an initial step, a review of literature on existing guidelines on IS Implementation and Management was carried out. This included a variety of academic and industry-based IS-specific guidelines as well as sponsoring company's internal IS development protocols, which are all aimed at planning, design, development, delivery and maintenance of IS and IS projects. Each guideline/protocol/framework was studied in terms of its purpose, key areas of concern, as well as the main weaknesses and strengths to help establish the general properties and formulation of the structure of an IOIS implementation framework. In the second step, the findings and implications of the research undertaken in Tasks 1 to 5 were incorporated into an IOS implementation framework. The third and final-step involved further refinement and consolidation of the framework to provide a coherent, strategic guideline for the delivery of IOIS projects.

### 3.5 Summary

This chapter has discussed the key issues on research methodology for the EngD project. It provided an overview of the main considerations in design of the research, including the ontological, epistemological and methodological choices and justified their adoption in the

Table 3:3 Research validation strategies employed in the case studied (Objective 2).

<i>Tests</i>	<i>Yin's (2014) suggested tactics</i>	<i>Phase in the Research</i>	<i>Strategies Adopted for Objective (Tasks 4 and 5)</i>
<b>Reliability</b>	<ul style="list-style-type: none"> <li>Use case study protocol</li> <li>Develop case study database</li> </ul>	Data collection	<ul style="list-style-type: none"> <li>Development of master spreadsheet to collect all relevant information in a single, reliable, and accurate register (Task 4 and 5)</li> </ul>
<b>Construct Validity</b>	<ul style="list-style-type: none"> <li>Use multiple sources of evidence</li> <li>Establish chain of evidence</li> <li>Have key informants review draft case study report</li> </ul>	Data collection Composition	<ul style="list-style-type: none"> <li>Multiple sources of evidence (observational data, email communications, development logs, archival data, questionnaires and statistical data) (Task 4 and 5)</li> </ul>
<b>Internal Validity</b>	<ul style="list-style-type: none"> <li>Do pattern-matching</li> <li>Do explanation building</li> <li>Address rival explanations</li> <li>Use logic models</li> </ul>	Research design	<ul style="list-style-type: none"> <li>Longitudinal approach to data collection and analysis (Task 4 and 5)</li> <li>Observation of multiple cases within a single-case study (Task 4 and 5)</li> </ul>
<b>External Validity</b>	<ul style="list-style-type: none"> <li>Use theory in single-case studies</li> <li>Use replication logic in multiple-case studies</li> </ul>	Data analysis	<ul style="list-style-type: none"> <li>Application of a well-established theoretical model in the IS literature: DeLone and McLean (2003) IS Success Model (Task 5)</li> <li>Comparisons with the lessons learned and critical success factors/challenges cited in the IS literature (Task 4 and 5)</li> </ul>

context unique to this research. Theoretically, the principle aim of this EngD study is to support the cross-fertilisation between cSCM and IOIS by providing conceptual, theoretical, and practical insight into their joint-application. The very nature of an EngD research project demands that traditional research methods should be adapted and adjusted to fit the organisational realities at the sponsoring company. A multi-methodological research strategy was adopted in order to focus more distinctively on all the three objectives of the research (see Table 3:4 for the summary). The data collection was not limited to a specific method or source, and involved collection of both qualitative and quantitative data in order to aid the reliability of the findings. The form of reasoning used in the analysis were based on a combined inductive and deductive strategy supported by a variety of statistical and non-statistical methods.

Following chapter presents the research undertaken and main findings drawn from the study.

Table 3:4 The data collection and research strategies adopted in the EngD study.

<i>Research Objectives:</i>	<i>Research Strategies</i>	<i>Research Tasks:</i>	<i>Data Collection Methods:</i> Primary Source (P) Secondary Source (S)				
			<i>Literature Review</i>	<i>Interviews</i>	<i>Questionnaires</i>	<i>Document Analysis</i>	<i>Participant Observation</i>
(1) Identify the current practices and challenges for ICT-enabled Supply Chain Management by contractor organisations	Survey Research	1. Review the state-of-the-art on construction-specific SCM and SRM.	P				
		2. Explore and identify the current practices and challenges for ICT-enabled SCM technologies by contractor organisations.	P	S		P	
		3. Explore the current AEC-specific Software-As-A-Service solutions that facilitate the collaboration and management of construction supply chains.	S			P	
(2) Examine the main challenges and barriers in Inter-Organisational Information Systems (IOIS) implementation projects and identify the key factors for successful implementation	Case Study	4. Examine the main challenges and barriers during supplier on-boarding phase of an IOIS implementation project.	S			P	P
		5. Examine the post-implementation challenges; the user adoption and on-going use of a private B2B e-Marketplace system.	S		P	P	S
(3) Develop a guideline for IOIS implementation by contractor organisations	Grounded Theory	6. Synthesize the previous work and develop a strategic guideline for contractor firms seeking integration with supply chain firms.	P			P	P

## **Chapter 4: Research Undertaken and Findings**

### **4.1 Introduction**

This chapter presents the work undertaken to satisfy the aim and objectives of the EngD project. To avoid repetition, references are made to the resultant academic publications and other relevant material attached to the appendices.

### **4.2 Objective 1. Identify the current practices and challenges for ICT-enabled Supply Chain Management by contractor organisations**

The aim of the first research objective was to investigate the cSCM from a relationship-centric perspective (Task 1) and the ICT tools and technologies utilised to facilitate the integration with downstream (and upstream) supply chain firms (Task2). To recognise different technologies implemented by contractor organisations (and their supply chain firms), this research also presents an overview of the technology landscape from the perspective of the SaaS vendors in Task 3.

#### **4.2.1 Task 1. Relationship-centric SCM and integration in the AEC industry**

In order for cSCM to be pursued with the right suppliers it is necessary to understand the intrinsic characteristics of the relationship between contractors and their suppliers. The aim of the first task was to develop an understanding of the inter-firm relationships in the AEC industry. The review of literature in Section 2.2 to 2.5 introduced the concept of SCM and the challenges that contractor firms face in its adaptation. The findings presented in this section develops a relationship taxonomy for implementing relationship-oriented cSCM.

##### **4.2.1.1 Method**

Task 1 was carried out as part of the EngD Short Project module undertaken towards the end of Year 1 of the EngD project. The relationship-centric cSCM is primarily concerned with the relational attributes that play a key role in formation and development of inter-firm relationships. Drawing on prior literature, a desk study was conducted to explore the key relationship indicators for effective and efficient construction supply chains. Furthermore, based on a review of business management and relationship marketing body of knowledge (where majority of relationship research is conducted), seventeen relational attributes were identified. Together with the earlier findings, the research developed a conceptual framework which categorise the contractor-supplier relationships into four types for a relationship-focused cSCM strategy.

##### **4.2.1.2 Findings**

The most common themes for effective and efficient supply chain relationships were mapped in a matrix-style spreadsheet which is presented in Appendix C-1 of Paper 2 (attached to Appendix C of this thesis). The thematic analysis carried out in Paper 2 revealed that the effective and efficient supply chains in the AEC context is usually judged on social, economic, organisational, inter-personal and technological dimensions of interaction where there is high emphasis on improving the organisational aspects of supply chains. Paper 2 documents partnering and collaboration as the two most important practices for relationships to function whereas ‘trust’ was identified as the single most quoted facilitator which must be deeply embedded into the relationships. However, despite being one of the most prominent attributes of non-adversarial relationships, the work undertaken in Paper 2 suggests there is more work needed to understand how different dimensions of trust (referred to as ‘ESPIO’— *economic, social, psychological, inter-personal and organisational* dimensions of trust) develop within

and between supply chain firms over the life-cycle of relationships. By combining these five dimensions of the trust construct, Paper 2 calls for a more holistic approach to study trust in construction supply chain relationships.

It was gathered from the literature study that most construction projects are formed of disjointed temporary multi-organisations which consequently create an immense barrier in the control and coordination of the network of supply chains. The literature studied also point out that it is not possible, or feasible, for contractor firms to manage all of its organisational and project supply chains. Consequently, the RE concentrated on exploring the different types of relationships that exist in an organisation's supply network. In contrast with the transaction-based view of construction supply chain relationships (which generally focus on the characteristics of the exchange and its control mechanisms), the relationship-oriented view to cSCM provides a better understanding in terms of the characteristics of the inter-firm relationships and the circumstances in which relationships are created, developed and/or ended. Moreover, the relationship-oriented view to cSCM enables the contractor organisations to focus on their relationship with the supplier firm in the immediate tier in order to co-ordinate, manage, integrate or enhance the supply chain operations across the extended supply chain tiers.

The work undertaken in Paper 1 identified four relational forms labelled as transactional, series of transactions, project collaboration and long-term strategic partnering. In brief, the four relationship categories can be described as follows.

1. *Transactional Relationships* are the most common type of relationships in the industry, characterised by one-off, short, and transient exchange/interaction. The transactional relationships can lead to further transactions or collective transactions can breed a higher category of relationship.
2. *Series of Transactions* occur when a buyer (main contractors) sources a product and/or service from a list of preferred or pre-qualified suppliers. For example, most contractors nowadays hold framework agreements with pre-selected suppliers who are contracted to supply a commodity, product and/or service at a pre-determined price, and, deliver on the contract as and when requested.
3. *Project Collaboration* relationships comprise of closer relational arrangements between a contractor firm and key supply chain partners on a project-by-project basis where the emphasis is on building and working in a collaborative and co-operative spirit in every project.
4. *Long-term Strategic Partnership (LTSP)* is strategic and long-term orientated relationship model which aims to create synergy and a 'win-win' outcome for the both parties involved in the relationship.

The relational categories above indicate varying levels of social, economic, organisational, individual and technological maturity where each relational form increase in terms of longevity, volume, complexity, integration and strategic importance as it progresses from one level to another (see Table 2 in Appendix B which summarise the best-practice relationship indicators and, Appendix D-1 in Paper 3, for the characteristics and attributes of each relationship category). The problem with classification of relationships is generally challenged with the view that every relationship is unique (composed of different relational entities that make up its 'DNA') and dynamic (relationships are never absolute but in a constant state of evolution). However, the aim of the above relationship typology is to identify the general properties of relationships, hence it does not imply that all relationships conform to particular category; but, rather describes the key determinants of different relational forms which can be used develop a taxonomy for cSCM. The work undertaken as part of the next research task provides an example of a relational oriented cSCM model.

## 4.2.2 Task 2. Contractor practices for ICT-enabled cSCM

Task 2 takes up the theme of the findings from Task 1 for undertaking a field study on tools and technologies that contractor firms adopt for management and integration with their supply chains. It is worth noting that, although Task 1 established that the ‘trust’ element is an essential part of construction supply chain relationships, following the advice from the industrial sponsor the research in Task 2 shifted its focus from exploring the soft relational attributes (that is, trust) to the hard elements (ICT) in functioning and management of relationships. In order to accomplish this task, the RE utilised the relationship categories developed earlier to explore the SCM practices by large contractor firms and the extent to which ICT-enabled cSCM are adopted with upstream/downstream supply chain tiers.

### 4.2.2.1 Method

The RE utilised questionnaire survey strategy to fulfil the research objectives in this task which is set to identify the contractor firms’ cSCM practices (the procurement and supplier relationship management approaches) and the ICT that are utilised across dyadic and extended network of supply chains. ICT was taken as a term to refer to the tools and technologies which are used during the execution of inter-firm design, construction, and procurement activities, and included tools/technologies which are commonly mentioned/reported in the construction-specific and generic SCM literature (n=11).

An online questionnaire survey was used for data collection. The profiles of respondents selected for the survey were procurement managers, supply chain managers, project managers, commercial directors, business development managers, project managers and construction managers. The rationale behind selecting these groups of respondents was to allow ‘breadth’ in answers given and capture full representation of the strategic and operational aspects of SCM and relationships at project and organisational levels. A pilot study was conducted with a small sample of respondents (n=4) in the form of interviews (each lasting about an hour) to identify any errors and come up with suggestions, comments and critique with regards to the design, structure, language and relevance of the questions.

Following the piloting phase, the respondents were invited to participate in the survey by telephoning them, followed by personalised e-mails which had information about the research and how to participate in the survey. Around 50 telephone calls were made to contractor firms and individuals whose details were obtained from internet search and company websites. The purpose of telephone calls was to pre-screen the companies to identify the key informants and if possible getting their prior commitment to participate in the survey. However due to low rate of response from this group the survey was further distributed to 115 people (via email) whose details were obtained from the sponsoring company’s database, internet searches as well as company websites. The whole data collection process was confined to 4 weeks and at the end the overall response rate was 30 per cent (49 responses) from a total of 165 people approached.

### 4.2.2.2 Findings

The findings of this task, which is reported in Paper 3 (attached to Appendix D for reference), provided interesting insight into the main contractors’ dyadic and extended relationships with their supply chain firms. In line with the prior literature, procurement was found to be the key mechanism that defined main contractors’ inter-relationship with supply chain firms. The one-off arrangements were reported as the most implemented procurement route for appointing the suppliers in a construction project whereas project partnering/collaboration, framework agreements and long-term strategic partnering relationships were less common. This is perhaps predictable given that the context in which supply chain firms come together to cooperate or collaborate is not the same in every project.

In terms of engagement with the extended supply chain firms, the results were split between two groups of organisations. About half of those surveyed indicated that ‘few’ aspects of their organisation’s supplier selection strategy considered supply chains beyond their immediate tier which reinforce the findings from literature that contractors have little, if none at all, awareness and knowledge about supplier firms who are located remotely in downstream supply chain tiers. Nevertheless, the other half of the respondents stated that ‘many’ or ‘most’ aspects of their selection strategy was extended to other tiers below the supply chain which indicates that some contractors are beginning to consider the impact of firms in downstream supply chain tiers. Indeed, this was confirmed when respondents were asked about the last tier of firms which they have a high involvement relationship (see Figure 4:1). In spite of the low levels of early engagement, majority of the firms surveyed have indicated that they have an intense interaction with firms deep in supply chain tiers, in particular with Tier 2 of the downstream supply chain firms such as ‘Suppliers to Subcontractors’. As can be seen by Figure 4:1 majority of the inter-firm relationships in downstream tiers are primarily composed of contractual and technical entities. Financial and inter-personal relationships were found to be less common (except with Tier 2 firms) indicating weaker ties in terms of monetary (financial) and social links.

The primary reason for contractors to extend the inter-firm relationships were reported as: to increase value; to reduce any risk associated with the supply chain; to reduce costs as well as to increase efficiencies, which all suggests a project-focused supply chain interaction with the extended supply tiers. In addition to this, the respondents have also indicated reasons such as technical requirement, increasing client satisfaction, strategic importance of the commodity of product/service, innovation requirement, size of the package/tender, and, maximising profits as their main reason for engaging with the extended supply chain tiers. Overall, although the findings reaffirm the fact that contractors’ primary focus is on Tier 1 supply firms, the results suggest that contractors operationally stretch their relationships to firms in deeper downstream supply tiers, albeit predominantly on a contractual and technical basis rather than long-term, co-operative and collaborative organisational supply chain decision making.

With respect to the upstream supply chains, the findings show that main contractors’ upstream relationships are generally confined to Tier 1 firms (the client, project architect, project manager, consultants and so on) where most of these relationships are made up of financial, technical, contractual and inter-personal entities. Few instances of the extended relationships were also reported by the respondents where it was indicated that some relationships extended to Tier 2 firms (such as Project Financiers and Local Authorities) and Tier 3 firms (such as tenants, end-users and owners) as a result of direct or extended contractual links (see Figure 4:1). However, in comparison with the downstream supply chain tiers, the results for the upstream supply chains were much more consistent. This finding indicates the persistence of the parochial practices reported in the past, that is, contractor firms largely focusing on their relationships with firms in the immediate upstream supply chain tiers (Tier 1 firms).

Two approaches were mentioned with respect to the upstream/downstream supply chain relationship management; one being characterised as strategic management of relationships by senior level managers, and the other is the use of specific processes, procedures and protocols that are embedded into the inter-firm interaction processes. Nevertheless, the discontinuity in the relationships, regular changes in relationship management processes and the set standards for forming relationships in public projects were cited as the main reason for lack of proper execution of supplier relationship management by contractor firms.

In terms of the ICT-enabled SCM practices, one of the key finding of the research was that contractor firms utilise similar set of ICT tools/technologies with both, Tier 1 upstream and downstream firms to help facilitate cSCM. The most used ICT technologies with Tier 1

upstream/downstream firms are ranked in the following order (refer to Table 3 in Paper 3 for further information).

1. Building Information Modelling (BIM)
2. Project Extranets
3. Integrated Databases
4. Advanced Planning and Scheduling Systems
5. Electronic Data Interchange

The high response rate for the BIM technologies is attributed to two reasons: the push by UK government which is driving the momentum to get supply chain firms on the BIM bandwagon or majority of respondents are early adopters of BIM technologies in some shape and form (for example, firms seeking to become level 1 or level 2 compliant). However, although the BIM technologies could be highly diffused in construction projects, from organisational viewpoint the simultaneous adoption of BIM and SCM is not thought to be equally high. This is because within the AEC industry, the BIM technologies and processes are in a constant state of evolution and are yet to reach maturity at *supply chain level* (Eadie et al. 2013).

The adoption of Project Extranets, Integrated Databases and Electronic Data Interchange Systems, on the other hand, indicate the key role of such technologies in sharing of project and commercial data with both upstream and downstream supply chain firms. Similarly, advanced planning and scheduling systems also enable sharing and exchange of project data for streamlining construction processes so their use by contractor firms indicate integrated supply chain operations. However, further analysis of the findings shows that there is inconsistency and disparity in the number and usage of ICT technologies along the supply chain tiers. Despite having high involvement relationships with Tier 2 downstream firms there is a considerable reduction in the number of tools adopted with the firms in lower supply chain tiers (see Paper 3 for further information). The main challenges for non-adoption of these technologies along the supply tiers were ranked as follows.

1. Cost
2. Lack of awareness

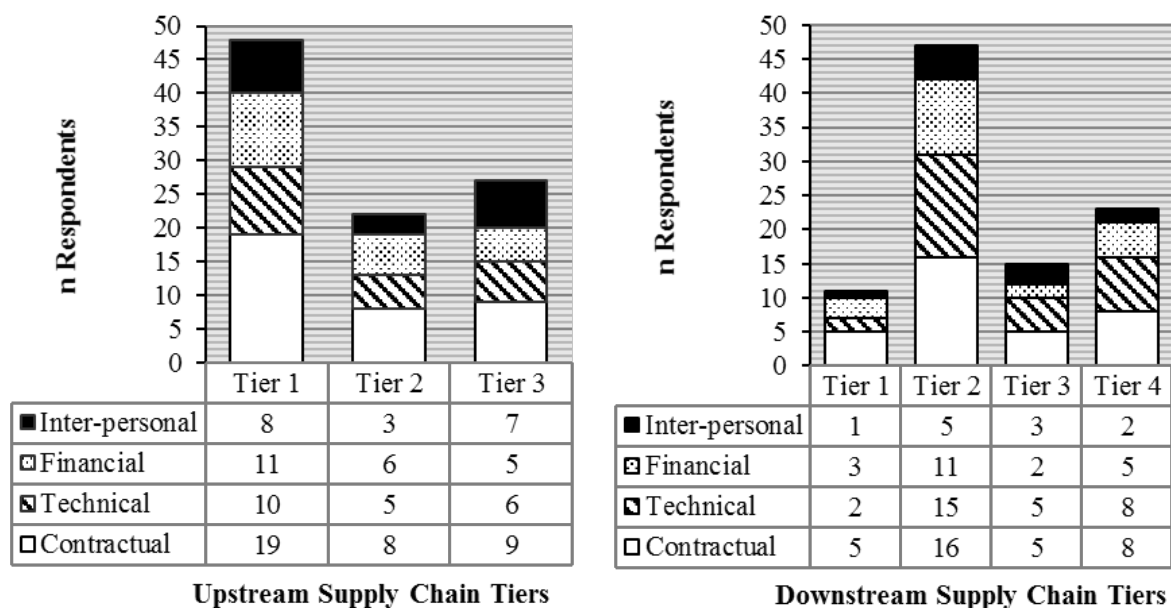


Figure 4:1 The extent of the contractor's relationships with firms in downstream and upstream supply chain tiers.



3. Supplier resistance or reluctance to adopt
4. Compatibility with current tools/technologies
5. Interoperability with different systems/tools

Overall, the main implications arising from Task 2 findings is that ICT-enabled cSCM is difficult, if not impossible, to adopt along the entire length of a construction supply chain. Nevertheless, the findings indicate that there exist opportunities for contractor organisations to stretch their ICT-enabled SCM mechanisms to Tier 2 downstream supply chains which could greatly benefit from closer cooperation and integration. Paper 3 suggests that alignment of cSCM and ICT must embrace a relationship-centric approach whereby the length of supply chain interaction and management strategy is maintained at a comparable complexity which is relative to the supply chain relationship with the supply firm in the immediate tier. Depending on the characteristics of the relationship, different ICT solutions should be utilised to facilitate efficient, timely and cost-effective supply chain interactions. Based on these findings, Paper 3 proposes a conceptual model (see *Section 5* for more information) for management, coordination, control and monitoring of the supply chain firms in extended tiers.

### **4.2.3 Task 3. Marketed functionalities of SaaS providers**

The rise of the ICT in the last decade has resulted in myriad of technological solutions being provided over the Internet. Considering the unique requirements of the construction projects and organisations, technology solution providers developed tailored Software-as-a-Service (SaaS) solutions for AEC firms to facilitate the coordination, integration and collaboration of construction supply chain operations. The literature study presented earlier established that there is a knowledge gap in relation to the system functionalities of the current SaaS vendors. To further facilitate our understanding of the cSCM tools/technologies, the research in Task 3 looked into the main functionalities provided in the current SaaS solutions. The questions pertinent to this task include what are the prominent features of the vendors' SaaS offerings and their relevance in cSCM to enable integration between construction supply chains? Acknowledging the fact that functionality reports tend to have a short life-span, an up-to-date assessment is considered to be beneficial in comparing and contrasting trends in development of collaborative technologies.

#### **4.2.3.1 Method**

The SaaS vendors were identified through internet search, industry magazines, and academic publications. Only those vendors which target the AEC industry and have use cases by contractor organisations were selected for the evaluation. In total seventy-eight SaaS vendors were evaluated for this task. The data obtained is substantially secondary data which is gathered through the survey of the key functionalities marketed by the vendors. The RE also extracted information from case study reports, software release notes, white-papers, and interviews with senior management roles (conducted by various influential AEC-technology bloggers) in order to help with the verification of the claims asserted by the vendors and increase the accuracy of the information gathered.

The evaluation involved an iterative process. The core functionalities marketed by each vendor were mapped in a matrix whereby six categories (procurement, project management, document management, logistics management, enterprise resource planning and social networking) were identified after going through the first stage of evaluation. Next, the key features supplied as part of the core modules were recorded at multiple levels and each vendor's solution was re-examined to make sure all the features are included and documented in the right context. Only the major functional aspects were documented to avoid over sophistication of the evaluation.

In order to analyse the commonalities and differences among the technology vendors, further categorisation was made in terms of the construction project stage focus, vendor's primary and secondary functionality category, deployment options, and the dominant (or emergent) marketplace of the vendor. For example, after the initial review it was clear that some vendors were focusing on a specific stage in a construction project whilst others were offering more comprehensive solutions aimed at construction project life-cycle management. Furthermore, in majority of the cases technology vendors were offering additional solutions/services besides their core product in the market. Thus, each vendor was classified in terms of its primary functionality category which relates to the vendors' main product, and secondary functionality category which is the supplementary or additional capability provided as part of the core product family. The type of deployment refers to the availability and access to the services via Cloud, mobile devices or on-premises installation, whereas the dominant (or emergent) marketplace is the region in which the vendor has an established presence.

Figure 4:2 is a snapshot of the matrix. Each vendor is tabulated in the blue area in Figure 4:2. The red area lists the functionalities and associated features. The green indicates the primary/secondary functionality category of vendors, the marketplace, construction project stage focus, and the deployment options. The yellow area is signposted with two markers where '+' indicates a supported feature/functionality, and 'o' indicates a limited feature/functionality (for example, in development or there is insufficient information regarding the feature/functionality).

#### **4.2.3.2 Findings**

The results show that majority of the SaaS vendors have emerged from and, have active operations in the UK AEC market (38%), followed by US (31%), EU (21%) and Australia (5%). Although most vendors operate in multiple regions, only few vendors are considered to have extensive presence worldwide (for example Bentley, Oracle, Microsoft SharePoint and Autodesk). Due to lack of reliable and comparable financial information it is difficult to determine the market share of the vendors, and the size of the sector. Owing to the highly dynamic and competitive nature of the technology industry, the marketplace for SaaS vendors seems to be in a constant change as many of the previously reported vendors are taken over by mergers and acquisitions, exited the market or gone bankrupt. Furthermore, there are many smaller start-up firms entering the market which, as a consequence make it difficult to predict or report on the financial state of the market and its key players.

As can be seen from Figure 4:3, the majority of vendors aim their solutions at construction project life-cycle (59%), followed by construction stage (21%), facilities management (9%), design and construction (6%), and procurement (5%). With the exception of few vendors (Asta PowerProject, BlueBeam, Causeway, Coins, IFS, RedSky-IT and Microsoft SharePoint) which its primary offerings are deployed locally on-premises, all of the solutions/services are Cloud-native and/or can be accessed through mobile devices (such as tablets and smartphones). In terms of the main characteristics of solutions being offered, 39 vendors (out of 78) target their solutions for Project Management with the remaining half concentrating on Document Management, ERP, Procurement and Social Networking (25, 8, 5 and 1 respectively).

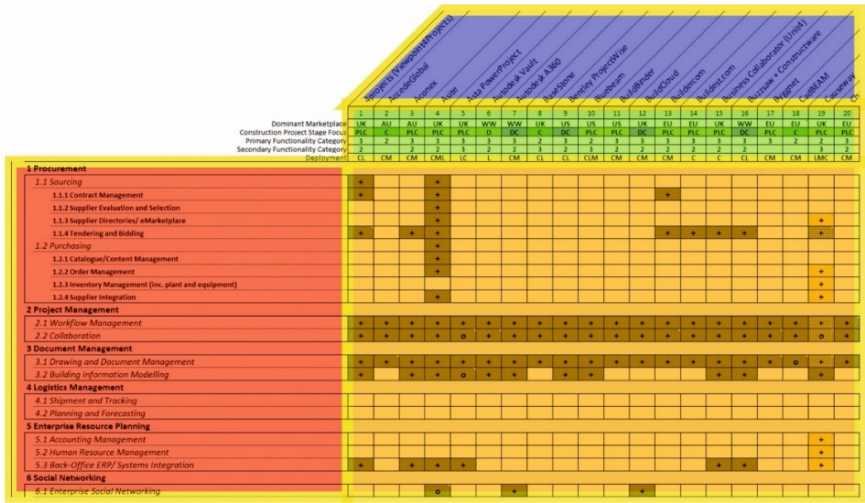


Figure 4:2 Snapshot of the software vendor’s evaluation matrix.



		Dominant Marketplace																												Construction Project Stage Focus																												Primary Functionality Category																												Secondary Functionality Category																												Deployment																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
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The most common functionalities amongst the vendors' offerings are Project Management (PM) and Document Management (DM) applications which are offered by 73 and 62 vendors respectively. There are several features embedded into the DM and PM. With respect to the PM, these are customisable workflow management and inter-firm collaboration for various project related tasks. An essential feature of inter-firm collaboration is the role-based privileges which help determine which role/team/company sees what information, thus allowing multiple organisations to work on the same project. Amongst the sixteen features identified, the most supported PM capabilities are RFx (for example, Request for Information, Instructions or Notices) followed by Task Management for auditing and management of the document related tasks (such as review for comments, approval and status change). Following provides the list in full.

1. RFx (40)
2. Task Management (38)
3. Snagging, Defects and Issue Management (33)
4. Project Plan, Program and Schedule Management (32)
5. Submittals and Transmittals (31)
6. Project Cost Control Management (25)
7. Facilities/Asset Management (24)
8. Safety Inspections (16)
9. Change Management (14)
10. Site Management (9)
11. Health and Safety Management (8)
12. Plant and Equipment Inspection (8)
13. Timesheet Management (7)
14. Risk Management (7)
15. Sustainability Management (4)
16. Knowledge Management (4)

With respect to the DM, while most vendors support basic file storage capability (either on Cloud or on client servers), in most cases the functionality extends to viewing, coordination and management of CAD and other common file types (for example spreadsheet, word-processing, image and pdf file formats). Another recurring capability within the DM is the mark-up, comments and discussion facility which includes an array of functional toolsets (e.g.: drawing comparison/overlay, measuring tools, layers and views, and so on). Given that such features involve constant updates and development they were not included in the evaluation. The ability to support BIM (by means of a common data environment through which different users/teams/organisations can work on development of a unified and intelligent model) is another key feature, however it is mostly supported by vendors in the construction project life-cycle management category.

Around half of the vendors (37/78) offer Procurement application to facilitate the sourcing and purchasing processes. In relation to the former, Tendering and Bidding is the most supported capability (33/37) with two primary features: ability to issue tender packages and sending out invitations to suppliers to bid, and support for the subsequent tender evaluation processes. The latter process is primarily supported in the form of Order Management, that is, ability to send/receive purchase orders and invoices. Alongside the Procurement component, considerable number of vendors provide ERP functionalities such as accounting management (12 vendors), and human resource management (8 vendors), systems integration (38 vendors), and commercial management (29 vendors). The remaining two groups of functionalities (Logistics Management and Social Networking) are not substantially included amongst the vendors' offerings and therefore considered to be an add-on feature complimenting the core functionality categories.

The SaaS vendors which were surveyed as part of this task provide on average three key features. Although none of the vendors provide all the features and functionalities listed in the matrix, the vendors which provide a total project life-cycle support offer a much extensive suit of application and functionalities (see Figure 4:4). However, it must be highlighted that most of these vendors' solutions are oriented towards PM and DM (37/46), indicating that the Procurement and ERP functionalities are offered as a complimentary package to facilitate the project-related commercial tasks. On the other hand, several vendors provide more specialised portfolio of ERP and Procurement solutions to support organisational SCM processes including construction project portfolio management (for example, Coins, Causeway, IFS World, and Red-Sky IT). However, although most of these applications are Cloud-native, they are primarily delivered through local deployment. Table 4:1 lists the Cloud-based PM solutions which are capable of interacting with external systems (via, for example, APIs and interoperability frameworks). Given that only 23 vendors are capable of interfacing and networking with other systems, this indicates that majority of the current solutions are siloed

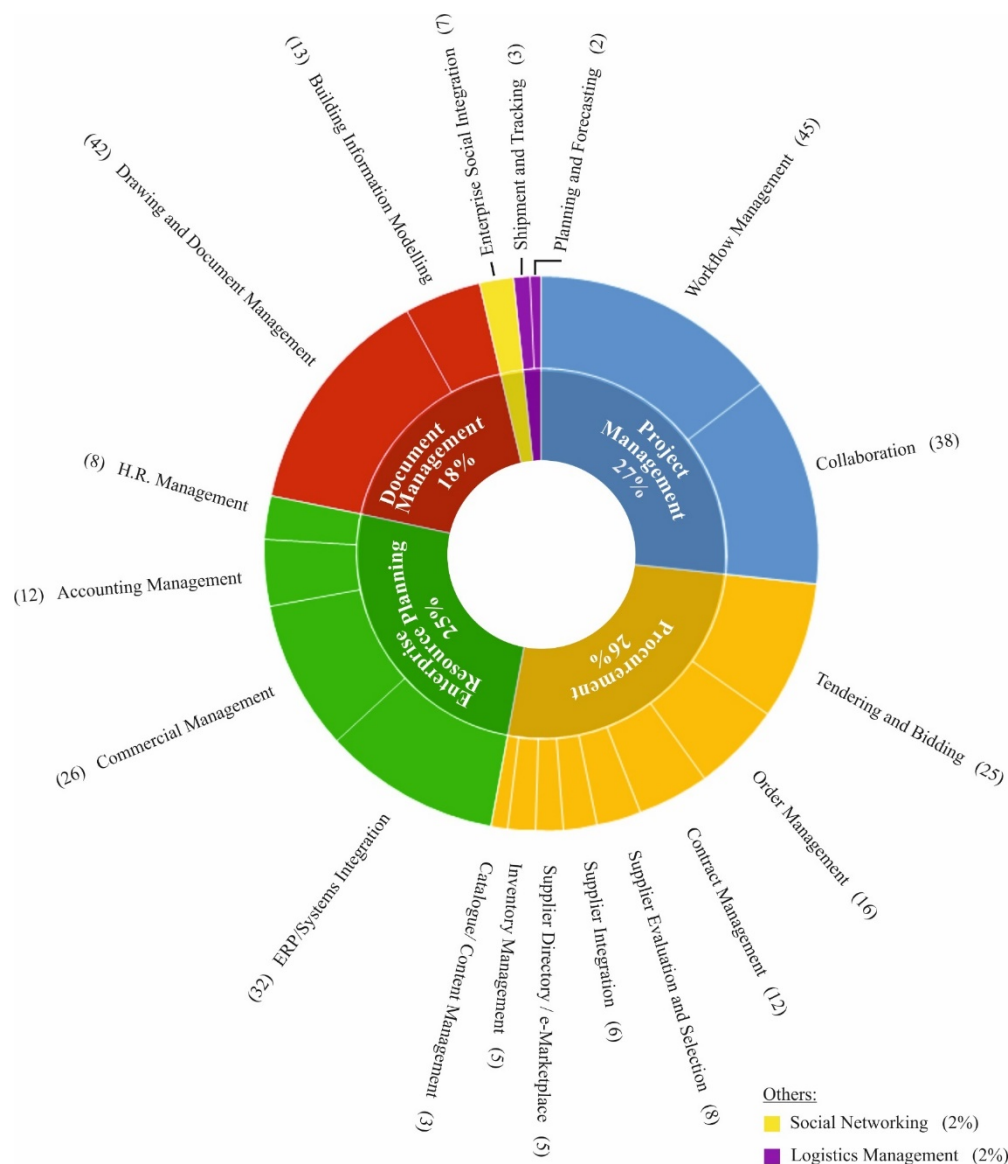


Figure 4:4 The SaaS vendors which offer project life-cycle management solutions (n=46).

and offer limited functionality to support the re-use of information generated within or residing in external systems.

The evaluation of the SaaS vendors provides corroborating evidence on the lack of a single comprehensive solution (and systems provider) which enables integration of actors, processes and technologies between construction supply chain firms. Whilst the PM and DM components leads the most implemented functionalities, and probably the most mature solution amongst the vendors' offerings, the Procurement and ERP modules, which are both essential for cSCM, do not encompass similar types of advanced features for more collaborative and integrated approach to construction project life-cycle management. Thus, beyond addressing the project-based inter-organisational communication needs, the existing solutions have limited capacity in terms of a holistic approach to control and management of the supply chain activities.

Table 4:1 Cloud-based SaaS vendors which provide inter-firm collaboration and back-end systems integration functionalities.

#	Vendor	Website	Dominant Marketplace	Construction Project Stage Focus	Primary Functionality Category	Secondary Functionality Category	Deployment
1	4projects (Viewpoint for Projects)	4projects.com	UK	PLC	2	3	CL
2	Aconex	aconex.com	AU	PLC	2	3	CM
3	Asite	asite.com	UK	PLC	2	3	CML
4	BuilderStorm	builderstorm.com	UK	PLC	2	3	CM
5	Business Collaborator	groupbc.co.uk	UK	PLC	2	3	C
6	CMiC	cmicglobal.com	US	PLC	2	5	C
7	Conject	conject.co.uk	EU	PLC	2	3	CM
8	EADOC	eadocsoftware.com	US	PLC	2	3	C
9	e-Grou	e-grou.com	EU	PLC	3	-	CL
10	Envision	envisionapp.com	AU	PLC	2	5	CM
11	GamePlan	gameplanpro.com	US	PLC	2	3	CM
12	Huddle	huddle.net	UK	PLC	2	3	CML
13	McLaren Fusion Live	mclarensoftware.com	UK	PLC	2	3	CM
14	PMWeb	pmweb.com	US	PLC	2	3	C
15	Procore	procore.com	US	PLC	2	3	CM
16	ProjectMates	projectmates.com	US	PLC	2	5	CM
17	ProjectPlace	projectplace.com	EU	PLC	2	-	CM
18	RIB Software	rib-software.com	EU	PLC	2	5	C
19	Stratusvue	stratusvue.com	US	PLC	3	5	C
20	thinkPROJECT!	thinkproject.com	EU	PLC	2	3	CLM
21	Union Square	unionsquaresoftware.com	UK	PLC	5	2	CLM
22	Viewpoint	viewpoint.com	US	PLC	5	2	CLM
23	Webforum	webforum.com	EU	PLC	3	2	CM

Key:

Construction Project Stage Focus: PLC= Project Life-Cycle

Deployment: C= Cloud, L=Local, M=Mobile

Functionality Category: 1= Procurement, 2= Project Management, 3= Document Management, 4= Logistics Management, 5= Enterprise Resource Planning



#### 4.2.4 Summary

The first stage of the research carried out the preliminary investigation into cSCM and ICT practices of contractor firms. Overall, the key findings and implications arising areas follows.

- The research carried out in Task 1 provides an anatomical study of the supply chain relationships in AEC industry context. It concludes that relationships in construction supply chains are composed of multitude of economic, social, organisational, individual and technological links where every relationship needs to be considered within its own context.
- The study also revealed the underlying attributes of each relational category and their degree of criticality which can help practitioners to standardise their approach to relationship management, and focus on developing appropriate integrative practices with firms in each category. The proposed relationship categories in Task 1 provide the list of attributes required in attaining different levels of relationship maturity. These attributes are thought to be extremely important when strategizing relational integration with the supply chain firms.
- The research in Task 2 confirmed that the focus of contractor organisations in ICT-enabled SCM has been on the operational activities of the immediate tier in a supply chain which falls short of the intended vision and strategy behind the SCM concept. A relationship-centric model was proposed, in which the length of supply chain interaction and management strategy is maintained at a comparable complexity relative to the supply chain relationship with the supply firm in the immediate tier.
- The research undertaken in Task 3 provides evidence that no single SaaS solutions provider meets all the information-processing needs of contractor organisations. Majority of the vendors focus on building capabilities and solutions to project-related activities. Nevertheless, some vendors offer multiple modules to encapsulate different activities in design, construction and procurement processes and thereby allow information re-use by different actors in various stages of the project lifecycle.
- Current SaaS providers offer bundles of capabilities where Document Management and Project Management lead the most mature solution amongst the functionalities. Some vendors couple their core solution with procurement related functionalities which include commercial management of individual and/or portfolio of projects. The lack of integration capabilities, however, is a major limitation which limits their use for an extended enterprise platform.

### 4.3 Objective 2. Examine the main challenges and barriers in Inter-Organisational Information Systems (IOIS) implementation projects and identify the key factors for successful implementation

Towards the second year of the EngD project, the sponsoring company began undertaking an IOIS development project for a large contractor firm. Since the project was still in its early stages (that is, the integration process with suppliers were just kick-started), the RE proposed to use this opportunity to investigate the IOIS implementation as part of a case study research. Following the consultation with academic and industrial supervisors, and the subsequent approval from the sponsoring company, the RE approached the contractor firm which gave permission to collect data for the research.

The research undertaken in Objective 2 revolved around two key facets of IOIS implementation. The first task (Task 4) concentrated on investigating the challenges and barriers in supplier on-boarding process whereas the second inquiry (Task 5) was concerned with the IOIS artefact, that is, the adoption and use of the IOIS throughout the case study organisation. Both tasks were carried out in a longitudinal time frame during which the RE was heavily involved with the monitoring and reporting of the project activities to the senior level management. This allowed the RE to conveniently observe each integration project and, collect and analyse data throughout the projects' life-cycle.

The main technologies and processes involved in both tasks are shown in Table 4:2. The back-end integration activity in Task 4 involved numerous technologies and processes to automate the procure-to-pay process between the contractor organisation and its suppliers. The go-live activity in Task 5 relates to the rolling-out of the system across the contractor organisation's business. During this task, the RE adopted a client-facing role which involved assisting the contractor firm with systems adoption and acceptance to ensure a smooth transition process. The research findings emanating from Task 4 is published in a journal article and attached to Appendix E for reference. The article which reports on findings from Task 5 (attached to Appendix F of this thesis) is submitted to an academic journal and is currently under review.

Table 4:2 The key technologies and processes involved in the IOIS development.

<i>Activities</i>	<i>Technologies</i>	<i>Processes</i>
<b>Back-end Integration</b> (supplier on-boarding)	<ul style="list-style-type: none"> <li>▪ Supplier Catalogues. Internally Hosted (Microsoft Excel file) or through OCI Punchout</li> <li>▪ Connectivity (EDI, ftp, https and sftp)</li> <li>▪ Messaging (BASDA, cbXML, CSV, EDI, EDIFACT, Tradacoms and xCBL)</li> <li>▪ Open standards (IFC, EDI, Hub Alliance and XML)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Business processes:               <ul style="list-style-type: none"> <li>• Blanket Order</li> <li>• Call-Off Order (Purchase Order)</li> <li>• Order Acknowledgement</li> <li>• Invoice</li> <li>• Goods Received Note</li> <li>• Credit Note</li> </ul> </li> <li>▪ Technical processes:               <ul style="list-style-type: none"> <li>• Mapping and transformation of the above-mentioned documents</li> <li>• User Acceptance and Testing</li> </ul> </li> </ul>
<b>Go-Live</b>	<ul style="list-style-type: none"> <li>▪ Asite e-Procurement application (the IOIS)</li> </ul>	<ul style="list-style-type: none"> <li>▪ End-user Guidance and Issue Resolution</li> <li>▪ Software Maintenance and Upgrade</li> </ul>

### 4.3.1 Task 4. Lessons learned during supplier on-boarding phase of an IOIS implementation project

Given that the IOIS is heavily reliant on integrating with suppliers' systems to function, the supplier on-boarding process becomes a crucial phase in the IOIS implementation project. The purpose of the research in Task 4 was to provide a retrospective analysis of the ten supplier integration projects undertaken in order to inter-connect suppliers and contractor firm's back-end ERP systems through the sponsoring company's platform (referred to as the Hub Provider in the current context). The portfolio of the suppliers, the details of the procure-to-pay process and the project development methodology adopted is provided in detail in Paper 4. Of the ten integration projects, four commenced almost simultaneously towards the end of 2011, whilst the other six projects were kick-started in the following six months (see Figure 4:5). Although each project was initially planned to follow a pre-determined schedule, most phases in the project run concurrently to speed-up the setup and project go-live. It is important to note that, Paper 4 uses the term eCIX (electronic exchange of commercial information) which refers to the intermediation of back-end ERP systems (and procurement processes) between the main contractor and its suppliers for seamless exchange of transactional information (including, but not limited to, product and pricing information, order, delivery and invoice data).

#### 4.3.1.1 Method

Utilising multiple sources of data as evidence, the RE gathered information in relation to the technical and project related issues during the supplier on-boarding process. For each integration project information extracted from emails, project development logs, technical documents and case study notes were compiled in a master spreadsheet. An example of the data collection instrument can be found in Appendix A. The master spreadsheet contained key

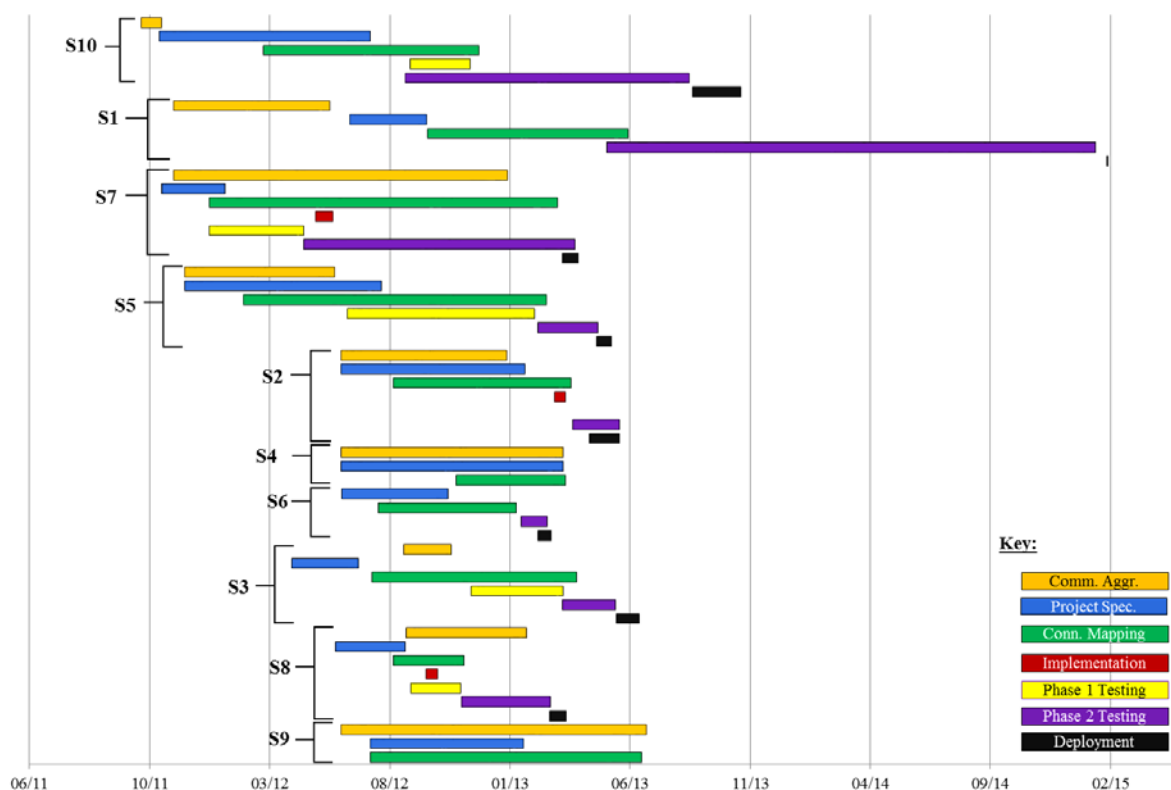


Figure 4:5 The supplier on-boarding project programme (actual).

information such as the start and end date of each project phase; the number of emails exchanged (including average response times) and; the duration of the technical development tasks. The reasons behind lack of progress were also recorded together with all the relevant information including the details of the delay, the source organization and the impact of the delay on the project timeline. The activities that resulted in unnecessary hold-ups include: non-communication, unavailability of the systems, setting up joint meetings, late change requests, and so on. The compilation of evidence from multiple sources produced detailed, reliable and accurate information over the lifetime of each project. In terms of data analysis, the major issues that resulted in project hold-up were codified for thematic analysis. In addition, the interaction patterns between project participants was extracted from the email data and visualised using an online data visualisation tool called 'Circos'<sup>9</sup> for descriptive analysis (Krzywinski et al. 2009).

#### **4.3.1.2 Findings**

The findings from the research revealed that supplier integration can be a very lengthy process, lasting anywhere between 6.5 months to over 3 years. Much of the delay is attributed to the prolonged periods of inactivity in the commercial agreement, project specification, connection and mapping, and phase 2 testing stages. Figure 4:6 provides a visual comparison of the mean duration of each stage where implementation, phase 1 testing and deployment stages are significantly lower than the grand mean, indicating the minimal impact of these stages in the overall duration of supplier on-boarding programme.

The case study analysis revealed four types of challenges and barriers (technical, coordination, integration and organizational) which surfaced during the supplier on-boarding process. Table 4:3 provides a summary of the key findings and lessons learned from the case study. It is important to note that these challenges and barriers are neither a purely technical development nor an entirely project management related issues. For example, although the findings point to significant amount of projects' duration (87% on average) being consumed by coordination related issues, the root cause of most delays stem from the complexity behind the technical setup. In particular, the business rules and validation logic applied (which is setup to enable highly accurate information exchange between the parties) increased the development efforts, which subsequently led to the complications arising in some integration projects. Paper 4 provides a detailed analysis of the rest of the issues that cropped up during the supplier on-boarding process.

Overcoming the challenges and barriers reported in Table 4:3 require significant effort from all parties involved in the integration process; including the main contractor, the suppliers and technology solutions providers (that is, the hub provider, and the third-party service providers to suppliers). Several critical success factors deduced from the case study findings. Accordingly, the implications of the findings for the supplier on-boarding stage of the IOIS implementation include the following.

- Develop an implementation strategy which provides a clear guidance and vision for the implementation teams.
- Ensure that the supplier integration strategy is coherent with the supply chain management strategy. For example, contractors should consider undertaking a long-term strategic evaluation of their relationship with suppliers to ensure that only the right selection of suppliers are incorporated into the IOIS project portfolio.
- Involve senior-level management for direction, guidance and support on decisions concerning business/supply chain process re-design.

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<sup>9</sup> Available at: <http://www.circos.ca> (Last accessed, 28/06/2018)

- Allow room for flexibility in business rule/validation logic in order to reduce interfacing issues and to avoid unnecessary complexity with the integration.
- Ensure that there is mutual commitment from the suppliers in terms of allocation of adequate time and resources for the project.
- Ensure effective coordination, communication and documentation of the project activities.
- Devise a risk management plan specific for each integration project.
- Adopt collaborative working principles and practices with the project participants.
- Appoint people with the right skills, knowledge and experience on EDI and procurement.

Although the case study contractor firm embarked on a journey to implement IOIS with ten of its suppliers, two integration projects were dropped due to relationship discontinuity whilst the decision to go-live for another project was significantly impacted by the changes in the supplier's business. Thus, only seven integration projects were operational and ready to go-live by around mid-2013. The next research task focusses on the post-implementation stage to investigate the extent of IOIS adoption and acceptance throughout the case study organisation.

### 4.3.2 Task 5. Post-implementation evaluation of IOIS

Once the IOIS development is completed the challenges that firms face in implementation change form from systems development to more of a change management issue (that is, the diffusion and infusion of the technology across the organisation). Indeed, many IS projects fail to deliver the key business benefits for the organisation because of unused or underused systems (Charette 2005; Dwivedi et al. 2015). This puts a significant emphasis on post-implementation evaluation which not only helps to identify the key issues that impact the systems uptake, but also the factors which play a vital role in implementation success. In this regard, the Task 5 can be viewed as the continuation of Task 4 where the aim is to analyse the IOIS adoption to determine the key issues that hinder the diffusion and infusion of the IOIS across the case study organisation. Although the IOIS in the case studied was operational with seven suppliers,

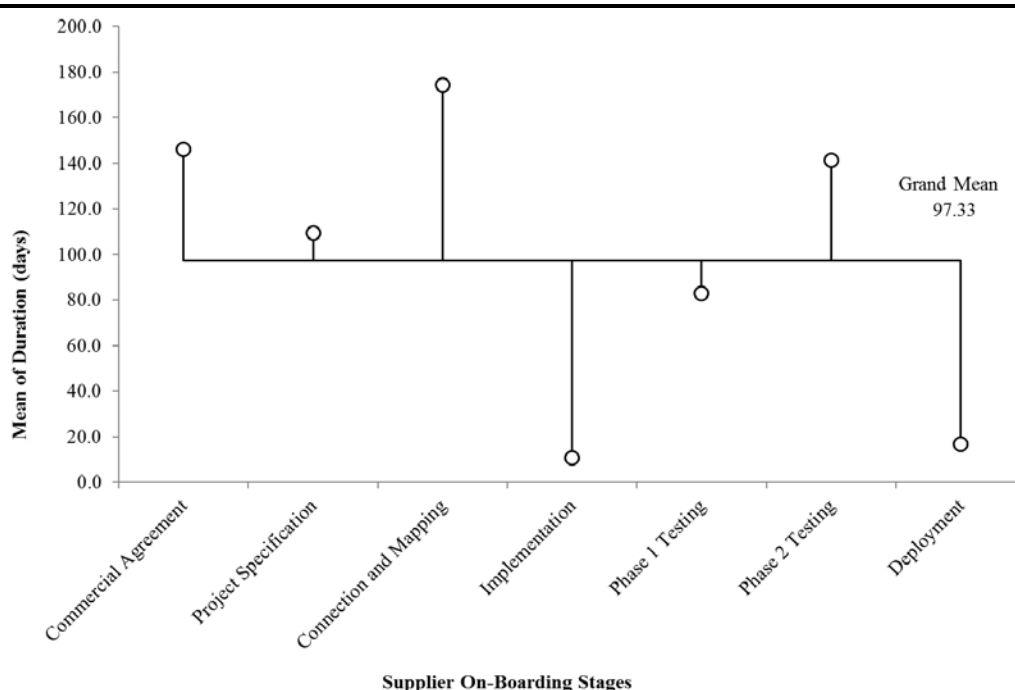


Figure 4:6 A comparison of the mean duration of the supplier on-boarding project phases.

following the piloting phase the contractor organisation decided to adopt the new system with only three suppliers. Historical purchasing figures indicate that the three suppliers on-board represent just over 10% of the case study organisations expenditure which is an evidence of the significance of the suppliers in the IOIS project.

#### 4.3.2.1 Method

Task 5 was primarily concerned with two research questions: (i) what is the extent of the IOIS adoption within the first year of going live with the implementation, and (ii) what are the challenges that the end-users face during its on-going use. The variables used to measure the IOIS adoption were borrowed from the IS literature which provide the foundational basis to research exploring the IS adoption, acceptance and continuance use (Dwivedi et al. 2015). Paper 5, which is attached Appendix F, provides a summary of the additional literature studied and the framework adopted. In brief, the framework (the DM model) adopted for the evaluation of the IOIS posits that the level of adoption and, ultimately the success of IOIS implementation, can be determined by looking at the IS quality (that is, system, information and service quality) and the use (user satisfaction, and intended or actual usage). Rather than investigating the extent to which the DM model variables moderate the IS adoption—or non-adoption (which is the most common application of the DM model in the literature), end-users' perspectives were taken as the primary source for understanding and investigating of the specific issues associated with IS adoption.

Similar to the previous task, a longitudinal, multi-method data collection and analysis strategy was adopted which is summarised in Table 4:4. The two questionnaire surveys were conducted with the help from e-Procurement managers in the case study organisation. The first

Table 4:3 The challenges and barriers experienced during the supplier on-boarding phase of case study IOIS implementation project.

<i>Category</i>	<i>Challenges</i>	<i>Barriers</i>
<b>Technical</b>	<ul style="list-style-type: none"> <li>▪ Capability and adaptation of existing systems</li> <li>▪ Availability of human and IT resources</li> <li>▪ Impact of integration on existing commercial processes and EDIs</li> <li>▪ Lack of clear specification</li> <li>▪ Late design changes</li> <li>▪ Inadequate documentation</li> </ul>	<ul style="list-style-type: none"> <li>▪ Lack of suppliers' flexibility to align their systems or accommodate the necessary changes required in implementation</li> <li>▪ Cost of development for suppliers</li> </ul>
<b>Coordination</b>	<ul style="list-style-type: none"> <li>▪ Lack of adequate project coordination</li> <li>▪ Inadequate change management</li> <li>▪ Large number of people involved</li> <li>▪ Clear identification of roles/responsibilities</li> </ul>	<ul style="list-style-type: none"> <li>▪ Dispersed virtual teams</li> <li>▪ Differences in time-zones</li> <li>▪ Social/cultural diversity of teams</li> </ul>
<b>Integration</b>	<ul style="list-style-type: none"> <li>▪ Single-hub connections: impact of any new changes on existing connections/processes</li> <li>▪ Inter-hub connections: duplicating data conversion efforts</li> </ul>	<ul style="list-style-type: none"> <li>▪ Competition amongst hub-providers</li> </ul>
<b>Organisational</b>	<ul style="list-style-type: none"> <li>▪ Poor implementation strategy</li> <li>▪ Lack of commitment from suppliers</li> <li>▪ Lack of strategic support from senior management</li> <li>▪ High staff turnover in project management/coordination teams</li> <li>▪ Lack of implementation teams' skills, knowledge and experience in EDI projects.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Supplier relationship discontinuity</li> <li>▪ Supplier business uncertainty</li> </ul>

survey was issued in the first 6 months of go-live to capture the end-users' perceptions on information quality, system quality, service quality and overall satisfaction with the system. The second survey, which was issued towards the end of first year, sought to capture the perceived utility of the IOIS from supplier integration perspective. More specifically, the survey explored the importance of the suppliers in the eyes of end-users.

On the other hand, the issue logs and usage statistics were obtained from the sponsoring company. The usage statistics consisted of three data sets: attraction (user logins), interaction (blanket orders raised for each project and business unit), and transaction (actual transaction data of each user, project and business unit). In terms of analysis, the qualitative data (issue logs and responses provided in the surveys) were analysed through thematic analysis, whereas sums and averages were used for the analysis of the quantitative data. Bar and pie charts were also used to display and compare the frequency and averages of various categories of data. It must be acknowledged that the four data sets were not cross-linked (as surveys were anonymised in order to encourage objective commentary and encourage participation from the end-users). Hence, the causality in the findings are not absolute but rather implicative of the relationship between the end-users' perception and the IS adoption challenges.

#### 4.3.2.2 Findings

The research findings in Task 5 point to number of issues that had serious impact on the adoption of the IOIS. The following issues were identified as a key factor in system quality.

- User-friendliness of the system and Graphical User Interface (GUI) design issues.
- Errors and performance related issues with the PunchOut interface.
- Internet connectivity issues experienced from the projects' site office.
- Inconsistencies in IOIS functionality in different web-browsers.

With respect to the information quality, following issues were prominent.

- Lack of information provided after a transaction is completed (for example end-users were unable to trace the orders placed and their status)
- Accuracy of the information provided on the supplier catalogues (for example information on stock levels).
- Lack of IOIS' ability to process information attached to the purchase orders.
- Lack of interaction functionality (for example, functionality to help with regular/repeat orders) other than creating purchase orders.

The key concerns that were raised by the end-users in relation to the service quality dimension are as follows.

- End-users training and support should incorporate variety of methods within its scope, including user guidance documents, demonstration videos and one-on-one session.

Table 4:4 The data collection approach adopted in Task 5.

<i>Data Sources:</i>	<i>Survey 1</i> (30 responses)	<i>Survey 2</i> (31 responses)	<i>Usage Data</i> (12 months)	<i>Issue Log</i> (48 issues)
<i>DM Model variables:</i>				
<i>System Quality</i>	✓			✓
<i>Information Quality</i>	✓			
<i>Service Quality</i>	✓			✓
<i>Use</i>			✓	
<i>User Satisfaction</i>	✓			
<i>Net Benefits</i>		✓		

- Technical guidance documents must cover all the use case scenarios in the purchasing process.
- Issue resolution process must adopt collaborative processes, procedures and protocols between the contractor firm, supplier, and intermediary hub provider's IT team for management of the technical and non-technical (e-commerce related) issues.

In terms of the user satisfaction, the responses to questionnaire survey indicate there were high levels of satisfaction with the IOIS amongst the majority (76%) of the end-users. Those who were dissatisfied with the system echoed their concerns in relation to the usability of the IOIS (e.g. difficult to use) and the e-commerce process which lacks extensive functionality to cater for the post-purchasing order management.

The level of IOIS use amongst the users/projects and business units reveal significant differences at each level of analysis. End-users in Administrator role were the key users of the system whom, compared with the rest of the user groups, were much more regular and consistent in terms of IOIS utilisation. At the project level, the findings showed that the IOIS usage has not been equally spread across different industries and sectors (see Figure 4 in Paper 5). Although the projects in Facilities Management industry utilised the IOIS more often, in terms of the value of the transactions, the projects within the Construction industry accounted for more than half of the total spend. The projects in the Transport sector in particular (where the duration of the projects span over a relatively longer period of time with budgets usually over several hundred million) were the most prominent users within the Construction industry. The analysis also revealed that the depth of adoption at the business unit level also differs significantly amongst the different businesses of the case study organisation (see Figure 5 in Paper 5). However, the usage data revealed a positive trend in the number and value of orders made at each business unit which is presumed as an indication of the gradual acceptance and continuance use of the IOIS across the organisation.

One way of measuring the IOIS success is studying the value of suppliers as perceived by the buyers (end-users) at the contractor firm. Findings in Task 5 outline several important advantages being obtained in relation to the actor, process and technology dimension of supplier integration (see Paper 5 for more information). However, findings from the survey responses indicate that the perceived significance of one of the three suppliers on-board (Supplier 3, which is a construction tools and equipment supplier) is comparatively low which indicates a lack of significant advantage from the IOIS implementation with that particular supplier. This finding was further supported with the supplier spend data which showed that the total value of transactions conducted through the IOIS for Supplier 3 was quite low (around 10%). In contrast, the level of perceived significance and the amount of supplier spend data for Suppliers 1 and 2 (which are 49% and 41%, respectively), were comparably substantial (see Figure 6 in Paper 5), which implies higher levels of net benefits being realised from the use of IOIS with these two suppliers.

Evident from the findings, long-standing issues which commonly plague the IS development projects also appear in the IOIS projects however there are a number of IOIS-specific issues (including the need for inter-firm issue resolution, interfacing across different systems, and functionality and performance of the system in different web-browsers) that were experienced in the case study. Paper 5 provides a discussion around the implications of the research findings for future IOIS implementation projects. Overall, the findings drawn from the case study have serious implications for the planning, design, development and implementation of the IOIS projects. In essence, the suggestions in Paper 5 frame around an IOIS development strategy which incorporates (i) requirements engineering, (ii) business process reengineering and (iii) change management activities within its framework. Since IOIS implementation involves joint effort by multiple parties (contractor firm and its suppliers) to integrate systems and processes, contractor organisations have to be selective in their supply



chain integration strategy. As well as carrying out a commercial assessment of the construction projects and business units (which could benefit from a more efficient and effective supplier engagement strategy), contractor organisations should take into consideration the end-user perspectives in integrating with particular suppliers.

### **4.3.3 Summary**

The research carried out in Objective 2 was focused in the study of IOIS integration, implementation and delivery, and drew on case study research strategy for an extensive evaluation of the key constraints in IOIS implementation projects. The RE took up the role of participant-as-observer to study an IOIS implementation project in its natural setting. This enabled detailed inferences to be made from multiple stages of the IOIS implementation lifecycle. In Task 4, the RE focused on the IOIS project, especially the supplier on-boarding process to identify the key challenges and barriers involved with its delivery. Findings suggest that the challenges and constraints regarding the supplier on-boarding are largely non-technical, coordination related issues which are borne due to poor planning and execution of the IOIS implementation process. Although the scope of the implementation in Task 4 is not a complex integration activity, the magnitude of transformation in the procurement process (i.e. from paper-based to digital approach) was quite significant for the supply chain operations. In Task 5 the RE turned his attention to adoption and acceptance of IOIS where the research was specifically concerned with the challenges and barriers that contractor organisations face when implementing IOIS. The results of the research carried out in Task 5 highlight a range of factors related to the system, service and information quality dimension of IOIS.

## **4.4 Objective 3. Develop a guideline for IOIS implementation by contractor organisations**

The IOIS implementation is not a trivial task. The complexity of the IOIS design, development, administration, and maintenance are expected to increase commensurately with the level and extent of integration involved with multitude of supply chain firms. Many of the issues are related to the lack of strategic guidelines in IOIS planning, design and development. Previous work substantiated the need to develop a set of guidance for facilitating improved IOIS planning, design, development, acceptance and use. Guidelines can be described as essential tools that help organisations in achieving successful delivery of their IS, or IOIS implementation projects. Through investigation of real-life case study IOIS implementation project and further review of IS implementation frameworks, it was possible to tease out the key components that needs to be addressed in IOIS implementation. The resulting work from Objective 3 led to development of a set of recommendations for contractor firms when implementing IOIS with their supply chain partners. This guideline is the direct result of the earlier findings and additional review of literature on IS implementation frameworks.

### **4.4.1 Method**

The IOIS implementation is part of a much bigger quest in enterprise IS implementation and thus it is necessary to identify and address the key characteristics of the existing frameworks that are reported in the literature. This necessitated a desk study on different types of frameworks adopted in IS planning, design, development, implementation and management. Literature points out that there is no single holistic framework to IS implementation and, in most cases, organisations adopt and adapt the different frameworks to meet their specific requirements. The frameworks in IS development and implementation can be broadly classified under four headings: (i) Enterprise Architecture Implementation Frameworks (EAIF) for design, development and management of complex enterprise-wide systems architecture, (ii) Business Process Management Frameworks (BPMF) for optimisation and alignment of the

business workflows, (ii) Service Management Frameworks (SMF) which focus on on-going management of the IS/IT and services, and (iv) Project Management Frameworks (PMF) for dealing with the actual delivery of an IS implementation project. Figure 4:7 provides examples of some of the well-known IS implementation frameworks in each category. The literature and knowledge base on IS implementation frameworks (which mainly reside in Management Information Systems, Business Information Systems, Enterprise Information Systems, Enterprise Application Integration domains) were surveyed as part of the research task in Objective 3. The core elements of the IOIS implementation guideline were coded and categorised in an iterative process that involved a matrix development and mind-mapping exercise (presented in Appendix G of this thesis).

The IOIS implementation entails five key phases in its successful realisation, acceptance and use (see Figure 4:8). Each phase is inter-linked and inter-dependent on one another to highlight the evolutionary and dynamic nature of the IOIS implementation process. The full version of the guideline is presented in Table 4:5. To ensure its practical use and to refrain from any unnecessary levels of detail, the design of the guideline follows a simple, adaptive and process-oriented structure that embeds a number of implementation activities, key objectives, critical success/failure factors, the controls and constraints, outcomes/deliverables, and the key stakeholders, within its framework.

- The main activities in each phase are provided in the left column along with the key objectives which describe the purpose of each implementation activity. These are based on principles of cSCM (identified from literature review and developed as part of a conceptual framework in Tasks 1 and 2) and IOIS implementation (identified through a literature study of implementation approaches related to integrated enterprise information systems).
- The controls/constraints are constituents that have an impact on the implementation activity, and primarily derived from the literature study and research carried out in Tasks 4 and 5.
- Critical success/failure factors are drawn from the earlier research findings as well as a detailed study of implementation issues on IS and IOIS literature.
- The main outcomes column outlines the key strategies, plans and procedures that must be prepared as part of the activity, and is derived from synthesis of prior research findings.
- The last column provides information on the type of involvement required by different stakeholder groups (such as End-users, Senior-level Management, Business Development Managers, Supply Chain Managers, IS Managers, System Analysts, Business Analysts and so on) in realisation of the implementation activity and is based on synthesis of prior research findings and the review of existing implementation frameworks cited in Figure 4:7.

#### 4.4.2 Task 6. The Guideline for Implementing IOIS Projects

The aim of the guideline is to provide a descriptive account of the key events in a highly complex IOIS delivery projects which involve multiple supply chain partners as well as technology solution providers (such as Hubs or Exchange Service Providers), and other third-party solution providers. For a holistic approach to IOIS strategy development, the guideline is developed from senior level management's perspective. The guideline addresses all the essential elements for developing and implementing an IOIS strategy, such as what are the key objectives in each implementation activity, what are the main critical success factors, what are the constraining factors that could impact the decision making, what are the main deliverables, and who will be involved and what is the type of involvement in each stage of the IOIS implementation.

The proposed guideline should not be viewed as a set of instructions but rather as recommendations for the smooth deployment and management of the IOIS implementation process. In this regard, contractor organisations can develop their IOIS implementation strategy by executing the courses of action set out in the guideline. Alternatively, the guideline can also be used to inform contractors organisations' existing internal policies in order to accommodate the future IOIS development projects. The guideline can also be adapted (for example, by adding new project participants or modifying the stakeholder groups or, revising the critical success/failure factors and so on) to incorporate and prioritise issues that organisations deem most important in their setting.

Aside from following the framework presented in Table 4:5, successful implementation of IOIS needs to exercise the following actions.

1. Top management involvement, support and leadership throughout the implementation process.

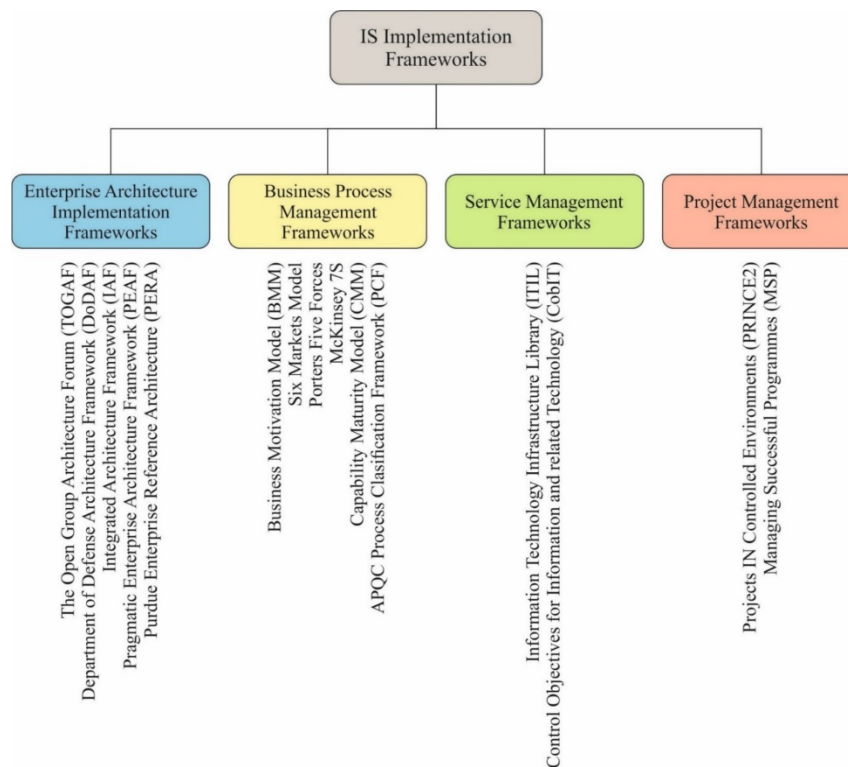


Figure 4:7 Examples of frameworks that are utilised in IS implementation process.

2. Involving cross section of people from the contractor organisation (as well as supplier firms, the IOIS solutions provider and third-party service providers) earlier on in the implementation.
3. Working on collaborative terms with IOIS solution provider and supply chain firms.
4. Incorporating appropriate best-practice tools, techniques and procedures when undertaking the implementation activities in each phase of the implementation process.
5. Providing appropriate training and ongoing support to prevent resistance to change.

Following sections provide a summary of the key considerations that must be taken into account at each phase of the IOIS implementation process.

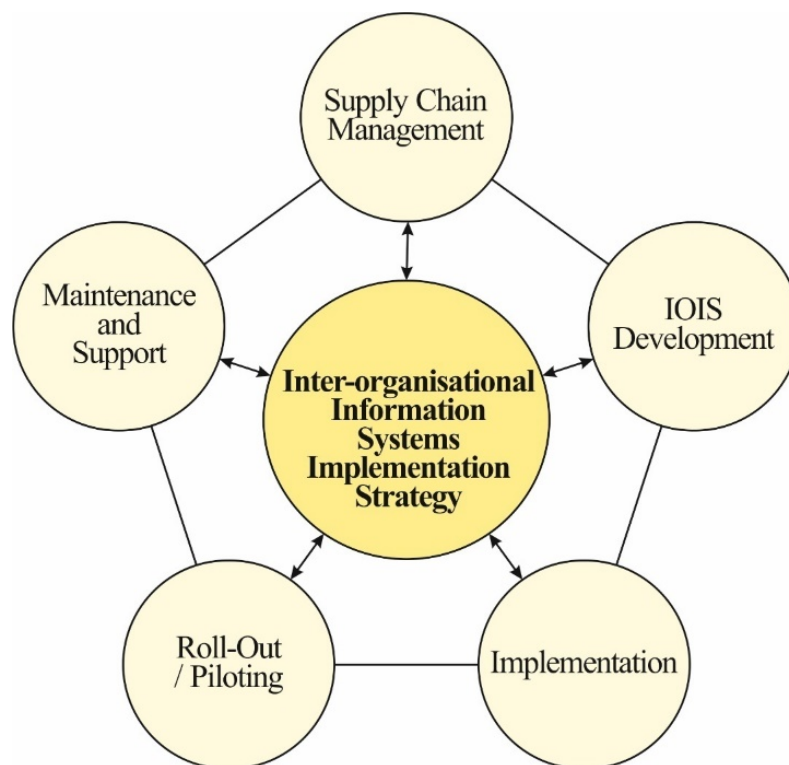


Figure 4:8 The key elements of the IOIS implementation framework.

Table 4:5 IOIS Implementation Guideline (Key: R= Responsible, A=Accountable, C=Consulted, I=Informed)

Phase	Implementation Activities	Key Objectives	Controls / Constraints	Critical Success / Failure Factors	Main Outcomes / Deliverables	Contractor		Firm's:		*	Suppliers':			
						Top Management	Supply Chain Managers	IS Manager / Sys. Analysts	End-Users		Project Steering Group	IOIS Provider's IT Team	Buss. Develop. Manager	IT Team
1. Supply Chain Management	1.1 Supply Chain Analysis	- Conduct Supply Chain Capability Analysis to identify the supply chain challenges and improvement opportunities. - Undertake a preliminary assessment of the benefits and advantages of integration with suppliers (e.g.: automation, integration, coordination, or synchronisation at actor and organisational level) for building a business case and strategy formulation.	- Supply chain complexity. - Risk and uncertainty associated with the supply chains. - Procurement strategy. - Existing purchasing/sourcing processes.	- Clear corporate vision on SCM and IOIS strategies. - Alignment of IOIS, SCM and business strategy. - Engagement by top management on issues relating to corporate level decisions. - Executive support, commitment and willingness to continue through the lifetime of the IOIS implementation. - Adequate resources (time and budget).	- Supply Chain Development Plan	A	R	C	I	C	I	C	I	I
	1.2 Supplier Evaluation and Selection	- Evaluate the supplier's technical capabilities and resources. - Evaluate the net benefits of co-creating IS/IT strategy - Agree with suppliers on a strategic roadmap to integrate.	- Supplier size. - Supplier industry characteristics. - Supplier power. - Supplier inter/dependence. - Supplier innovation competency. - Supplier IS utilisation. - Purchasing spend/volume with suppliers. - Frequency of interactions. - Supplier business uncertainty. - Cost/Benefit analysis.	- Degree of trust and co-operation in the relationship. - Partners with the willingness and capability. - Suppliers' attitude towards integrative and collaborative relationships. - Relational closeness and purchase situation, that is: supply market, type of commodity, purchase history, future portfolio expenditure and so on.		A	R	C	I	C	I	I	I	
2. IOIS Development	2.1 IOIS/Business Strategy Alignment (internal)	- Identify the project and organisational level information requirements. - Evaluate the current internal technologies and process integration capabilities. - Carry out an as-is analysis of current technologies and processes for identifying the gaps and opportunities for standardisation and streamlining of internal (operational and functional) processes.	- Existing IS/IT infrastructure. - Enterprise Data Strategy. - Project Level Data and Information Management Strategy (BIM). - Current IS/IT resources. - Organisational structure.	- Organisational and environmental contingencies (e.g.: industry dynamics, e-business maturity, culture, administrative structure and so on). - Stakeholder participation and end-user approval. - Lack of supervision, leadership and direction from top management. - Lack of clarity, completeness and certainty on the scope and functionality of the IOIS.	- IOIS Roadmap	C	A	R	I	C	C	C	C	C
	2.2 Supplier IS/IT Alignment (external)	- Assess the current technologies and process integration capabilities of selected supply chain partners. - Identify and establish the optimal levels of systems integration opportunities with supply chain partners. - Decide and prioritise the IOIS features and functionalities. Consider, system requirements, functional design requirements and graphical user interface requirements at user, project and organisational levels.	- Technical constraints (interoperability standards) - Customisability of the legacy systems. - The impact of the IOIS on current 'as-is' processes, technologies, and people skills as well as business relationships and organisational structure.	- Interoperability and level of standardisation of the processes/systems. - Suppliers' capability, will and commitment to accommodate the changes required for the new processes/technologies. - Suppliers resources (time, budget, human, and IT). - Level of complexity involved in the project. - Level of customisation required by the trading partners and third-party technology providers. - Stakeholder participation and involvement. - Ability of the IOIS to evolve with the changes in the company and advancements in IT. - Scalability to accommodate requirements for suppliers systems as well as third-party technology solution providers. - Inappropriate selection of system capabilities.	- Supplier Integration Strategy	C	R	A	I	C	C	C	C	C
3.Implementation	3.1 Project Setup	- Develop a project management strategy. - Establish formal project management procedures, processes and mechanisms for the management of the development activities. - Identify project team members and delegate responsibilities.	- Complexity of the IOIS. - Geographical proximity of the project participants. - Time-zone differences of project team members. - Social/cultural diversity of teams.	- Clear identification of roles and responsibilities. - Clearly articulated objectives and detailed project plan. - Effective communication. - Cross-functional team members with the appropriate skills, knowledge and experience in IS development. - Commitment, dedication and support by top management to continue with project. - Disputes and conflicts between participants in the project team(s).	-Implementation Strategy	I	A	R	I	C	R	C	C	C
	3.2 Development and Testing	- Develop benchmarks to measure the progress and performance of each integration project against other similar projects. - Decide on a testing strategy and approach.	- The choice of development methodology. - Implementation timeframe.	- Inadequate documentation of project activities. - Late/unaccounted changes in project specification. - Customisation of the development methodologies.	- Software Development Methodology	I	A	R	C	I	R	C	A	C
	3.3 Deployment and Release	- Identify and understand the deployment audience: end-user profiles, project types (the industry sectors which the projects belong to) and organisational structure. - Develop a deployment and release strategy that ensures smooth transition from testing environment to live stage.	- Construction projects' phase and duration. - Procurement and purchasing strategy adopted in projects. - Organisational structure.	- Inappropriate selection of deployment and release approach. - Too much time taken between the implementation at the piloting phase and roll-out phase.	- Technical Documentation	I	A	R	I	I	R	C	A	C
4. Roll-Out / Piloting	4.1 End-User Training and Documentation	- Develop a competency inventory, educational framework, and learning modules.	- End-user profiles. - Training resources/budget.	- Preparation of the self-learning materials ('How-to' guidance, FAQ and Support documentation) - Hands-on and one-to-one training. - Availability of the training resources. - End-user non-participation.	- Training Strategy	I	R	R	C	I	A	C	C	C
	4.2 Supplier On-boarding Project Evaluation	- Carry out lessons learned exercise to evaluate the key learning outcomes from individual projects and IOIS project as a whole.	- Supplier involvement and co-operation.	- Taking proactive measures to prevent similar issues arising in future projects.	- IOIS Project Evaluation	I	R	R	C	C	A	C	A	I
	4.3 Supplier Integration Evaluation	- Develop quantifiable, easy to collect, and relevant metrics for measuring strategies and operational benefits of the IOIS. - Measure and evaluate the systems success as perceived by end-users in projects in which it is used as well as across the organisation.	- Supplier involvement and co-operation.	- Evaluation of the end-user response to supplier integration. - Lack of clearly defined strategic and operational success measures.	- Supplier Performance Evaluation	I	R	R	C	C	A	A	I	I
	4.4 Change Management	- Identify and appoint technology champions. - Conduct awareness sessions across the organisation. - Set rewards and recognition plan for early adopters. - Obtain and act on feedback received from end-users. - Identify the level of IOIS diffusion and infusion among the projects and business units.	- Deployment strategy adopted (hard or soft approach to roll-out).	- Adequate resources to implement the change. - Organisational culture. - E-Readiness and E-maturity of the end-users/organisation. - User resistance to change, for example because of fear of job losses, end-users apprehensive about their future roles and so on... - Company-wide change plan not implemented/followed.	- Change Management Strategy	I	R	A	C	C	A	A	A	I
5. Maintenance and Growth	5.1 Maintenance	- Develop a system update and maintenance plan.	- Conflicts in maintenance cycles with that of supply chain firms.	- Co-evolution of the IOIS with the contractor and suppliers' IS/IT systems. - Communication of new releases with all end-users. - Communication of non-interface related releases with all relevant IS/IT stakeholders. - Co-operation on planning and design of new releases. - Adequate regression testing.	- Maintenance and Release Management Plan	I	A	R	I	I	A	A	A	C
	5.2 End-user Support	- Agree and develop a collaborative issue resolution process with suppliers and third-party technology solution providers (for both, technical and non-technical interfacing issues). - Revise the help and support process/documentation/strategy as and when needed.	- Scope of the supply chain operations covered by the IOIS.	- Involvement of all stakeholders for a coordinated approach on technical (IOIS related) and non-technical (business process related) issues.	- Service Level Agreement	I	A	R	C	C	R	A	A	A
	5.3 Continuous Improvement	-Exploration of potential value-adding B2B functionalities and enhancements to achieve/sustain (competitive) advantage in adoption and utilisation of IOIS.	- Stakeholder involvement / participation.	- Lack of consideration given to end-user suggestions. - Lack of commitment, buy-in and sponsorship from top management. - Lack of business case/value for implementing the new developments.	- Continuous Improvement Plan	I	R	A	C	C	R	A	A	A

#### **4.4.2.1 Phase 1. Supply Chain Management**

Successful implementation of IOIS demands adequate SCM mechanisms to be in place. The research undertaken in Tasks 1 and 2 revealed that there is no 'one size fits all' approach to SCM, and every supply chain has to be planned according to individual requirements of relationships. Contractor organisations implementing IOIS with their key supply chain partners must conduct a thorough analysis of its supply chain capabilities to ensure that maximum efficiency and productivity gains can be achieved from supply chain integration and alignment. Contractor organisations not only need to develop metrics for assessing the technical/process capability of their suppliers, but they also need to take into account the relational factors to determine which suppliers are best to integrate with. Paper 1 provides the key relationship development attributes for different relationship levels (transactional, series of interactions, project collaboration and long-term strategic partnering), whilst Paper 2 presents a strategic framework for extending the integration into network of supply chain firms. Therefore, within the SCM phase contractor organisations must carefully consider the impact and the role of IOIS on their relationship maturity with supply chain firms. Besides the relational factors, some of the controls/constraining factors that could influence the decision making include the following:

- supplier size.
- supplier industry characteristics.
- supplier power.
- supplier inter/dependence.
- supplier innovation competency.
- supplier IS utilisation.
- supplier business uncertainty.
- purchasing spend/volume with suppliers.
- frequency of interactions.

The first phase in IOIS implementation must be initiated by top level management to kick-start the project, however other stakeholders (as identified in the guideline) must also engage with the phase activities for a comprehensive planning and solution development. This is to ensure all stakeholders' needs are addressed and to develop a sense of ownership of the IOIS solution. The main outcome expected in the SCM phase is the development of a Supply Chain Development Plan which will provide guidance and vision on integration and partnership strategy with different types of supply chain firms/relationships. Since the SCM concerns the strategic organisational decisions, high-level management and mid-level SCM roles are the key stakeholders who are responsible for the development of the Supply Chain Development Plan.

#### **4.4.2.2 Phase 2. IOIS Development**

Having determined the supply chain firms to be involved in the IOIS implementation, contractor firm needs to work hand-in-hand with the IOIS provider and suppliers to develop the blueprint for the IOIS solution. This phase will involve significant amount time and effort spent on planning and specifying the functional, informational and operational needs of the IOIS. The IOIS Development phase entails two key activities: IOIS/Business Strategy Alignment (internal), and Supplier IS/IT Alignment (external). The first activity focuses on the internal technology and process improvement areas within the organisation whereas the second activity shifts the focus to supply chain firms to identify and prioritise the optimal levels of integration (in relation to actor, process and technology dimension) with each supplier. As a result of these activities the contractor organisation needs to devise two key strategies as part of their implementation strategy: IOIS Roadmap which provides long-term vision for the IOIS to evolve to, and Supplier Integration Strategy which is not only concerned with the short-term

integration goals to achieve critical mass of suppliers on-board, but also contain long-term strategic goals for deeper levels of integration with different types of suppliers/relationships.

#### **4.4.2.3 Phase 3. Implementation**

The Implementation phase mainly consists of the project management activities related to the IOIS development. The management focus is not only on individual projects, but also concern the portfolio of supplier integration projects. The key deliverables that underpin the success at this phase are Implementation Strategy, Software Development Methodology and Technical Project Documentation. The Implementation Strategy must outline the project KPIs in order to track and measure the performance of each supplier integration project. The Implementation Strategy must also cater for an effective communication strategy and risk management approach. The choice of Software Development Methodology will determine the way development activities are carried out. The IOIS implementation must follow a proven software methodology with very few modifications to be made. All stakeholders must be familiar with the methodology to avoid any time lag taken to reach the learning curve. Up-to-date, accurate and comprehensive documentation of all implementation activities must be recorded for historical record as well as for future reference (for example during updates and maintenance).

#### **4.4.2.4 Phase 4. Roll-Out / Piloting**

The Roll-Out/ Piloting Phase concerns the post-implementation activities such as providing training and documentation for the end-users, IOIS evaluation (evaluation of the IOIS itself and the supplier on-boarding process), as well as ensuring a smooth transition to the IOIS (the infusion and diffusion of the IOIS across the organisation). In relation to the former activity, the Training Strategy should consider the diversity of the end-users' requirements in delivery and execution of the training. Organisations that do not conduct formal retrospectives could be destined to repeat the same mistakes over and over again. Hence, organisations should formally undertake formal evaluation of their IOIS implementation project (including individual supplier integrations) as well as the net benefits of integration with suppliers. The success of an IOIS depends on, more than anything else, whether end-users are enticed to utilise and, in this way, contribute to the organisational uptake of the system. An organisational change management plan should be developed to take proactive measures towards resistance to change. An important point to note here is that management should not strictly mandate the change but rather aim to inspire end-users through purpose.

#### **4.4.2.5 Phase 5. Maintenance and Growth**

The steps involved in the last phase are maintenance, end-user support, and continuous improvement. Following are requirements product as part of this phase: (i) a maintenance and release management plan for bugs, errors, and system related issues encountered during ongoing use of the IOIS, (ii) end-user support for technical (IOIS related) and non-technical (business process related) issues, (iii) continuous development of the IOIS to increase the scope of the IOIS to cater for other value-adding supply chain operations. Since the IOIS is highly dependent on the continuity of the relationship between contractor organisation and its supply chain firms it may not be possible to determine what the IOIS will evolve to over time. Hence it is important that the systems in place are adaptable and flexible to support the future maintenance and growth strategy.

### **4.4.3 Limitations of the Proposed Guideline**

The proposed guideline was intended to be simple yet effective in its application in real-life implementation projects. However, this is also the biggest limitation of the guideline (the lack of detail to the executable workflow level) which may render its use. Concrete guidance requires mapping the details of specific tactics to achieve the operational objectives of an IOIS

strategy. Nevertheless, the structure of the guideline makes it possible to adapt and extend its use by revising each section to suit to different organisation/projects' needs (that is, by defining other context specific implementation activities, objectives, controls/constraints, critical success/failure factors, main outcomes/deliverables, and actors). Furthermore, earlier in Objective 2, it was suggested that in order for IOIS implementation to be implemented successfully it needs to be developed in a co-operative and collaborative manner with all the stakeholders involved in the implementation process (that is, main contractor, IOIS provider, supply chain partners, and third-party technology providers). The guideline proposed as part of the Objective 3 describes the implementation process pre-dominantly from the perspective of contractor firms and does not fully consider the needs and requirements of supply chain firms involved in the IOIS deployment. Additionally, what has been proposed in the guideline is not validated for identification of areas for improvement.

#### **4.4.4 Summary**

The goal of the Objective 3 was to define the key steps in the delivery of IOIS implementation projects to help decision makers in contractor organisations to manage the implementation process in real life. The IOIS implementation highly resemble the development processes followed in traditional IS delivery. However, the SCM-oriented approach to highly integrated IOIS entails its own unique challenges, which require all the relevant factors to be considered during its planning, design, development and implementation. The guideline developed in Table 4:5 can be used as a high-level strategic road-map for implementing IOIS projects with multitude of supply chain firms.



## **Chapter 5: Conclusions**

The last chapter of this thesis presents the key conclusions drawn from the research along with the implications of the research findings for the research sponsor and the wider industry. The sections that follows highlight a number of recommendations for further research. The chapter ends with a critical evaluation of the research.

### **5.1 Realisation of Aim and Objectives**

Table 5:1 highlights the key research findings emanating from the study. The aim of the research as stated in Chapter 1 was to investigate the cSCM for better integration of construction supply chains through IOIS implementation. Three research objectives were pursued in order to satisfy this aim.

#### **5.1.1 Objective 1. Identify the current practices and challenges for ICT-enabled Supply Chain Management by contractor organisations**

This objective was achieved thorough a literature review, desk study and survey research, of which the main findings of research are presented in Section 1.3-1.5 of Chapter 1, Section 2.1-2.5 of Chapter 2, and Section 4.2 of Chapter 4. The results of the research are also published in Papers 1-3.

The research work began with examination of the SCM and SRM literature. The literature review revealed that the application of cSCM has not been an easy task, predominantly due to the structural and cultural dynamics which are largely governed by the temporary, one-off, project specific, irregular and disjointed supply chain interactions (Section 2.3). In terms of relationship management, a desk study was conducted to identify the key characteristics of collaborative supply chains (Paper 2, Appendix C). Trust, partnering and collaboration were identified as the key attributes associated with the collaborative and integrative supply chain relationships. Given that there are multitude of relationships in an organisation's supply network, a relationship taxonomy was developed which classified the industry relationships into four main types (transactional, series of transactions, project collaboration and long-term strategic partnerships) based on 17 relational attributes identified in the relational marketing literature (Paper 1, Appendix B).

To have a better understanding of the construction-specific SCM and SRM practices by contractor organisations, a survey questionnaire was developed and administered to large UK contractor firms (Paper 3, Appendix D). The questionnaire study sought to investigate the two key aspects of cSCM: the contractors' relationship with their downstream supply chain firms, and the systems, technologies and processes they employ to manage these relationships. In line with the literature review findings, the study confirmed that the current application and practice of the cSCM and SRM falls short of the intended vision and strategy behind the SCM concept, which is concerned with the transformation of an entire supply chain into a 'value chain'. Although, the findings revealed that some contractor-supplier relationships are beginning to stretch beyond the immediate tier in the supply chain (for example, as a result of project specific, financial, technical and contractual demands), the study concluded that current form of cSCM by contractor organisations is that of 'supplier management' rather than 'chain level' management. A relationship-oriented framework was developed to address the management, coordination and control needs in dyadic and extended network of supply chain firms (Paper 3, Appendix D).

Similarly, in relation to the latter point, the study revealed that ICT-enabled mechanisms adopted for cSCM are largely focused on supply chain operations with the immediate firm in the supply tiers (both downstream and upstream). There exists a variety of ICT-enabled systems and technologies (most notable being the BIM, Project Extranets and Electronic

Document Interchange systems), however the study found inconsistent use of these technologies along supply chain tiers. Although, the findings revealed the importance of utilising a variety of inter-organisational systems and technologies to facilitate efficient, timely and cost-effective supply chain interactions, the study concluded that it may be inherently difficult to introduce, or adopt, integrated solutions with the firms in extended tiers unless contractor organisations have the influence and power to exert pressure on their downstream supply chains.

The final task in Objective 1 was to investigate the technological landscape to assess the technological solutions that facilitate integration and collaboration between supply chain firms (Section 4.2.3). The findings drawn from the vendor analysis matrix in Section 4.2.3 indicates that most vendors offer solutions for project-related workflow activities, where the Document Management and Project Management leads the most implemented suit of functionalities. Although a significant proportion of vendors offer procurement and ERP packages, the functionality of these solutions are split between two core tasks: (i) facilitating the sourcing needs of projects, such as tendering, or (ii) commercial management of supply chain

Table 5:1 Summary of key findings.

<i>Research Objectives / Research Tasks:</i>	<i>Findings:</i>
1. Identify the current practices and challenges for ICT-enabled Supply Chain Management by contractor organisations	
1.1 Review the state-of-the-art on construction-specific SCM and SRM.	Transactional, one-off and adversarial relationships are the norm in the industry with the exception of some integrated, collaborative practices with upstream supply chain firms.
1.2 Explore and identify the current practices and challenges for ICT-enabled SCM technologies by contractor organisations.	ICT-enabled mechanisms for management of supply chain firms do not extend beyond the immediate tier in the supply chain. BIM, Project Extranets, and Integrated Databases are the top three ICTs for sharing of project and commercial data with upstream/downstream supply chains.
1.3 Explore the current AEC-specific Software-As-A-Service solutions that facilitate the collaboration and management of construction supply chains.	Current SaaS vendors provide bundles of capabilities/functionalities for Document Management and Project Management which leads the most mature solution amongst the majority of vendors. Currently, no vendor offers a single, comprehensive solution for end-to-end functional or collaborative integration.
2. Examine the main challenges and barriers in Inter-Organisational Information Systems (IOIS) implementation projects and identify the key factors for successful implementation	
2.1 Examine the main challenges and barriers during supplier on-boarding phase of an IOIS implementation project.	In what follows from the case study findings, technical factors did not emerge as being significant factor in the supplier on-boarding process of the IOIS implementation. Rather, the findings point to a number of 'soft' organisational and management issues such as lack of top management support/commitment, absence of IOIS implementation strategy and, poor communication and coordination.
2.2 Examine the post-implementation challenges; the user adoption and on-going use of a private B2B e-Marketplace system.	Issues of user/system-interface design, interfacing of the IOIS with the supplier's systems, and end-users' perceived significance of suppliers for integration, underpin the successful adoption, and continuance use of the IOIS.
3. Develop a guideline for IOIS implementation by contractor organisations	
3.1 Synthesize the previous work and develop a strategic guideline for contractor firms seeking integration with supply chain firms.	Successful implementation of an IOIS is dependent on the dynamics of relationship between the large contractor firm and its supply chain firms, as well as the IOIS provider and other third-party service providers. A practice-oriented best-practice framework for IOIS implementation was developed and presented in Section 4.4 of this thesis.

organisations. However, it was revealed that majority of these solutions are focused on internal processes and lack integration functionality to seamlessly interact with or, support the re-use of information generated by external systems.

### **5.1.2 Objective 2. Examine the main challenges and barriers in Inter-Organisational Information Systems (IOIS) implementation projects and identify the key factors for successful implementation**

This objective was achieved by undertaking a case study research which is detailed in Section 4.3 of Chapter 4. The findings of an earlier desk study are also partially presented in Section 2.5-2.7 of Chapter 2. The results of the research are published in Paper 4, along with another research article presented in Appendix F of this thesis (currently under review).

A longitudinal case study research strategy was adopted to analyse the main challenges and barriers in IOIS implementation. The retrospective analysis of the case study IOIS allowed the research to establish the crucial implementation factors in two distinct phases of the IOIS project's lifecycle. In the earlier supplier on-boarding phase, the IOIS project was investigated, and during the post-implementation phase the research focused on the IOIS artefact.

Evident from the case study, implementing IOIS to facilitate integration with supply chain partners is a complex endeavour which not only demands joint commitment from suppliers, but also requires significant re-engineering of the existing internal (and external) business processes. In terms of the systems development activities, the challenges and barriers that commonly crop-up in IS development projects also seem to appear in the earlier stages of the IOIS project delivery. However, due to the number of supply chain firms (and other third-party technology solution providers) involved in the planning, design, development, and the implementation, there are a few distinct challenges that require further attention by senior-level management. These are categorised as technical, coordination, organizational, and integration issues with the IOIS intermediary, which are discussed in more detail in Section 4.3.1 and in Paper 4. The research concludes that majority of these issues stem from poor IOIS implementation strategy and, points to several critical success factors that needs to be taken into account during IOIS strategy development.

In relation to the second task (the post-implementation evaluation of the IOIS), the research adopted a well-established theoretical framework (DeLone and McLean IS Success Model) to explore the case study IOIS's adoption, acceptance and continuance use over a 12-month period, in eight business units, across 42 projects, and by 135 users (Paper 5). The data was obtained through two questionnaire surveys (administered in 6 months interval), system usage data, and issue logs to investigate the six IS success variables (system quality, information quality, service quality, use, user satisfaction and net benefits). The study identified several important (system, service and information quality) issues from the questionnaire surveys which were also supported with the evidence gathered from the issue logs (See Section 5 of Paper 5). In terms of usage, the findings from the study revealed that IOIS adoption rate varies significantly amongst the user base, projects, and business unit levels. Differences in perceived significance of suppliers by end-users were also validated to assess the net benefits of the IOIS. For example, one of the supplier integration projects was found to be failing in realisation of the full benefits of IOIS implementation, which highlight the importance of supplier selection process in the earlier phases of the IOIS implementation.

### **5.1.3 Objective 3. Develop a guideline for IOIS implementation by contractor organisations**

This objective was met as detailed in Section 4.4 of Chapter 4 by synthesizing the findings from the previous tasks into a practice-oriented guideline for implementing IOIS with supply chain partners. The IOIS implementation consists of six cyclical/iterative phases which include

Supply Chain Management, IOIS Development, Implementation, Roll-Out/Piloting and, Maintenance and Growth. The guideline aims to bring together the key elements of a strategy development framework by incorporating the following within its structure: breakdown of the implementation activities in each phase, the key objectives, the critical success factors, the control/constraining factors, the main deliverables, and the type of participation required by different stakeholders.

## **5.2 Contributions to Existing Knowledge and Practice**

There have been limited studies on IS dimension of SCI, in particular on implementation of IOIS with key/strategic supply chain firms. The findings and conclusions drawn from this study contribute to existing knowledge and practice by:

1. systematic theorizing of construction supply chain relationships through identifying the attributes specific to different relationships in the construction industry.
2. developing a conceptual model for construction-specific Supply Chain Management, which can be adopted by industry firms for strategizing their approach to dyadic and extended management of supply chain firms.
3. developing a software vendor's evaluation matrix which can serve as a competitor analysis as well as used as a tool to track developments in technological landscape in the Cloud-era.
4. identifying the key challenges and barriers during IOIS implementation lifecycle from the perspective of a large contractor firm.
5. demonstrating the application and use of a well-known IS success model (the DM Model) for evaluating the IOIS acceptance and use.
6. providing a blueprint for industry firms (and technology solutions providers) by setting out the key phases and preliminary procedures in IOIS implementation.

## **5.3 Implications for the Sponsor**

The findings reported in this research project has the following implications on the research sponsor.

1. The lack of contractors' SCM practices (or capabilities) with their extended supply chains undermine the opportunities available for the sponsoring company to build highly-integrated IOIS for the industry firms. Since cSCM is best executed through a relationship-centric approach, the sponsoring company should actively focus on improving the dyadic linkages between supply chains where relationships have already established.
2. In relation to the IOIS implementation, the sponsoring company plays the crucial role of systems/process integrator between the supply chains and therefore needs to build an effective development methodology for successful IOIS implementation. Given that majority of the issues encountered during IOIS implementation are non-technical (for example, organisational and project management issues), sponsoring company needs to ensure effective coordination and communication mechanisms are in place for a much quicker turn-around on IOIS delivery.
3. It is likely that a large number of people from different backgrounds and roles will be involved in the IOIS delivery. While the sponsoring company has limited influence on contractor-supplier relationships, it needs to develop effective, formal and informal project governance structures for successful IOIS project delivery.

## **5.4 Implications for the Wider Industry**

There are two main areas where this research project has implications on the wider industry. These are as follows.

1. There is a significant scope for implementing a variety of ICT-enabled cSCM solutions in the AEC industry. cSCM should be augmented with the appropriate tools and technologies which are not bound by the intra-firm activities, but rather extend to activities outside of the contractor organisations' supply chains. The IOIS has the potential to significantly transform the relationships with supply chain firms. Accordingly, contractor firms must start working on inter-enterprise integration capabilities by integrating at functional, informational and operational levels to make most out of their relationships with their supply chain firms. If applied and utilised appropriately, ICT-enabled cSCM presents organisations a substantial operational efficiency and effectiveness. Large contractor organisations that pursue the realisation and adoption of ICT-enabled cSCM have a higher propensity to differentiate themselves and reach higher levels of supply chain performance. In order to increase the adoption of such technology, key issues with cost, lack of awareness, supplier's reluctance to adopt, end-user training/resistance as well as data compatibility and interoperability of needs to be given due consideration.
2. Implementation of IOIS requires contractor organisations to invest significant amount of managerial attention to the supplier on-boarding process. Given that contractor organisation will want to integrate with as many of its key/strategic suppliers as possible, the difficulty of managing the supplier on-boarding phase is expected to increase in tandem with the number of suppliers incorporated into the IOIS. For example, it is possible that multiple integration processes will be in progress at any one time and that such integration tasks will most likely be at different stages of the systems development life cycle. The management of these tasks are not only crucial for individual integration projects, but also for the IOIS as a whole.

## **5.5 Recommendations for Further Research**

In view of the research findings and conclusions, following recommendations are proposed in future studies.

1. To meet the challenge of IOIS implementation projects is difficult given the current state of research. Neither has the IOIS or cSCM implementation has been sufficiently understood nor applied in research and practice. Accordingly, there is a need to develop appropriate study designs to provide direction for further research as well as addressing the knowledge and research gap between AEC-specific and wider IOIS and SCM domain.
2. Whilst the most pressing problems in IOIS implementation projects relate to a combination of organisational, integration, coordination, technical, and management related issues, further developments in methods and tools to support implementation activities (for example during the supplier on-boarding phase) could help organisations to the speed up the IOIS implementation process. In this regard, further research is required for developing best-practice guidelines, identification of the key performance indicators and the critical success factors for more effective management of IOIS implementation projects.
3. The implementation of IOIS is best undertaken when it is supported with appropriate IS/IT management strategies. This demands a detailed investigation into how contractor organisations plan, design and implement their IS/IT strategies as part of either their business or technology driven agendas.
4. One of the limitations of studies on IOIS is the lack of focus on supply chain level where the unit of analysis for implementation is often considered from the perspective of a single organisation. Future studies could attempt to explore the IOIS implementation from the perspective all participants involved to identify the benefits of IOIS

implementation, perceived importance and value of the integration with one another as well as the key interfacing issues related to technology, process and business relationships.

## 5.6 Critical Evaluation of the Research

Following highlights some of the limitations of the research.

1. Although the conceptual frameworks proposed in Task 1 and 2 provided a detailed explanation of different levels of supply chain relationships, they are highly descriptive and falls short of offering answers to how to manage the supply chain relationships.
2. Due to the rapid pace of developments in the technology industry, the evaluation of the SaaS vendors (presented in Task 3) have a very short life-span. This could render the evaluation matrix presented in Section 4.2.3 as out-of-date. Nevertheless, it is important to note that such evaluation is extremely valuable for tracking the key and emerging developments in this niche marketplace.
3. Adopting a longitudinal approach for research Tasks 4 and 5 meant that the RE was bound by the circumstances which were outside the control of the RE. For example, the duration of the implementation activities resulted in research timeframe (data collection and analysis) being extended, which consequently, had an impact on the overall completion of the thesis. Nevertheless, this research adds to the limited number of longitudinal studies on IS implementation within its real-life context.
4. The observations and findings that emerged from the case study research in Tasks 4 and 5 are descriptive due to the nature of the chosen research strategy (case study research). In addition, as with any case study research approach, the generalisability of the findings can be regarded as a major concern for validity of the findings in different settings. Although multiple methods (triangulation) were used to reinforce the generalisability and increase the internal and external validity of the findings, conducting further interviews would have strengthened the conclusion drawn from the research.
5. The guideline proposed for Objective 3 is highly descriptive and lacks methods to its practical application at operational workflow level. However, this is expected given that the guideline is the result of the amalgamation of prior research findings. On the other, it would have been highly valuable for the contents of the guideline to be field-tested (for example, through conducting interviews, focus groups, and surveys) to increase its reliability and validity. In addition, evaluating the proposed guideline in a real-life implementation project would have proven very useful for its testing and refinement for further improvements and identification of its major limitations.

## 5.7 Conclusion

The overall aim of this project was to investigate the cSCM for better integration of construction supply chains through IOIS implementation. The research project began with a review of the generic SCM concept and the drivers, benefits and challenges that organisations face in its application to AEC context. The review established that a relationship-centric focus is the most appropriate approach for application of the SCM to construction context and proposed a conceptual framework for relationship-based approach to cSCM. The ICTs utilised for the cSCM were explored in an industry survey which validated the literature review findings and confirmed the lack of systems integration along the contractors' extended downstream and upstream supply chains. As a consequence, the research attention shifted its focus from chain level analysis onto the studying of supply chain integration (SCI) practices in dyadic relationships. The technological solutions that facilitate SCI were explored in detail to help with further understanding of the main advantages and opportunities from Inter-Organisational Information Systems (IOIS) implementation. Next, a real-life IOIS implementation project was

examined to explore the challenges and barriers that contractor organisations (and end-users) faced during ex-ante and ex-post stages of the implementation process. Finally, the research amalgamated these findings and conclusions into a practice-oriented framework which provides a strategic guideline for large contractor organisations (and technology solutions providers) to plan and implement their IOIS projects.

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## Appendix A An Example of the Case Study Data Recording Document (Master Spreadsheet)

Project Stages	Phase Completion Dates			Development (days)				Project Hold (days)	Email Count (no)	Average Email Response (days)
	Start Date	End Date	Phase Duration (workdays)	HP	CF	Supplier	Total			
<b>1. Commercial Agreement</b>	<b>14/09/2012</b>	<b>13/02/2013</b>	<b>101</b>				<b>0</b>	<b>0</b>	<b>11</b>	<b>22</b>
<b>2. Project Specification</b>	<b>18/06/2012</b>	<b>14/09/2012</b>	<b>63</b>				<b>0</b>	<b>54</b>	<b>15</b>	<b>5</b>
2.1 Requirements gathering	18/06/2012	14/09/2012								
HP No response from HP	19/06/2012	09/08/2012						37		
S8 No response from S8	09/08/2012	13/08/2012						2		
S8 No response from S8	13/08/2012	23/08/2012						8		
HP/S8 Meeting arrangement	23/08/2012	29/08/2012						3		
HP HP feedback on S8 query	10/09/2012	14/09/2012						4		
<b>3. Connection and Mapping Exercise</b>	<b>29/08/2012</b>	<b>26/11/2012</b>	<b>63</b>	19	6	3	<b>33</b>	<b>32</b>	<b>22</b>	<b>4</b>
3.1 Punch in/out Setup	12/10/2012	15/10/2012		8			<b>8</b>			<b>0</b>
S8 OCI connection setup. Waiting for response from S8	14/09/2012	18/09/2012						2		
HP HP to share connection details for S8 to connect	12/10/2012	15/10/2012						1		
3.2 CO Order/Acks Mapping	18/09/2012	22/11/2012		2			<b>2</b>			<b>0</b>
S8 Feedback on sample documents shared	20/09/2012	24/09/2012						2		
HP/S8/CF Meeting arrangement	24/09/2012	01/10/2012						5		
S8 Waiting for feedback on Delivery address field	03/10/2012	08/10/2012						3		
3.3 Invoice/CRN Mapping	09/10/2012	26/11/2012		7			<b>7</b>			<b>0</b>
HP Feedback on sample invoice shared	19/10/2012	31/10/2012						8		
HP Feedback on invoice matching	31/10/2012	01/11/2012						1		
S8 Response regarding the CN	01/11/2012	06/11/2012						3		
HP HP to share CN mapping documents	06/11/2012	08/11/2012						2		
S8 Waiting for S8 to feedback on CN	09/11/2012	16/11/2012						5		
3.4 Connection Setup (QA and Live)	15/10/2012	16/10/2012		2			<b>2</b>			<b>0</b>
HP Connection Setup	18/09/2012	19/09/2012								
<b>4. Implementation</b>	<b>09/10/2012</b>	<b>22/10/2012</b>	<b>9</b>		3		<b>3</b>	<b>0</b>	<b>4</b>	<b>3</b>
CF CF implementation	09/10/2012	22/10/2012	9				3	0		
<b>5. Phase 1 Testing</b>	<b>20/09/2012</b>	<b>21/11/2012</b>	<b>44</b>				<b>0</b>	<b>0</b>	<b>25</b>	<b>4</b>
<b>6. Phase 2 UAT Testing</b>	<b>22/11/2012</b>	<b>12/03/2013</b>	<b>71</b>	4		3	<b>7</b>	<b>48</b>	<b>142</b>	<b>2</b>
HP UAT activities	27/11/2012	29/11/2012		1						
CF CF to create CO orders for testing	29/11/2012	04/12/2012						3		
S8 S8 to create invoice	05/12/2012	12/12/2012						5		
S8 Invoice not being received	10/12/2012	12/12/2012						2		
HP HP to correct error and notify CF	13/12/2012	17/12/2012						2		
HP HP to correct mapping for commas in CSV files	19/12/2012	02/01/2013		3				3		
CF CF requests to stop work on S8	07/01/2013	13/02/2013						27		
S8 Waiting for S8 to create test invoices	19/02/2013	22/02/2013						3		
CF S8 system is having issues with rounding, so cannot start UAT testing	27/02/2013	04/03/2013				3		3		
<b>7. Deployment</b>	<b>12/03/2013</b>	<b>02/04/2013</b>	<b>13</b>	1			<b>1</b>	<b>5</b>	<b>40</b>	<b>1</b>
S8 Connection problems	15/03/2013	18/03/2013						1		
HP Go-Live documentation prep.	22/03/2013	27/03/2013						3		
CF Go-live date	28/03/2013	02/04/2013						1		
<b>Totals</b>	<b>24</b>	<b>9</b>	<b>6</b>	<b>39</b>	<b>139</b>	<b>259</b>				

\* The project lasted 200 days of which only 61 days were considered as 'active'.

## **Appendix B      Achieving Effective Project Delivery Through Improved Supplier Relationship Management (Paper 1)**

### **Abstract**

Supplier Relationship Management (SRM) has a critical and unique role in the management of construction supply chains. Within the Architecture, Engineering and Construction (AEC) industry contractors generally rely on formal legal arrangements to manage their relationships with subcontractors and suppliers. As a result of the reliance on legal options, it is common to find confrontational and adversarial relationships in many projects. The disputes and claims that arise from such confrontation tarnish the reputation of the AEC industry and more importantly have a significant impact on project processes, with regard to cost, time, and quality. Despite the efforts to have better interactions within and between different supply chain actors, few attempts have been made to understand the variables that help develop, maintain and re-build more co-operative and collaborative relationships.

Within this paper the authors provide a review of progress in construction specific supply chain management as a backdrop to an empirical investigation on improving project delivery by AEC companies. The paper is based on a study aimed at developing a framework that can serve as a roadmap on how supply chain relationships can be better monitored, controlled and managed, which is a research partnership between academia and an industrial sponsor. It reports on the first phase of the study which addresses the attributes of various types of relationships where relationships are categorised into four categories. Without an understanding of the different levels of relationships that a contractor firm has with its supply chain firms, management strategy for various relationships will not be effective as every relationship is composed of different entities that make up its 'DNA'.

The discussion on four types of relationships point out that further empirical study is needed with regards to the processes and technologies currently being applied in construction projects as well as identification of roles and responsibilities of decision makers in AEC supply chains.

**Keywords:** Supply Chain Management, Supplier Relationship Management, Relationships.

**Paper type:** Research Paper

# 1 Introduction

The importance of relationships in supply chains has always been seen as essential for the delivery of construction projects. This is because construction projects involve complex interaction processes, supplies of raw materials, information, products, and services between supply chain actors that create an immense structure of supply networks. Increasingly therefore, relationships are considered to be the veins and arteries of supply networks that create an intense and unique structure with economic, legal, technical and social dimensions (Håkansson and Ford, 2002). At the same time, the emphasis on management of these relationships is extending beyond immediate tiers of a focal company, thus, giving relationships a greater priority within an organisation's supply chain management practice (Monczka *et al.*, 2011).

Within the scope of construction specific supply chain literature, supplier relationship management is regarded as one of the most important aspects for achieving efficient supply chain management (Maqsood and Akintoye, 2002 and Bemelmans *et al.*, 2012). Despite the significance of relationships for the delivery of projects, there is a dearth of research in this area (Bemelmans *et al.*, 2012). What research interest exists is mostly focused on defining specific relationship types, in particular 'partnering' relationships, and significant proportion of these studies show very little appreciation of how to manage different relational elements for the various types of relationships. Furthermore, majority of research has been on the contractor-client interface, ignoring the downstream supply chains which account for up to 80% of the total project interaction (Holti *et al.*, 2000). The consequences of unmanaged relationships are strongly related to the problems that currently exist at different layers of the industry (Meng, 2010). The resultant issues of win-lose transactions and adversarial relationships that arise from a lack of relationship management not only tarnish the reputation of the AEC industry, but more importantly have a significant adverse impact on project processes with regard to cost, time, and quality.

Gadde and Snehota (2000) state that relationships are one of the most important and valuable assets of a company. Relationship management do not only play a key role on procurement and transactional relationships (Gadde and Snehota, 2000) but determine the realisation of many other facets of business activities (Chen and Paulraj, 2004b). For example Chen and Paulraj (2004a, b) and Monczka *et al.*, (2011) particularly emphasise the following aspects where relationships play a key role on: outsourcing; supplier selection; supplier certification; supplier involvement; supply base reduction; value-driven interaction; communication; cross functional teams; trust and commitment; and establishing close partnership relationships with strategic or key suppliers. All of these elements have significant importance in the relationship development process but unfortunately relationship management has not received adequate attention to reflect its critical role within construction supply chain management (cSCM).

Despite the efforts to have better interactions within the construction industry, few attempts have been made to understand the inter-organisational and inter-personal dynamics of different types of relationships. Based on a review of relevant literature this paper aims to classify the different categories of relationships that exist within construction supply chains. In particular, it defines four types of relationships based on variables identified within construction and relationship marketing literature. It argues that there are three essential components of supplier relationship management which are people, processes and tools. The discussion of these elements points to the need for further empirical research in order to have a more detailed definition for the types of relationships; the processes, protocols and procedures employed; and the tools that facilitate and enable effective relationship management process.



## 2 Defining Relationship Management

There are two conceptual fields of study that attempt to develop theoretical and industrial knowledge on inter-firm relationships: Supply Chain Management (SCM) and Industrial Network Approach (INA). From relationship management perspective, the purpose of SCM is to seamlessly integrate all stakeholders in a process through effective and efficient relationships between supply chain actors (Bygballe *et al.*, 2010), whereas INA perspective tries to define and address how various actors, their connections and resources can be managed in intra-firm, inter-firm and network of relationships (Håkansson and Snehota, 1995). Both of these perspectives are thought to have a complementary role within firm-firm relationships where one emphasises a structured, formal approach to management of relationships (SCM) (Bygballe *et al.*, 2010) and the other is more concerned with informal aspects of relationships (INA) (Håkansson and Snehota, 1995). Halldorsson *et al.* (2007) argue that there is no single-unified theory for managing supply chain relationships and suggested a blending of both SCM and INA concepts to develop a framework from a multi-theory perspective that will complement each other's weaknesses.

Generally, relationships are characterized as having a multi-dimensional relationship structure where many elements (both human and firm) shape a relationship's type, form, duration and intensity. Håkansson and Ford (2002) and Gummesson (2008) defined the core concepts of relationship management as relationships, interaction and networks. For Pryke and Smyth "*interaction that is more than a brief encounter, or that is long lived, is a relationship*" (2006: 23). Interaction is the activity which occurs within that relationship (Ford *et al.*, 2003) and a network is where complex pattern of interactions between many parties occur (Gummesson, 2008).

Although, majority of studies conducted on relationship management are from INA perspective, both the SCM and INA studies conclude that relationships; in terms of its content, dynamics and evolvement, are unique to every transaction/interaction (Ford *et al.*, 2003). Therefore, as reinforced by Briscoe and Dainty (2005) every relationship requires a different approach to its management which makes the management of relationships complex process. Despite the fact that INA perspective lacks a structured, formal and manageable approach to relationship management; by applying some of the principles developed in the SCM literature inter-firm relationships can become more manageable and controllable.

## 3 Relationship Management in the AEC Industry

For Maqsood and Akintoye (2002) relationship management is one of the driving components of supply chain management which facilitates execution of purchasing and logistics related activities of construction projects. However, this is a rather narrow perspective. Within this study construction specific SRM (cSRM) is defined as a company-wide business strategy to manage its interconnected, dynamic and multi-dimensional interactions through its various resources within the firm and at the interface with other businesses so that it facilitates development of better relationships throughout its upstream and downstream supply chains. The approach should be unique to each relationship, pursue a long-term vision and must extend beyond a simple exchange of product, process and project to cover *all other entities* associated with the relationship (be it value creation process, a new product development, a project package and so forth) (Eriksson *et al.*, 2007). This approach can also be regarded as Total Relationship Management.

Existing literature on construction supply chain relationships explore the subject mainly from two perspectives. On the one hand cSRM is primarily argued from Transaction Cost Economics perspective where the role of cSRM is mainly concerned with procurement and sourcing of suppliers (Svahn and Westerlund, 2009 and Frödell, 2011). Such a perspective emphasises a cost reduction perspective to management (Vrijhoef and Koskela, 2000) and is

not holistic for a wider view of relational entities embedded within the interaction process. On the other hand, cSRM is considered to be management of relationships through human, structural and social capital of firms (Pryke and Smyth, 2006). Moreover, majority of studies that investigate relationship management are usually spread between two dichotomies: (i) management of a single sourcing of a commodity; product or service and, (ii) strategic sourcing; where the aim of SRM is comprehensive management of relationships, to cover management of suppliers and client (or even end-users) from end-to-end perspective. The former is usually blurred within the purchasing function of SCM (Svahn and Westerlund, 2009) whereas the latter is discussed within the context of collaboration and partnering literature (Kumaraswamy *et al.*, 2000; Maqsood and Akintoye, 2002 and Bygballe *et al.*, 2010).

However, the research on SRM is disparate and there appears a very limited empirical study which focuses on relationship types adopted by construction firms within their supply network (Meng, 2010; Meng *et al.*, 2011 and Bemelmans *et al.*, 2012). By understanding how best to manage, coordinate and control different types of relationships, workflow procedures can be improved and better relationships can be formed at all levels in the supply chains and networks.

## 4 Classification of Relationships in the AEC Industry

In a typical construction project supply chain a number of actors are connected together through multiple, dynamic, and context specific relationship layers such as product/information/material flows, contractual relationships, monetary relationships, information exchange networks and social networks (Pryke, 2004). Within the project environment the length of the supply chain or complexity of the network is dependent on the characteristics of the project defined by size, duration, complexity, procurement route, and number of stakeholders (London, 2004). Responsibility for managing this complex, iterative and interactive process usually rests with the main contractors who generally coordinate the design and construction process end-to-end. Considering that the focal firm in a supply chain is the main contractor, other actors at different levels of the supply chain can be associated with the main contractor as in *Figure 1*. This depicts a schematic where the vertical structure of the map is characterised in terms of degree of specialisation and the horizontal structure refers to the number of firms represented within each tier.

Cox and Ireland (2002) have suggested that classification of various types of supplier relationships is not clear. Classification of a supply chain relationship is important because multitude of relationship types exist in an organisation's supply network and not every relationship type is appropriate for different contexts (Spekman *et al.*, 1998; Cox and Townsend, 1998; and, Cox and Ireland, 2002). Another reason why classification is important is because added value in every relationship differs from one another as some relationships are considered to be more valuable than others (Ford and McDowell, 1999).

This is supported by Spekman *et al.*, (1998: 114) who suggested that “*not all suppliers are treated equally, nor should they be*”. Therefore, some relationships may require greater resources for its maintenance and development whereas some relationships may need a specific strategy which is tailored for its continuity. In addition to this relationships have an interdependent role within a supply network such that certain types of relationships will influence and be influenced by other relationships (Cox and Ireland, 2002 and Bygballe *et al.*, 2010). Similarly, certain strategic decisions can have different level of impact on some relationships (Ford and McDowell, 1999), therefore, by categorising relationships firms will be able to manage, develop and re-build their relationships with correct sets of tools, processes, procedures and motives so that relationships become an asset for the company, not just a mere mechanism to interact with other businesses.

As identified previously, within the cSRM literature relationships are generally studied from two perspectives: procurement relationships and firm-firm relationships. For example, Vrijhoef and Koskela (2000) identified four levels of interactions at project supply chains; however they did not make a clear distinction between various relationship types within these supply chains. From the literature reviewed it seems that there is a gap of knowledge in AEC supply chain relationships in terms of what are the characteristics of different types of relationships; in what circumstances these relationships are created, developed and ended; and, what are the core components and elements of each relationship type.

Table 1 summarises different types of relationships that have been mentioned in the past studies. Majority of research concerning supply chain relationships have only analysed the partnering relationship and typified different levels of partnering within their studies, hence they are biased towards one particular form of relationship. Secondly, one of the main weaknesses in almost all of these studies is the inadequate coverage of key relationship characteristics for each relationship category. In other words there is a lack of detailed description on what each relationship type encompasses in terms of actors in the relationship and links between them.

Meng *et al.*, (2011) and Meng (2010) have developed a relationship maturity model which describes some of the key relationship elements within each relationship category. The study by these authors provide a good model for evaluating different types of relationships in a buyer-supplier interface however key aspects of relationships and its management are not fully covered within their model. For example, some key relationship elements such as duration of

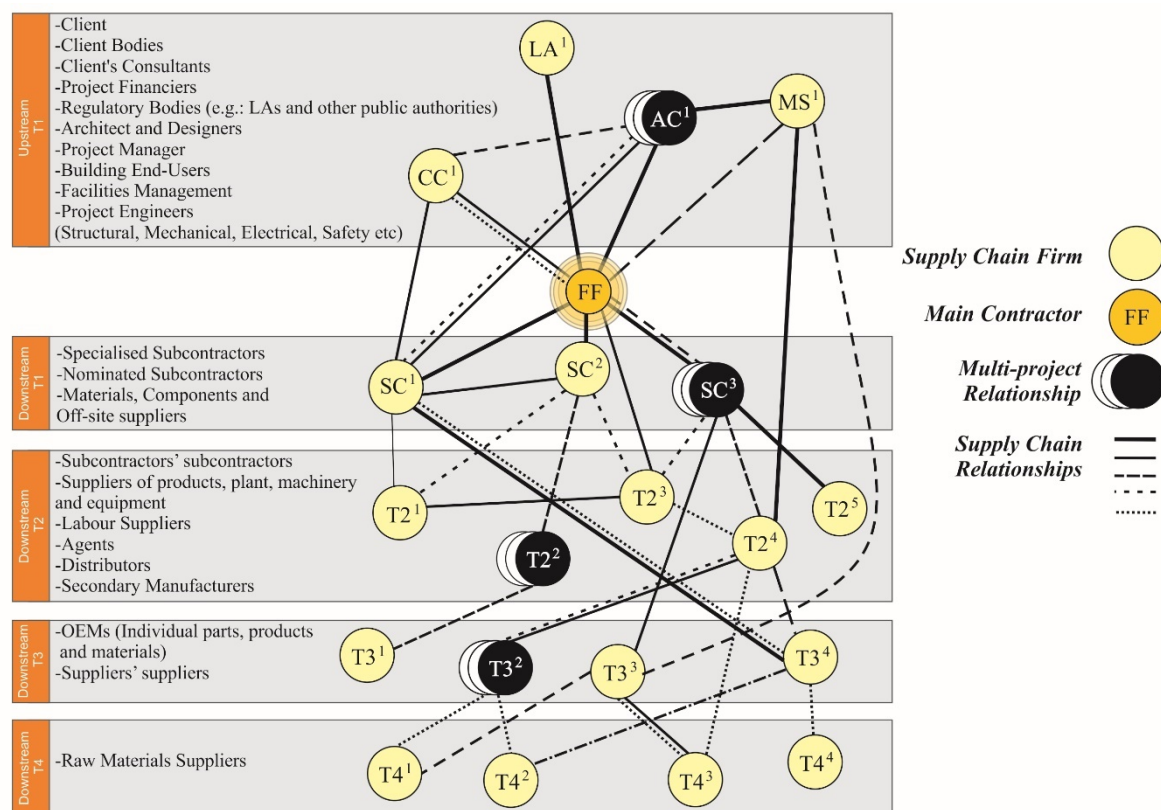


Figure 1: A conceptual supply chain map and description of the actors involved at each stage (Marceau *et al.*, 1999; Edum-Fotwe *et al.*, 1999; Cox and Ireland, 2002; London, 2004 and Beach *et al.*, 2005).

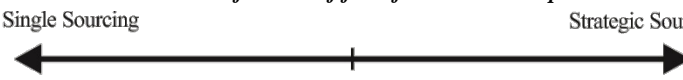
the relationships, extent of adaptation and attraction, power symmetry, and length of the supply chain is not included in their model.

From the review of literature on construction supply chain management four categories of relationships can be identified. These categories are labelled as transactional relationships, series of transactions, project collaboration and long-term strategic partnerships. The literature distinguishes these relationship categories by the following generic characteristics: counter-productive, compliant, cooperative and collaborative, respectively; however it does not clearly differentiate these relationships in terms of their multi-level, multi-faceted and dynamic relational elements. Following sections will discuss these relationship types in more detail.

## 4.1 Transactional Relationships

In the construction industry, the most common type of relationship that a firm has with its suppliers and buyers is a transactional relationship (Thompson *et al.*, 1998). This is not surprising as the construction projects are generally characterised as collection of temporary multiple organisations (Dubois and Gadde, 2000). Transactional relationships are short, simple and price-based transactional interactions between dyadic actors in the chain. At the project level, Dubois and Gadde (2002) described this kind of relationship as low involvement relationships and cited that transactional project relationships have better localised adaptations (i.e. firms can benefit from knowledge transfer); can serve as a buffering mechanisms against unfavourable conditions (such as logistical issues); provide a sensitive sensing mechanism; appropriate for situations where a greater number of mutations and novel solutions required (i.e. as there are more options for variety and innovation); and, sign of an interest in further transactions/relationships. However, at a much smaller scale, one of the driving forces for adapting transactional relationships is that it requires very little investment and involves less risk in the transaction process which is favoured in situations where there is an element of

Table 1: Studies on relationships in construction supply chains.

Authors	Topic	Classification of firm-firm relationships			
					
		Commodity, Product or Service	Project	Total Relationship Management	
Jones and Saad, 2003	Partnering	Traditional	Two-stage with negotiation	Project Partnering	Strategic Partnering
Thompson <i>et al.</i> , 1998	cSCM	Preferred Supplier	Single Sourcing	Network Sourcing	Strategic Alliance
Li <i>et al.</i> , 2000	Partnering	-	Pseudo-partnering	Project Partnering	Strategic Partnering
Saad <i>et al.</i> , 2002	cSCM	Contractual	Project Based	Full Partnership Alliance	Strategic Partnering
Maqsood and Akintoye, 2002	cSCM	-	Cooperative	Coordination	Collaboration
SFfC, 2003	SCI	-	Historic	Transitional	Aspirational
Humphreys <i>et al.</i> , 2003	Partnering	Traditional	Semi-Project Partnering	Project Partnering	Strategic Partnering
Gadde and Dubois, 2010	Partnering	-	Local Level Partnering	Central Level Partnering	Intermediate Level Partnering
Meng, 2010	cSCM	Traditional	Limited Cooperation	Project Based Collaboration	Long-term Collaboration
Meng <i>et al.</i> , 2011	cSCM	Price Competition	Quality competition	Project Partnering	Strategic Partnering/Alliancing
Bemelmans <i>et al.</i> , 2012	cSCM	Project Level	Regional Level	Division Level	Corporate Level

uncertainty and complexity in the project (Dubois and Gadde, 2002; and Gadde and Dubois, 2010).

However, the main disadvantage of having a transactional relationship is the discontinuity in the relationship (Cox *et al.*, 2006). Dubois and Gadde (2000) noted that transactional exchange hampers the development of both, temporary and permanent network relationships. Transactional relationships generally comprise of short-term, operational and limited relational interaction between the firms. For example, every transaction is considered to be a new relationship making this type of relationship inefficient (i.e.: a new learning curve is climbed at every interaction and higher transaction costs associated with searching and finding information, negotiation costs such as bargaining costs and, enforcement costs which are related to costs associated with monitoring and enforcing contracts).

Furthermore, on transactional relationships suppliers are usually selected on a minimum cost basis and greater emphasis is placed on fully documented conditions of the contract (Thompson *et al.*, 1998). Findings from empirical studies show that the main problems with transactional relationships are related to the lack of commitment; misaligned values, visions, goals and objectives between the actors; transfer of knowledge and experience to subsequent projects; and “*deep-rooted cost driven agendas in transactions*” (Wood and Ellis, 2005: 324); which consequently results in opportunism and mistrust.

From the INA perspective, transactional relationships may not be created merely by an exchange of a commodity or service but also thorough other variables between firms and individuals (Holmlund, 2004). A transactional relationship could have different entities that constitute to its formation (London, 2004). For example, a transactional relationship can occur as a result of structural and behavioural characteristics of procurement events (London, 2004) such as a social, legal, economical, technical, inter-personal interaction between the firms and individuals (Holmlund, 2004). Furthermore, a transactional relationship could trigger or result in another transaction as well as lead to more intense form of relationships (i.e. series of transactions) (London, 2004). Here, it must be highlighted that an empirical study is needed to find out which relationship elements and dimensions of interaction result in further transactional engagement within and between the supply chain firms.

## **4.2 Series of Transactions**

The next level in relationship category is called series of transactions. This kind of relationship usually occurs between a client who is a regular buyer or a contractor who interacts with a supplier more intensely and frequently (Cox *et al.*, 2006). It is also termed as ‘parallel sourcing’ where a buyer sources a product and/or service from a list of preferred suppliers for multiple projects (Homlund, 2004). For example, most clients and contractors nowadays have a framework agreement with their pre-selected suppliers, so the transaction may happen in a stream of projects, but sometimes the type and nature of the product/service may be different compared with the previous transaction (London, 2004).

The main advantage of having this type of relationship is to benefit from the ties/links that exist in an extended relationship. Dimensions of interaction are much more dynamic compared to the transactional relationships therefore there could be opportunities for cooperation, however these also depend on the strength of the entities associated with the interaction (e.g.: volume of transaction, frequency of interaction, degree of strategic importance, level of actors involved in the relationship and so forth) (London, 2004).

Series of transaction relationships are usually blamed for the same adversarial conditions that arise during a transactional relationship. This is mainly due to the fact that firms have little interaction outside the transactions and relationships generally embrace standard forms of contracts. Dubois and Gadde (2000) reasoned the first point to the lack of interdependence, standardisation and adaptations between parties which inhibits forming of

sustainable long-term relationships. Furthermore, Thompson *et al.*, (1998: 37) noted that majority of the contracts used at this level of interaction are “*reactive* mechanisms designed to apportion blame between the parties”, therefore relational elements are marginally reflected in the interaction/transaction process.

### 4.3 Project Collaboration

The third level of relationship in the relationship categories is the project collaboration. The literature describing this kind of relationship is generally concerned with the firm-firm relationships which comprise of closer relational arrangements between firms. An example of this is the alternative forms of procurement to source suppliers as well as alternative forms of contracts between project firms (Thompson *et al.*, 1998 and Kumaraswamy *et al.*, 2000). Project collaboration may have been evolved from the previous relationship levels (series of transactions or transactional relationships over a period of time) or a firm may decide to work collaboratively with a supplier in a specific project for strategic purposes (Gadde and Dubois, 2010).

Relationships at this level are described as ‘cooperative’ and partnering arrangements between main contractor and the client is one of the most adopted relationship approaches. At this level of interaction, relationships are primarily characterised on length and duration of the interaction which is generally as long as the project’s duration (Humphreys *et al.*, 2003). Other common characteristics include integration of facilities/infrastructure (such as sharing project offices for teambuilding); predetermined risk/benefit sharing mechanisms (framework agreements); early involvement in the projects; focus on the project and client requirements; and, focus on logistics and economic efficiency and performance.

### 4.4 Long-Term Strategic Partnerships

The highest-ranking relationship type is considered to be the long-term strategic partnerships (LTSP). These are high level, strategic and long-term orientated relationships between two actors in the supply chains (Gadde and Dubois, 2010). Most firms engage in LTSP relationships with limited number of firms as it requires a lot of investment and commitment from the parties involved. The reviewed literature on construction specific supply chain management reveals that much of the research and practice in the industry has only considered the relationships between contractors and client, ignoring the downstream supply chain firms, so the extent of relationship management is restricted to immediate tier of the partnering firm.

The most common terminology that appears to describe this type of relationship is ‘collaboration’ within the context of Integrated Supply Chain Management (ISCM) literature. The term ‘collaboration’ is used interchangeably in the literature however at this level of interaction collaboration is described as a hybrid business operation where the aim is to create synergy by achieving vertical and virtual integration between the two supply chain actors (Gadde and Dubois, 2010). Gadde and Dubois (2010) described the main characteristics of this kind of relationship as longevity, interdependence, relationship atmosphere, previous interaction, mutual orientation and adaptations in the relationship. The intensity of the interaction can be easily figured out by looking at the relationship characteristics in *Table 2*. The relationship variables in *Table 2* are drawn from relevant literature which describes what the best-practice for each relationship type should be. It can be easily identified that LTSP relationships embrace all of the relationship variables as an essential entity. However literature reviewed warns that LTSP is very difficult to realise in practice (Khalfan *et al.*, 2008). Yet, if all relationship elements are in place, it is the best relationship type that a business can have for a long-term sustainable inter-firm relationship strategy.

## 5 Discussion

The literature describing relationship levels in the AEC industry is fragmented and there are only a few studies which look at characteristics of different relationship types that exist in supply networks (for example: Meng, 2010, Meng *et al.*, 2011 and Bemelmans *et al.*, 2012). This study has categorised the supply chain relationships into four categories which are transactional relationships, series of transactions, project collaboration and long-term strategic partnerships. Although *Table 2* provides the essential relationship variables for each relationship type, the core characteristics of these relationships are not fully covered within this study due to space permissions. The contexts within which these relationships occur are presented in *Table 3*. By analysing the relationship characteristics further studies can establish the contextual factors that give shape and form to a relationship.

Each relationship level described above requires a specific and tailored management approach as every relationship is considered to be distinct and context specific (Spekman *et al.*, 1998; and, Cox and Ireland, 2002). Therefore, it would be acceptable to describe *what* the management should pursue for rather to define *how* to manage each relationship level. Literature reviewed indicates that the role of SRM within construction projects is strongly related to characteristics of a relationship. By focusing on the key aspects of a relationship, relationship management strategy can become more effective and efficient. For transactional relationships the aim of relationship management would be to monitor the relationship rather than manage the links and actors in that relationship. This is because there are many different entities that constitute to the formation of a transactional relationship where exchange/interaction is very short and transient. Management at this level would refer to the supplier selection process where the monitoring the transactions/interactions and determining the core characteristics of the relationship would enable a targeted management strategy to be applied to that relationship (Cox and Ireland, 2002). At the project level, monitoring of transactional relationships would generally concern the interface between the supply chain actors and the construction site (Vrijhoef and Koskela, 2000).

SRM for series of transactions would involve an active administration procedure to control that relationship. At series of transaction relationships, the elements that shape the relationship would be more settled and identifiable. This would make relationship management relatively easy as the connections and actors in that relationship are more rigid and traceable due to relationships being more systematic and structured. Management of relationship can be extended by the focal firm depending on the relationship determinants such as power symmetry, trust, continuity, interdependence and degree of strategic importance. However, in a study on Dutch construction firms, Bemelmans (2012) found that this was not the case. The authors' study indicated that relationship management for frequent transaction relationships was mostly implemented at project level confined to immediate tier of the focal firm and lacked majority of the relationship management constructs. As pointed out by Vrijhoef and Koskela (2000) relationship management at this level would be highly concerned with monitoring and control of actors and processes so that costs related to logistics, lead-time and inventory on project supply chains are reduced.

Table 2: Suggested best-practice relationship variables relative to four relationship levels in the literature reviewed.

Type	Relationship Elements	Transactional	Series of transactions	Project Collaboration	LTSP
Social	Honesty		○	●	●
	Trust (Universal)		+	●	●
Economic	Open book accounting		+	○	●
	Joint conflict resolution		○	●	●
	Best value approach (i.e. whole-life-value and value for money)	+	○	●	●
	Profitability and repeat business	+	○	○	●
	Logistics and operations management		+	○	●
	Alternative forms of procurement and sourcing		○	●	●
	Sharing of risks and rewards	+	○	○	●
	Transparency	+	○	○	●
	Power Symmetry			○	●
Organisational	Partnering			○	●
	Reliability and interdependence	+	+	○	●
	Previous experience	+	○	●	●
	Common purpose-mutual Interest (coalescence and win-win)	+	+	○	●
	Project teambuilding		○	●	●
	Structural alignments for strategic interactions			+	●
	Organisational trust	+	○	●	●
	Customer/Sub-Contractor/Supplier Relationship Management		+	●	●
	High level commitment		○	●	●
	Organisational culture			●	●
	Cooperation	+	○	●	●
	Project Culture			●	●
	Early involvement		+	●	●
	Continuous Improvement		+	+	●
	Long-term focus		+	+	●
Individual	Alignments for operational interactions		+	●	●
	Individuals' trust in and between organisations	+	+	○	●
	Individual commitment		+	○	●
	Training and skills		+	●	●
	Individuals' attitude, behaviour and culture		+	●	●
Technological	Collaboration	+	+	●	●
	Lean Construction Principles		○	●	●
	Integrated ICT infrastructure/Virtual Organisations			○	●
	Communication/Information Exchange	●	●	●	●

Key:

- Essential
- Necessary
- + Desirable



As relationships get more intense, the dimensions of interactions increase and consequently relationships get harder to control. Project collaboration relationships comprise of simultaneous relational entities which have more physical content and span over a longer period of time. The influence of the relationship management strategy can extend beyond the first-tier supply chain firms as well as beyond several project phases (i.e.: design development, construction, hand-over) as relational entities are attached to the various project and organisational processes. The main roles of different actors, the links between the actors, the resources and all other primary characteristics of collaborative relationships are usually determined, structured and embedded into the project-wide processes. Past interactions provide a historical record of relationships and a reference for future transactions. Thus, the project collaboration relationships need to be controlled and coordinated in a proactive manner e.g.: to transfer activities from the site to earlier stages of the supply chain.

The management strategy for the LTSP relationships would require a total relationship management approach where all the dynamics of the relationship is managed. With regards to the role of contractors in managing their supply chain relationships it would mean that management approach would embrace an integrated management of the supply chains with the emphasis on improvement of supply chain and the site production (Vrijhoef and Koskela, 2000). Therefore, total relationship management would involve monitoring, controlling, coordinating and managing all relational aspects of the interactions at many dimensions as possible such as project, organisational as well as organisation-individual.

Within the literature reviewed there is a general consensus that the impact or influence of relationship management strategies in dyadic relationships is determined by five important factors which are power symmetry, trust, continuity, and degree of strategic importance and interdependence of the other actors. However there appears lack of knowledge on what strategy would be most appropriate for managing different relationship levels in supply networks that extend beyond a simple dyadic relationship. Identifying the best route for a management

Table 3: Relationship characteristics.

<i>Relationship Variables</i>	<i>Description</i>
<b>Continuity</b>	Frequency, regularity and intensity of the interaction
<b>Complexity</b>	Number of people involved, volume of transaction and asset specificity
<b>Symmetry</b>	Power differences in terms of human, knowledge, financial and technological resources
<b>Process Nature</b>	Nature of exchange interaction, dynamism in relationships and future perspective
<b>Relationship Embeddedness</b>	Existing connections, links, and legal ties
<b>Attitude, Trust and Commitment</b>	Level of attitude and commitment to collaborative practices, and inter-firm trust
<b>Firm Position</b>	Firm position in the supply chain/network
<b>Dependence, Competence and Congruence</b>	Extent of dependence, competence and congruence that is required in the relationship
<b>Collaboration</b>	The degree of collaboration in the relationship
<b>Risk and Uncertainty</b>	Risk and uncertainty involved in the relationship
<b>Adaptation</b>	Level of investment in the relationship and synergy
<b>Attraction</b>	Commitment, dependency and importance, i.e.: financial motives, psychological factors, firm reputation and brand image
<b>Closeness and Remoteness</b>	Physical proximity of the parties, e.g.: geographical distance, cultural differences, language differences)
<b>Formality, Informality and Transparency</b>	Level of formality and informality in the relationships. Existence of risk and reward sharing mechanisms
<b>Routinization/ Standardisation</b>	Degree of routinization and standardisation of procedures, processes, protocols
<b>Social Network</b>	Extent of inter-personal and social network on the inter-firm relationships
<b>Market Structure</b>	Availability of the product/service in the market

strategy across a supply network would involve mapping different dimensions of relationships within supply chains so that different routes can be used to apply incentives or penalties to penetrate deep into the required tiers in supply networks.

The process for mapping the supply network relationships must consider the three essential components of relationships identified earlier. In terms of the actors involved in supply networks further research is needed to identify the individuals who are decision makers during procurement, design and construction process at a project level. In an organisational level, there is also a need to study the influence of these decision makers in supply network relationships. Future studies can look at the correlation between power, trust, interdependence, and strategic importance which helps to develop better relationships with those actors.

There are various processes, procedures and protocols mentioned in the reviewed literature for supplier relationship management process, however there is scarcity of research with regards to their use by contractor firms. Such processes can be studied in two contexts: formal and informal, where formal processes are referred to as written hard facts about how to implement a relationship management approach and informal processes are those that belong to activities within social context. Some of the formal processes used to manage relationships include Supply Chain Council's Supply Chain Operations Reference framework; Integrated Project Delivery method; Constructing Excellence's Strategic Forum for Construction Integration; OGC Guidance Documents; and British Standards 8534 and 11000.

Lastly, the tools and technologies which facilitate the interaction/transaction processes also need to be further studied. There are plethora of ICT tools and technologies available to support and enable the above-mentioned processes however the extent of their use by supply chain actors in construction supply networks is not thoroughly researched. The objective of these studies could be steered towards identifying and exploring the role of ICT tools and technologies in maintaining and sustaining relationships within project networks and in inter-firm relationships.

## **6 Conclusions**

Studies in the past and the practice in the industry have seriously neglected the strategic and operational importance of managing their relationships within project and organisational networks. The attention of focus in the past studies was solely directed on dyadic relationships between upstream firms (client-contractor) and certain types of relationships, such as partnering, were given more consideration despite the fact that no single type of relationship is appropriate for a firm's relationship strategy. This study has explored some of the relationship types that exist in the AEC industry and defined four relationship levels where characteristics of each relationship type were outlined from INA and SCM perspectives. In summary, each of the above relationship type needs appropriate management strategy as every relationship is composed of different entities that make up its 'DNA'. The most appropriate strategy for each of these relationship levels would involve: monitoring transactional relationships; monitoring and/or controlling more frequent relationships; control and coordinating collaborative relationships; and, managing long-term strategic partnering relationships. Improving relationships at operational and strategic level would involve looking at three core components of relationships; people, process and technologies. Further empirical studies are needed to fill the gaps within these three areas so that performance of construction projects could be improved through better relationships between the supply chain firms.

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## **Appendix C      Improving Supplier Relationship Management within the AEC Sector (Paper 2)**

### **Abstract**

Due to changes in many facets of projects and organisations, relationships between firms in the delivery of construction projects have consequently become more critical for the success of the project. Whether it is a transactional exchange or series of transactions spread over a period of time, relationships need to be managed. However, the concept of managing supply chains and relationships between firms has been relatively new to construction industry. Early pioneers of the concept, primarily automotive, aerospace and manufacturing industries, have greatly benefitted from non-adversarial, long-term and collaborative relationships. Although contextual factors within those industries largely shape each industry's approach to SCM (Supply Chain Management), its application within the AEC industry is slowly beginning to appear in a distinct shape and form.

Through a comprehensive review of literature on construction-specific SCM (cSCM), the study has identified that partnering, collaboration and trust are the three most prominent variables within the cSCM literature. Partnering and collaboration are considered to be relationship management tools, whereas trust is identified as the most significant relationship facilitator.

In spite of its significance on relationship development, there is very limited research carried out on the trust aspect of relationships. By understanding how trust is built and maintained, and what the conditions that result in mistrust are, firms can better manage their supply chains and their relationships with firms in the supply chains, manage factors that result in mistrust and mitigate potential conflicts arising from mistrust. Consequently, this will facilitate better collaboration, result in high-level of commitment, improve project teambuilding, and avoid conflict and adversarial relationships. Drawing on organisational relationship management literature, we argue that trust must be approached from five dimensions; economic, social, psychological, inter-personal and organisational. These dimensions are unidirectional, and they must be accounted conjointly as they are interrelated and interdependent.

**Keywords:** Construction Supply Chain Management, Relationships, Trust, Partnering, Collaboration.

**Paper type:** Research Paper

# 1 Introduction

Management of supply chains within the AEC industry is beginning to attract more interest from academia and industry. Early pioneers of the concept, primarily automotive, aerospace and manufacturing industries, have greatly benefitted from non-adversarial, long-term and collaborative relationships. Although the concept of managing supply chains has been adopted and adapted to the construction industry from these industries there is still large amount of work to be done to improve the AEC organisations' supply chain management operations. One of the most prominent variables suggested in the literature for an effective and efficient supply chain management strategy is 'trust'. The purpose of this study stems from the fact that although trust has been suggested as the most important relationship attribute it is not considerably studied within the construction specific supply chain management literature (cSCM).

Importance of supply chains in achieving industry wide improvement plans, enterprise level business strategies and project level operational objectives is significant for all the actors involved in a construction supply chain. Most firms have realised that by managing their supply chains effectively potential cost-savings can be achieved on projects as well as throughout their relationship; for example, through better supplier management practices and long-term relationships with key strategic suppliers/subcontractors (Matthews *et al.*, 2000). Consequences of unmanaged supply chain relationships are 'arm's-length', opportunistic and adversarial relationships which further results in disputes and inefficiencies in construction processes and increased cost and waste (Briscoe and Dainty, 2005).

To add to the problem further, both the research and the practice had an hindsight approach where majority of attention has been given to firms who are at the upstream level (Akintoye *et al.*, 2000; and, Briscoe *et al.*, 2004) ignoring the downstream supply chains (Saad *et al.* 2002) where up to 90-95% of contractual relationships occur in a project (London, 2004). As reinforced by Briscoe and Dainty (2005) every relationship requires a different approach to its management which makes the management of supply chain relationships a complex process. In addition to this, it has been highly advocated that firms must re-evaluate their approach to engage with both clients and suppliers. It must be noted here that attention should not be solely directed on certain relationships which are only 'dyadic' (i.e.: partnering) but consider the extended network of relationships between buyers and suppliers where the aim should reflect a total relationship management approach.

The aim of this study is to explore the 'trust' attribute in construction supply chain relationships by conducting a desk study on relationships in construction supply chains. Although there are a few conceptual ideas beginning to form (McDermott *et al.*, 2005; Khalfan *et al.* 2007; Lau and Rowlinson, 2010; and, Laan *et al.*, 2011) the discussion seems to be fuzzy and disconnected from one another. The conceptual base of 'trust' in construction supply chain relationships is not adequately developed for it to be empirically tested in the industry. It is repeatedly preached that supply chain firms should trust one another during a transaction/interaction however there seems to be limited study on how to execute a trust-based relationship. This study argues that a multi-dimensional perspective on trust is needed for comprehensive coverage of the concept in empirical studies.

## 2 Trust in Construction Supply Chain Relationships

Generally, relationships are characterized as having a multi-dimensional relationship structure where many elements (both human and firm) shape a relationship's type, form, duration and intensity (Håkansson and Ford, 2002). Hence there could be many multiple, dynamic, and context specific relationship layers within construction supply chains (Pryke, 2006). Trust is placed at the core of these layers, however within the AEC industry lack of trust undermines majority of interactions within supply chains (Briscoe *et al.*, 2001b; Lau and Rowlinson, 2009;

and, Laan *et al.*, 2011). Trust can have a direct or indirect consequence on almost every element of supply chain interactions. There is a unanimous agreement within the literature reviewed that trust is one of the most important constituents of long-term, collaborative and non-adversarial construction supply chain relationships.

In terms of its main function, trust has three primary roles in organisational relationships. Accordingly, it's a (i) 'social mechanism' that works outside formal arrangements (Möllering *et al.*, 2004); (ii) 'lubricant' that enables smoother flow of information, products and services (McDermott *et al.*, 2005); (iii) 'glue' that holds people and organisations together and creates synergy (Noteboom, 2002). For instance Spekman (1998) claimed that trust is the foundation of supplier relationship management. Eriksson and Laan (2007: 389) stated that *"to obtain advantages and synergies of cooperative relationships, establishment of trust is vital"*. Latham (1994: 87) noted that *"disputes will continue as long as people fail to trust one another."* Frödel (2011) argued that trust is the most critical factor and most important relationship enabler between strategic partners.

Despite its significance in supply chain relationships there appears rather limited research concentrating on this vital attribute specific to cSCM. The research carried out on trust aspect of relationships is primarily descriptive and lacks empirically tested studies. More specifically, there appears very limited research which explains how trust is built and maintained, and what are the conditions that result in distrust in construction supply chains. Anecdotal research generally focuses on impact of trust on partnering arrangements (for example Eriksson and Laan, 2007; Lau and Rowlinson, 2009; and, Laan *et al.*, 2011) and does not consider the various dimensions of trust embedded in construction supply chain relationships. By understanding and establishing high level of trust within and between firms and individuals; supply chain firms can manage their relationships with fewer resources, understand the consequences of their decisions, increase and maintain trust to the highest level and then reap the benefits of trust-based relationships. This is illustrated in Figure 1.

### 3 Discussion

Within this study 40 articles published in various peer-reviewed journals were selected to identify the most common themes for effective and efficient supply chain relationships (see Appendix C-1). Majority of these articles are empirical studies which are based on cSCM. Analysis of the articles was carried out using coding where each specific relationship attribute mentioned in the article was mapped in a matrix.

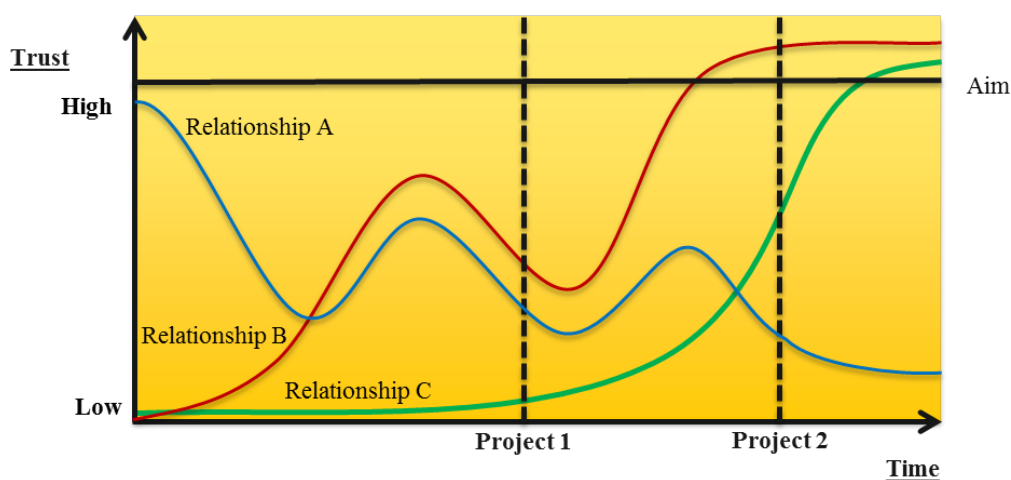


Figure 1: Development of trust in project relationships.



An effective and efficient supply chain is usually judged on social, economic, organisational, interpersonal and technological dimensions of interaction. Therefore the key relationship attributes were categorised into these five areas on the vertical axis where each specific attribute for effective and efficient cSCM were identified and then marked with a sign to indicate its agreement, disagreement or contextual arguments in relation to that variable.

*Appendix C-1* shows there is more emphasis on improving the organisational aspects of supply chains. According to this matrix partnering, trust and collaboration are the top three relationship attributes associated with effective and efficient supply chains. Partnering and collaboration can be considered as the relationship management tools which give rise to the physical interaction between supply chain firms. The trust attribute can be described as the facilitator of the interaction which enables a relationship to form, develop and function.

### 3.1 Development of Trust in cSRM

The effectiveness, efficiency and other resource qualities of a collaborative supply chain can only be as good as the weakest link in the chain. The primary reason for this is the knock-on effect which is triggered by the weakest firm in the supply chain which is further cascaded upstream or downstream in the chain. In addition to this, the transient, independent and multi-organisational characteristics of construction projects require development and alignment of *relationships* in a much faster way. Management and control of these relationships are crucially important to ensure that system works smoothly without any obstructions. Therefore the role of trust within these contexts can have a considerable impact on many facets of projects and organisations. In spite of its significance in relationships, ‘trust’ has been studied from a parochial view within cSCM literature where all of the constructs of trust have not been adequately discussed. Available literature on construction supply chain trust (for example McDermott *et al.*, 2005; Smyth, 2006; Khalfan *et al.*, 2007; and, Lau and Rowlinson, 2009) only studies the relationships from interpersonal or organisational perspective.

Trust is a multi-perspective and multi-dimensional construct which can be categorised into five broad dimensions: economic, social, psychological, inter-personal and organisational (referred to as ‘ESPIO’ dimensions of trust, see *Figure 2*). When studying the impact of trust on relationships the ESPIO dimensions of trust must be accounted conjointly as they are interrelated and interdependent. For example, organisational trust can be shaped by the individuals within that organisation and individual trust in turn, can be shaped by psychological or social trust vice versa.

The literature on trust is very diverse and covers a variety of levels within the scope of these dimensions. Some of the forms of trust identified within the literature are presented in the box opposite to the dimensions of trust in *Figure 2*. However, it must be noted that there could be many overlaps or cross-disciplinary dimensions of trust, hence a form of trust (i.e.: the label which addresses trust within that dimension) can be used interchangeably within different dimensions (*Figure 2*). An example of this is macro-level trust within a socio-organisational dimension.

In relation to the sources of trust; that is the attributes of the trustee, there are wide range of sources (objects, traits and characteristics) identified and grouped according to its relative dimension. Contributing factors are considered to be the antecedents, in other words factors that facilitate development of trust. Several studies have revealed some construction specific factors within different project environments (for example Khalfan *et al.*, 2007), but the list mainly consists of inter-personal and organisational attributes that contribute to the development of trust and lacks economic, social and psychological dimensions of trust.

In most of the studies on trust, the trust construct is primarily regarded as a concept made up of several abstract entities which give rise to its existence. This is termed as ‘*sine qua non*’ of trust (Laan *et al.*, 2011) which is the conditions of trust, without which trust would not exist. For example, Rousseau (1998: pg.395) argued that trust is “a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behaviour of another”. This implies that trustor has to be vulnerable to the actions of trustee under the conditions of risk, uncertainty, vulnerability, opportunity, dependence and unpredictability.

Two arguments are noted with regards to the control and trust in relationships (Noteboom, 2002). On one side, it has been argued that more control on above elements will result in less trust and vice versa, and on the other side, it has been argued that trust and control are complementary in counteracting these elements (Schoorman *et al.*, 2007). In relation to the first point, for example the use of governing mechanisms to monitor a subcontractor’s activities and/or create reward structures that reinforce the contractor’s desired activities may not necessarily facilitate the development of trust (Noteboom, 2002). Therefore actions of the trustee may be attributed to the existence of these incentives or governance mechanisms rather than to the trustee.

With regards to the second point contracts can be regarded as sources of trust where existence of these control mechanisms eliminates the need for trust. However, no contract is complete in its scope for covering every possible factor that may affect the relationship. Therefore, conditional trust is adopted by the trustee until a relational trust is built between the trustee and trustor. For Smyth (2006) the development of trust requires a ‘socially orientated’ approach to build trust-based long-term relationships between supply chain actors.

In view of the above, two arguments can be made in relation to developing trust-based relationships in the AEC industry: formal and informal. Formal tools which are mainly applied from ‘transaction cost economics’ practices are not favoured for developing long term

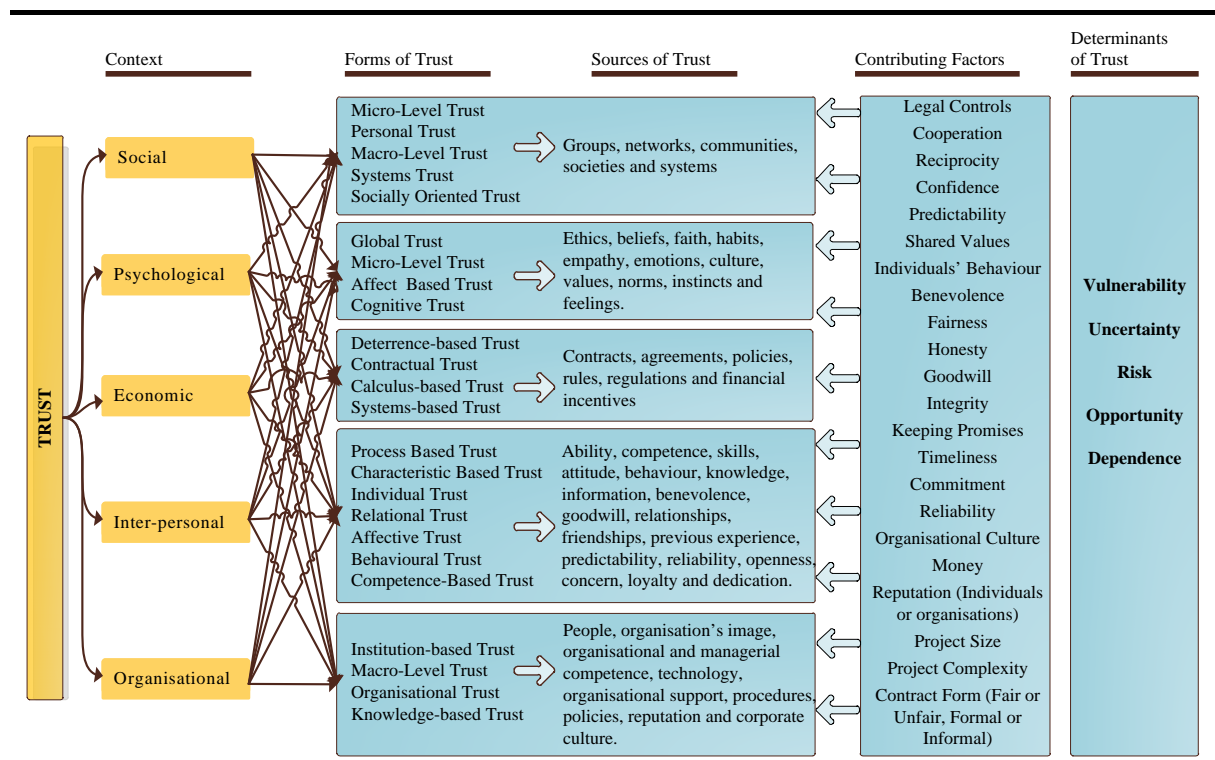


Figure 2: ESPIO dimensions of trust.

relationships and informal mechanisms such as social and cultural-structural dynamics embedded in supply firms are highly advocated for development of trust. In addition to this, there are many 'soft' tools such as high-level and individual commitment; effective information sharing and communication; team-working; openness of relationships; organisational culture; individuals attitude, behaviour and culture; honesty and reliability which have been mentioned within the matrix. For example Briscoe *et al.*, (2004) identified that collaborative relationships evolve more effectively when not constrained by the formal aspects of contractually defined relationships.

Furthermore, there appears two opportunities for further investigation. Measurement of different dimensions of trust may not be the same therefore how different dimensions of trust develop within and between supply chain firms must be studied in order to measure the inter-firm trust between supply chain firms. Secondly, in relation to social dynamics of relationships social capital should be considered in understanding how trust develops within socio-organisational dimension of relationships.

## 4 Conclusions

Responses to the challenges that plague the construction supply chains have predominantly discussed partnering, collaboration and trust between supply chain firms. This was also confirmed from the review of 40 articles in construction specific supply chain management literature. Partnering and collaboration are two important practices for relationships to function whereas trust is the single most quoted facilitator of that mechanism which has a multiple role between the supplier buyer interfaces. The importance of managing supply chain relationships should never be underestimated. Management of the various interfaces that a firm has with other supply chain actors could have an impact on the project network where many buyers and suppliers contribute to the development of a project. If mistrust between the parties overshadows the collaborative environment it can result in adverse relationships between supply chain actors but if the opposite is the case than benefits gained from trust-based relationships must be persistent and further developed for subsequent interactions.

cSCM must be a high-priority at the project level and enterprise level for long-term, non-adversarial, mutually beneficial and synergistic inter-firm relationships. In order to develop better relationships between supply chain firms 'trust' must be deeply embedded into these relationships so that benefits of the high-trust relationships can be fully reaped. The literature discussing trust in construction relationships is inadequate and falls short of covering various dimensions of the trust construct. This paper introduced the argument that trust as a construct comprise of economic, social, psychological, inter-personal and organisational dimensions which are intertwined and enmeshed in a complex web of interactions between individuals and organisations. A conceptual base for developing trust is what is needed so that further research can focus on each element in more detail.

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		Core Themes																																									
		Partnering																SCM									SRM						Trust					Power					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40		
	Google Scholar Citation Index	90	47	115	166	260	147	47	96	53	40	1	11	103	4	2	2	166	245	2	74	40	34	26	99	139	1	42	9	116	19	16	38	66	25	11	1	3	6	62	16		
Generic Attributes	Specific attributes of effective and efficient supply chains																																										
Social	Honesty	●	●	●							●		●						●			●	●	●	●	●		●					●	●	●	●	●	●	●	●	●	10	
	Trust (Universal)	●	●	●	●	△		●	●	●	○	●		●	●			●	●		●	●	●	●	●	●		●				●		●	●	●	●	●	●	●	△		30
Economic	Open book accounting	●		○									△		●						●															●	●	●	●	●			7
	Joint conflict resolution					△	△		●	●				●	●						●			●	●	●	●				●	●	●	●		●	●	●	●			16	
	Best value approach		●	●	●	△	△		●	●							○	●			●	●		○	○	○	●						●			●						11	
	Profitability and repeat business					△											●	○					●			○	○	●						●			●		△	●		7	
	Logistics and operations management																			●						●				●						●						3	
	Alternative forms of procurement and sourcing		●	●	○	△		●	●			●				●	●	●		●	●	●		●	●	●	●				●	●	●	●		●	●	●	●				22
	Sharing of risks and rewards			○	●				●	●				●	●	●				○	●					●	●		●			●	●	●			●	●	●				16
Organisational	Transparency	●	●	●							●								○		●				●						●			●	●	●	●		△			11	
	Power					△																△				●									○			△	△		1		
	Partnering	●	●	●	●	△	△	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	○	●	33		
	Reliability and interdependence								●				●				●		●	●			●		●	●	●		●		●	●	●	●	●	●	●	●	●	△	●	16	
	Previous experience						△						●	●	●						●			●				●		●				○							7		
	Common purpose-mutual Interest	●	●			△		●	●			●	●	●	●	●	●	●	●	●	●			●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	△		23	
	Project teambuilding		●				△	●				●			●			●	●	●				●	●						●			●		●						6	
	Structural alignments for strategic interactions		●		●			○			●					●	●	●			●	●		●	●	●				●			●		●		●					12	
	Organisational trust			●	●			●	●									●	●	●				●	●	●			●			●		●	●	●	●	●	●			12	
	Relationship Management				●							●	●				●	●		●	●	●				●	●	●				○	●	●	●	●	●		△			11	
	High level commitment				●	△	△	●		●				●		●	●		●	●		●	●		△	●	●	●		●		●	●	●	●	●	●	●	●				14
	Organisational culture	●			○	△	△	●	●															△		●	●	●				●	●	●	●	●	●	●				9	
	Cooperation	●	●	○		△	△	●		●		○			●	●	●	●	●	●	●	●	△		●	●	●	●					●	●		○	●	●	●	△			20
	Project Culture		●																														●	●								3	
	Early involvement		●	●	●		●	●	●						●	●	●				●	●	●		●		●				○	●	●	●								15	
Continous Improvement		●	○		△			●	●					●	●	●				●	●	●								○		●	●			●					10		
Long-term focus					△	△	●				●			●	●	●				●	●		○	●			●			○	○	●	●			●			○			12	
Individual	Alignments for operational interactions				●	△	△				●	●				●	●	●	●	●	●	●			●										●	●						11	
	Individuals' trust in and between organisations			●																●												●	●		●	●					6		
	Individual commitment			●						●						●									●							●	●	●		●						7	
	Training and skills	●	●	●	○			●	●					●	●	●																	●		●	●						12	
Technological	Individuals' attitude, behaviour and culture	●	●	○	●	●	●	●			●				●								△		●							●	●	●	●	●						13	
	Collaboration			●		△	△			●	●	●	●	●	●	●	●	●	○	●	●	●	●		●	●	●	●	●						●	●	●	△	●			28	
	Lean Construction Principles	●	●							●	●	●	●								●										○			●					△	●		4	
	Integrated ICT infrastructure/Virtual Organisations	●		○											●	●					●	●	●		●		●				●	●	●			●					13		
	Communication/Information Exchange	●		○	●			●	●	●		●		●						●	●	●	○	●	●	●	●	●		○		●	●	●	●	●	●	△	●			23	

## Appendix D      Contractor Practices for Managing Extended Supply Chain Tiers (Paper 3)

### Abstract

**Purpose** – The purpose of this paper is to examine how contractor firms manage their relationships with extended supply chain tiers and investigate the range of ICT technologies used to facilitate such practices.

**Design/methodology/approach** – An on-line questionnaire survey was conducted to gather information about supply chain management operations, supplier relationship management and the ICT technologies used by contractor firms to manage their extended supply chain tiers.

**Findings** – The extended supply chain relationships of contractor firms are primarily composed of contractual, technical and financial entities, but findings suggest that the vision to consider extended supply chain firms when selecting suppliers are still myopic. Majority of ICT technologies are used between Tier 1 supply chain firms and there is an inconsistency in the number of technologies adopted with the extended supply chain tiers. Despite having a high involvement relationship with Tier 2 downstream firms, findings indicate a lack of use of ICT technologies to manage the organisational, personal and technological interactions with these firms.

**Research limitations/implications** – On the basis of different relationship types this study develops an initial framework for management of supply chains that are facilitated by relevant ICT technologies.

**Originality/value** – This paper provides insights into the management of extended supply chain firms by contractor firms from a relationship-centric perspective and develops an initial framework for relationship-centric supply chain management.

**Keywords:** Construction, Supply Chain Management, ICT, Relationships, Contractors

**Paper type:** Research Paper



# 1 Introduction

The complex and dynamic association between firms, projects, markets and commodities makes it a very difficult task for contractor firms to manage their supply chains (Hughes *et al.*, 2006; London, 2008). Indeed, no single firm would be able to, nor would have the power and resources to, manage all the supply chain firms in a project (Holti *et al.*, 2000). However, the firm with the biggest influence in construction projects (generally main contractors due to magnitude of their stake in the project) can exercise different levels of control to different supply chain firms in a project. Moreover, clients who have dominant position in projects usually appoint responsibility of supply chain management (SCM) to main contractors to better coordinate, control and/or manage project supply chains (Jones and Saad, 2003; Briscoe *et al.*, 2004). Depending on the procurement route selected contractor firms can have huge influence as well as the resource capacity to coordinate and steer supply chains in a construction project (Smyth, 2005; Wolstenholme *et al.*, 2009).

An optimal SCM strategy is said to be one which is extended to include firms in many layers down or up in the supply chain tiers (Jones and Saad, 2003). However, in construction industry many studies report that contractors dominantly focus on demand side of supply chains and spend too little time and effort to understand suppliers who are located in downstream tiers (Akintoye *et al.*, 2000). As there is a growing trend to incorporate the whole-life-value, innovation, sustainability, and supply chain risk reduction concepts into extended supply chains, contractors are becoming increasingly dependent on their downstream supply chains too (Cheng and Li, 2001). In addition to this the push by UK government to cascade the good practices to tiers down in the supply chain is also considered to be a catalyst for management of extended supply chain tiers.

As a result of these factors there is a growing demand for traceability and openness by construction contractors to monitor, control, coordinate, and manage the extended supply chains. However, management of extended supply chain actors by contractor firms do not usually go beyond Tier 1 suppliers (that is immediate subcontractors or suppliers to contractors) as very few suppliers own all the activities along the chain (Vrijhoef and Koskela, 2000; Humphreys *et al.*, 2003; Briscoe and Dainty, 2005; Bemelmans *et al.*, 2012a, b). Further to this many supply firms in the industry refrain from being transparent and open about their supply chains (Briscoe and Dainty, 2005). Strategically, commercial confidentiality is believed to be one of the main factors that result in companies keeping their cards close to their chest. Exacerbated by the structural formation of construction supply chains, the inability to leverage supply market and complexity of the products are also recognised as some of the main barriers to reaching down to firms in the extended supply tiers (Cheng and Li, 2001; Lambert and Pohlen, 2001; Briscoe and Dainty, 2005). Thus, it is believed that contractors have little, if none at all, awareness and knowledge about firms who are located remotely at many layers down/up in the supply chains.

The purpose of this paper is to shed light onto contractor firms' supply chain practices from a relationship-centric perspective and examine how construction contractors in the UK manage their upstream and downstream supply chain firms in extended tiers. It aims to reflect on the relationship management approaches and provide insights into the use of ICT technologies that directly or indirectly facilitate such practices. In construction-specific literature there is dearth of research on the use of ICT technologies for extended supply chain interactions and inter-firm relationships. ICT technologies support a wide range of needs in supply chain interaction processes, including automation of a task, facilitation of collaboration process, and the enabling the communication of information (Benton and McHenry, 2010; Hadaya and Pellerin, 2010). However, there is a lack of research into the adoption of these technologies to manage inter-firm relationships with extended supply chain tiers (Hadaya and

Pellerin, 2010). It is argued that through an understanding of inter-firm relationships ICT technologies can better facilitate cooperative, collaborative and non-adversarial supply chain interactions between contractor firms and their extended supply chains.

This paper is structured in the following order. It begins with the definition of main relationship types that exist in construction supply chains and review of the use of ICT technologies for strategic and operational SCM. Research methodology is explained in the section thereafter, followed by discussion and analysis of research results. The study goes on to suggest a relationship-centric SCM framework supported with appropriate ICT technologies and concludes with a summary of the paper.

## **2 Construction Supply Chain Relationships and ICT Technologies in Relationship-centric cSCM**

There are at least three types of supply chains associated with construction projects; (i) temporary supply chains, (ii) framework-specific supply chains and (iii) company strategic supply chains (permanent supply chains) (Dubois and Gadde, 2000; Bankvall *et al.*, 2010). Vrijhoef and Koskela (2000) argued that construction specific SCM (cSCM) is about management of inter and intra-firm interactions with these supply chains in a construction project and suggested a cSCM framework that is concerned with (i) the interface between the supply chain and construction site; (ii) reducing costs related to logistics, lead-time and inventory on specific project supply chains; (iii) transferring activities from the site to earlier stages of the supply chain; and, (iv) integrated management of the supply chain with emphasis on improvement of supply chain and the site production. This approach provides a good plan for development of operational cSCM however it needs to be applied in the right context as argued by Cox and Ireland (2002). A cSCM also has a strategic organisational dimension for extended supply chain tiers. Here we follow Cox *et al.*, (2006) who describe different types of engagement in construction supply chains and the strategic management approach for each (e.g.: supplier selection, supply chain sourcing, supplier development and supply chain management strategies) in dyadic and extended supply chain interactions.

A way to manage construction supply chains is through a relationship-centric perspective where the aim is to maintain an effective operational and strategic engagement with suppliers. This study defines Supplier Relationship Management (SRM) in a broader context as one of the components of SCM which is a company-wide business strategy to manage its interconnected, dynamic and multi-dimensional interactions through its various interfaces so that it facilitates development of better relationships with its suppliers. In this paper the term suppliers and subcontractors are used interchangeably and refer to any firm which provide materials and/or specialist service for a contractor firm in a construction project.

cSCM that is based on relationships is an important area which is not fully explored in the literature (Meng, 2012). An earlier study by the authors indicates there is a lack of definition of different relationship types in the literature (Pala *et al.*, 2012b). The relational cSCM is recognised as important for several reasons. First, there are many different types of relationships in an organisation's supply network and not every relationship type is appropriate for different contexts (Spekman *et al.*, 1998; Cox and Townsend, 1998; Cox and Ireland, 2002; Ford *et al.*, 2003). Without a clear record of with whom a business interacts and what the attributes of that relationship are, any business and operations strategy will fail to deliver the aspired benefits and develop longer-term relationships. As a result, it is advocated that cSCM must be unique for each relationship (Briscoe and Dainty, 2005). Secondly, value in every relationship differs from one another as some relationships are considered to be more valuable than others (Ford and McDowell, 1999). For instance, Spekman *et al.*, (1998) suggested that relationship management should be distinct for every supplier. This is supported by Holti *et al.*, (2000) who argued that it is not possible to manage all suppliers in a construction project.

Hence a relationship-based approach which puts appropriate emphasis on the links, values and associations in inter-firm relationships is regarded as an important facet for alignment of multiple-temporary organisations in construction projects. Lastly, certain strategic decisions can have different level of impact on some relationships (Ford and McDowell, 1999) therefore with a relationship-based approach firms are able to apply correct sets of tools, processes, procedures and motives for an agile, efficient and smooth interaction.

Although the mainstream relationship research on construction supply chains is about purchasing and procurement relationships, there exists different relationship variables in an organisation's supply network in terms of value, strategic importance, complexity and other relational entities (Spekman *et al.*, 1998; Cox and Townsend, 1998; Cox and Ireland, 2002; Meng, 2012). The relationship attributes that describe the interaction between two firms is generally conducted in relationship marketing and business management research. For example, Gummesson (2008) described relationships from 30 different perspectives. Hakansson and Snehota (1995) list four variables for describing inter-firm relationships: continuity, complexity, symmetry and informality, whilst Harland (1994) and Croom *et al.*, (2000) point to the various attributes that influence the type relationships formed. Similarly, Holmlund and Törnroos (1997) describe four factors that shape the type, form, length and intensity of relationships: mutuality, duration, process nature, and context dependence. In construction research Smyth and Edkins (2007) classify the entities of inter-firm relationships into two groups: soft attributes such as social, psychological and, personality and cultural dynamics of relationships and hard attributes such as technical, contractual and financial elements. For example, as have been revealed by Lau and Rowlinson, (2009) and Laan *et al.*, (2011) the trust attribute of supply chain relationships is recognised to be one of the most important factors that give shape and form to construction supply chain relationships.

The framework that describe relationships in construction projects are based on a previous study by the authors (Pala *et al.*, 2012b). The four relationship types commonly cited in the literature are transactional, series of transaction, project collaboration and Long-Term Strategic Partnering relationships (Pala *et al.*, 2012b). These relationships are characterised by seventeen attributes found in the literature and shown in Appendix C-1. Transactional relationships- which are the most common type of relationship that a firm has with its suppliers- are short, simple, once-off and price-based transactional interactions between dyadic actors in the chain (Thompson *et al.*, 1998). The series of transaction relationship usually occurs between a client who is a regular buyer or a contractor who interacts with a supplier more intensely and frequently (Cox *et al.*, 2006). For example, most clients and contractors nowadays have a framework agreement with their pre-selected suppliers. Project collaboration relationships are project-based close relational arrangements between firms. Project collaboration may have been evolved from the previous relationship levels (series of transactions or transactional relationships over a period of time) or a firm may decide to work collaboratively with a supplier in a specific project for strategic purposes (Gadde and Dubois, 2010). The Long-term Strategic Partnerships (LTSP) are high level, strategic and long-term orientated relationships between two actors in the supply chains (Gadde and Dubois, 2010). Each of the above relationship type has advantages and disadvantages. Given the multi-level, multi-faceted and dynamic nature of any inter-firm relationships the advantages and disadvantages of these relationships are summarised in Table 1.

The four relationship categories can appear at various levels depending on the size, type and structure of the firms and projects (Dubois and Gadde, 2000; Male, 2003). In broad terms firm-firm relationships can form and develop as a result of direct or indirect encounters (Stuckenbruck, 1997). From a general project management perspective Wren (1967) describe the points of interaction or 'meeting points' as *interfaces*. The activities occurring at each project interface can be between organisational units, disciplines and people, and systems such

as technological and physical (e.g.: on-site activities) interactions (Stuckenbruck, 1997). With regards to the former interface, Bemelmans *et al.*, (2012b) described the inter-firm relationships at four levels. Bemelmans *et al.*, (2012b) stated that firms come to contact with each other during purchasing and procurement process to create relationships at project level, regional level, division level and corporate level. Here it must be noted that the interface and the level at which a relationship is conducted can be different on each project but in terms of the actors involved in the relationship Alshawhi and Ingirige (2003) stated that highest interaction occurs between middle-level managers known as ‘knowledge workers’.

In relation to the technological and physical interfaces ICT technologies are recognised as crucial to coordination and integration of supply chains (Hadaya and Pellerin, 2010). The core function of ICT in each of the above relationships is to support wide range of needs ranging from automation of a task and facilitation of a collaboration process to enabling of inter-firm and intra-firm communication of information between individuals (Alshawhi and Ingirige, 2003; Gohil *et al.*, 2009; Benton and McHenry, 2010). Despite the fact that communication is the key to effective project delivery majority of supply chain firms do not consistently share accurate, up-to-date, timely and reliable information with each other or with the other parties involved in the project (unless it’s expressed as an obligatory condition in the contract) (Humphreys *et al.*, 2003; Briscoe and Dainty, 2005; Titus and Bröchner, 2005). The consequent outcome of such knowledge and information deficiency is the key reason for conflicts between supply chain firms, poor quality, mistrust, delay, re-work and client dissatisfaction (Briscoe and Dainty, 2005).

There are various factors that effect a firm’s decision to adopt and deploy ICT technologies (Anumba and Ruikar, 2008) however as demonstrated by Hadaya and Pellerin (2010) characteristics of the supply chain relationships (dependency, bargaining power, collaboration, and relationship length) are the main determinants of ICT adoption for different interaction needs at each interface (organisational, individual and physical). As have been argued by Dubois and Gadde (2000) and Bankvall *et al.*, (2010) different supply chains exist in a project so each relationship that a contractor firm has with a supplier will exhibit different characteristics. Therefore, in terms of its ICT requirements the four relationship types will require distinctive technological resources for management of supply chain firms. For example, as relationships progress towards LTSP the characteristics of each relationship type increase in terms of longevity, volume, complexity, integration and strategic importance. In other words, as relationships gain more dimensions in terms of activities, actors and resources, the magnitude of the ICT-based relationship management required to embrace these dimensions also increase (Håkansson and Snehota, 1995; Cheng, 2009).

Although there are different ICT technologies available to enable transaction, information exchange and collaboration between firms (such as Electronic Data Interchange, Project Extranets and Enterprise Resource Planning Systems) (Anumba and Ruikar, 2008; Cheng, 2009; Hadaya and Pellerin, 2010) there is scarcity of empirical research that examines contractor firms’ use of any particular ICT facilitated relationship management technologies to provide them with assistance during and after the supplier selection process. What is most intensely talked about and used are web-based inter-firm collaboration technologies which are beginning to encapsulate different forms of interaction (such as tendering, procurement, design, project planning, and project management) within a common collaboration platform (Anumba and Ruikar, 2008). For example, Hadaya and Pellerin (2010) argued that the main function of inter-firm ICT technologies is to support transactional and collaborative inter-organisational processes, such as exchange technical documents and drawings, and share inventory information between a construction company and its key suppliers.

The interface(s) where two firms interact in a project vary from project to project however the most project relationships form at the procurement stage of a building process. This is because procurement methods and contracts are one of the earliest stages in a project and it is the first interaction that contractor firms have with their suppliers (Briscoe and Dainty, 2005). Hence procurement, purchasing, and contract management are the dominant approaches to manage inter-firm relationships in the construction industry (Khalfan *et al.*, 2001). However,

Table 1: Advantages and disadvantages of four relationship types.

	<i>Advantages</i>	<i>Disadvantages</i>
<b>Transactional Relationships</b>	<ul style="list-style-type: none"> <li>▪ Low involvement, simple, price-based transactions,</li> <li>▪ Requires very little or no investment,</li> <li>▪ Less risk involved,</li> <li>▪ Better localised adaptations to change,</li> <li>▪ Buyers can benefit from wider access to knowledge,</li> <li>▪ Can be a buffering mechanism against unfavourable conditions (during uncertainty and risky conditions)</li> <li>▪ More options for variety,</li> <li>▪ No commitment.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Knowledge and experience does not get transferred to next transaction/project hence a new learning curve is climbed at every interaction,</li> <li>▪ Lack of trust between parties,</li> <li>▪ Adversarial terms and conditions in contracts,</li> <li>▪ Hampers development of both, temporary and permanent network of relationships,</li> <li>▪ Limited relational interaction between firms,</li> <li>▪ Higher transaction costs,</li> <li>▪ Selection of suppliers based on price only,</li> <li>▪ Lack of commitment; misaligned values, visions, goals and objectives.</li> </ul>
<b>Series of Transactions</b>	<ul style="list-style-type: none"> <li>▪ Existing/previous relationship is maintained,</li> <li>▪ Opportunities for more cooperation and collaboration,</li> <li>▪ Performance-based relationship can easily develop to a more intense interaction.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Little interaction outside the transaction,</li> <li>▪ Standard forms of contract can be reactive mechanisms in high-risk conditions,</li> <li>▪ Firms are only committed to the extent of their agreement,</li> <li>▪ Conflicting business culture/vision,</li> <li>▪ Short-term focus,</li> <li>▪ Relatively high level of uncertainty.</li> </ul>
<b>Project Collaboration</b>	<ul style="list-style-type: none"> <li>▪ Cooperative and collaborative arrangements between firms,</li> <li>▪ Early involvement in projects,</li> <li>▪ Sharing of risk/benefits,</li> <li>▪ Mutual understanding of the vision, mission, and client's requirements,</li> <li>▪ Level of risk is contained to current/existing project(s).</li> <li>▪ Low level of uncertainty.</li> </ul>	<ul style="list-style-type: none"> <li>▪ New ways/methods of working can cause conflict between individuals, teams and firms,</li> <li>▪ There may be high power asymmetry between the two firms resulting in win-lose transaction,</li> <li>▪ It may not be appropriate for certain market and project conditions,</li> <li>▪ Requires senior level support/commitment and operational level integration.</li> </ul>
<b>Long-term Strategic Partnering</b>	<ul style="list-style-type: none"> <li>▪ Integrated project delivery,</li> <li>▪ Joint conflict resolution,</li> <li>▪ Competitive advantage,</li> <li>▪ Savings on transaction costs,</li> <li>▪ Savings from improved performance and efficiencies,</li> <li>▪ Mutual commitment and organisational alignment,</li> <li>▪ Innovation and value creation,</li> <li>▪ Increased client satisfaction,</li> <li>▪ Faster response to market/project needs,</li> <li>▪ Continuous development.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Very difficult to integrate with a supplier unless the commercial gains achieved from collaboration is profitable for both firms,</li> <li>▪ Requires large amount of investment, commitment, and resources in the relationship,</li> <li>▪ High level of interdependency can cause locked-in relationships.</li> </ul>

to implement a comprehensive SCM requires all the other interfaces during the subsequent phases of the relationship to be managed too. Managing all the entities of a relationship in turn requires a cross-functional, dynamic and long-term orientated approach (Lambert and Cooper, 2000; London, 2008).

The methods used by contractor firms to manage supply chain relationships during procurement stage (or during purchasing and procurement of materials or services which is at any point in a project lifecycle) are generally supplementary to supplier selection strategies. At the operational level contractor firms base their supplier relationship management on their supplier selection, evaluation and negotiation strategies (Kumaraswamy *et al.*, 2000; Cox *et al.*, 2006) where pre-qualification metrics (e.g.: PQQ: Pre-Qualification Questionnaires), KPIs and other supplier performance measurement criteria are used to shortlist and manage supply chain firms. These mechanisms are mostly adopted in transactional, framework and project-based collaborative relationships and they are mostly concerned with cost and time performance analysis of suppliers (Millett and Dainty 2000; Cox *et al.*, 2006). During the latter stages of a project, contractors make use of ICT technologies such as logistical and inventory management systems, cost accounting systems and customer/supplier relationship management systems to assess performance of suppliers but these systems are generally executed in an intra-firm setting and their use in relationship management prior to forming of a relationship is not well known (Benton and McHenry, 2010). This is probably attributed to the fact that majority of these tools are used as a reactive rather than proactive mechanism to SRM.

At the strategic (organisational) level supply chain relationships are conducted in the form of project collaboration and LTSP relationships (London, 2008). Senior level professionals who are usually regional, divisional or company directors generally employ informal (or inter-personal) approaches to manage their inter-firm relationships. However high-level managers would also be concerned with *strategic* aspects of purchasing, logistics, materials management and construction activities of projects, hence ICT technologies such as decision support systems and knowledge management systems appear to be most relevant technologies for this level (Benton and McHenry, 2010). Nevertheless, their use in management of inter-firm supply chain relationships is not evident in research or practice.

In summary, cSCM must take into account the form of relationship that exists between supply chain firms. The transient, independent and multi-organisational characteristics of construction projects and supply chain firms require development, maintenance, and alignment of relationships in a much faster way. Due to their dynamic, multiple interface, multi-level and multi-project nature construction supply chain relationships are not easy to investigate let alone manage. Relationships-centric SCM is important but the role of ICT in facilitating better relationships requires equally important attention. While there is lack of information on the methods and tools adopted to manage inter-firm relationships in ex-post procurement stage, extensive research is conducted on inter-firm relationships which concern purchasing and procurement interactions. By utilising a relationship-centric approach this study will investigate the ICT supported SRM practices of contractor firms for dyadic and extended supply chain interactions.

### **3 Research Methodology**

The research methodology was developed with the purpose of identifying ICT facilitated relationship management technologies which are currently being employed by contractor firms to manage their dyadic and extended network of relationships. The study explores the concept of cSCM from a relationship-centric perspective. The framework which describes inter-firm relationships in construction supply chains are defined in an earlier study by the authors (Pala *et al.*, 2012b). Appendix D-1 shows that each of these relationship types exhibit different characteristics in terms of longevity, volume, complexity, integration and strategic importance

for contractor firms. The study argues that each of the above-mentioned relationship types will require different ICT resources to manage, control and coordinate the dyadic and extended network of interactions.

The aim of this paper is to report on how contractor firms form relationships with their downstream suppliers, and the systems, technologies and processes they employ to manage their dyadic and extended supply chain relationships. Based on the findings of this survey the study goes on to suggest a framework on deployment of ICT technologies in relationship-centric cSCM.

### **3.1 Questionnaire Design**

Questionnaire design followed a two-stage process which was also carried out in a similar study by Hadaya and Pellerin (2010). An on-line questionnaire survey was developed to capture information about contractor firms' procurement and supplier relationship management practices and the use of ICT technologies with their supply chain firms. Following the suggestions of Thietart (2001) a pilot study was conducted to increase the reliability and validity of the data collection instrument. The profile of respondents for pilot study was Procurement, Commercial Business Development and Project Managers who are representative of the target audience of this survey due to their high involvement in supply chain activities (Alshawhi and Ingirige, 2003). Four interviews were conducted where participants were asked to comment and discuss the design, structure and, language and relevance of the questionnaire to their role. The feedback of interviewees was combined in a matrix table to reflect a non-biased analysis and refinement of the questionnaire. Final version of the questionnaire consists of four sections: (i) general questions, (ii) role and involvement, (iii) procurement practices, and (iv) relationship management. Multiple data collection techniques were adopted in the questionnaire design. Alongside some closed-ended questions the questionnaire design made use of 'Likert Scale' type questions to explore the perceptions of participants. There are also several questions which require respondents to rank the answers provided in the survey as well as 'open-ended' questions to develop a deeper understanding of the context.

### **3.2 Sampling Procedure**

The profile of respondents selected for the sample population are Procurement Managers, Supply Chain Managers, Commercial Directors, Business Development Managers, Project Managers and Construction Managers who are working for UK contractor firms. The rationale behind selecting these groups of respondents was to allow breadth in answers given and capture a complete representation of the strategic and operational aspects of cSCM and relationship management at various project phases (design, procurement, construction and facilities management). These professions are usually involved with different aspects of cSCM and SRM, so the data collected allows a comprehensive review of inter-firm relationships at multiple levels and interfaces (Alshawhi and Ingirige, 2003).

Respondents were invited to participate in the survey by telephoning them, followed by personalised emails which had information about the research and how to participate in the survey. Initially around 50 telephone calls were made to contractor firms and individuals in order to pre-screen the companies to identify key informants who were engaged with inter-firm activities. However due to low response rate from the original group the survey was distributed to a further 115 people whose details were obtained from search engines, professional networking sites and company websites. The whole data collection process was confined to 4 weeks and at the end the overall response rate was 30% (49 responses) from a total of 165 people approached.

## 4 Analysis and Discussion

Following section will present the research findings in the format that was arranged in the questionnaire survey and discuss the significance of the results in the context introduced earlier.

### 4.1 Role and Involvement

Survey results indicate that on average participants had 17 years of experience working in the industry. Responses were gathered from 27 different contractor firms where large contractor firms with £100m+ turnover are dominantly represented in the survey. With regards to the role and involvement of participants *Figure 1* shows that majority of respondents engage with other supply chain firms primarily at project level (19 responses) indicating that they have a direct involvement with operational aspects of supply chain management. However further analysis of the questionnaire data suggest that respondents are involved at multiple levels (17 respondents) where their job function extend beyond project-based relationships to inter-firm relationships. In addition, *Figure 2* confirms that survey represents responses from various interfaces where the multi-level involvement is reflected across different project phases (albeit mainly on design, procurement and construction).

Further to above over 73% of respondents indicated that they had considerable influence on inter-firm relationships whether at project, organisational or enterprise level. Insight into their role in strategic supply chain management shows that respondents relate their strategic decision-making activities in the following order: (i) supplier relationship management, (ii) strategic supplier selection, (iii) supply-chain risk management, (iv) supplier development, (v) supplier coordination and (vi) client relationship management. These results suggest that the views represented in this study reflect both, operational and strategic cSCM and SRM activities of contractor firms and yield important information about inter-firm supply chain relationships at different interfaces.

### 4.2 Procurement Practices

Findings of this survey agree with the previous studies (Thompson *et al.*, 1998) which reported that the short-term transactional practices in supplier contract methods still persist amongst contractor firms. Respondents ranked the one-off arrangements as the most implemented procurement methods when appointing suppliers in a project. This was followed by Project Partnering/Collaboration, Framework Agreements and Long-Term Strategic Partnering relationships. It must be noted here that the adoption of transactional procurement practices should not be accused of being wrong type of relationship as value gained from every relationship differs (Ford *et al.*, 2003). This is because the *context* within which supply chain firms come together to 'cooperate or collaborate' cannot be intrinsic for every relationship (Cox *et al.*, 2006). For example, in addition to the problems with infrequent and geographically fragmented projects, Akintoye *et al.*, (2000) and, Akintoye and Main (2007) reported that main barriers to the implementation of collaborative relationships by contractor firms are largely related to the factors such as lack of market opportunity, risk sharing, trust, organisational structure, need for resource efficiency and client requirement. Therefore, what needs probing is whether a particular firm is the best candidate for specific type of relationship (either Transactional, Series of Transactions, Project Partnering or LTSP relationship) and how to develop the one-off/transactional relationships which has a long-term prospect into much more cooperative and collaborative relationships.



The survey explored the relationship attributes which respondents deemed critical for any supply chain relationship. Complementing the arguments of Jones and Saad (2003), Lau and Rowlinson (2009) and Laan *et al.*, (2011) that the trust component of relationships is a *sine qua non* of any business transaction; the trust, attitude and culture of the supplier firm along with their previous performance in terms of price, quality and time are the most significant factors considered by the respondents (42 and 43 responses consecutively). Relatively less emphasis was placed on the inter-personal connections, ties and networks on inter-firm relationships (20 responses) and commonalities between the firms (14 responses). Thus, supplier selection strategy that is based on qualitative aspects of the tender submission rather than cheapest price alone seems to be the most important aspect of relationship initiation process. Equally important it indicates the need to focus on qualitative entities of inter-firm relationships in relationship-centric cSCM.

Table 2 shows the ranking of the evaluation criteria that are adopted by contractors to assess their suppliers. According to this Previous Relationship/Interaction has a huge influence in procurement decisions of contractor firms. A history of relationship/interaction increases the suppliers' credibility and reputation and become a reference for future transaction. Previous relationships are an important aspect for continuity in the relationship, so management of relationships should be utmost concern for better functioning of post-project operations and inter-firm relationships. On the other hand, a pre-qualification criterion is normally the first

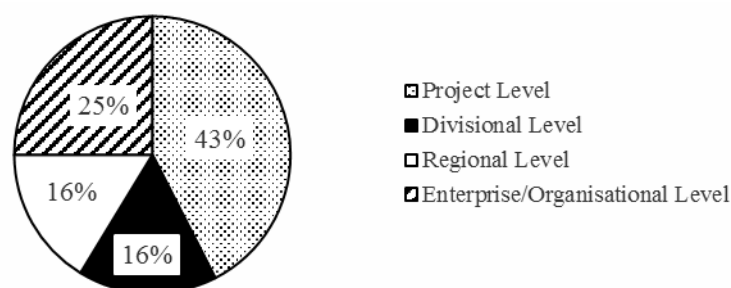


Figure 1: Respondents' level of involvement.

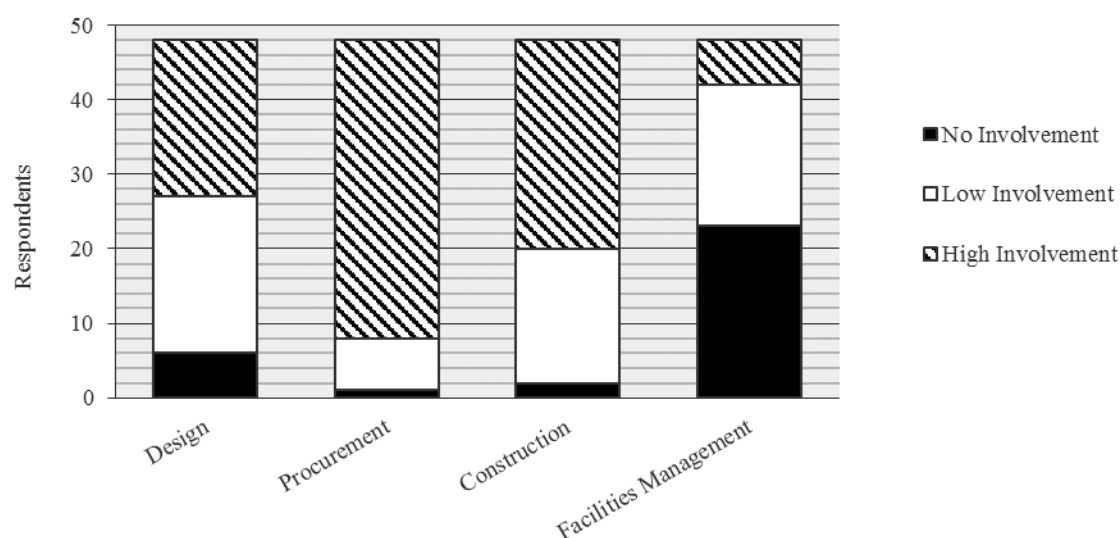


Figure 2: Respondents level of involvement during different project phases.

interface in a procurement process and it is a set of minimum requirements or standards (such as financial track record, technical resources, health and safety record, relevant experience and so on) that all supply chain firms have to meet before being accepted to submit their tender and bids. It is used as a means to check the compatibility of the supplier firm with the contractor firm; hence findings support the view that pre-qualification criteria should be configured to reflect the unique entities of the relationship.

### 4.3 Contractor Practices for Managing Extended Supply Chain Tiers

Literature reviewed warns that realisation of better supply chain performance cannot be achieved by dyadic interactions alone (Jones and Saad, 2003). Akin to unregulated processes in construction supply chains, the lack of traceability of materials and commodities, transparency and openness prevent the opportunities for improving problems associated with 'muda' in extended supply chains. Rather than individual companies working in isolation to add value to the product/service supply chains are now increasingly becoming required to add value from the earliest stages in supply chains (Vrijhoef and Koskela, 2000). Within the construction context, for example, sustainable sourcing, whole-life-value, innovation and supply chain risk reduction are some of the core requirements that push the need for integrated supply chains (Akintoye *et al.*, 2003; Briscoe and Dainty, 2005). However, in line with the earlier reports of Bemelmans *et al.*, (2012b), Vrijhoef and Koskela (2000), Akintoye *et al.*, (2000; 2003; 2007), findings suggest that contractor firms' vision to consider extended supply chain firms when selecting suppliers is still myopic. From the responses given about half of respondents indicated that 'few' aspects of their supplier selection strategies considered supply chains beyond their immediate tier and other half of the respondents indicated 'many' or 'most' aspects of their selection strategy was extended to other tiers below the supply chain. The polarisation of responses reflects the degree of collaboration and disintegration that exist within and between supply chain firms where both groups of respondents are equally represented in this survey.

The problem with controlling and coordinating extended supply chains is especially 'problematic' as construction projects are often formed of temporary multi-organisations (Gadde and Dubois, 2010). It was noted earlier that few contractors manage and coordinate their interaction activities along the supply chain let alone become integrated with their upstream and downstream supply chains tiers. However, the survey findings reveal that the last tier of firms which contractors have a high involvement relationship with are the Tier 2 of the downstream supply chain firms such as 'Suppliers to Subcontractors' (20 responses out of 45). This was followed by Tier 4- Raw Materials Suppliers (11 responses), Tier 3- OEMs and Suppliers' Suppliers (8 responses), and Tier 1- Specialist Subcontractors/Suppliers (6 responses). As can be seen by *Figure 3* majority of inter-firm relationships are composed of contractual and technical entities. Financial and inter-personal relationships were found to be

Table 2: Ranking of evaluation criteria adopted in projects.

Evaluation Criteria	Ranking:	1	2	3	4	5	Mean	Overall Ranking
Previous relationship/interaction	Response Count	9	17	9	8	4	2.60	1
Pre-qualification Criteria		18	8	4	7	10	2.64	2
Cheapest priced offer		11	9	9	8	10	2.94	3
Contractor's Strategic Criteria		5	8	15	8	11	3.26	4
Case-based reasoning		4	5	10	16	12	3.57	5

less common (except with Tier 2 firms) indicating a weaker engagement in terms of monetary and social links.

These findings suggest that contractors are beginning to stretch their relationships to firms in extended tiers primarily on a contractual and technical basis (mostly with Tier 2 firms). As the length of interaction stretches to extended tiers, findings point out to the need for identification of commercial mechanisms (such as continuity of work, incentives and open-book accounting) and technical interfaces with immediate suppliers to facilitate and diffuse transparency in contractual, technical and financial relationship layers. By managing the interfaces at each of these layers cSCM can be implemented with a more precise plan. The results with regards to the Tier 4 firms are an important indication which suggests that some contractor firms have an intense interaction with firms deep in supply chain tiers. However there could be a possible misinterpretation of this data by the respondents resulting in over representation of Tier 4 firms. This is due to the fact that some construction contractors regard their Raw Materials Suppliers, for material items such as aggregates, as their immediate (Tier 1) suppliers rather than an extended supplier in a chain of production.

The survey also attempted to understand the reasons for extending the relationships with downstream supply chain firms. In conjunction with earlier findings, survey results suggest that contractors use their financial, technical and contractual relationship to engage with extended supply chain firms to; add value to the product/service; reduce any risk involved in the supply chain; reduce the costs associated with the supply chains as well as to increase efficiencies. All of these reasons indicate a project-focused supply chain interaction with extended supply tiers. However, in addition to these results respondents also indicated external reasons such as; technical requirement, increasing client satisfaction, strategic importance of the commodity of product/service, innovation requirement, size of the package/tender; and, maximising profits as their main reason to engage with extended supply chain firms.

Findings with regards to contractor firms' relationships with their upstream supply chain firms are shown in *Figure 4*. The extent of relationship with upstream firms is generally confined to Tier 1 firms (20 responses out of 45) where most of these relationships are made up of financial, technical, contractual and inter-personal entities. Rest of the respondents stated that their relationships extend to Tier 2 firms (such as Project Financiers and Local Authorities)

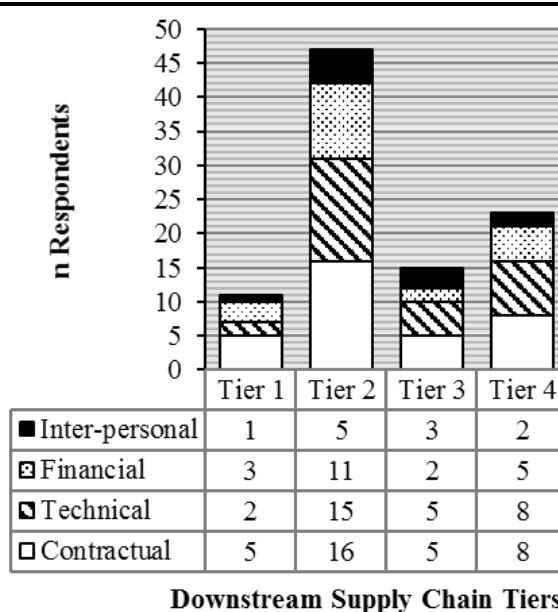


Figure 3: The extent of downstream supply chain relationships and relationship types.

(12 responses), Tier 3 firms (such as tenants, end-users and owners) (13 responses) as a result of direct or extended contractual links. These results are in line with the earlier findings of Akintoye *et al.*, (2000; 2003; 2007) and Briscoe and Dainty (2005) which concluded that contractor firms largely focus on their relationships with their immediate upstream firms.

Survey results also reveal that there are generally two approaches to SRM by contractor firms. Out of 48 respondents who filled this section 22 of them have indicated that SRM is left to senior level managers within their organisation. Around same number of respondents (20 responses) expressed that they used collaborative and cooperative relationship management procedures, processes and protocols (such as the BS11000 which is the British Standard for collaborative working), or their own company-specific relationship management procedures. Several respondents noted that the SRM practices are embedded into their inter-firm interaction processes however the discontinuity in relationships, regular changes in relationship management processes and the set standards for forming relationships in public projects were cited as the main reason for lack of SRM execution within their organisation. For example several respondents echoed public procurement policies and regulations (which requires selection of firms based on compulsory competitive tendering procedure) and the EU directives (which state that procurement of materials and services above a certain threshold are subject to 2004/18/EC legislation and must go through the OJEU website) as the main reason for lack of implementation of relationship management in public projects.

#### 4.4 ICT Technologies in Supply Chain Interactions

Table 3 shows the use of ICT technologies by contractor firms to facilitate cSCM with their upstream and downstream firms. According to this the most used ICT technologies with extended supply chain firms are Building Information Modelling technologies, Project Extranets (both 64 instances for all supply chain tiers), and Electronic Data Interchange Systems (62 instances). The variances, in terms of core functionality of these technologies, suggest that contractors adopt different kinds of technologies to facilitate different types of relationships they maintain with their upstream and downstream supply chains.

Although it is interesting to see BIM utilisation on top of the list (for both upstream and downstream supply chain firms) this data must be approached cautiously. Succar (2009)

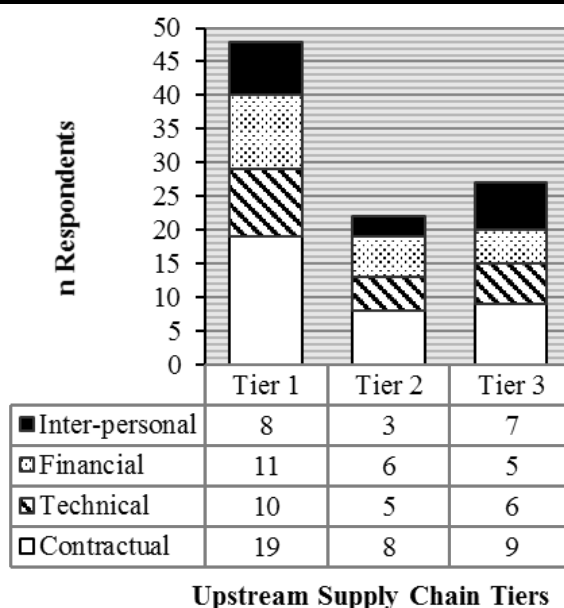


Figure 4: The extent of upstream supply chain relationships and relationship types.

showed that adoption of technologies such as BIM is limited as they are being evolved and have not reached to a maturity stage. The high response rate for use of BIM technologies can be attributed to two factors: (i) the push by UK government which is driving the momentum to get supply chain firms on the BIM bandwagon or majority of respondents are early adopters of BIM technologies in some shape and form, (ii) BIM has become a buzzword where many studies reported the ambiguity in the BIM domain in terms of concept, the definition and the technologies. Adoption of Project Extranet technologies, Integrated Databases and Electronic Data Interchange Systems indicate that there is an increased sharing of project and commercial data with both upstream and downstream supply chain firms. Similarly, advanced planning and scheduling systems also demand sharing and exchange of project data for streamlining construction processes so their use by contractor firms indicate an integrated supply chain with their upstream and downstream firms.

However further analysis of this data reveals there is a disparity in the number and usage of ICT technologies with upstream and downstream supply chain tiers. The survey results in *Table 3* show that there is a large difference in the number of responses received for upstream (38 responses) and downstream supply chain tiers (28 responses). Further to this, contractors use more ICT technologies with their Tier 1 upstream supply chain firms (4.93 technologies on average) than their Tier 1 downstream supply chains (3.44 technologies on average). A Chi-Squared Test was used to check if there is a statistical difference in the responses to the ICT technologies and upstream/downstream supply chain tiers. The Chi-Squared test results on *Table 3<sup>t</sup>* confirm that with 10 degrees of freedom and 95% level of confidence ( $\alpha=18.31$ ) there is no relationship between the ICT technologies adopted between *Tier 1* upstream and downstream supply chains (the Chi-Square value of 2.172 is smaller than critical value of 18.31, hence the null hypothesis of independence is accepted). This is an interesting result which indicates that the influence of upstream suppliers on contractors' technology adoption with their downstream supply chains is relatively low. Findings also reveal that there is a high number of adoption of inter-organisational technologies (that is for both upstream and downstream supply chain tiers such as BIM technologies, Project Extranets, Electronic Data Interchange Systems, Advanced Planning and Scheduling Systems and Integrated Databases) for the integration of upstream and downstream supply chain tiers. Rest of the technologies utilised by contractors are intra-firm technologies which are used in-house to support their activities with their upstream and downstream suppliers.

Due to low number of instances for Tier 2 and Tier 3 supply chains (that is both upstream and downstream) a paired two-sample *t*-test was chosen to test if there is a significant difference in the number of ICT technologies adopted with firms in extended upstream/downstream supply chains. The paired two-sample *t*-test was chosen as the supply chain tiers were linked with the ICT technologies. Similar to Tier 1 supply chains, the results indicate with a 95% confidence (as indicated with a *p* value of 0.007) that there is a significant difference in the number of ICT technologies adopted with extended upstream and downstream supply chain tiers. Therefore, findings of this survey suggest that despite having high involvement relationships with Tier 2 downstream firms the use of ICT technologies for interacting with tiers beyond Tier 1 firms is non-existent.

The main challenges and barriers that respondents perceived to the uptake of ICT technologies with their extended supply chains were also investigated. Recognising the financial difficulties faced in the current economic climate, 18 respondents viewed the cost aspect as the primary concern for the adoption of these technologies. Equal number of respondents reasoned the lack of awareness of these technologies to functionally extend to cover Tiers beyond their immediate supplier as another big challenge. Majority of these technologies require a mutual adoption to be implemented so without suppliers buy-in of these technologies the uptake was believed to be poor (15 responses). Another concern that was

raised was the issue with compatibility and interoperability which makes it difficult to exchange information and integrate with supply chain firms (14 and 13 responses respectively).

## 5 Discussion on Relationship-centric cSCM with ICT Technologies

ICT technologies have a great potential to facilitate better cSCM between supply chain firms. Each of these technologies can support various needs of the strategic and operational aspects of cSCM. Based on four relationship categories identified earlier this study argues that cSCM should take into account the characteristics of each relationship that a contractor firm has with its suppliers as illustrated in *Figure 5 (a)*. Recognising the fact that every relationship requires a different management approach, the study argues that the length of supply chain interaction and management strategy for each relationship should be maintained at a comparable complexity. For example, Long-term Strategic Partnering relationships which are the most intense relationship types should be managed up-to Tier 4 in the supply chain to derive all the benefits desired from the relationship such as competitive advantage, integrated project delivery, increased client satisfaction and so on. This is shown in *Figure 5(b)* which builds on the theoretical framework of Vrijhoef and Koskela (2000) and Cox *et al.*, (2006) for strategic and operational cSCM. On the basis of survey results and earlier desk study it can be argued that different ICT solutions should be utilised to facilitate efficient, timely and cost-effective supply chain interactions for different relationship types.

For transactional relationships it would be suffice to monitor the interface between the construction site and Tier 1 suppliers. Monitoring would allow the core entities of a relationship – such as the supply market, type of commodity, purchase history, future portfolio expenditure and performance of supplier within the cost/time/quality criteria, to be surfaced so correct

Table 3: Ranking of ICT tools/technologies used by contractor firms with the upstream and downstream supply chain firms.

<i>ICT Technologies that facilitate cSCM</i>	<i>UPSTREAM</i>			<i>DOWNSTREAM</i>			
	<b>Tier 1</b>	<b>Tier 2</b>	<b>Tier 3</b>	<b>Tier 1*</b>	<b>Tier 2</b>	<b>Tier 3</b>	<b>Tier 4</b>
Building Information Modelling	23	5	6	<b>20</b>	6	2	2
Project Extranets	22	9	2	<b>15</b>	7	4	5
Advanced Planning and Scheduling Systems	20	9	1	<b>14</b>	6	5	3
Integrated Databases	18	8	2	<b>14</b>	6	4	3
Electronic Data Interchange Systems	23	7	2	<b>13</b>	9	4	4
Customer/Supplier Relationship Mgmt. Sys.	23	4	4	<b>13</b>	7	2	5
Cost Accounting Systems	16	11	3	<b>13</b>	7	3	5
Enterprise Resource Planning System	14	4	1	<b>11</b>	3	2	5
Order Management Systems	17	7	1	<b>10</b>	7	3	9
Logistics Management Systems	12	6	2	<b>10</b>	9	2	8
Inventory Management Systems	14	3	4	<b>8</b>	3	4	7
<b>Total</b>	<b>202</b>	<b>73</b>	<b>28</b>	<b>141</b>	<b>70</b>	<b>35</b>	<b>56</b>
<i>Number of Responses</i>	<b>38</b>	<b>23</b>	<b>14</b>	<b>28</b>	<b>26</b>	<b>11</b>	<b>15</b>
<i>Average number of ICT Technologies used by all (41) respondents who filled this section:</i>	<b>4.93</b>	<b>1.78</b>	<b>0.68</b>	<b>3.44</b>	<b>1.71</b>	<b>0.85</b>	<b>1.37</b>

Chi-Square Test Results for Tier 1 Downstream and Upstream Supply Tiers:

*Critical Value:* 18.31

*Chi-Square Test Statistic:* 2.172

*p-Value:* 0.995

\*Indicates that responses are ranked by answers given to Tier 1 Downstream Supply Chain firms.

decisions about future transactions can be made. From the strategic perspective, the process should involve monitoring contractor's own supplier selection strategies so that most appropriate firm which is capable of providing best value for the contractor firm is selected. Such selection strategies should be supported with dynamic ICT technologies that monitor suppliers' performance (in terms of price, quality and timing) and, compliance with standards and requirements set out in contractor's pre-qualification criteria.

In series of transaction relationships, the aim would be to control the relationships up to Tier 2 in the supply chain. From an operational perspective, the aim of the control strategy would involve an active administration procedure to reduce the costs related to logistics, lead-time and inventory. The strategic approach would be principally concerned with the supply chain sourcing strategies that take into account the extended supply chain tiers. Moreover, it would also be concerned with the workflow, procurement and electronic tendering processes with the aim of improving the flow of exchange of information, payments, billing and logistical activities between extended supply chain tiers. How much of the existing ICT technologies can support these interactions is an interesting avenue for further research but it must be recognised that ICT technologies can enable such interaction only if organisational challenges are overcome.

In project collaboration relationships, cSCM strategy would be related to getting suppliers involved early in the construction process. Information sharing and coordination of physical activities would be the main focus where coordinating the suppliers that are beyond Tier 3 of contractor firms would be the operational aim of cSCM. In terms of strategic cSCM, the aim would be to develop the extended supply chain firms so that performance gains can be achieved from management of extended supply chain tiers. This requires a flexible approach

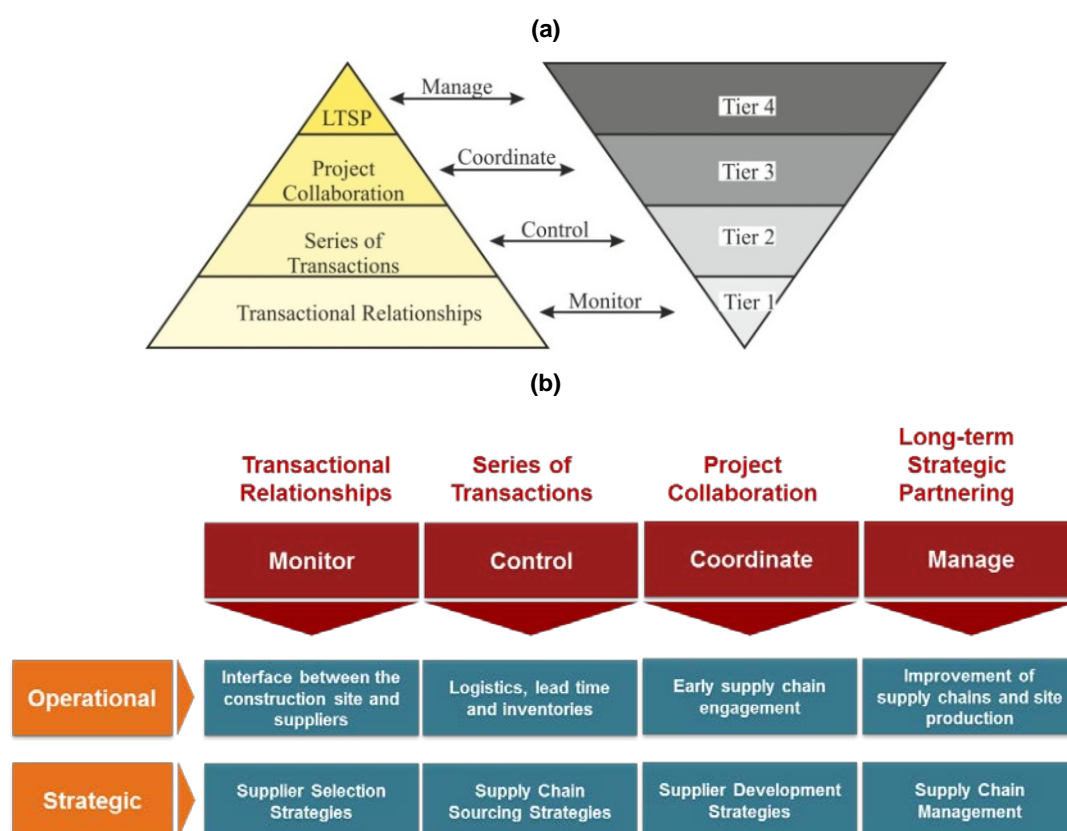


Figure 5: SCM approach for four categories of relationships.

to cSCM where all firms up to Tier 3 in the supply chain is organised and coordinated in an agile fashion. Here the alignment of ICT technologies as well as systems and process along the supply chains needs to be effective and efficient to work harmoniously with each other.

The Long-term Strategic Partnering Relationships require a total relationship management approach where the supply chains extend right down to the last tier in the supply chain. Operationally, further to all of the above-mentioned methods, the objective of the cSCM would be concerned with all entities attached to a relationship to gain competitive advantage, added value and reduced costs. The strategic aspect of management would involve monitoring, controlling, coordinating and managing all relational aspects of the interactions at many layers as possible such as project, organisational as well as inter-personal dimensions. It must be recognised that ICT technologies can enable such relationships only if these solutions are embraced and utilised effectively by each firm in the supply chain tier.

## **6 Conclusion**

The transient, independent and multi-organisational characteristics of construction projects require development and alignment of relationships in a much faster way. Management and control of these relationships are crucially important to ensure that supply chains operate in an agile, efficient and smooth manner. Rather than looking into how to improve dyadic relationships between contractor firms and its upstream/downstream supply chain firms, this research was concerned with the management practices of contractor firms for their extended supply chain relationships.

Findings of the questionnaire survey reveal that two approaches are employed by contractor firms for relationship management: strategic management by senior level managers and specific collaborative and cooperative processes, procedures and protocols. Despite the existence of a high involvement relationship, the evidence from the study suggests that the majority of ICT technologies deployed by contractors did not extend to their Tier 2 downstream firms. These findings indicate a very limited approach to SRM by contractor firms that restrict the opportunity for a 'seamless and efficient' management of supplier relationships by taking advantage of effective and available ICT technologies. Most common ICT technologies used between contractor firms and their supply chains were Building Information Modelling technologies, Project Extranets, Electronic Document Interchange systems which were primarily used between Tier 1 upstream/downstream supply chain firms. Comparison of ICT technologies adoption between upstream and downstream supply chains revealed that there is an inconsistent adoption of technologies along the extended supply chain tiers where contractor firms' upstream relationships' have no influence on the adoption of technologies by downstream firms. In order to increase the adoption of these technologies within and between supply chain firms, as well as make their use more effective, key issues with cost, lack of awareness, suppliers' reluctance to adopt, as well as compatibility and interoperability needs to be given due consideration for the whole industry.

In terms of managing extended supply chain tiers, the questionnaire survey revealed that contractor firms' main association with supply firms in Tier 2 downstream supply chains are contractual, technical and financial. This finding points to a need for identification of commercial mechanisms and technical interfaces with immediate suppliers so that relationships can be built with extended supply chain firms. Contractual and commercial mechanisms such as continuity of work, financial incentives and open book accounting are some of the concepts that foster transparency in dyadic relationships but what is their effect on extended supply chain relationships is unknown. Similarly, for streamlined collaborative supply chain practices the technical involvement with extended supply chain firms must be supported with appropriate ICT technologies. The technical supply chain interactions and interfaces need to be investigated so that ICT technologies can be used to facilitate SRM with extended supply chains.



The review of literature and the evidence from the study reveals that SRM is a vital element of extended cSCM and ICT technologies can facilitate relationship management process if they are used consistently and effectively between supply chain firms. The theoretical framework for relationship-centric cSCM is a work in progress which involves additional development, testing and analysis. Currently such a development is being undertaken to create a cSCM framework for contractor firms who play a key role in the management and control of construction project supply chains.

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## APPENDIX D- 1

Table: Characteristics of each relationship type against relationship determinants.

<i>Relationship Elements</i>	<i>Transactional Relationships</i>	<i>Series of Transactions</i>	<i>Project Collaboration</i>	<i>Long-term Strategic Partnership</i>
<b>Continuity</b>	Infrequent and irregular interactions and transactions. Transactional relationships are dynamic and can lead to another transaction or series of transactions.	Dimensions of interaction are much more dynamic, frequent and intense but lack consistency and regularity.	Project based relationship, i.e.: interaction and transaction based on projects where the relationship is regarded as the best option for the contracting firm.	Continuous, long-term relationships. Intense form of relationship at every project that contractor firm gets.
<b>Complexity</b>	Low volume of transactions, low asset specificity products, materials and services. Generally involves interaction/transaction between two companies (dyadic). Inter-personal relationships are at operational/project level.	Volume of transaction/interaction is high due to benefits to be gained from economies of scale or strategic purchasing, however focus is on a particular component OR single element of a project. Complexity therefore is low (no interaction between other supply chain firms). Managers and more senior people get involved in the relationship.	High asset specificity and transaction is generally at project level; however, volume of transaction/interaction depends on the project's properties (size, complexity, design etc.) Length of the supply chain extends beyond immediate tier of the supplier/buyer. Teams of people get engaged in the relationship.	Length and complexity of the chain is very sophisticated. Involves integrated project delivery which include complex and high-volume interaction/transaction between the firms. More senior level involvement in decision making but relationships extend beyond a few individuals to cover majority of the project team and people who deal with, for example, accounts, marketing and PR.
<b>Symmetry</b>	High power asymmetry in terms of human, knowledge, financial and technological resources between firms.	Usually high power asymmetry in human, knowledge, financial and technological resources of the firms.	High power asymmetry may be compensated by one of the party's strength in a particular resource.	Low or no power asymmetry between firms, however one party may be able to dominate or influence the relationship more due to its purchasing power.
<b>Exchange/ Interaction</b>	Content of the exchange generally include a single product/service which is acquired on a one-off basis.	Relationship consists of stream of transactional interactions in multi-projects. Content of exchange may extend beyond single product and include series of commodities.	Content of the relationship concerns interactions which is at project level and include all the sub-components of the project such as a project package.	Integrated project delivery for majority of the projects involved.
<b>Relationship Embeddedness</b>	Few connections, ties and legal links prior to the interaction.	May have been involved in a transactional relationship before. There are some connections, ties and contractual agreements between the parties embedded in the relationship.	May have been involved in portfolio of projects and have an established relationship setting where parties work together which would have a low-medium level of impact on relationships with other firms.	Relationship is highly embedded within both parties' businesses and could have serious impact on other relationships.

<b>Formality, Informality and Transparency</b>	Interaction is highly formal and follows standardised generic business processes/procedures (e.g.: paying and receiving for the products/services). No transparency in the relationship (i.e.: break down of costs)	Formal procedures with some configured business processes and procedures. Transparency is limited to specific interaction.	Risk and reward sharing mechanisms for individual projects. Some informal processes/procedures are in place when completing a task although majority of these are between senior/middle managers.	A lot of formal and informal connections between different levels. Processes/procedures/pr protocols can follow informal arrangements between individuals/firms. Risk and reward sharing mechanisms may exist in all interactions. Transparent business operations between inter-firm relationships.
<b>Attitude, Trust and Commitment</b>	Commitment, trust and attitude is irrelevant in the transaction/interaction.	Some trust exists; parties are committed to the extent of their agreements.	There is an established project culture, high level of trust and commitment between the parties however it is generally discontinuous as same project teams rarely re-assemble on subsequent projects	Organisational and project culture in an environment of honesty, blame-free, high level of inter-firm trust and commitment at all levels.
<b>Market Structure</b>	Product/service is largely available in the market and there are competing firms for the supply of similar commodity	Product/service is largely available in the market and there are competing firms for the supply of similar commodity	Firms generally operating in single market and/or specialised in a particular product/service.	Firms generally operating in single market and/or specialised in a particular product/service.
<b>Firm Position</b>	Can be two or three tiers above/below in the supply chain (relative to the focal firm), however transactional relationships can also be next tier supply chain firms which are nominated by the client.	Firms which are one or two tiers above/below in the supply chain.	Firms which are one tier above/below in the supply chain.	Firms which are one tier above/below in the supply chain
<b>Dependence and Congruence</b>	No dependence and highly differentiated businesses.	Low level of dependence and highly differentiated businesses.	High level of dependence and some congruence required in the relationship.	Interdependence and high level of congruence in the relationship.
<b>Collaboration</b>	No collaboration.	Collaboration is rare.	Collaboration takes place on a project-by-project basis.	Collaboration is long-term and involve all levels of the inter-firm interaction.
<b>Risk and Uncertainty</b>	Low level of risk to buyer firm. Relatively higher uncertainty in the quality of the product/service, although much of it depends on the standardisation and asset specificity of the commodity.	Low level of risk for the buyer firm. Uncertainty is low due to previously established transactions/interactions .	Level of risk is contained to current project only. Minimum uncertainty as firms has established a longer-term relationship.	Risk of relationship failing is low and uncertainty is minimal.
<b>Adaptation</b>	No specific adaptations between the firms.	Some adaptation between the firms but limited in scope and extension (e.g.: temporary adaptations such as code of practice for business transactions)	Majority of the investment by both firms are on operational adaptations which are at project level.	Mutual adaptations are long-term and companywide (both strategic and operational, e.g.: technical adaptations, administrative routines, knowledge-based adaptations)

<b><i>Attraction</i></b>	Independent relationships that involve no commitment. Relationships are not seen important. Transaction/interaction is attractive primarily due to cost factors.	Firms are beginning to show appreciation and commitment for a more frequent interaction. Relationship is attractive due to cost, brand image, experience and other factors.	There is a commitment from both firms for their relationship to continue. Firms are dependent on each other due to shared stakes in the project.	High level of commitment from both parties to maintain the relationship. Firms are highly dependent on each other due to amount of investment in the relationship and strategic importance.
<b><i>Closeness and Remoteness</i></b>	Weak connections between firms (only operational links between firms) and none/very limited physical contact with offices. If the transaction is international there is probably a high level of cultural and organisational differences between the firms	Some strong connections but these are generally at the managerial level. Firms are generally close to each other as arrangements normally involve firms who are at local and regional proximity of the buyer firm.	Teams may share the same facilities. Firms' office location may be distant to each other, but regular meetings are carried out to keep close contact.	Firms have shared project offices and facilities to support structural and functional integration.
<b><i>Customisation, Standardisation and Prefabrication</i></b>	No specific or standardised processes/procedures in and between the dyadic interactions.	Some established custom processes/procedures but interactions are not standardised.	Standardised processes are in place to complete routine project tasks.	Majority of the routine tasks/processes/procedures are standardised.
<b><i>Social Relationships</i></b>	No social interaction between the firms/individuals	Social interactions are rare and only contained within senior/managerial level relationships.	Established social relationships through professional/social network sites (e.g.: Facebook, LinkedIn, Twitter).	Strong social connections through professional/social networking sites or through other social activities (personal or organisational).

## **Appendix E      Implementing Commercial Information Exchange: A Construction Supply Chain Case Study (Paper 4)**

### **Abstract**

The concept of electronic trading (e-trading) has transformed supply chain interactions in many industries, yet little research explored its implementation by Architecture, Engineering and Construction (AEC) supply chain firms. E-trading relies on commercial information exchange by supply chain partners which is generally adopted through intermediary technology partners (Hub Providers) to facilitate the accurate and timely communication of transactional data between buyers and supplier. A case study was conducted to explore the challenges and barriers to implementation of cross-firm commercial information exchange. The study primarily involved investigation of the interfaces between software development and organizational functions assisting with the electronic exchange of commercial information (eCIX) implementation. Findings from the case study show that implementation of commercial information exchange is not an easy task with several themes of factors to be considered during delivery of such projects, namely technical, coordination, integration and organizational. The study contributes to the knowledge and deployment of e-trading solutions within the context of AEC firms, and should be of interest to the practitioners contemplating similar projects.

**Keywords:** Case Study, Commercial Information Exchange, Electronic Data Interchange, e-Trading, Implementation.

**Paper type:** Research Paper



# 1 Introduction

In an attempt to streamline their procurement processes, many contractor firms (CF) are considering tighter integrative practices with their key supply chain partners which represent as much as 75% of the cost of the construction projects (Harris, 2013). One of the solutions that enable streamlined and synchronous commercial interaction is the Business-to-Business (B2B) electronic trading (e-trading). The purpose of B2B e-trading is to enhance the existing relationships through transformation and integration of the interfirm commercial processes (Gunasekaran and Ngai, 2004). In broad terms, the central role of B2B e-trading solutions is to facilitate the buying and selling aspect of the business interaction.

In order to effectively implement e-trading, trading partners need to embrace an integrated approach whereby systems and technologies used for e-trading purposes are interlinked with the companies' backend Enterprise Resource Planning or ERP systems (Dai and Kauffman, 2002). However, many of the current e-trading systems used by the industry firms lack an integrated approach to exchange of commercial information generated during the procurement and supply of materials, equipment, goods and services (e.g. purchase orders, quotations, requisitions, invoice, delivery notes, catalogues and many other documents part of the procurement process) (Cole, 2008). Consequently, there are silos of information residing in different systems which not only leads to inefficiencies and waste in storage, processing and management of data, but also results in increased transaction costs for both buyers and suppliers. Through streamlining of the commercial processes and automation of the transactional information between the back-end systems (for example, automation of highly repetitive and voluminous purchasing activities) CFs would not only achieve time and cost savings in administration of the purchasing process, but also benefit from less or no paperwork, improved purchasing lead time, and reduced inventory (CITB, 2006; E-Business W@tch, 2006).

Prior literature provides little information on e-trading systems implementation which involves electronic exchange of commercial information between the backend ERP systems. A number of studies investigated implementation of ERP systems by construction organizations (Shi and Halpin, 2003; Voordijk *et al.*, 2003; Yang *et al.*, 2007; Acikalin *et al.*, 2008; Chung *et al.*, 2008) however the scope and focus of these studies has been on intra-firm ERP applications rather than cross-firm application integration. Cole (2008) discussed the Electronic Data Interchange implementation which is one of the ways to achieve end-to-end integration. He gave several examples of issues with integration however the findings are largely based on his personal experiences with electronic data exchange hubs. Other studies have focused on the e-readiness of organizations where key factors related to people, process and technology dimension of implementing new and innovative technologies have been addressed (Goulding and Lou, 2013). However, e-readiness dimension only provides a strategic overview of the issues and challenges that enable or hinder technology implementation projects, and falls short of addressing the variety of issues that crop up during the actual deployment phase.

Against this background, the premise of the article presented here is to contribute to the understanding of e-trading systems implementation, with specific reference to the end-to-end commercial information exchange by Architecture, Engineering and Construction (AEC) supply chain firms. The objective of the study is to investigate the challenges and barriers that surface during deployment phase of the implementation. The research adopts a case study approach to investigate a real-life project between a large contractor organization and ten of its key trading partners through a third-party e-trading solution provider. Commercial information is defined as data that has transactional detail relating to the sale of materials, equipment, goods and services, and electronic exchange of commercial information (eCIX) is considered as one of the central tenets of the e-trading concept.

The remainder of the paper is arranged as follows. First, an introduction to technologies that facilitate e-trading is provided. The methods by which end-to-end integration is conducted are discussed in the following section to provide a background into implementation of eCIX projects. The research methodology is introduced next, followed by a detailed insight into the case study context. The findings of each integration case are presented next. The challenges and barriers experienced across each integration project are collectively grouped under four headings and lessons learned from the case study are drawn out in the next section. The article ends with a brief summary of the study, as well as pointing to the limitations of the current research and opportunities for future research.

## **2 Electronic trading technologies in the AEC industry**

The concept of electronic trading is rooted in the idea of e-business which is commonly defined as electronic conduct of business operations (Chaffey, 2009). According to Gartner Group (2016), a research and advisory firm, e-business is a process rather than an absolute state of company. The principle aim in its implementation is to streamline the business processes, improve productivity and increase efficiencies (Bocij *et al.*, 2008). The e-trading phenomenon is based on the same principle; however, it is much narrower in the sense that it is primarily concerned with B2B commercial exchange over computerized networks, in particular Internet and web-technologies. This definition should not be confused with another commonly used term in the literature; e-Procurement, which its boundaries stretch beyond the commercial exchange to embrace other associated (intra-firm and inter-firm) procurement activities, including identification of need, negotiation, contracting and settlement (Grilo and Jardim-Goncalves, 2011). Thus, being a narrower scope than e-Procurement, e-trading is described as web-based technologies that facilitate the B2B commercial exchange between a buyer and supplier.

Driven by the advancements in internet, connectivity and web-services, the technological solutions for e-trading have evolved significantly over the years from stand-alone Electronic Data Interchange (EDI) applications to much more sophisticated, multi-functional and multi-purpose technologies. In examination of the literature on digital technologies used in procurement of construction projects Ibem and Laryea (2014) distinguish the latter type as 'intelligent systems' which are largely web-based information systems used for communication, collaboration, integration and coordination needs at different stages of construction procurement activities. A prominent example of the e-trading technology used by the AEC supply chains includes Web-based Project Management Systems (WPMS) (Nitithamyong and Skibniewski, 2004). In addition to their core functionality of project documentation and drawing management, and collaboration, WPMS can also facilitate the systematic sourcing; which typically include organization, planning and management of tenders and contracts of production-related materials, goods and services (Nitithamyong and Skibniewski, 2004). However, Ren *et al.* (2008) argue that a major limitation of the WPMS is that they are primarily designed to facilitate the business and workflow processes for strategic sourcing needs of firms (or projects) rather than support the inter-firm operational activities related to buying and selling.

Another type of e-trading technology is the e-Marketplace systems which are primarily used to facilitate the organizational exchange of information, goods, services and payments between the buyers and suppliers (Standing *et al.*, 2006). Whilst there is a lot of confusion over their roles and functions, extant literature often distinguishes e-Marketplace systems on the basis of the ownership model. Accordingly, there are three main types of e-Marketplace systems where each offers a variety of different value propositions to participating firms (Dai and Kauffman, 2002; Balocco *et al.*, 2010).

- *Public e-Marketplace* systems are centralized portals for procurement of direct and indirect supplies for public projects, for example, CompeteFor<sup>1</sup> originally developed for the 2012 London Olympic Project and used by public authorities to publish contract opportunities for subcontractors and suppliers.
- *Independent e-Marketplace* systems are privately owned marketplaces which concentrate on bringing as many buyers and suppliers together with an aim to generate business transaction. To give a few examples; RS<sup>2</sup> is an intermediary marketplace for sale of various electrical, mechanical and IT products and services. In addition, there are various material/product specification directories primarily used by architects, engineers and facilities managers such as ESI.info<sup>3</sup>, BuildingDesign<sup>4</sup> and Barbour<sup>5</sup>; however, the use of these marketplace systems does not generally extend beyond product information sharing.
- *Private e-Marketplace* systems are governed by the hierarchal structure in the relationship where one of the parties (usually a buyer firm) invites its portfolio of supply chain firms to conduct a full procure-to-pay business transaction via an intermediary technological solution provider. The e-Marketplace system is generally outsourced to an intermediary Exchange Service Provider whose scope of the functionalities offered may extend beyond the transactional exchange to value-creating interactions (such as collaboration, collaborative forecasting and replenishment, logistics and so on) (Wang and Archer, 2007).

More recently the ubiquitous drive towards adoption of Building Information Modelling (BIM) has put Cloud-based Software-As-a-Service at the forefront for sharing, collaboration and coordination of information-rich 3D model files in a vendor neutral ‘Common Data Environment’ (Succar, 2009). Developments in this particular field are fast-changing and recently a number of authors either proposed (Ren *et al.*, 2012) or reported on the development of the work that is underway to initiate e-trading activities directly through the Cloud-based BIM models (Grilo and Jardim-Goncalves, 2011; Costa and Grilo, 2015). However, as also acknowledged by these authors, lack of standardization of procurement processes and problems with interoperability of product data presents a complex challenge for collaborative and transactional processes across BIM models and e-Marketplace systems. Hence, presently the Cloud-based BIM models fall short of its potential to be effectively utilized for e-trading purposes.

### **3 Implementation of commercial information exchange by AEC firms**

In addition to streamlining the cross-organizational commercial activities, a vital ingredient of e-trading is the alignment of trading parties’ back-end ERP systems (Dai and Kauffman, 2002). Most often the above-mentioned systems work in isolated fashion where parties to trade have to reprocess the information manually in their back-end systems, leading to loss, distortion, and duplication of data across systems. A fully integrated e-trading system supports inter-operation of data through electronic exchange of commercial information (eCIX) where different types of transactional information (including, but not limited to, product and pricing information, order, delivery and invoice data) is exchanged seamlessly amongst businesses and their back-end ERP systems.

There are multiple ways to implement eCIX with suppliers. EDI can be considered as the simplest form where two firms link their legacy systems to communicate, share or exchange business documents such as order and invoice data. Typically, EDI messages contain highly structured product, order, or invoice data which is exchanged over a communications network. However, in order for EDI to work, both organizations (sender and receiver) must agree to a

common standard on syntactic (data format), structural (description of how the data will be structured), and semantic (definition of content of data) dimensions of interchange. Implementation of EDI can be direct (i.e. B2B) or by Value Added Network (VAN) providers who intermediates the connection, translation and transition of the transactional messages. Despite its long history, reported usage of EDI is scanty within the AEC industry (Lu *et al.*, 2014), with builder's merchants and CFs being the most notable users (Samuelson and Björk, 2013). Kong *et al.* (2004) reasoned the initial cost of set-up and complexity of standards for the low levels of adoption whilst Lewis (1998) concluded that lack of clear business case with little apparent benefits from its application, deferred AEC firms' decision to invest in the technology.

Other approaches to eCIX include using platform independent common data formats, most notably the eXtensible Mark-up Language (XML) document types which is considered to be the lingua franca to data exchange between different software solutions. Similar to EDI, implementation of XML-based eCIX heavily relies on existing frameworks to standardize the syntactic, structural and semantic representation of the data. Although there are several open-source and proprietary XML-based frameworks available, for example, aecXML,<sup>6</sup> agcXML,<sup>7</sup> bcXML<sup>8</sup> and eBuildXML<sup>9</sup> (where the scope of the business activities covered varies in each framework) their adoption and utilization by the AEC firms are not well known. In addition to the XML-based messages, the Industry Foundation Classes (IFC) and STEP file formats (which are primarily used in design and construction stages of a project) allow embedding of the building specification data within its content (Shen *et al.* 2010). Ren *et al.* (2012) explain that the information stored in these files maybe part of the 3D model file which contain additional intelligent data about the 3D building objects and elements, or separate from the model file itself. However, since their application aimed primarily for the design, construction and ex-post processes in a project's life cycle, the use of the IFC and STEP file types for the transactional exchange is currently limited to cost information sharing: for example, data from an IFC can be exported into CIS/2 exchange standard for cost analysis of structural steel (BuildingSmart, 2015).

Besides the data exchange standards and formats, another important consideration in eCIX implementation is the construction product catalogues (CPC) which contain the necessary information about the details of the transaction (for example item description, specification, price, unit, quantity and so on). The mechanisms adopted for exchange of CPC information can be either file-based (e.g. PDF or spreadsheet document) or through establishing inter-connection with a web-based supplier hosted catalogue (through services such as PunchOut or RoundTrip interface). The prime issue related to CPC is the management of product information data, in particular the categorization and classification of the goods/services where many firms utilize a customized and bespoke product code, description and specification (CITB, 2006).

One of the biggest challenges in inter-connecting the back-end systems relate to the compatibility of the existing ERP modules and applications. The back-end ERP systems used by supply chain firms are often configured and customized to the specific needs of firms which make integration with external systems a complex activity; especially when implementation involves multiple supply chain partners (Cheng *et al.*, 2010). This results in significant amount of efforts to be spent on mapping, transformation, and translation of data (Samtani, 2002). In addition, the capability of the existing systems to connect and exchange data with external systems also presents a big issue during implementation. The existing legacy systems that are used to store, process, and manage commercial information may lack the functionality to automate real-time exchange of information. In such cases a messaging layer or middleware provider may be required to help with the connectivity before integrating with external systems (Samtani, 2002). Given that an e-trading system supported by eCIX requires a complex technological infrastructure, firms can choose to outsource the development activity to third-party service providers known as Hub Providers (HP) (Dai and Kauffman, 2002). Many HPs

act as mediators who are responsible for facilitating the cross-organizational commercial processes as well as translation, conversion and communication of transactional data between the back-end systems of the trading parties (Samtani, 2002). They not only support all open data exchange standards, but are also capable of handling data validation and business rules for a highly accurate data exchange (Cole, 2008). Some of the essential components of HPs include (Samtani, 2002): (i) a connection layer through which transactional messages can be communicated with the backend systems (e.g. EDI, http, ftp, sftp and email); (ii) services layer which enable range of capabilities and functionalities such as supplier directory, purchasing and order management, product search and so on, and; (iii) presentation layer, which provides a web-based front-end interface where users can view and interact with the system.

## 4 Methodology

The eCIX implementation project requires support from different disciplines including software engineers to execute the technical operations at the backend. The interaction between the technical team and project coordination team is, therefore, an essential part of the eCIX implementation process. Furthermore, eCIX projects become even more complex if the e-trading solution is outsourced instead of developed in-house (for example in cases where e-trading is outsourced to HPs). In relation to this point Willcocks *et al.* (2011) argue that as the complexity of the development (for example mapping, transformation, and translation of data) increases, issues with project coordination, information management and control, and meeting end-user expectations becomes harder to manage. In addition, given that firms will want to integrate with as many key suppliers as possible (for example in order to derive maximum benefits from the e-trading operations), the difficulty of managing the eCIX implementation project is expected to increase in parallel with the number of suppliers incorporated to the project. As a consequence of these factors, there is a need to explore the interface between software development and organizational functions assisting with the eCIX projects for deeper understanding of the implementation process.

In framing the methodological concerns surrounding the information systems (IS) research (which many e-trading systems fall under), Benbasat and Zmud (1999), and Davis (2000) make a compelling case in order for IS research to become more industry relevant. Case study method is one of the most widely used approaches in IS research. Case study research can yield many important insights as to ‘how’ and ‘why’ a phenomenon occurs given its specific context. It allows in-depth study of the phenomenon which the researcher can use to form as the basis of a more extensive study (Yin, 2014). However, the case study approach also has limits in the sense that generalization of the findings would be difficult due to the fact that the study is bound to the case study context only. Whilst recognizing this weakness, a case study approach is considered to be the most appropriate method of investigation because it allows the study to report on full lifecycle of the project with a significant amount of qualitative and quantitative data to support the research findings (Yin, 2014).

Table 1: List of suppliers implementing eCIX.

Supplier Code	Sector	Company Turnover <sup>(a)</sup>	Percentage of Orders <sup>(f)</sup>	Percentage of the Total Number of Orders <sup>(g)</sup>
S2	Safety and workplace commodities	£100m	40.7%	<b>8.8%</b>
S10	Construction materials (timber and building materials)	£1.9bn	13.9%	<b>3%</b>
S1	Heating and Plumbing supplies	£1.8bn	12.1%	<b>2.6%</b>
S7	Underground Drainage Materials	Unknown <sup>(e)</sup>	9.7%	<b>2.1%</b>
S5	Construction materials (timber and building materials)	£1.8bn	7.2%	<b>1.6%</b>
S8	Office and stationary supplies	£250m <sup>(d)</sup>	5.2%	<b>1.1%</b>
S6	Printing and document management	£50m <sup>(b,c)</sup>	3.5%	<b>0.8%</b>
S9	IT Services	£50m	3.3%	<b>0.7%</b>
S3	Construction tools and equipment	£100m	2.6%	<b>0.6%</b>
S4	IT hardware, software and services	£350m	1.7%	<b>0.4%</b>
Totals:			100%	<b>21.6%</b>

Note: Bold values indicate percentage of the total number of orders raised in 2010.

(a) UK turnover only. Except otherwise stated, figures are based on 2013-2014 financial year submitted to the Companies House and rounded to nearest £50k.

(b) Figure published in 2012 for the trade period between 2011 and 2012.

(c) The company was acquired by a competitor for an undisclosed amount in 2014.

(d) Unofficial estimate only, not based on any factual data. The global turnover of the company is £14.5bn.

(e) The company went into administration in 2012 and no financial information before pre-acquisition could be found.

(f) Percentage of Orders placed with each company in 2010.

(g) Percentage of the total number of orders raised in 2010.

## 5 Research Method and Process

The aim of the current study was to explore the challenges and barriers faced during delivery of a case study eCIX implementation project between a large UK CF and ten of its suppliers. As part of its ongoing business improvement programme, the CF identified an overall operational cost saving, and increased efficiencies in procurement processes by moving away from paper-based transactions to e-trading. During 2010, the company deployed its own custom-built ERP system to manage accounting related operations for all of its projects and, business and operating units. A year later it had selected a HP in order to interconnect with its supply base and start e-trading with the selected suppliers. The initial goal set was to get at least 20% of firm's overall transactions to trade electronically (see Table 1). Table 1 gives the profile of the supplier firms and the number of orders sent to suppliers before commencing with the project. The name of each supplier company participated in the project is removed for the reasons of commercial confidentiality. In addition, the contractor company will be referred to with the code 'CF' whilst 'HP' will be used to refer to the HP.

The reason for the selection of this particular case for data collection was primarily based on availability of the project and access to data (between 2012 and 2015). At the beginning of the project, the researcher, who is one of the authors, was primarily involved with monitoring, and reporting of project activities and progress on behalf of the HP. This opportunity gave intimate access to the project and allowed the researcher to collect as much rich data as possible from the earliest stages of the project until completion.

## 6 Data Collection and Analytical Procedures

Data collection involved capturing of data from multiple sources including project development logs (the back-end software activities involving mapping, coding and implementation), meeting minutes, and project reports as well as observational data gathered through face-to-face and

teleconferencing meetings. In addition, the researcher had access to the email archives of the project coordinator who was responsible for managing the project from the HP's end. The project coordinator was the central authority who was in control of all the project communication therefore availability of this data gave the case study the opportunity to explore the full picture, that is, the communication and correspondence patterns between the project participants (the teams at the CF, suppliers, as well as the internal correspondence between the HP's technical project delivery team). Over the course of the study, the total number of emails exchanged was 3646; which were between 98 people working across 15 different companies (including the CF, HP, ten suppliers and three third-party service providers to the supplier firms).

With regard to the data analysis, emails were initially grouped according to the project and later categorized into the appropriate implementation stage. For each implementation, information from the emails, project development logs, technical documents and case study notes were compiled into a single spreadsheet in a three-level work-breakdown structure. The reason behind lack of progress was codified along with all the relevant information including the details of the delay, source organization and impact of the delay on the project timeline. The activities that resulted in unnecessary hold-up such as non-communication, unavailability of the systems, setting up joint meetings, late change requests, and so on, were tracked to determine their impact on projects' schedule. On the other hand, the development activities which include tasks such as implementing the mapping schemas and conducting testing to validate the implementation were also recorded. The project monitoring spreadsheet provided a large amount of detailed and reliable information over the lifetime of all the 10 projects. A simplified version of the project monitoring spreadsheet can be found in Appendix 1 which shows high-level summary of one of the projects. Finally, the information from the project monitoring spreadsheets was extracted into a single workbook which allowed the study to identify the trends and patterns, and categorize them into several themes of challenges and barriers.

## **7 Case Description**

Following sections aim to provide a background into the case study context. First, the eCIX implementation method is introduced. This is followed by the description of processes which the eCIX facilitates and the phases in the project. The next two sections introduce the CF and HP who were the main partners in execution of the project. Each supplier case is then presented to give further insight into challenges and barriers faced during project deployment.

### **7.1 Case Study Context**

#### **7.1.1 Supplier Integration Method**

The e-trading functionality is enabled through the HP's Cloud-based e-trading portal which is interconnected with the CF's (CF) back-end ERP system (Figures 1(a) and (b)). Buyers at the CF access the portal via a secure login and can be given multitude of access rights to projects (referred to as workspaces) to trade electronically with any supplier connected to CF's private e-Marketplace. The e-trading functionality is also supported by spend analytics features of the HP's platform, including: (i) access to all of the transactional documents exchanged with full audit history, (ii) running custom reports on spend data, and (iii) monitoring purchasing activities of each project or business unit.

Depending on whether suppliers' back-end system is capable of connecting with external systems, integration with the suppliers can be implemented with direct connection with the supplier's ERP or legacy system (Figure 1(c)) or through an intermediary, third-party HP who provides the connection infrastructure for the supplier (Figure 1(e)). Alternatively, suppliers can use the off-the-shelf package offered by the HP which is an online portal for

management of the procurement process (Figure 1(d)). This is regarded as the most appropriate method for low-spend, project-specific suppliers where the transactions are not frequent and low in volume.

### 7.1.2 General Characteristics of the eCIX Implemented

Figure 2 shows the process adopted for the eCIX. The information that CF wanted to exchange with its suppliers are shown in white boxes whilst black boxes show the supplier sourced commercial information. As can be seen from Figure 2, four-way validation is implemented on all documents sent/received to ensure maximum data accuracy. The first stage in purchasing the process is to publish an electronic catalogue (e-catalogue) through which buyers can purchase goods/services from. There are two ways by which e-catalogues can be implemented; either through HP's portal or supplier's own web store. With regard to the former, suppliers are provided with a spreadsheet template which is populated with the item/product details and then uploaded onto HP's portal. In the latter method, supplier maintains its own catalogue facility and interface with the e-trading application through the PunchOut or RoundTrip solution.

The blanket order (BO) is a form which contains information about the value of spend allocated to project buyers in each project. Generally a BO contains much more detailed information including the period of BO agreement, items or categories of items covered by the BO, pricing and quantity restrictions etc. however, within the context of the CF the details of the commercial contract was maintained within the ERP system therefore the purpose of the BO was mainly to manage the spend at each project for different suppliers (as well as informing suppliers, for example, their depots or branches, about the potential value of spend by a particular project).

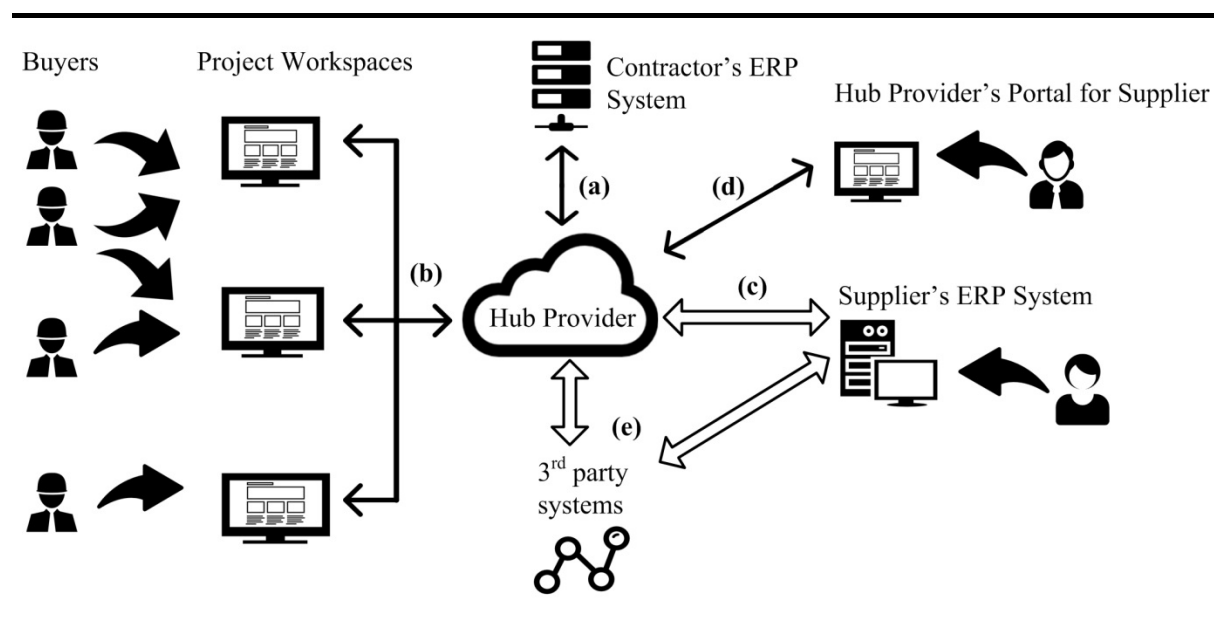


Figure 1: eCIX implementation map (supplier implementation options shown by white arrows).



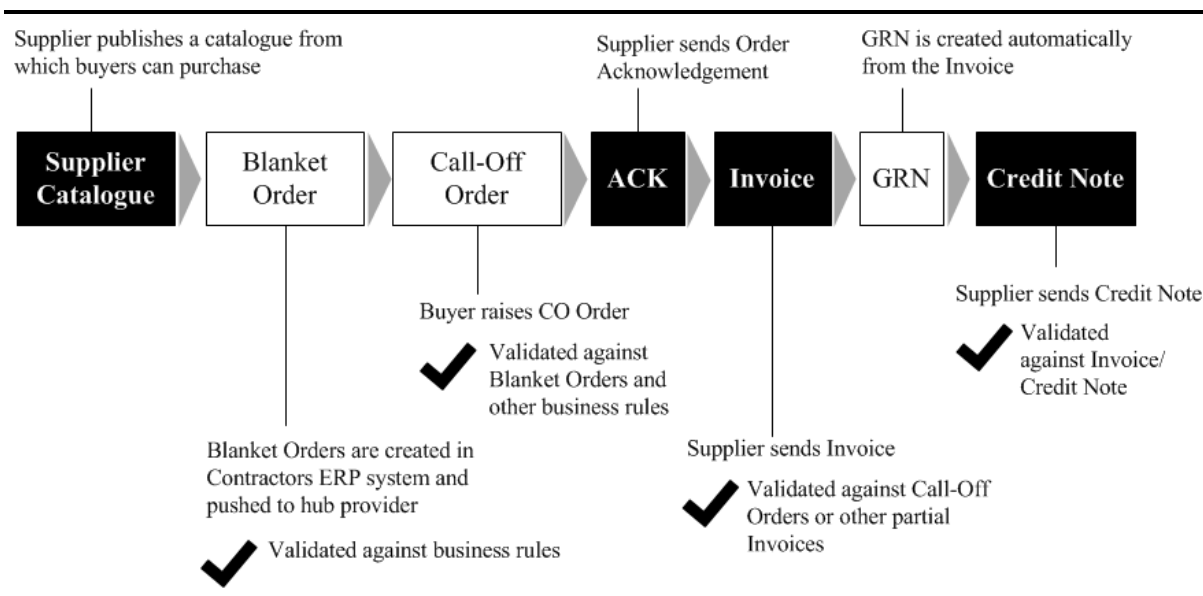


Figure 2: The eCIX procurement process.

Call-off orders, in the context of the case studied, are essentially purchase orders sent to each supplier in the supplier's requested file format (along with the necessary data transformation). In order to raise a call-off order buyers use the HP's Cloud-based online platform. There are a number of business rules applied to call-off orders before they can be issued to a supplier. These include:

- Check whether call-off order exceeds the total BO limit;
- Check whether call-off order value exceeds individual buyers' monthly and transactional limits;
- Check whether buyer has permission to order products/items.

Upon receiving of the order message suppliers send an order acknowledgement message to the buyer to confirm safe receipt of the order message. This is a standard transmission message which does not have any information concerning the content and status of the order. Once the goods/services have been dispatched supplier issues the invoice(s). The invoice document goes through similar checks to validate the information being passed on and make sure it contains accurate information. For example, invoices must conform to validation and business rules such as invoice number should be unique and refer to a call-off order, mandatory references (such as BO number, call-off reference number etc.) must be correct/present, pricing and product details on the invoice file should match with those in the corresponding call-off order and total value of partial invoices should not exceed the total order value. The creation of a GRN document is not covered within the implementation process due to way CF handles deliveries but for reporting reasons the HP automatically creates a GRN message when an invoice is successfully processed. Lastly, supplier sends credit note after the CF clears the payment (which is outside the system) and similar to the way invoices are processed, validation and business rules are applied to credit notes to ensure highly accurate data exchange.

### 7.1.3 Approach to eCIX Implementation

The implementation process can be considered as a bolt-on exercise where the HP worked with CF's supply base to interconnect the CF with the suppliers. The eCIX implementation process followed the sequential software development methodology, called waterfall model (see Figure

3) which is one of the most widely used frameworks for software project management (Cadle and Yeates, 2008). Description of each activity/stage is given below:

**Requirements gathering/commercial agreement:** This is the first stage in engaging with the suppliers. It involves high level talks between the project coordination team at the CF and HP, and business managers and IT specialists at the supplier company. The aim of this stage is to capture supplier's specific requirements to come up with the most appropriate strategy for the integration. A technical questionnaire is issued to supplier to filter down the most appropriate solutions for the project so a commercial agreement between supplier firm and HP can be settled.

**Project specification:** Once the technical questionnaire is returned to the HP, together with the CF's IT team, a detailed project specification phase takes place to clarify the requirements. This stage is highly dependent on the issues which have been identified at the prior stage following the technical talks with the supplier's IT team. A number of technical documents (connection documents, business rules and mapping documents) are shared with the supplier's IT team to provide more detailed technical information on the project.

**Connection and mapping exercise:** This stage aims to establish a test connection between the supplier and HP to initiate the actual implementation process. Implementing eCIX between two heterogeneous systems entail intense mapping exercise to restructure a source data into an instance of a different schema (target format). Although this is a relatively easy development task, issues arise when one system is not capable or flexible enough to accommodate the mapping requirements. This is one of the most intense stages in the project where file formats, message content and, validation and business rules are analysed in detail and configured as necessary.

**Implementation:** Any development task arisen as a result of mismatch between two systems, e.g. where the supplier's system cannot accommodate the standard integration requirements, or where supplier asks for a change request, it is usually carried out in the implementation stage which may or may not be in parallel with the earlier stage(s).

**Phase 1 testing:** At this stage, all the mapping and implementation is done and testing between the supplier and HP is carried out to test both, connection and successful transmission/validation of messages (e.g. call-off orders, order acknowledgement, invoices and credit notes) between the HP and the supplier.

**Phase 2 testing:** This is the stage where an end-to-end testing is carried out by CF, HP and the supplier. It is the stage where the procurement process is tested from beginning to the end (i.e. procure-to-deliver). If the testing fails any business logic, validation, and/or any of the mandatory business rules, or if there are any bugs identified in the data exchange process, solutions are proposed/developed and implemented followed by another round of testing.

**Deployment:** Once Phase 2 testing is signed-off by the supplier and CF, a Go-Live date is agreed and any work related to setting up of integration on live system is carried out.

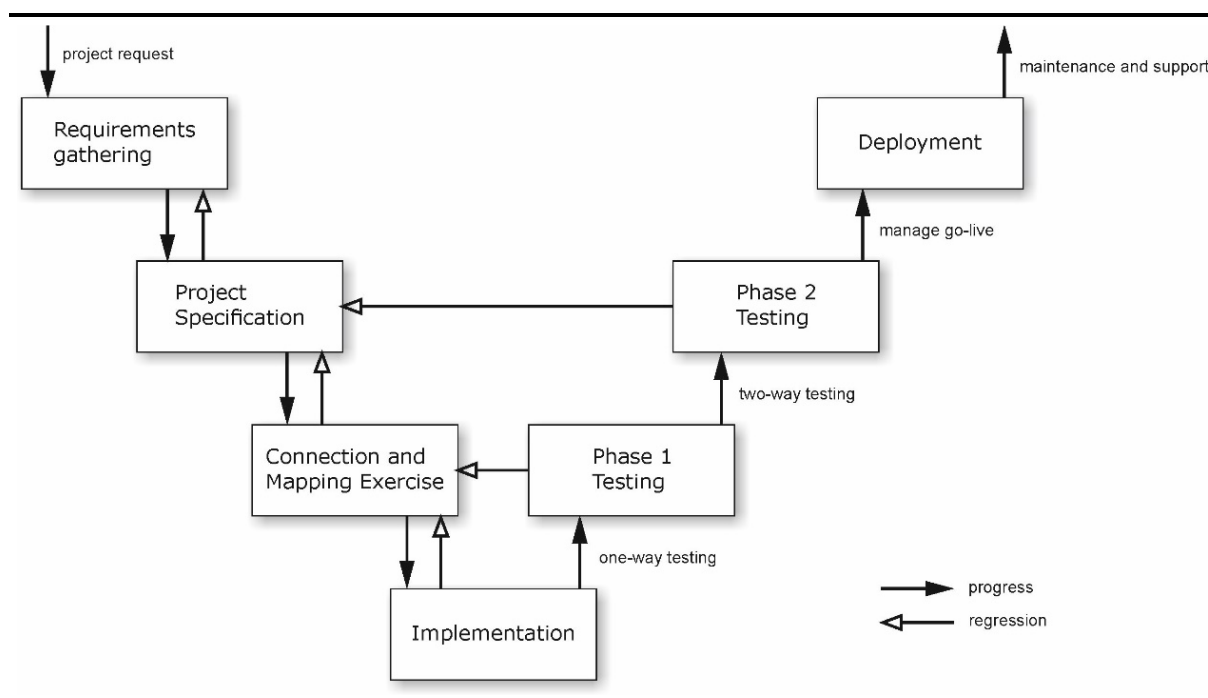


Figure 3: Stages involved in implementing eCIX shown in V-diagram (a slight variant of waterfall model) (After Cadle and Yeates, 2008).

#### 7.1.4 Contractor Firm

The company studied is one of the major contractors in the UK which is part of a multinational construction firm. The focus of the study is on the UK arm of the business which has presence in various sectors including engineering, construction, utilities, infrastructure, healthcare, facilities services as well as undertakings through Joint Venture, Public-Private-Partnership and Private-Finance-Initiative. The organizational structure of the firm consists of several business and operational units responsible for different sectors. In terms of the procurement process the firm utilizes de-centralized procurement process where sourcing for each construction project is carried out by procurement departments within each business/operating units. However, corporate level agreements are made with some of the key suppliers in order to increase the bargaining power.

As can be seen from Table 1 two groups of supply chain firms are selected for eCIX where top five firms are characterized by construction-specific supplies and the bottom five (except S3) are considered as firms operating in multiple industries. The CF's rationale for selecting these companies were based on (i) the number of transactions taken place in the previous year; (ii) number of transactions estimated in the future; and, (iii) purchasing requirements of projects which will be piloted when eCIX project is completed.

#### 7.1.5 Hub Provider

The HP involved in the project is one of the few IT companies specializing in collaboration Software-as-a-Service (cSaaS) for the AEC/FM industry. Along with other collaborative, document management and project management solutions, it also offers solutions for sourcing and procurement requirements of AEC firms. The sourcing application offers comprehensive eTendering functionality for firms to manage their tendering process from Pre-Qualification to Invitation to Tender to selection and awarding of the tender. The eProcurement application on the other hand provides a platform for buyers and suppliers to transact with each other through its Cloud infrastructure.

The project implementation team at the HP Company consisted of a project coordinator and technical project implementation manager who was based overseas (along with the developer team). The technical project manager was responsible for technical development whilst the UK-based project coordinator was the principle point of contact between the CF and suppliers. Responsibilities of the project coordinator included engaging with suppliers to agree on commercial proposal and coordinating the technical development work between all the parties. Communication between the internal project team members was usually through emails and telephone conversations.

Figure 4 shows the interaction patterns (emails exchanged) between the project participants (including the third-party service providers for the supplier companies) throughout the duration of the case study. The graph was produced with the help of an online data visualization tool called Circos<sup>10</sup> which is the work of Krzywinski *et al.* (2009). Each segment in the graph represents a company, and the incoming and outgoing emails by the companies. The inward flow (emails received) is represented by the ribbons touching the white space under a segment (that is, the colour of the ribbon touching the white space shows the source company). The outward flow (emails sent) is indicated by ribbons where the target segment colour (company receiving the email) is touching the source segment bar. The stacked bar plots outside the segment shows the percentage of emails received (inner bar), outgoing emails (middle bar) and all messages for the segment (the outer bar).

As can be seen from Figure 4 there is a complex and intertwined communications pattern in the eCIX project which entails significant number of email exchange. The number of emails analysed (3646) include all of the emails sent directly to a project participant, i.e.: everyone in 'To' field, and does not include the count of copies in 'CC' field. The Circos graph shows that HP is the biggest processor and consumer of information. The number of internal and external communications by the HP reinforces its central role in technical coordination of the eCIX implementation. The graph also shows that CF is interacting heavily with HP, albeit it is interesting to see that it sends more information than it receives from HP.

## **8 Ecix Implementation Cases**

### **8.1 Supplier 1 (S1)**

One of the biggest firms in its sector supplying heating and plumbing materials to construction industry, the CF was keen to connect with S1 due to volume of trade and number of transactions. The initial meetings were held between project coordinator from HP, supply chain manager from CF and business relationship manager at S1 to commence with the project. The supplier firm was using an intermediary HP (X1, who is a co-member with the HP on the Hub Alliance<sup>11</sup> network) so four parties were engaged in the implementation process. The chosen method of catalogue connection was internally hosted e-catalogue (i.e. through HP).

The first activity in the process (requirements gathering) was inactive for several months which delayed the technical discussion and project specification talks. This was due to S1's approval process for the project and signing of the commercial agreement with the HP. In the next stages of the project, progress was impeded by delays in correspondence, poor communication during phase 2 testing, developments in supplier's ERP system, and late change

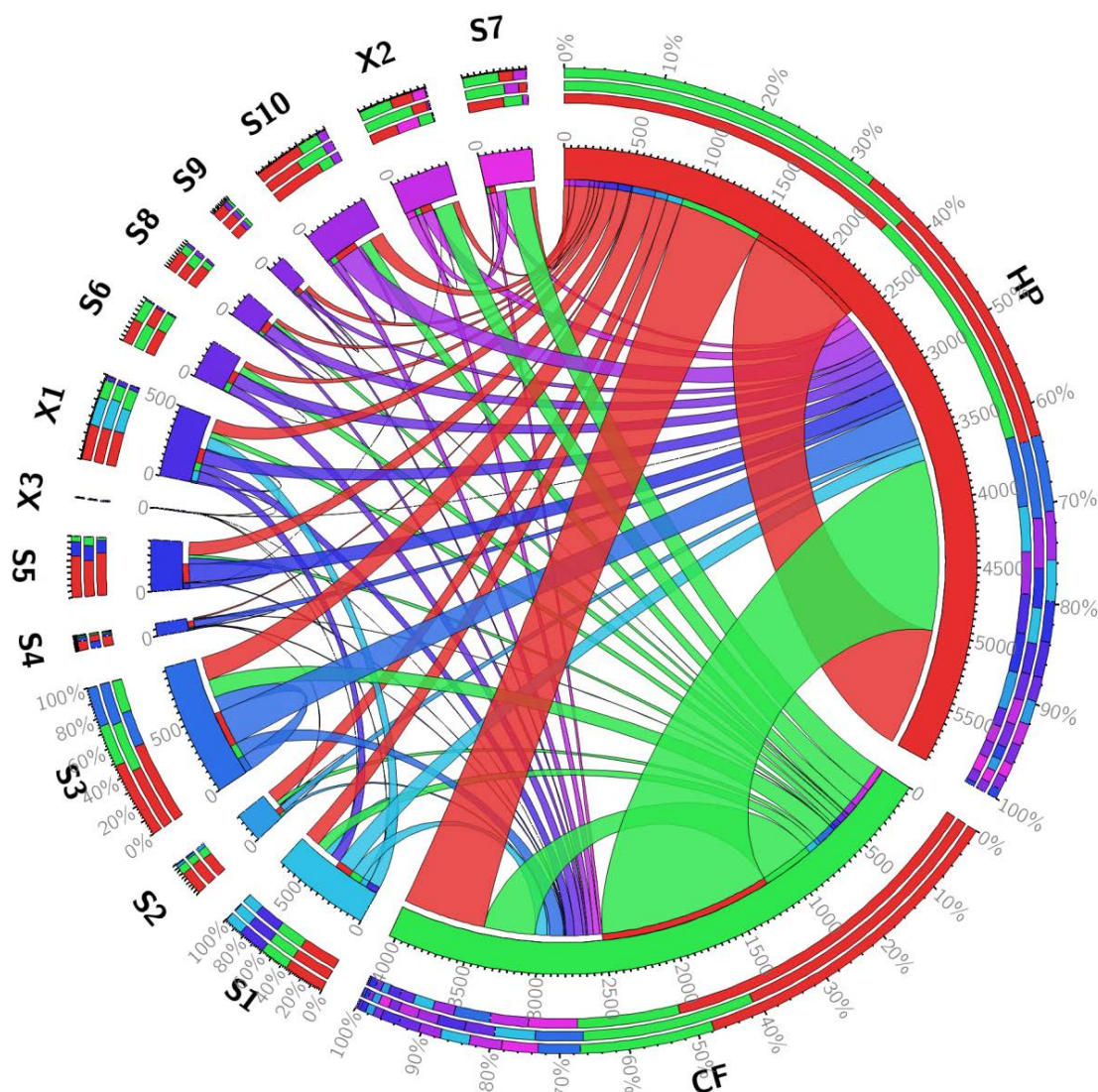


Figure 4: The Circos graph of email communication (after Krzywinski *et al.*, 2009).

request to implement mapping for invoice and credit note documents. In the end, the project took 1166 days to complete. In terms of the technical development at HP's end, the total tracked time was only 3% of the project duration. The waste activities which held the project, such as feedback on mapping schemas; creating, sending and feedback for test documents (orders, invoices and credit notes); and, organizing project meetings between all the parties accounted for 93% of the project's duration.

## 8.2 Supplier 2 (S2)

As one of CF's key supplier with high number of repeat transactions in almost every type of project, implementation of eCIX was vital to improving the procurement process with the supplier. Despite the close relationship between the CF and S2, the process for getting the commercial agreement (that is, between the supplier and HP) sealed took long time to settle. However due to importance of the supplier for the CF's project activities, technical implementation was pushed to start in parallel whilst the contractual agreement was formalized.

The route adopted for connecting with the supplier's catalogue was through PunchOut connection where the e-catalogue of the supplier was hosted externally on supplier's web store. Connection and mapping exercise was the longest stage in the project with few issues experienced during PunchOut connection, mainly due to wrong set-up. A few development tasks were deployed by the HP (as per S2's request) to facilitate validation of invoices and credit notes. The duration of the project was 347 days. The project progress sheet tracked that waste activities in the project contributed to 96% of project's duration, whilst technical development was responsible for only 11% of the project's duration. The overlap in percentages is due to technical development work being completed whilst waiting for additional information from CF and S2.

### **8.3 Supplier 3 (S3)**

The supplier had an established trading link with at least five of the CF's business/operating units as well as a number of JV projects. Although the number of documents transacted pre-eCIX implementation were relatively low, the value of transactions was one of the highest compared to the other suppliers. Furthermore, due to the lengthy paper-based procurement process, implementation of the eCIX was considered to be important for eliminating some of the waste activities in the current procurement process.

Similar to the previous set-up, the route adopted for connecting with the supplier was through PunchOut connection. Issues which impacted the project schedule include delays in creating the necessary set-ups for testing (such as account numbers and catalogue items to be used during testing), confusion over connection method and issues with connectivity, unavailability of supplier's test system, as well as development work to map some of the elements in order and invoice schemas. As a consequence, 64% of the project's duration was idle (433 days). The technical development work on the other hand equated to 24% of the project's duration.

### **8.4 Supplier 4 (S4)**

This was another supplier who wanted to implement PunchOut connection to automate the procure-to-deliver process. Face-to-face meetings took place between the project participants to initiate the project and get the commercial agreement signed off. Although the technical talks started whilst the contract was being approved, major system changes at the S4's IT systems and issues with connection set-up held the project for over 3 months. Once the system became available project connection and mapping exercise was resumed, albeit shortly later CF decided to drop off the supplier from the project; ending the project after 280 days.

### **8.5 Supplier 5 (S5)**

Operating with a turnover of over £1.8 bn, the supplier is one of the largest suppliers of timber and building materials in the UK. Majority of the projects and business/operating units of the CF have trading links with the supplier's regional and local branches which describes the importance of the eCIX implementation for the CF. The project got underway straightaway from the initial engagement meeting where teams began to work on project specification (where internally hosted catalogue connection was agreed, i.e. through HP) and connection and mapping schemas. A third-party HP for the supplier firm (X2) was also involved in the project to facilitate the integration with the supplier's ERP system.

The mapping and phase 1 testing stage was the longest as the development of schemas also involved input and data conversion for the interface between HP and X2. Late responses by parties, confusion around the ordering process, incorrect mapping and issues with connection set-up were the main cause of delays in the project which accumulated to 88% waste and inefficiencies in the project's duration (which was 532 days). The technical development tasks

(which included custom development work for the S5 to enable validation of invoice and credit note documents) were only 7% of the total project duration.

## **8.6 Supplier 6 (S6)**

Although the number of transactions with this supplier was comparatively low, the value of the transactions and interaction with the supplier put considerable emphasis on eCIX. Due to the purchasing process adopted by the CF only exchange of invoice documents were covered within the project (with special business rules put in place to validate and process the Invoices received). Despite the low level of integration, the project took 258 days to implement. The technical development work related to facilitate this functionality was 22% whereas 91% of the project's duration were held-up by incorrect connection configuration, incorrect mapping, feedback on invoice mapping and delayed responses to email correspondence.

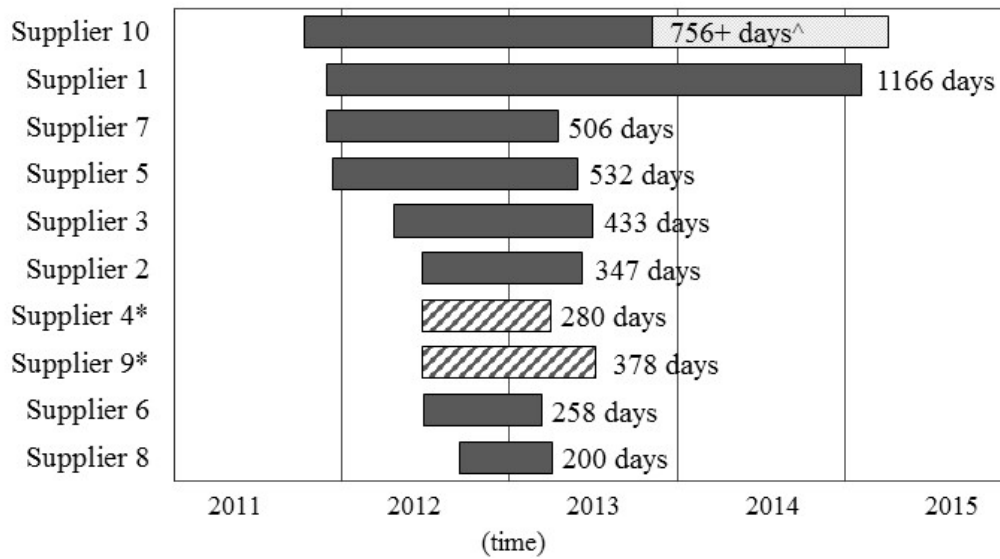
## **8.7 Supplier 7 (S7)**

Both the supplier and CF was keen to get this implementation deployed as quickly as possible due to long existence of their relationship. The project specification started straightaway after the initial engagement between all the parties. The supplier agreed to host the e-catalogue through HP however to connect to the supplier's ERP system another HP (X2) was also involved in the project. The project took 506 days to implement. Issues which commonly appeared in other projects also plagued this project and resulted in significant amount of idle time in project progress (95%).

Difficulty of holding meeting with all the parties, confusion over the test cycle, incorrect mapping, waiting for information, extremely slow testing cycles, late change requests for mapping schema and issues with supplier's ERP system all had impact on the project schedule. In addition, during the course of the implementation the supplier's business went into administration which delayed the progress for at least 2 months as the fate of the project was waiting to be decided. Several technical development activities were required which were implemented by X2 and HP, which constituted to 12% of the project's duration.

## **8.8 Supplier 8 (S8)**

The supplier is a key partner of the CF who holds a worldwide business agreement. The eCIX implementation however, was only between the UK companies. The method of connection to supplier's catalogue was the PunchOut solution. Although the project was the quickest out of all the cases (200 days) it too experienced considerable delays in the project due to; a period of hold-up until the commercial agreement between CF and supplier is renewed, delayed correspondence, issues with the test systems, incorrect mapping and delayed test plans, which all contributed to 71% of idle time in the project. Technical development works (which include CF's implementation of a technical update in its ERP system) amount to 20% of the project's duration.



\* indicates suppliers which were dropped-off from the project

<sup>^</sup> The project duration is 1271 days in total

Figure 5: eCIX implementation project summary.

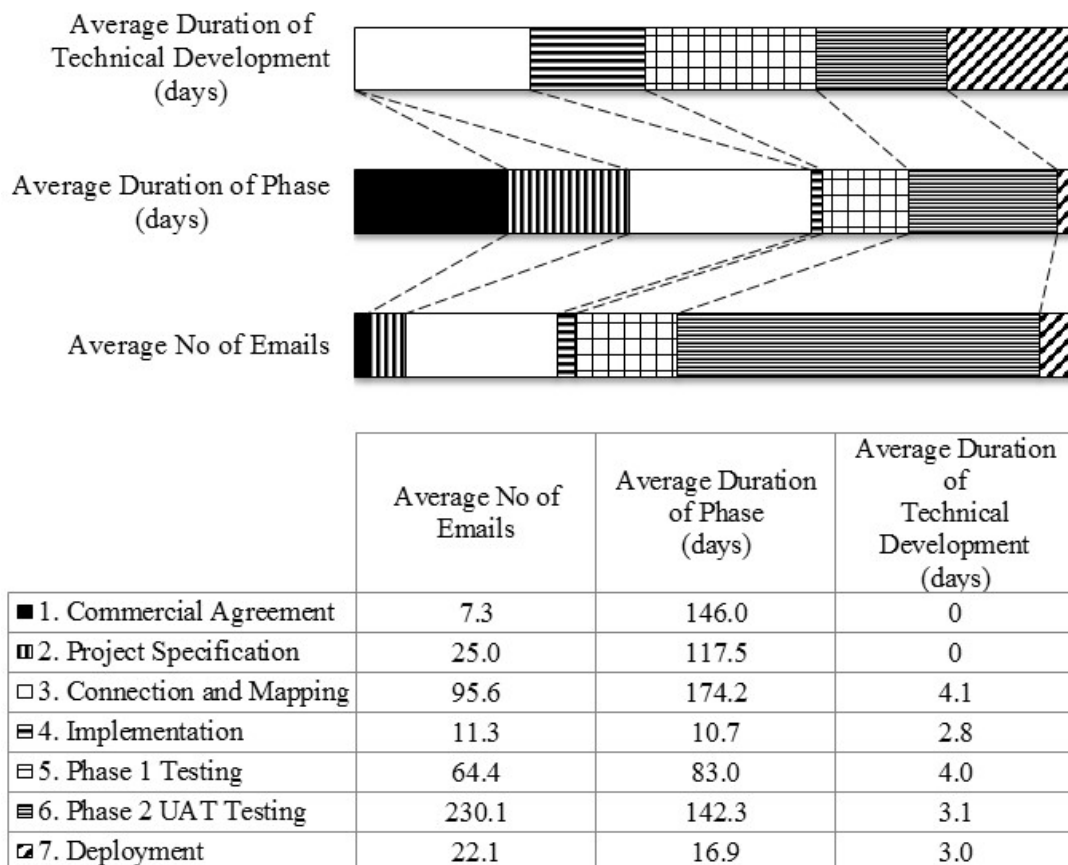


Figure 6: Average duration of each project stage, development activities and email communication



## 8.9 Supplier 9 (S9)

This is another incomplete project which was dropped off by CF towards the half-way in the implementation process (after 378 days) due to CF ending its relationship with the supplier. The proposed method of catalogue set-up was hosting on the HP's environment. During the connection and mapping exercise a number of issues surfaced which required development work at the HP's end. Common issues as with the other projects (such as waiting for information from supplier and supplier to share sample documents for mapping exercise and so on) also appeared in this project resulting in 94% of the project's duration being held-up. Technical development activities on the other hand constituted to 10% of the project's duration.

## 8.10 Supplier 10 (S10)

eCIX was seen highly important by both CF and supplier firm for the relationship to evolve into a tightly integrated form. The preferred method of catalogue set-up was through HP's environment. The project's schedule suffered heavily from prolonged periods of inactivity due to unavailability of team members, confusion over mapping, late change requests by the supplier, incorrect set-up of the test/live environments, and unavailability of supplier's test system, delayed correspondence, and sluggish test cycle. As a result of these factors, project's duration was held 82% of the time. The technical development activities on the other hand account up to 9% of the project's duration. It must be noted that although the project was completed and planned to go live, it was stopped after it became apparent that there was a crucial information missing on call-off orders which would interrupt the procurement process. As a result, the project was on hold until a resolution was found and implemented, which consequently extended the project's duration to 1271 days.

## 9 Findings and Discussion

As can be seen from Figure 5 the journey to implement eCIX between CF and its suppliers was a lengthy process where majority of projects took several years to finish whilst some did not even get chance to reach to the end (suppliers S9 and S4). The phases which took the longest to implement are: Commercial Agreement, Connection and Mapping, and Phase 2 Testing (see Figure 6). It must be noted that except in the case of S7, S1 and S10, the implementation process started whilst the commercial documents were being approved/signed so the duration of the commercial agreement phase was not critical for these three projects. The email exchange data in Figure 6 shows that Connection and Mapping, Phase 1 and 2 testing stages are the most intense stages where communication and coordination efforts were at the peak. It must be emphasized that the projects went through an iterative development cycle where most projects did not follow a strictly sequential implementation process however in terms of the project activities these stages were the most information and communication intensive.

It is difficult to determine whether the delivery of the eCIX projects has been a success or failure as there are no benchmark data to make any comparisons. During the early phases in supplier engagement it was anticipated that each project would take several months to complete, which indicates a failure of expectations but perhaps most importantly, poor execution of the project. The thematic analysis of the case study data point to four types of challenges and barriers: technical, coordination, integration and organizational; which are discussed in detail below:

## **10 Challenges and Barriers to Implementing eCIX**

### **10.1 Technical**

The company HP was responsible for conversion and transmission of commercial messages between the CF and its suppliers, therefore majority of development tasks were undertaken by the HP with little or no development work for suppliers' IT department (apart from implementing the mapping schemas). Development tasks that were deployed by HP only account for an average of 14% of the projects' duration (not including suppliers S9 and S4) which indicates that technical complexity of the eCIX implementation projects are very low. A striking proportion of technical challenges faced during the connection and mapping, and phase 2 testing stages stemmed from highly customized procurement process which CF has adopted for the eCIX. Although the rigid business and validation rules ensure almost 100% accurate data, it creates many problems when suppliers' ERP system cannot handle the necessary mapping requirements. Secondly, some suppliers were concerned about the impact of the implementation on their existing commercial processes and EDIs. At this stage, HP had to step in to facilitate the data exchange in accordance with the business rules and mapping requirements, which further complicated the integration and increased the cost of development for suppliers.

Another source of technical challenge was the lack of clear specification and inadequate documentation. Projects were developed with no clear definition of what each procurement process in the integration entails and identification of interfaces to be integrated which caused a lot of ambiguity in some projects. Further to this, no guidance or documentation was issued to suppliers' implementation team such as the purpose of the project, the scope, deliverables, project assumptions, development and risk management plan and so on; which are all essential for through understanding of the project. Also, the project activities were largely managed through email communication with no documentation of information on supplier-specific development activities, which all created a lot of confusion about the particulars of each project and resulted in late changes in mapping schemas.

The lack of human and IT resources also added a considerable delay to projects' duration. A number of suppliers' test system and ERP application was unavailable for a period of time which added few weeks and in some cases months to the testing and development cycle. On the other hand, unavailability of IT technicians from suppliers/contractor's implementation team has also caused problems with the testing and implementation. Generally, one or two people were involved from the suppliers' IT team or the third-party HPs' team. As a result, delays in testing, implementation or when organizing meetings, was prominent throughout the projects' life cycle.

### **10.2 Coordination**

High level of interdependency in project activities and large number of people involved in the project meant that coordination was vital part of the project governance. As teams were dispersed across geographies and time zones the demand for a more effective communication and coordination strategy was extremely important for the implementation teams. The results from the case study show that on average 87% of the projects' duration was plagued with waste activities including waiting for information, delayed correspondence and poor coordination of project activities.

This can be partly attributed to lack of adequate coordination whereby implementation teams were left to work in silos, often unaware of the on-going project activities. The HP controlled the project coordination efforts whilst the project manager from CF was mainly responsible for management of decisions concerning the CF, HP and supplier interface. Despite these governance mechanisms, coordination and communication issues were persistent

throughout the projects' lifetime. Here, it must be noted that social and cultural diversity of the teams can also be said to play a role in communication effectiveness and team cohesion as teams were mix of people from Asia, UK and Europe.

The second issue with coordination was primarily borne out of change requests being raised by CF, suppliers, and suppliers' HPs. Some of the development requests coming through CF or supplier firms were hurriedly implemented without proper understanding of their impact on existing development activities and processes. In addition to this, multi-disciplinary professionals (with varying levels of rank in the organizational/functional hierarchies) were involved at different stages of the project. The technical teams, in particular, were assembled without formal and proper identification of their roles and responsibilities, creating a less effective intercommunication of information and messages at the initial stages of the project.

### **10.3 Integration**

As seen from the case study there are two forms of integration: inter-hub connections and direct connection with the supplier. In cases where inter-hub connections had to be established, project coordination and management became an arduous task. This was primarily due to increased number of project participants which demand higher levels of coordination and management. The interaction between the two competing HPs was also susceptible to un-cooperative behaviour which sometimes resulted in longer waiting times for completion of a technical development task.

Further to above, suppliers' HPs often reworked the mapping between themselves and suppliers which duplicated the connection and data conversion efforts, subsequently resulting in an increase in duration of the mapping process. In addition to this, where suppliers were connected directly through HP, the consequence of a change request (i.e. its impact on other connections/processes) had to be carefully considered. For example, CF had to ensure that any configuration to the parts or whole of a supplier-specific eCIX process would not interfere with the standard eCIX implementation process adopted with rest of the suppliers.

### **10.4 Organizational**

Several highly critical organizational issues cropped up during the project's lifetime hindering timely completion of implementation. During the course of the implementation the project saw three project managers from CF and one coordinator and one technical implementation manager from HP's team leaving the project. This is thought to have a significant impact on the projects' progress as the persons filling in the role took time to be acquainted to the project. Most of the newcomers were not familiar with the project (some with poor understanding of eCIX implementation) so a new learning cycle had to be acquired every time someone joined the project.

In terms of the strategic aspects of eCIX implementation, poor execution strategy as well as lack of strategic support from the top management has led to the project being planned, developed and executed immaturely. The strategy to get suppliers on-board was a one-sided decision by the CF and there was little engagement with suppliers prior to the implementation; for example, co-involving suppliers in the design and development of the new electronic process. Moreover, other than weekly and monthly reports and internal meetings, the top management had seldom interaction with the project execution team during the lifetime of the project and did not provide sufficient strategic support for the implementation teams. For example, the variations in purchasing process across projects and business/operating units of the CF was largely left to the implementation team to resolve, with little input from the cross-firm operational and strategic decision makers. The issue was further complicated in cases where suppliers' processes and systems required different adaptations to be made.

Whilst some projects were able to commence with an agreement in principle, suppliers S2, S5 and S8 were reluctant to commit themselves without a formal approval from the higher-

level management. Overall, the initial phase was a lengthy process where the average duration was 146 days which gives an indication of the difficulty in getting suppliers to commit to the project. On the other hand, the discontinuity in the CF-supplier relationship, as well as uncertainties in the suppliers' business (S7) were some of the main causes of project delay, and in several cases (S4 and S9), project abandonment.

## **11 Critical Success Factors for Implementing eCIX**

The thematic analysis of case study data show there are a large set of challenges and barriers (summarized in Table 2) which must be overcome for a much more efficient delivery of eCIX projects. The discussion in this section is based on the findings reported earlier through which the study suggests several factors for an effective execution of eCIX implementation projects.

First of all, as identified in the case study, one of the underlying factors for poor implementation was the lack of a proper implementation strategy by the CF. It is argued therefore, without a proper implementation roadmap eCIX projects are bound to go astray. Although there needs to be a much-detailed work in this area, based on the case study findings it would be appropriate to suggest the following critical factors for the implementation strategy: (i) identifying the key suppliers to be integrated, (ii) the objectives of eCIX, (iii) identification of the interfaces for integration and (iv) a strategic plan for the implementation process which includes performance metrics to measure project progress. With regard to the first point, Cole (2000) has identified several important factors when deciding whether to implement CIX with a business partner. However, as seen from the case study, the future business prospects with the supplier as well as supplier's financials is also another important point that must be considered when implementing eCIX. This is because once the business relationship ends it is highly likely that eCIX will become inactive (or used very little), resulting in waste of efforts.

eCIX implementation is more than just the exchange of commercial documents between two firms. It involves bringing the two tightly controlled and isolated processes together to complete the procurement process without any manual intervention. Although the exchange of invoice messages are considered as a straightforward task for EDI (Cole, 2000), the scope within the case study was a much more challenging task whereby application of business rules and logic significantly increased the complexity of the implementation process. Therefore, a balanced approach to business/validation rules is needed to avoid unnecessary complexity with the eCIX.

eCIX implementation projects require a two-way strategic commitment (from buyer and supplier company) to be successful. Commitment requires both, time and resources from everyone involved in the project and must spread from higher managerial levels to operational team involved with majority of the technical implementation tasks. Without this commitment it is highly likely that projects will fail or at best deliver an inconsistent eCIX solution which will subsequently have negative impact on the adaptation, acceptance and diffusion of the technology. Commitment can exist in many different forms, but as a starting point firms can

Table 2: Challenges and barriers to eCIX implementation.

	Challenges	Barriers
<b>Technical</b>	<ul style="list-style-type: none"> <li>• Capability and adaptation of existing systems</li> <li>• Availability of human and IT resources</li> <li>• Impact of eCIX on existing commercial processes and EDIs</li> <li>• Lack of clear specification</li> <li>• Late design changes</li> <li>• Inadequate documentation</li> </ul>	<ul style="list-style-type: none"> <li>• Flexibility of suppliers to accommodate changes</li> <li>• Cost of development for suppliers</li> </ul>
<b>Coordination</b>	<ul style="list-style-type: none"> <li>• Lack of adequate project coordination</li> <li>• Inadequate change management</li> <li>• Large number of people involved</li> <li>• Clear identification of roles/responsibilities</li> </ul>	<ul style="list-style-type: none"> <li>• Dispersed virtual teams</li> <li>• Differences in time-zones</li> <li>• Social/cultural diversity of teams</li> </ul>
<b>Integration</b>	<ul style="list-style-type: none"> <li>• Single-hub connections: impact of any new changes on existing connections/processes</li> <li>• Inter-hub connections: duplicating data conversion efforts</li> </ul>	<ul style="list-style-type: none"> <li>• Competition amongst hub-providers</li> </ul>
<b>Organisational</b>	<ul style="list-style-type: none"> <li>• Lack of commitment from suppliers</li> <li>• Lack of eCIX implementation strategy</li> <li>• Lack of strategic support</li> <li>• High staff turnover in project management/coordination team</li> <li>• Inaccurate business strategy for suppliers</li> <li>• Lack of people with appropriate skills and experience in EDI projects</li> </ul>	<ul style="list-style-type: none"> <li>• Supplier relationship discontinuity</li> <li>• Supplier business uncertainty</li> </ul>

adopt a strategic corporate agenda for e-trading with their suppliers. In cases where there is resistance from suppliers, firms can enforce their buying power and assert the use of e-trading as a contractual condition to transact with each other.

Before beginning an implementation journey all parties to the project (i.e. buyer, supplier and intermediary HPs) must carefully consider both technical and non-technical aspects of the project so that it does not only result in savings from automation but also creates efficiencies in the inter-firm commercial processes. For example, each business/operating or construction project unit may have different ways of interacting with a supplier, or vice versa a supplier may adopt different methods to process orders and invoices for different business/operating units. A clear understanding of how the internal business processes are managed currently and, how the eCIX will be interfaced is a critical element in the project. It is quite possible that firms will want to make alterations to their eCIX strategy hence, it is important that the systems in place are adaptable and flexible to support future change requests.

The task of coordination plays a pivotal role in management of any type of project. Inter-firm integration projects (be it eCIX, EDI or any other systems integration project) involve highly interdependent activities which require heavy coordination between all the actors involved with the project. The stages where most interactions occur in an eCIX implementation project are the Connection and Mapping, and Testing stages. For example, as identified from the case study, coordination and project management issues account for the 87% of the projects' duration. Together with a practice of consistent and pre-emptive communication, better planning of activities is a 'must' in an eCIX implementation project. Beginning from the earliest stages in the project (i.e. requirements gathering) to the Deployment, all of the decisions taken,

and any development activities implemented, must be recorded and shared with all the team members. eCIX implementation is an abstract activity which produces an intangible output at the end of the project, therefore such documentation would be essential for development of the project as well as become a valuable source of information for future reference (for example during system maintenance and upgrades).

Companies implementing eCIX must work towards a well-defined project programme which is realistic and built around project participants' needs, requirements and concerns to ensure confidence in timely project delivery. More importantly, teams should work more closely, rather than in isolation from each other as seen in the case study, to benefit from advantages associated with collaborative working. It is highly likely that project teams will be assembled on a virtual environment where they interact through emails, teleconferencing and telephone communication. This places an important emphasis on project managers/coordinators to manage the technical and non-technical issues associated with virtual teaming.

It is highly likely that, as experienced from the case study, eCIX implementation can take a long time to complete. Indeed, one of the common characteristics of software projects is being overdue. However, with effective project management majority of the challenges reported can be eliminated and/or controlled, allowing a quicker turn-around for delivery of eCIX projects. An important element of project management is to plan a management strategy for risks involved with the implementation. The risks can be technical (for example, unavailability of systems, wrong implementation of mapping schemas, and incorrect connection set-up) and process such as design changes to the functionality/scope of the integration and other events such as changes in suppliers' circumstances (i.e. suppliers' business going bust and evolving relationship with the supplier). The risk management plan must identify all the potential risks with each integration project and develop appropriate action plans to prevent risks becoming issues.

Lastly, lack of skills and knowledge of project team members as well as lack of continuity of critical team members (i.e. project managers and coordinators) can have significant impact on the project's performance. In relation to the first point, the eCIX implementation process involves intense interaction between software developers who are assigned all the technical tasks and, project managers/coordinators who are responsible for delivery of the e-trading solution. The teams that undertake such activity must possess sufficient understanding of processes, tasks and activities involved with the software projects and inter-firm commercial processes. With regard to the latter point, where possible, the successor of key project personnel should be promoted inside of the organization and have knowledge and awareness on technologies being implemented for a quicker orientation with the project. Further to this, project participants must have their roles and responsibilities clearly defined and communicated with all the team members from the beginning of the project. This will avoid inefficiencies in communication (such as sending emails to wrong people) and allowing a much responsive interaction between the team members. As teams usually rely on written and verbal communication, an effective communication and collaboration strategy is needed to utilize the most effective ways to share, discuss and exchange project related information. Making use of collaboration technologies could provide vital support for the management of eCIX implementation projects which are likely to be executed simultaneously.

## **12 Conclusion**

Electronic exchange of commercial information (eCIX), which enables end-to-end integration of commercial information between the trading parties' back-end systems, is one of the key mechanisms in reaping the full benefits of e-trading. Despite the importance and benefits of its adoption, eCIX is not commonly adopted by the industry which perhaps explains why there is dearth of empirical research in the literature. As part of a longitudinal case study research, the

aim of the study reported here was to evaluate the findings on an eCIX implementation project between a large CF and ten of its supply chain firms and thereby contributing to the understanding of fully integrated e-trading deployment by the AEC firms.

The case study CF had implemented a ‘connect once, transact anytime’ approach whereby through an intermediary service provider it would connect to its suppliers to manage its procurement activities, including linking of ERP systems to allow an automated, efficient and secure delivery of commercial transaction data. The findings of the study demonstrate that this is not an easy task to implement. The challenges and barriers that were experienced during deployment phase were categorized into technical, coordination, integration and organizational issues; however, it is evident from the research that management factors (or more specifically the project management, coordination and organizational issues) rather than technical development issues are the prime cause of the lengthy implementation period. Based on these findings, the study suggests a number of critical success factors which should be taken into consideration by both AEC supply chains and technology vendors (i.e. HPs).

The study suffers from several limitations which are worth mentioning. First, the choice and method of implementing eCIX is highly specific to the case study company which inevitably restricts the generalizability of the findings to wider context. Second, as the case study is based on researcher’s observation of the project activities, arguably it may contain some bias in data collection. Third, there is lack of existing benchmark data which prevents the case to be compared with other implementation projects. Lastly, although the case study employed a multi-source data collection, the study lacks methodological triangulation. Conducting interviews with project participants and organizational decision-makers would have reinforced the validity of the findings. Many opportunities exist for further research on e-trading systems implementation. First of all, there is more work needed to convince the AEC industry to adopt B2B practices. Without seeing the quantifiable benefits of the technology it is highly likely that industry will hold back for some more time until convincing evidence of such benefits are produced. Future studies therefore, could explore the benefits and savings derived from a real life end-to-end eCIX integration case. With regards to the case study findings, the challenges and barriers cited in this study can be tested through survey of professionals, companies or similar implementation projects to confirm (or reject) their validity and significance.

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## **Notes**

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## Appendix F-1

Project Stages	Phase Completion Dates			Development (days)				Project hold (days)	Email count (no)	Average email response (days)
	Start Date	End Date	Phase Duration <sup>a</sup>	HP	CF	Supplier	Total			
1. Commercial Agreement	14/09/2012	13/02/2013	101				0	0	11	22
2. Project Specification	18/06/2012	14/09/2012	63				0	54	15	5
3. Connection and Mapping Exercise	29/08/2012	26/11/2012	63	19	6	3	33	32	22	4
4. Implementation	09/10/2012	22/10/2012	9		3		3	0	4	3
5. Phase 1 Testing	20/09/2012	21/11/2012	44				0	0	25	4
6. Phase 2 UAT Testing	22/11/2012	12/03/2013	71	4		3	7	48	142	2
7. Deployment	12/03/2013	02/04/2013	13	1			1	5	40	1
Totals				24	9	6	39	139 <sup>b</sup>	259	

<sup>a</sup> Workdays (excludes holidays)

<sup>b</sup> The project lasted 200 days of which only 61 days were considered as 'active'.

## **Appendix F      Post-Implementation Analysis of a B2B e-Marketplace (Paper 5)**

### **Abstract**

The advent of Business-to-Business (B2B) e-Marketplaces gave the AEC (Architecture, Engineering and Construction) firms the opportunity to conduct more efficient and effective commercial interaction with their supply chain partners. Despite the large body of literature in generic Information Systems (IS) domain, there has been a very little work done to-date to investigate the B2B e-Marketplace systems implementation by AEC firms. By adopting a case study research method with a longitudinal approach to data collection, the study on which this paper is based explored the challenges in the adoption and on-going use of e-Marketplace systems from the perspective of end-users. Utilising a well-established theoretical model from the IS body of knowledge, the analysis revealed several important challenges related to system (functionality and usability), information (content quality) and service (training and support) dimensions of e-Marketplace systems implementation. Through incorporating the case study findings to the conceptual model, the study offers several suggestions for AEC firms to take on board during implementation of the B2B e-Marketplace systems.

**Keywords:** e-Commerce, e-Marketplace, Adoption, Evaluation, AEC, B2B Case Study

**Paper type:** Research Paper

# 1 Introduction

The evolution of Inter-Organisational Information Systems (IOIS) has provided the AEC (Architecture, Engineering and Construction) firms with the opportunity to build a closely integrated relationship with their supply chains. The term Inter-Organisational Information System (IOIS) describes the environment which mediates the inter-connection between enterprise information systems to facilitate boundary spanning business (and in the case of this paper construction project related) activities. Within AEC industry, the IOIS has been implemented at various forms. The IOIS environments generally support business and project collaboration and are referred to by different authors as ‘collaboration environments’ (Erdogan et al. 2008), ‘web-based project management systems’ (Nitithamyong and Skibniewski 2004), and ‘project extranets’ (Wilkinson 2005). According to Skibniewski and Zhang (2005) the solutions provided by such environments are often offered in the form of Software-As-a-Service (SaaS). Another type of IOIS is the B2B e-Marketplace systems which facilitate the cross-firm procurement activities between two or more trading firms with the added functionality of back-end system integration (Dai and Kauffman 2002). Mediated by the surge in Internet technologies, B2B e-Marketplace systems can be said to represent a second wave of e-commerce propagation (Brunn et al. 2002). The terms e-commerce and e-Marketplace are used interchangeably within the article to refer to the same phenomenon.

Although e-commerce has experienced some setbacks, it has maintained its potential in becoming an industry-wide norm (including the AEC industry) for facilitating the Business-to-Business (B2B) commercial interactions (Xu 2015). The manufacturing and retail industries are recognised as flagship bearer in adopting B2B e-commerce systems across their supply chains (Xu 2015). The main drive for introducing e-commerce system is the automation of commercial information exchange which eliminates the ‘waste’ processes in cross-organisational procurement operations (Dai and Kauffman 2002). Historically, firms relied on Electronic Data Interchange (EDI) to facilitate the automation of their procurement activities. The resultant benefits of EDI use are less paper and administrative work, greater order accuracy, reduced or no data re-keying errors and improved purchasing process (Cole 2008). However, with the developments in Internet and web-based services, the role of B2B e-commerce have extended to encompass a number of value-adding business functions including supplier aggregation and matching, supply chain integration, and collaboration (Xu 2015). Therefore, as a result of its implementation, it is recognised that firms not only benefit from streamlined commercial processes but also reap the rewards of improved communications, reduced cost of operations, lower inventory, reduced lead times, increased control over spend, faster invoice processing and increased bilateral relationships (Xu 2015).

In this study, the term implementation is taken as a set of activities which consists of three phases: (i) pre-implementation activities such as technology vendor selection and requirements specification, (ii) implementation which is concerned with the development activities and the actual delivery of the technology, and (iii) post-implementation where the focus turns to adoption and on-going use of the technology until the solution becomes fully diffused into an organisation’s core business and information systems strategy (Linton 2002). Gallivan (2001) has proposed that the decision to implement a new technology can be made at the corporate level and then either (i) mandated for adoption throughout the organisation at once, or (ii) allow voluntary adoption and diffusion whilst providing the necessary infrastructure and support, or (iii) set up pilot projects and observe the processes and outcomes for company-wide roll-out strategy. Regardless of the chosen strategy however, many authors (including (Beynon-Davies et al. 2004; Standing and Lin 2007; Williams et al. 2009) argue that post-implementation evaluation is of primary relevance for understanding the factors that

determine the success or failure of information systems development and implementation projects.

The post-implementation stage is crucial for driving the user acceptance and continuance use. There are different perspectives in the literature to the question of how to overcome resistance to technology adoption. For example, top management support and commitment, organisational culture, appointing technology champion, training and change management, are some of the key points discussed in the literature which are also considered to be applicable to the B2B e-Marketplace implementation (Lu et al. 2014). Although AEC firms' use and adoption of the IOIS is researched and documented extensively in the literature, past studies primarily focused on web-based collaboration and project management technologies (Arnold and Javernick-Will 2013; Becerik and Pollalis 2006; Erdogan et al. 2008; Hjelt and Björk 2007; Lee and Yu 2012; Nitithamyong and Skibniewski 2006, 2011; Peansupap and Walker 2006; Ruikar et al. 2005; Samuelson and Björk 2013; Sargent et al. 2012; Wong 2007; Wong and Lam 2010). Drawing extensively from IS and IT implementation literature there has been a particular interest in the management aspects of implementation projects such as documenting the best practices and critical success factors for IS/IT implementation (Nitithamyong and Skibniewski 2011; Tatari and Skibniewski 2011), innovation diffusion (Miller et al. 2009), e-readiness (Goulding and Lou 2013) and change management (Hartmann and Fischer 2009). On the other hand, a number of authors have conducted studies on intra-firm ERP (Enterprise Resource Planning) systems implementation to identify the success factors and the perceived benefits of ERP implementation (Chung et al. 2008, 2009; Gajic et al. 2014; Kwak et al. 2012; Ozorhon and Cinar 2015; Tatari et al. 2008; Yang et al. 2007). Whilst the prior research discusses the conditions necessary for successful IS/IT implementation projects, it offers limited understanding of the B2B e-Marketplace systems implementation projects, and in particular, fails to address the evaluation of actual or on-going use of systems once they are fully deployed and ready to use.

Although there are myriad of studies on generic (and sector-specific) e-commerce systems evaluation in the IS literature, their applicability to AEC context is seen as problematic since e-commerce systems are generally shaped by different technological, organisational and environmental factors amongst the different industries (Teo et al. 2003; Turban et al. 2002). Furthermore, evidence from generic e-commerce studies show that the industrial context within which e-commerce systems are adopted vary considerably from one another (Gibbs and Kraemer 2004; Teo et al. 2006). Thus, there is a strong justification for an AEC sector-specific study to complement the current knowledge and understanding of B2B e-Marketplace systems adoption.

The aim of the current study is to contribute to this research gap. Through a longitudinal case study research design, the purpose of this study is to investigate the post-implementation phase of a Cloud-based B2B e-Marketplace system. The system— which comprise of Cloud-based front-end interface and back-end integration with contractor and suppliers' ERP systems, was initiated by a large UK contractor firm to streamline its procurement operations with three of its key supply chain firms. The focus of the research is on the post-implementation stage; covering the first year of going live with the implementation where the use was not fully mandated across the case study organisation. There were two questions which the research sought to address: (i) the extent of the e-Marketplace adoption and acceptance at user, project and business unit levels, and (ii) post-implementation challenges that the users face during on-going use of a B2B e-Marketplace system. The variables which were used to measure the user adoption and acceptance was borrowed from a previously tested and validated theoretical model developed in the IS literature.

The paper is organised as follows. First, along with a background on Cloud-based Software-as-a-Service, the review of literature on e-Marketplaces is presented. Second, the

theoretical framework which guides the empirical part of the study is given. Third, the rationale for the case study approach, the background to the case study organisation, and the method of data collection is introduced to provide the context for the study. The findings and discussion are presented next, followed by limitations of the research and recommendations for further study, and finally conclusion.

## **2 Background on B2B e-Marketplace Systems and IS adoption**

The purpose of this section is to provide background into the research on B2B e-Marketplace systems and theories on IS adoption (which is specific to AEC organisations context). The Cloud-based Software-as-a-Service is introduced briefly, since it is considered as the backbone of the B2B e-Marketplace system reported in this study.

### **2.1 Cloud-based Software-as-a-Service and e-Marketplace Systems**

The Cloud-based Software-as-a-Service (SaaS) is an evolutionary software delivery model whereby companies buy subscription licences to use the software online via a web-browser, rather than locally deploying software on premises (Wilkinson 2005). The ‘Cloud’ metaphor used in this article refers to the computing architecture which comprise of platform and infrastructure to support the delivery and use of software on the web. In the early days, SaaS solutions began to surface in the form of so-called ‘project extranets’ which were primarily used by large firms to manage their project documentation and information (Becerik and Pollalis 2006). With the advancements in internet technologies and transformation of web-facilitated services, the number of SaaS solutions for the AEC industry has grown significantly in the last fifteen years to serve the wide-ranging needs of the industry (Shen et al. 2010). Indeed, over the years many AEC-specific collaboration solutions have been developed. For example, Liu *et al.*, (2011) cite between 200 and 250 vendors (providing predominantly isolated systems and technologies) targeting a specific industry problem such as management of project documents and drawings. On the other hand, some vendors built sophisticated multifaceted solutions to coordinate, manage and collaborate on project and inter-enterprise information needs (Wilkinson 2005). Besides the effectiveness and efficiency gains from implementing these systems (Becerik and Pollalis 2006; NCCTP 2006), there are several other factors which are believed to spur the Cloud-based SaaS’s uptake. For example, Cloud-computing solutions has several significant advantages over traditional software delivery methods including: (i) rapid deployment- it does not require any forefront development meaning that deployment is a matter of user training and migration from previous/existing system, (ii) scalability- subscription based use means companies only pay for the features they use and how much they use (e.g.: number of users), and (iii) cost-efficiency- it does not require capital expenditure or consume any resource regarding development and version upgrade which is undertaken by the SaaS vendors (iv) ubiquitous network access- can be accessed from standard internet-enabled devices at any time and from any place (Wilkinson 2005).

Prior to Cloud-based collaboration technologies, traditional e-commerce systems relied on EDI technology which allows exchange of transactional data between two firms (buyers and suppliers). The concept of EDI is based on the Application-to-Application data exchange between the trading parties for sending and receiving transactional data such as e-orders and e-invoices (McIvor and Humphreys 2004; Xu 2015). EDI implementation can be direct (B2B) or through Value Added Network (VAN) providers who provide the connection, translation and transition of the transactional messages. Despite its long history, reported usage of EDI is limited within the AEC industry, with builders’ merchants and contractor firms being the most notable users (Samuelson and Björk 2013). Kong *et al.*, (2004) reasoned the initial cost of setup and complexity of standards for the low levels of adoption, whilst Lewis (1998) showed that

unwillingness to change, lack of awareness and lack of clear business case with little apparent benefits from its application deferred AEC firms' decision to invest in EDI.

Although the automation of transactional data is acknowledged as the most important aspect of EDI (Lewis 1998), its implementation is most rewarding when coupled with e-Marketplace systems since end-to-end purchase cycle can be completed without any manual intervention (Cole 2008; Dai and Kauffman 2002; Eng 2004; Standing et al. 2006; Xu 2015). An e-Marketplace can be defined as an online market in which business operations (such as tendering and procurement activities) between buyer and seller firms are conducted (McIvor and Humphreys 2004). In a review of literature on e-Marketplace systems, Balocco *et al.*, (2010) show that there is a lot of confusion about the roles and functions of e-Marketplace systems where many studies often exhibit overlapping definitions and interpretations of the different e-Marketplace concepts. The ownership model is often used to distinguish between different types of e-Marketplace systems. There are three types of ownership generally associated with the e-Marketplace systems: Public, Intermediate, and Private. To give few examples from the AEC industry; Public marketplaces are owned and managed by public authorities to publish contract opportunities for subcontractors and suppliers. Public marketplaces in the construction industry are largely oriented towards sourcing for projects, for example tenders for subcontractors and aggregate commodities. An independent e-Marketplace provides an online platform for communities of buyers and suppliers to either transact or share product information (such as price and technical specifications) with each other. In the latter transactional form of e-Marketplace systems one of the parties (usually buyers) setup a private 'one-to-many' trade link with their suppliers either directly or via an intermediary Hub Provider (such as Ariba.com, Asite.com and Coins-Global.com). The focus of this study is on the latter private e-Marketplace type (also labelled as e-Hubs by some authors) (Cole 2008).

The review of literature indicates that there is very little research on AEC specific e-Marketplace systems where majority of the studies proposed or developed e-Marketplace prototypes for the industry. For example, Kong *et al.*, (2004) proposed the e-Union framework where suppliers' trading sites are joined together by a web-based application, whilst Ren *et al.*, (2008) proposed the e-Hub concept which includes both collaboration and procurement functions within its core service. In another study, Cheng *et al.*, (2010) reported the development of a web-based portal (Supply Chain Collaborator) for use between contractor firms and suppliers/manufacturers. Although the concept behind the development is the coordination and management of the supply chains, the authors describe that with the use of the e-procurement layer the application could potentially function as a private e-Marketplace system. Similarly, Ren *et al.*, (2012) and Grilo and Jardim-Goncalves (2013) proposed frameworks for the development of Building Information Modelling (BIM) integrated e-Marketplace in the Cloud. Many of the concepts reported in these studies are highly abstract and lack application in real life (that is, they are not implemented except in the cases reported by the authors), which limits their relevancy to this study.

In another stream of research, Alarcón *et al.*, (2009) examined the perceived benefits of an independent e-Marketplace of Chilean construction companies. Their findings revealed a number of individual, organisational and industry wide challenges to the wider adoption of e-Marketplace systems. Some of these include lack of trust in the e-Marketplace, absence of technical infrastructure, lack of highly-trained workforce, behavioural issues, high degree of fragmentation in the industry, and lack of investment in technology. Iben and Laryea (2014), more recently conducted a literature review on digital technologies used in construction procurement. Concurring with Brandon *et al.*, (2005) and Anumba and Ruikar (2002), they noted that despite the reported value propositions and benefits of adoption, e-Marketplace uptake by AEC firms is scant, and research is yet to proliferate, which indicates that AEC firms have little or no experience to draw upon for successful e-Marketplace implementation.



## 2.2 Theories on Information Systems Adoption

The IS and generic e-commerce stream of knowledge (which e-Marketplace systems fall under); where much of the theoretical models are developed and empirical testing is conducted, is abundant with frameworks on evaluating IS adoption. The Technology Acceptance Model (TAM), originally proposed by Davis (1989), is one of the most widely utilised theoretical models to measure IS adoption (Williams et al. 2009). Based on the theories in social psychology, including the Theory of Reasoned Action (TRA) and Theory of Planned Behaviour (TPB), the aim of TAM is to provide a general framework for the measurement of user acceptance *behaviour* across different technologies and user populations (Davis 1989). The TAM model posits that IS acceptance is directly influenced by perceived usefulness (the extent to which using the system will enhance the person's job performance) and perceived ease of use (the extent to which a person believes using the system will be free of effort) (Davis 1989). In the revised version (TAM2) of the model, the main determinants of perceived usefulness are described as social (subjective norm, voluntariness, and image) and cognitive (job relevance, output quality and result demonstrability) influence processes (Venkatesh et al. 2000).

Although the behavioural acceptance is a necessary precondition to adoption, there is a large body of literature which suggests other external factors (including climate for the implementation, top management support, organisational structure and project management and so on) that play a key role in technology adoption and the subsequent performance and success of IS implementation (Petter et al. 2008). With this shortcoming in mind, and in an attempt to integrate the fragmented theories on user acceptance, Venkatesh *et al.*, (2003) proposed the Unified Theory of Acceptance and Use of Technology (UTAUT) which incorporate the measures developed in eight previously established theoretical models. Simply put, the UTAUT model hypothesises that together with behavioural intention (which is influenced by performance expectancy, effort expectancy, and social influence) the facilitating conditions (for example, organisational and technical infrastructure) determine the level of usage (Venkatesh et al. 2003). The effects of these variables are found to be moderated by age, voluntariness, gender and experience of the users.

Another well-known model for evaluating the IS adoption is the DeLone and McLean's Information Systems Success Model (DeLone and McLean 1992) (referred to as DM Model hereafter). The DM Model, which is based on TAM, posits that there are five variables (system, information and service quality, and user satisfaction and use or intention to use) which influence the level of adoption and, ultimately the success of IS implementation. The model has been tried and tested in a large number of studies, and has gone through revision by the authors in 2003 to take into account critiques noted in previous studies (DeLone and McLean 2003). The updated version of the DM Model proposes three dimensions for evaluating the IS itself (system, information and service quality) and the use of the system (that is, user satisfaction, and intended or actual usage) as shown in Figure 1. Arrows in Figure 1 indicate the inter-relationship between these dimensions where the system usage and user satisfaction has direct impact on net-benefits of adoption. DeLone and McLean explain how each of the DM Model variables relates to IS in e-commerce context in below points (DeLone and McLean 2003):

- (1) System features which are valued by the user and have a direct impact on user experience (such as usability, availability, reliability, adaptability and response time).
- (2) Information or content quality which is personalised, complete, relevant and easy to understand.
- (3) Quality of support services provided such as training and availability of resources for self-learning.

- (4) User satisfaction with the e-commerce.
- (5) Where the use of the system is voluntary, behavioural information related to usage including visits to the site, navigation within the site and number of transactions made (or, if the system is not yet implemented or mandated to be used, the attitude towards intention to use the system).
- (6) The resultant net benefits which includes both positive and negative impact of implementation.

The most difficult aspect of measurement in the DM Model by far is the latter variable (Wong 2007), that is, the perceived benefits by the users which ultimately influence the level of IS success (DeLone and McLean 2003). There are two complexities surrounding the measurement of IS success. First, as shown by Thomas and Fernández (2008) and Dwivedi et al. (2015), the notion of success is a complex and contested phenomenon as it is perceived differently at different stages of the IS implementation and amongst the different stakeholders. For example, in e-commerce implementation projects, Standing *et al.*, (2006) point out that e-Marketplace success can be classified according to its economic, relational, service or community implications. The second issue relates to the measurement of each of these aspects, where the outcome from IS implementation is largely intangible and indirect, and therefore cannot be easily quantified and measured in practical sense (Standing and Lin 2007). This study considers the role and purpose of B2B e-Marketplace implementation as the key enabler of supply chain integration. At a very broad context, achieving supply chain integration requires combination of actor, processes and technology integration. Actor integration refers to the inter-connecting of individuals in construction projects and organisations to undertake their job function. Process integration refers to the adjustments and alignments that organisations make to integrate their business processes. Technology is the facilitator that enables the integration of actors, systems and processes. Having insufficient space available here to further discuss supply chain integration, this study views and measures the IS success as the extent to which the B2B e-Marketplace system impact on these three key components of supply chain integration.

With respect to validation of above theories/models on AEC-specific IS literature, a number of studies have applied and validated the above-mentioned theories/models with two specific aims: (i) to test and measure the correlation between IS implementation and their impact on project success, or (ii) to evaluate the IS implementation from user acceptance and adoption perspective. Within the former stream of research, using the DM Model theory as their frame of reference, Raymond and Bergeron (2008) and Lee and Yu (2012) conducted large scale questionnaire surveys to determine the extent to which project management information systems (PMIS) assist certain project roles for fulfilling their tasks as well as investigating the impact of these systems on project success. Their findings reveal that perceived information, service and system quality of PMISs are highly correlated with project success and, effective and efficient construction management.

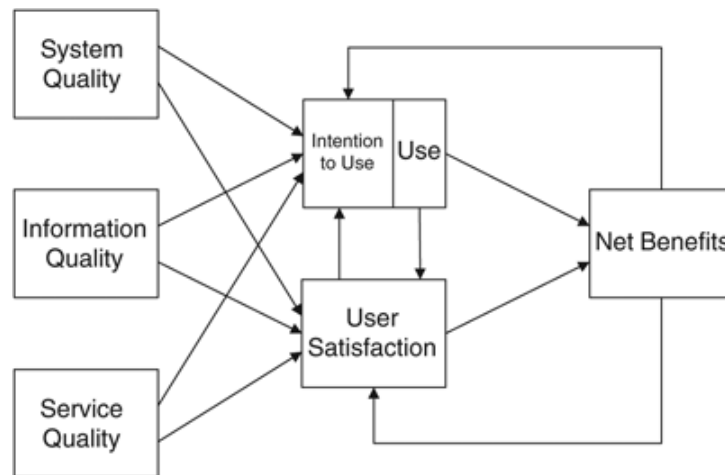


Figure 1: The DM Model for IS success (adapted from DeLone and McLead, 2004).

The research on the latter stream describe the degree to which various factors influence the technology adoption within an organisation. Several studies in the literature utilised the TAM to study the user acceptance of IOIS and intra-firm ERP systems. Adriaanse *et al.*, (2010) adopted the TAM framework to study the user acceptance and adoption of a web-based document management and collaboration system in a single case study project. Their findings reveal a number of ‘dynamic’ factors, which include personal motivation, external motivation, knowledge and skills, and acting opportunities, that determine the system use. Similarly, Hjelt and Björk (2007) combined the DM Model and UTAUT, and investigated the electronic document management systems (EDM) acceptance and adoption amongst the group of end-users in a large construction project in Finland. One of the important finding from their study is the need for high levels of training and support for first time users. In addition, drawing on DM Model and UATAT theories as well as findings from their own research, the authors postulate that, along with end-user specific properties, four factors; system quality (functionality and usability), information accessibility, information quality (up-to-datedness, completeness and structure), and support quality (training and guidelines) highly influence the ‘acceptance factors’, which in turn impact the level of EDM use and adoption. Meanwhile, Chung *et al.*, (2008, 2009) incorporated the TAM2 and the DM Model, and developed a conceptual framework to analyse ERP systems implementation by contractor firms. Based on the survey data collected from ERP end-users they identified that ERP adoption is determined by a number of user related (output, image, compatibility, result demonstrability and system reliability) and project related (internal support, consultant support and function) factors. In order to increase the ERP systems’ usefulness and the level of adoption, they suggest ERP implementation to consider the system functions (and functionalities), subjective norm, output, perceived ease of use, and result demonstrability (that is, the benefits of using ERP should be explicit). More recently, Kwak *et al.* (2012) used the TAM framework to investigate the factors that determine user acceptance and intention to use in ERP systems implementation projects. Although their study suffers from a narrow focus (that is, it only considers user acceptance as a success measure), one of the key finding of their study is that the customisation of ERP functionality is a key determinant of perceived usefulness; albeit with a negative impact on the success of the ERP implementation projects.

### 3 Rationale for the Case Study Approach

The case study approach is one of the most widely adopted research methods in the IS literature (Davison and Martinsons 2015; Williams et al. 2009). Information systems are purposeful artefacts built to address an important organisational problem and thus, they are difficult to separate from the context of an organisation and its processes (Hevner et al. 2004). This implies that the evaluation of IS cannot be independent of the organisational context in which it is designed, implemented and used (Stockdale et al. 2006). Hence, the case study approach naturally finds its way in IS evaluation research. Furthermore, the case study research design not only makes a good instance of documentation and analysis of rare cases (implementation and use of IOIS by AEC firms) but it also provides detailed insight into ‘how’ and ‘why’ certain outcomes occur in a particular context (Yin 2014). This in our case is the user adoption (or conversely non-adoption) of a private e-Marketplace by a large contractor firm which is not commonly reported or investigated in the AEC domain.

A shortcoming of the prior research studies is that, in majority of the cases, the conclusions are drawn from cross-sectional surveys which fail to account for the dynamic and evolving nature of the ex-post implementation process. In recognition of this gap, Samuelson & Björk (2013) advocate the use of longitudinal approach in studies of IS/IT adoption. Accordingly, the longitudinal perspective provides rich and dynamic insight into the width and depth of technology adoption where the “width is the spread of the use in companies and projects, and where the depth is about how developed and mature this use has become” (Samuelson and Björk 2013 185). However, Oates (2006) warns that the case study method imposes limitations on generalisability of findings as the study is bound to the ‘case study firm only’. Nevertheless, Stockdale *et al.*, (2006) suggests that generalisability can be increased if the existing frameworks or theories are used and a detailed account of context is provided. This is so that future studies can follow the same process, allowing them to conveniently compare and contrast the findings with their own (Benbasat and Zmud 1999).

Since the focus of the evaluation is on systems dimension, the theories that were considered appropriate for the study were the TAM and DM Model. The intensive focus on prediction or explanation of the relationship between TAM constructs (including TAM variants) and IS adoption has been heavily criticised by Benbasat and Barki (2007), partly for directing the research away from exploring ‘what makes a system useful’. Concurring with this point, Lee *et al.*, (2003) argue that the TAM model is of little value in assisting the design and development of systems with high levels of acceptance. With these shortcomings in mind, the DM Model was chosen as it extends beyond user acceptance: it covers the full life-cycle of IS implementation from creation and use to the consequences of IS deployment.

### 4 Case Study

The concept of the B2B e-Marketplace system was based on end-to-end integration of contractor firm and suppliers’ ERP systems (more details of the back-end development project can be found in another study by the authors, (Pala et al. 2016)). A number of validation and business rules were implemented to ensure highly accurate data exchange and seamless interaction between the trading parties. Both services (the e-Marketplace system and ERP integration) were delivered through a Cloud-based Software-as-a-Service (cSaaS) model by a third-party Hub Provider (HP). The HP’s platform provided the front-end interface to the e-Marketplace system and was integrated with the suppliers’ electronic catalogue through a service known as the PunchOut connection method (which is also referred to as RoundTrip, CommerceOne, OracleExchange, or Open Buying over the Internet (OBI) by different software providers implementing the same concept). With the PunchOut functionality, the end-users (buyers) are transferred into the suppliers’ webstore where they fill their shopping cart, and, once finished transferred back onto the e-Marketplace platform for confirming and

communicating the order to the supplier. The main benefit of the PunchOut method is that it gives the suppliers the ability to host live and interactive catalogues within their own webstores. From buyer's perspective, however, it results in a lack of consistent and standardized catalogues as well as loss of control and management of supplier catalogues.

The case study reports the findings on purchasing of indirect (non-production) goods and services where the prices were determined on pre-negotiated contracts. In terms of the purchasing process adopted, the contractor firm implemented a de-centralised approach to purchasing whereby a vast majority of the purchases were done locally at projects and by the purchasing department of individual Business Units.

## **4.1 Organisation Studied**

The case study organisation reported in this article is one of the top 20 contractor firms in the United Kingdom (UK) in terms of turnover. It has operations in a range of sectors and markets including engineering, construction, utilities, infrastructure, healthcare, and facilities services. In addition to sole project ownership, the company has undertakings in Joint Venture (JV), Public-Private-Partnership (PPP) and Private-Finance-Initiative (PFI) projects. The business model of the company comprises of a number of vertically integrated businesses, including civil engineering, construction, facilities management and specialist subcontracting services such as Mechanical and Electrical, Ground Engineering, and Building Interior Solutions.

The decision to implement the B2B e-Marketplace system was made at the organisational level by the senior level management. Following a short trial period with one of the Business Units (BUs), the e-Marketplace system was rolled live across the three BUs (construction, facilities management and infrastructure), five specialist subcontracting businesses (Civil Engineering, Custodial, Groundwork Engineering, Interiors and, Mechanical and Electrical) (collectively referred as BUs hereafter) and 42 projects of which five were Joint-Venture projects (see Table 1). Typically, 80% to 85% of the costs of the projects relate to the purchases of goods and services from external suppliers. Prior to the e-Marketplace implementation, orders raised with the three suppliers on-board the e-Marketplace accounted just over 10% of the total number of orders across the whole organisation. Suppliers represent three different sectors and primarily supply (i) office equipment and stationary products, (ii) construction tools and equipment, and (iii) safety and workplace commodities. For the reasons of commercial confidentiality, all identity information is anonymised in the article.

## **4.2 Data Collection and Analysis**

A number of qualitative and quantitative data resources were utilised when conducting the research. First, two electronic questionnaire surveys were issued to capture end-users' perceptions about (i) system, information and service qualities of the e-Marketplace, (ii) overall satisfaction and, (iii) perceived significance of suppliers participating in e-Marketplace. The first survey was issued towards the end of 2013 which was about 6 months into the system roll-out. Using a Likert-scale type questions respondents were asked to indicate their level of satisfaction/dissatisfaction with the first two items: that is, (i) look and feel, speed and, ease of use, (ii) supplier catalogue content and information provided (iii) the training and technical support provided, and finally (iv) overall satisfaction with the e-Marketplace. Respondents were also given the option to add any further comments at the end of each question to provide a detailed reflection on their choice of selection. A total of 30 responses were received from a potential of 135 system users, representing 22% response rate. The second survey attempted to gather information about the perceived importance of suppliers for the case study contractor firm's supply chain integration strategy in order to determine whether the e-Marketplace adoption accrued the same level of benefits with each supplier. The second survey was issued towards the end of first year in implementation and received a similar response rate. In order to encourage participation (and to reduce the observer bias) both surveys were anonymised.

In addition to above, detailed records of all issues logged to the HP's Customer Relationship Management (CRM) system were extracted in an effort to identify the technical issues encountered within the first year. Any non-relevant data such as RFIs, general queries and administrative requests were filtered out to reveal only the system related issues. A total of 48 issues were identified which helped to pinpoint the root cause of the issues when analysing the *system quality* variable.

The last stage in data collection focused on the B2B e-Marketplace usage. Following the suggestions of Lee *et al.*, (2003) and Petter *et al.*, (2008) who claim that actual usage is more reliable measure of system use (as opposed to self-reported usage data which may contain high levels of end-user bias), the study gathered statistical information at three levels: user, project and business unit. The level of use during the first year of implementation was captured through three main datasets: user attraction, interaction and transactions made through the e-Marketplace system. According to Molla and Licker (2001) the website 'hits' and 'visits' can be used as a valuable source of information to understand the actual level of use. Through the capture of user logins (unique visits to the e-Marketplace), the study identified the degree of actual usage (attraction to the e-Marketplace) by each user per project or BU. The allocated spend for each project and BU (which is gathered from the Blanket Order data) is the value set aside relative to the projects' contract value or the BU's spending volume. The BO data is considered as an indication of the *potential interaction* with each supplier. Lastly, the transactional data exchanged through the e-Marketplace is evidence of the system utilisation where the number of orders (and their values) were considered as an indication of the depth of use.

Together with the questionnaire surveys, the collected data, such as the *issue log* and *usage statistics* provided a detailed cross-analysis of system performance and adoption. Given that the e-Marketplace was already implemented, *intention to use* was not relevant for the study. Table 1 shows the collected data in relation to the variables in the DM Model.

Data analysis primarily involved descriptive statistics. The questionnaire survey results were analysed through measuring the frequency of the responses. In addition, the commentary information provided in the questionnaire surveys were used to either support the findings, or in some cases, highlight the contradictory statements given by the respondents. The actual usage information was tabulated in an excel spreadsheet at multiple levels (user, project and business units) and consisted of a large data set which contained monthly usage statistics of the number of logins (4,323), the number and value of transactions (2,106 and £415k respectively), and value of BOs (over £2.7m). Frequency distribution, arithmetic mean, and time-series analysis methods were used to evaluate the attraction, interaction and transactions made through

Table 1: Types of projects which implemented the e-Marketplace

Industry	Market Sector	Number of Projects	Number of JV, PFI or PPPs	Total
<b>Construction:</b>				<b>(16)</b>
	- Commercial Offices	2	1	3
	- Healthcare	2	-	2
	- Mixed Use	1	-	1
	- Transport	7	2	9
	- Infrastructure	-	1	1
<b>Facilities Management:</b>				<b>(26)</b>
	- Commercial Offices	14	1	15
	- Healthcare	8	-	8
	- Mixed Use	3	-	3

the B2B e-Marketplace system. Lastly, information collected from the issue logs were extracted into an excel spreadsheet for thematic analysis of the system and non-system related issues reported by the end-users.

The profiles of users assigned to the system show that majority of the users belonged to the Administrator role (48%), followed by the Project/BU role (36%). Supplier management or senior roles concerned with strategic management of suppliers represented 9% of the total user base. The remaining percentile of users (7%) belong to IT support team roles. The response to the questionnaire surveys reflects a similar distribution of these roles, indicating that the collected data represents a balanced view of the main users concerned with the system.

## 5 Results of Case Analysis

### 5.1 System Quality

System quality is one of the important considerations influencing the degree and level of adoption. DeLone and McLean (2004) state that users' perception of usability, availability, reliability and responsiveness can be measured to determine the system quality and performance in the eyes of users. Findings from questionnaire survey revealed that, overall; users were satisfied with the B2B e-Marketplace system: that is ease of use, look and feel, and speed. However, the comments received in the questionnaire and the issue logs revealed a number of concerns which seemed to have considerable impact on some users' experience with usability of the e-Marketplace.

Although, in general, users agreed with the ease of use, multiple comments were received in relation to the graphical user interface (GUI) and user-friendliness of the HP's system. In addition to this, issue logs revealed that system errors related to the PunchOut interface (that is, when users navigate in-and-out of HP and suppliers' systems) have plagued the user experience for some users. The received commentary in the survey questionnaire evidently supports this. For example, several users have questioned the usability and reliability of the system during large purchase orders where the end-users' browsers crashed and cancelled the transaction. However, when each case was investigated in an in-depth manner it was found that the some of the issues were due to local user settings and unsupported browsers. Although the contractor firm implemented a corporate IT policy on each user's computer (which satisfied the minimum system requirements for the e-Marketplace), not all hardware and software were completely standardised across the whole organisation. Besides this, some users customised the browser and computer settings in accordance to their specific needs, or for other behavioural reasons. As a consequence, the e-Marketplace in general and the PunchOut interface in particular, did not always function as expected. In addition to this, several users who were accessing the system from the site office also mentioned issues with the speed and response

Table 2: Overview of data sources versus the DM Model variables.

<i>Data Sources:</i>	<b>Survey 1</b> (30 responses)	<b>Survey 2</b> (31 responses)	<b>Usage Data</b> (12 months)	<b>Issue Log</b> (48 issues)
<i>DM Model variables:</i>				
<b>System Quality</b>	✓			✓
<b>Information Quality</b>	✓			
<b>Service Quality</b>	✓			✓
<b>Use</b>			✓	
<b>User Satisfaction</b>	✓			
<b>Net Benefits</b>		✓		

time. However, as the up-time of the e-Marketplace was almost 99.99%; this could be due to the internet connectivity issues experienced by the project sites rather than the system itself.

As also mentioned by Wong and Lam (2010) and Ruikar *et al.*, (2005), the web-browser aspect and internet connectivity/speed issues are the two important determinants of the web-based IS quality. In order for the Cloud-based B2B e-Marketplace systems to appeal to all users it must be flexible enough to function in different internet browsers, that is; users should not have to switch to a specific, and sometimes disliked web-browsers. Developing and maintaining functional consistency in-and-across multiple browser/versions would not only eliminate the issues around access to the system but it would also improve the system quality. In relation to the GUI, both the suppliers' webstore and intermediaries' front-end interface needs to be well adapted to the users' requirements. The intermediaries' role here is pivotal. As well as providing a user-friendly interface, intermediaries must provide a seamless integration and end-user experience across multiple supplier catalogues/web-stores. After all, it can be challenging for the buyers to use and be accustomed with multiple supplier catalogues with varying functionality and interface.

Issues with the internet speed pertain to the most of the web-based collaboration systems and, frequently reported in the literature as a major drawback for systems use (Nitithamyong and Skibniewski 2011). Since the B2B e-Marketplace system relies on Internet to function, it is important that project sites are provided with adequate network facilities to connect to e-Marketplace as-and-when required. A reliable and high-speed internet connection would not only ensure user satisfaction with the system but also prevent users reverting to the traditional methods of paper-based purchasing.

## **5.2 Information Quality**

Information or the content available within the e-commerce system is of prime concern for users to adopt e-commerce. Molla and Licker (2001) point to two aspects of content quality, (i) the attributes associated with the catalogue content (the goods/services provided), such as accuracy, up-to-datedness, comprehensiveness, understandability, completeness, timeliness, reliability, relevancy, currency and preciseness, and (ii) presentation and the layout of the information content. Through the use of the PunchOut functionality the B2B e-Marketplace system users were securely transferred to the suppliers' own commerce website which was configured (for buyer-specific content) for the case study buyer company. The suppliers' commerce website provided search functionality (for example, for product code, name, and item description) and displayed information about the goods/services. At the checkout users were transferred back to the main e-Marketplace platform and presented with the order details to confirm the order before sending it to the supplier.

The questionnaire approached the information/content quality from a broad perspective and asked user's perception on whether: (i) suppliers' catalogue was easy to browse and contained the items they were looking for, and (ii) they were able to check-out quickly and efficiently. Majority of the respondents echoed their satisfaction in both areas however a large number of users given feedback about their experiences regarding the information/content quality of the overall e-Marketplace facility. Amongst these were: (i) lack of information provided after a transaction is completed (ii) difficulty of tracing an order, (iii) "products showing as 'in stock' when ordered then not being delivered because they're out of stock", (iv) not being able to attach additional information to purchase orders, and (v) not being able to save favourite products for future purchase orders.

The aforementioned points reveal the importance of adequate interaction mechanisms for facilitating the engagement between e-Marketplace system users and suppliers. More specifically, it points to the need for e-Marketplace to encompass the post-purchasing process within its scope. In order to improve the information quality, use relevant functionalities should



be considered to enhance system-user interaction. A number of suggestions can be made here, including detailed product/item specifications; more relevant and customised content (based on, for example, buyers' purchasing behaviour); option for goods/materials to be forwarded onto or to be picked-up from a particular supplier branch (due to proximity to delivery address and stock availability, and so on); and information on supplier activities in other projects (Ren et al. 2008). Going one step further, as also suggested by Wang and Archer (2007), collaborative functionalities should be considered in order to support other inter-organisational business processes, for example: demand and forecast planning, workflow integration, quality control, contract management, marketing intelligence and supply chain management (Chen et al. 2007; Cheng 2009; Ren et al. 2008; Xu 2015). Development of the new e-commerce process (which may require profound changes in internal and external business processes) should not be designed or configured separately from system development tasks, as for example, some of the functionalities would be dependent on the technical and operational capabilities of the suppliers (Balocco et al. 2010; Eng 2004).

### 5.3 Service Quality

DeLone and McLean (2004) argue that the level of support and training provided greatly influence the degree of satisfaction and user attitude towards the e-commerce systems. They suggest measuring the responsiveness and technical competence of the support services provided. Within the case studied, in-house and hands-on training was delivered to system users; however, as the user base was geographically dispersed it was largely available to users within the regional proximity of the contractor firm's head office. For those users who could not be given one-on-one training, interactive self-learning and training materials were made available online.

The need for training was apparent in the case studied mainly due to the fact that the system had a complex commerce process embedded within its structure. In addition to this, there were many business rules and logic (for example; transaction limits, monthly limits, items which are restricted, and so on) incorporated into the B2B e-Marketplace system. Mixed responses were received when asked if the training was adequate. Around half of the respondents indicated that they were happy with the training and support materials provided, whereas the other half appealed for more helpful user guidance documents, demonstration videos and one-on-one session. One user rightly pointed to the fact that "*the user guide does not prepare you for errors*", suggesting that 'how-to' documents should provide fool proof guidance for all the use case scenarios throughout the purchasing process. It follows that, since e-Marketplace implementation brings many change (in terms of process and the technology), users must be trained on both aspects, and given multiple learning and training opportunities including self-learning materials, interactive learning, and hands on one-to-one training. Indeed, many studies recognise these as a critical failure/success factor for the adoption and use (Alarcón et al. 2009; Hjelt and Björk 2007; Nitithamyong and Skibniewski 2011; Peansupap and Walker 2006; Tatari et al. 2008; Tatari and Skibniewski 2011; Wong and Lam 2010), however, as rightly pointed out by Peansupap and Walker (2006), overemphasis on the technical aspects can lead to a poor perception of the potential benefits of use. Therefore, users should also be provided with the information on value derived from e-Marketplace adoption (at personal and organisational levels) to justify the need for adoption.

With regards to the technical issue resolution process, the investigation was first carried out by the case study firm's IT department to identify the cause of the issue and then elevate it to HP if it was found to be a non-local issue. Amongst those who have contacted the HP's helpdesk (19 users), 78% indicated that quality of service received was satisfactory whilst the remaining indicated otherwise and noted several cases where the HP's correspondence was slow and the queries were not fully resolved. However, it seems that the technical support

process was not well understood by the users as considerable number of users contacted HP (who merely acts as an intermediary between the contractor firm and suppliers) for late and wrong deliveries, order queries, and so on. Nonetheless, one user pointed out that “*there doesn’t appear to be a structure within {HP Support} which allows them to pass on the query if they are unsure themselves*”. As the concept of B2B e-Marketplace is built on integration of multiple back-end systems, this implies the need for appropriate resolution processes between all the parties; including buyer, intermediary, and each supplier, to solve both, technical and non-technical issues and queries. As also suggested by Nitithamyong and Skibniewski (2011), along with a collaborative issue resolution process, dedicated support team members who are equipped with detailed knowledge of the system functionality should take care of the queries being raised in order to ensure swift turn-around on issue resolution. Without these support mechanisms in place users may perceive the system as a black hole; making them ever more reluctant to use the e-Marketplace system in the first place.

## **5.4 Use**

DeLone and McLean (2004) argued that the level of use has a significant impact on realisation of operational benefits of e-commerce, therefore system use is considered as one of the main determinants of implementation success or failure (Yeo 2002). Based on review of past studies Petter *et al.*, (2008) provide strong evidence on the relationship between use and organisational benefits of e-commerce implementation. Following section describes the nature and extent of the e-Marketplace usage at three levels: user, project and business unit (BU).

### **5.4.1 User Level**

The red line in Figure 2 shows that, in general, user adoption of the e-Marketplace has been on an upward trend. Nevertheless, there was a slow progress towards routinisation and acceptance amongst the users within each role and across the whole of the user base. Out of the 135 users, only a small share (15%) of the users (n=20) who were predominantly Administrators used the system frequently and somewhat regularly (the black line in Figure 2). On average 40% of the end-users actively used the system (that is, logged in at least once a month). This figure was slightly higher amongst the Administrator group of users (46%). On the other hand, comparison of the number of logins against the number of purchases completed suggests a purely transactional use of the system (that is, the informational use was not significant). Furthermore, Figure 3 shows clearly that Administrators conduct most of the purchasing followed by project/company roles. The average value of orders placed by this group was around £1,100 per month which, compared with the rest of the user groups, was much regular and consistent in terms of their purchasing behaviour. It must be pointed out that this is primarily attributed to the structure and hierarchy in the case study organisation whereby Administrators undertook a large proportion of the purchasing activities under the order of other project/BU roles. The remaining user base was primarily responsible for project/company related activities where purchasing was their secondary job function. Nevertheless, an increase in undertaking of the high value purchasing through the B2B e-Marketplace system indicates that Administrators have adopted and adapted the laborious purchasing operations around the new system.

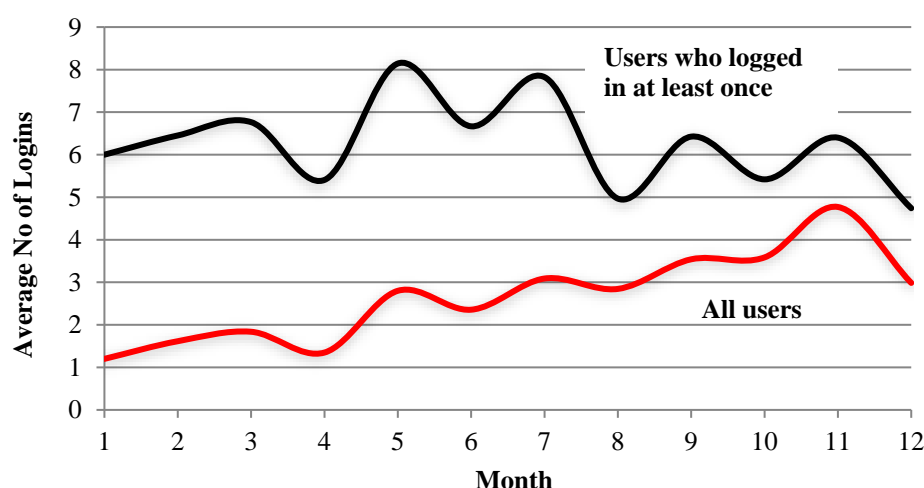


Figure 2: Average number of user logins

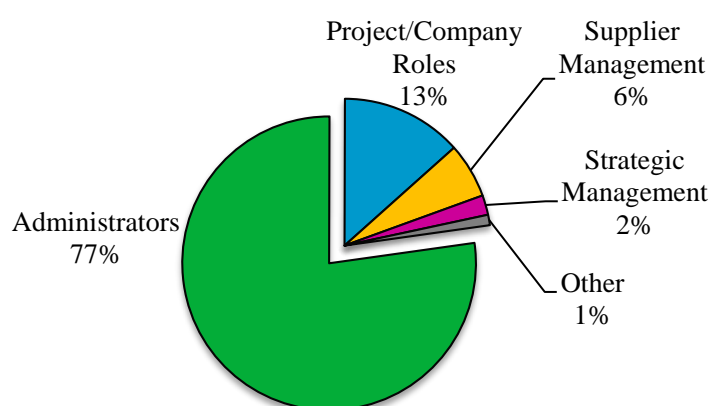


Figure 3: Users who completed transaction (percentage of overall value of transactions)

### 5.4.2 Project Level

Out of the 42 projects only 14 used the B2B e-Marketplace system to create purchase orders above £1k. Overall, 836 purchase orders totalling just over £205k were created from an allocated spend value of £1.3m, which is about 30% utilisation. On average, each project had four users (buyers) assigned to the system. Findings indicate that usage has not been equally spread across different industries and sectors which the projects belong to (see Figure 4). Three projects in the Transport sector (of which one was a Joint Venture) was responsible for the near 60% of the total spend. Although adoption was much more steady and regular in projects in Facilities Management industry, in terms of the value of the transactions completed, projects within the Construction industry accounted for more than half of the total spend. This could be reasoned to several factors. First, due to the number of suppliers on-board not all projects have the same spend levels with the suppliers connected to the e-Marketplace. As a consequence, the use of the B2B e-Marketplace system was limited for some projects. Secondly, the duration and stages of development for each project vary from one another resulting in different purchasing volumes for different projects. In construction for example, projects which are in earlier phases of development have larger spend allocation/volume than projects which are

about to be handed-over. This explains why the uptake was most prominent amongst the projects in the Transport sector, where the duration of its projects spans over a relatively longer period of time with budgets usually over several hundred million.

### **5.4.3 Business Unit Level**

Moving to a higher level of use, the analysis shows that e-Marketplace adoption differs significantly amongst the different BUs in (see Figure 5). It is interesting to note that BUs created almost the same value of transactions as the projects, however the number of purchase orders were considerably higher at 1,270. From a potential £1.45m spend, around £211k were transacted through the B2B e-Marketplace system. The supplier level data reveals that the nature of e-Marketplace use is primarily the repeat purchase of business overheads; that is, the office and stationary items, and safety and workplace commodities, but this finding is treated with caution due to limited number of suppliers on-board the e-Marketplace. Figure 5 shows the Infrastructure arm of the business (which includes Utilities, Highways and Transport) and Mechanical and Electrical subcontractor business contributed more than two thirds of this figure. The depth of adoption amongst the different BUs is thought to be attributed to the differences in company turnover; the size of the contracts they operate within, as well as the commodity/product based purchasing at each BU. In terms of actual transactions conducted, positive trend was identified in number and value of orders, indicating that each BU have gradually began to accept and use the new e-commerce system for trading with the three suppliers on-board the B2B e-Marketplace system.

## **5.5 User Satisfaction**

Based on a review of empirical studies on e-commerce implementation Petter *et al.*, (2008) reported a strong association between user satisfaction and e-commerce benefits. However, Molland and Licker (2001) make an important distinction to refer to two types of user satisfaction to describe one which is related to e-commerce system satisfaction and other in relation to the e-commerce process. The responses to survey indicate that 24% of respondents were dissatisfied with using the system whilst the remaining 76% have said they were either quite or very satisfied. Most of the scepticism about the system was concerned with the usability (e.g. difficult to use) however there were also considerable dissatisfaction with the e-commerce process after a purchase order is completed (most of which are discussed in Information Quality section above). Many of the concerns with the usability can be eliminated with a good system design, however it must be highlighted that in addition to the system features, the post-purchasing process forms an essential constituent of e-commerce use and user satisfaction. It is therefore suggested that entire purchasing cycle is taken into account and users are consulted and considered early in the systems development process in order to ensure user satisfaction with all aspects of the system.

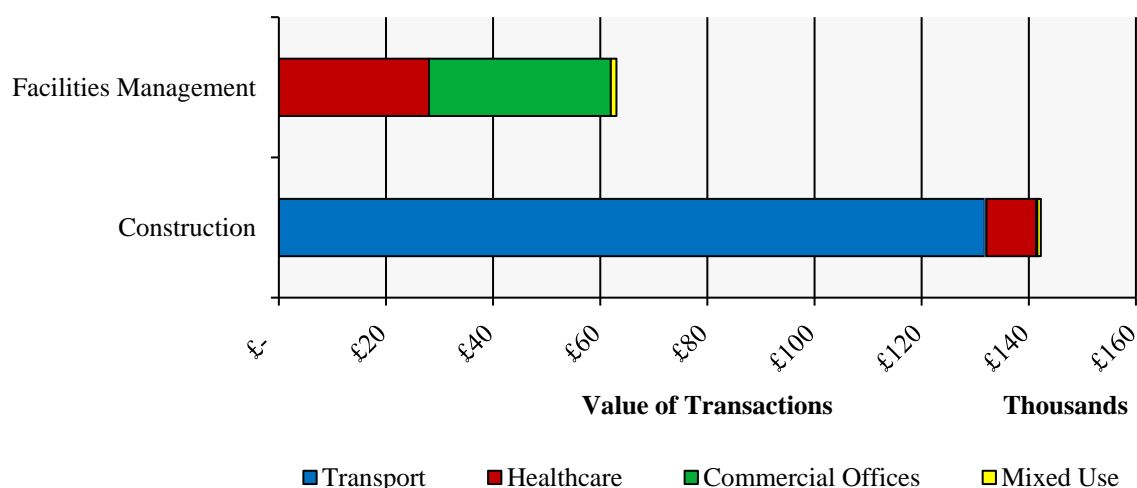


Figure 4: Project level adoption (including Joint Venture projects)

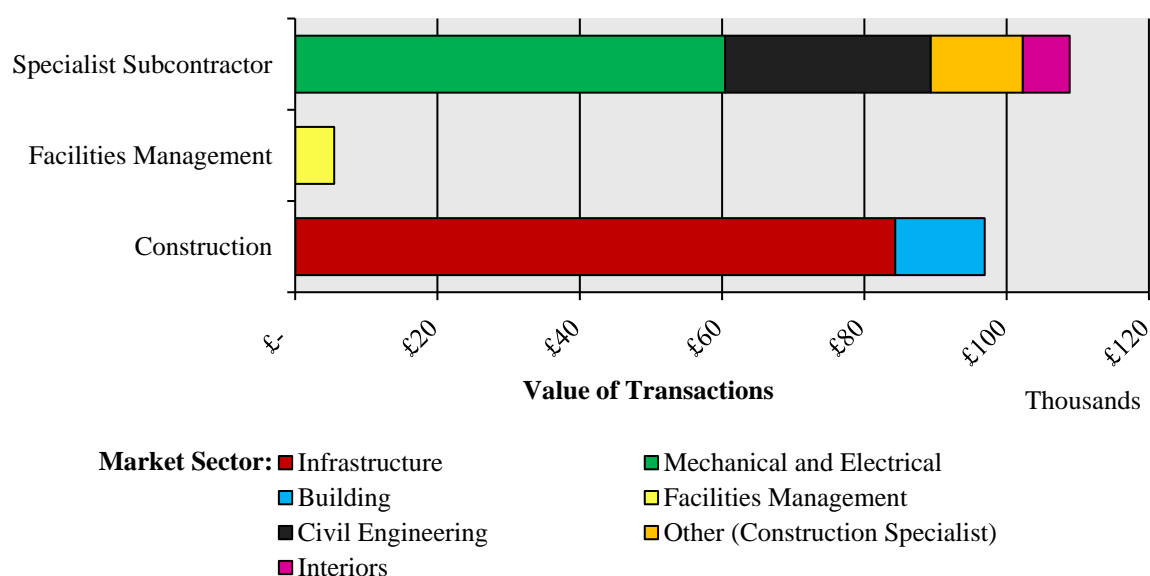


Figure 5: Adoption by each business unit

## 5.6 Net Benefits

Given that the main drive behind the B2B e-Marketplace system implementation was to achieve greater efficiency in supply chain interaction process, the objective here is to describe some of the anecdotal benefits realised with the adoption of the e-Marketplace. Undoubtedly, the introduction of e-commerce brought changes at three levels: actor, process and technology. At the actor level, the B2B e-Marketplace system had shifted the dimension of interaction from individual-individual to individual-firm level. Therefore, one of the resultant benefits of the system for project and BU actors was the reduction in direct and intense human interaction in the purchasing process (at least for the three suppliers who were on-board the e-Marketplace). With the e-Marketplace system, the contractor firm was able to streamline the otherwise manual, paper-based and time-consuming purchasing operations. Consequently, the management of purchasing operations were significantly reduced, resulting in savings in time

and labour costs for the contractor firm as well as allowing contractor firm to focus on the value-added aspects of their supplier relationship. In addition, integration of the back-end ERP systems has been at the forefront for automating accurate and timely exchange of transactional information. Only with the help of the HP however, the contractor firm was able to transact with multitude of supplier systems, transforming the physical commercial interactions into virtual relationships.

In an attempt to weigh the above benefits and to determine whether the B2B e-Marketplace system accrued the same level of benefit for all three suppliers, the second survey explored (i) the importance of suppliers for integration, (ii) the level of supplier impact on case study firm's operations, and (iii) the stages in the construction project which would benefit most from integration (e-commerce). Responses given to question one and two indicate that Supplier 1, which is a safety and workplace commodities supplier, and Supplier 2, office equipment and stationary products supplier are very important for supply chain integration (Figure 6), whereas Supplier 3 was considered as comparatively low in terms of integration strategy and the impact on the case study firm's operations (Figure 7). With regards to the last question, respondents generally agreed that the procurement stage would benefit most from the e-Marketplace implementation. This is perhaps unsurprising since the bulk of purchasing operations are conducted during the procurement stage of a construction project. The construction and FM stages were also deemed to benefit from the e-Marketplace system (albeit at a lesser degree), primarily due to buyers' continuing need to purchase as the projects progresses.

Since the perceived significance of suppliers vary in the eyes of users (Figures 6 and 7), findings indicate that integration and synergy with Supplier 3 did not yield significant advantage for the case study firm (compared with Supplier 1 and 2). This finding implies that choosing the right partners for the B2B e-Marketplace systems implementation does not only lead to benefits being realised but it also increases the opportunity for enticing users to the e-Marketplace; as for example, users who find the suppliers on-board critical for their operations will be more likely to use or continue making use of the system. Conversely, if the chosen suppliers are regarded as unimportant, the B2B e-Marketplace system adoption and use will be less received amongst the user base (Brunn et al. 2002; Grieger 2003). In addition to this, whilst the findings indicate that the B2B e-Marketplace implementation is of more benefit for the procurement stage, construction and facilities management phases must equally guide the implementation for a comprehensive e-commerce solution.

## **6 Discussion on E-Marketplace Systems Implementation**

The research findings shared above present the specific factors which hindered the B2B e-Marketplace system adoption and use in a case study contractor organisation's context. This section builds from the case study findings to make several suggestions to the implementation of the B2B e-Marketplace systems by AEC organisations. As far as the case study findings are concerned, the results are broadly consistent with the prior literature on IT/IS adoption. Commonly cited issues which has longstanding history in the work cited in IT/IS adoption literature also appear in the B2B e-Marketplace systems implementation projects. Nevertheless, few distinct challenges were identified owing to the inter-organisational nature of the B2B e-Marketplace systems and the processes implemented.

The findings from the study demonstrate the degree and level of complexity that underlie the implementation of B2B e-Marketplace systems. For instance, the multiplicity of business units and the industry sectors highlight the variety of issues (for example the organisational structure, business process re-design, business strategy and so on) that needs to be considered in design, development and implementation of the B2B e-Marketplace systems. Added to this complexity is the diversity in the project characteristics, the projects' phase and duration, supplier spend volumes and purchasing characteristics of projects, which may demand

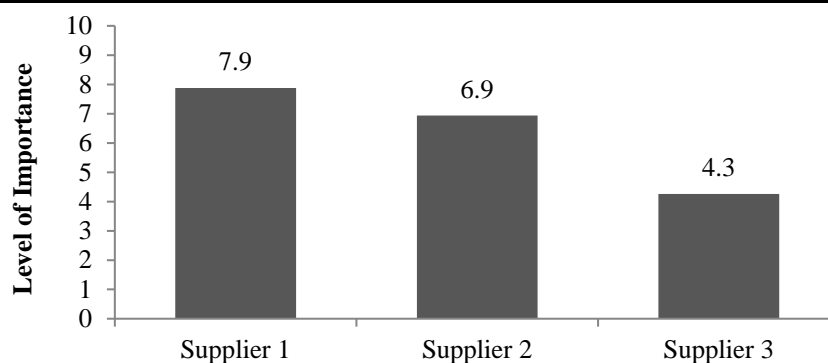


Figure 6: Importance of suppliers in integration of the supply chain firms (results based on average weighting).

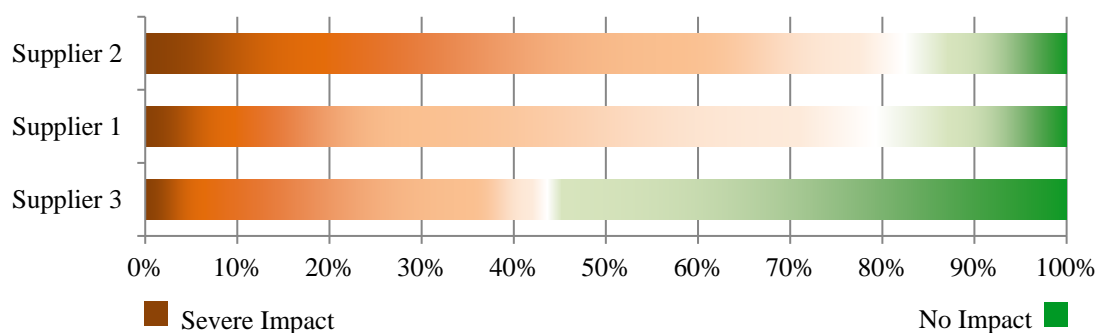


Figure 7: Suppliers' impact in terms of time, cost and quality on case study firm's operations (responses blended near the average values to aid the interpretation of the results).

different implementation strategies and decision making for the acceptance, use, and routinization of the B2B e-Marketplace systems. At the user level, the adoption and acceptance is highly correlated with the end-users' job function where people with administrative responsibilities and supplier-facing roles become the most prominent users of the B2B e-Marketplace systems. Thus, the system functionality, ease of use, information quality, training strategy and other key dimensions of IS implementation, are required to appease the demands of this user-base.

It is worth to note that post-implementation evaluation is not only crucial for understanding of the challenges that plague acceptance, routinization and continuance use, but equally important for pointing out to what needs to be done at the earlier phases of the implementation. Applying the case study findings to the DM Model, Figure 8 lists the main system and information related features which must be addressed at the earlier stages of the B2B e-Marketplace systems development. Since the people in Administrator role are the dominant users it is important that requirements and needs of this user group are not underestimated during development of the B2B e-Marketplace systems. It must be highlighted that technical limitations may hinder some of the development tasks for closely integrated e-commerce systems and processes; for example, the ability of suppliers' systems to support the pre- and post-purchasing process information needs, and the flexibility of intermediary firm to

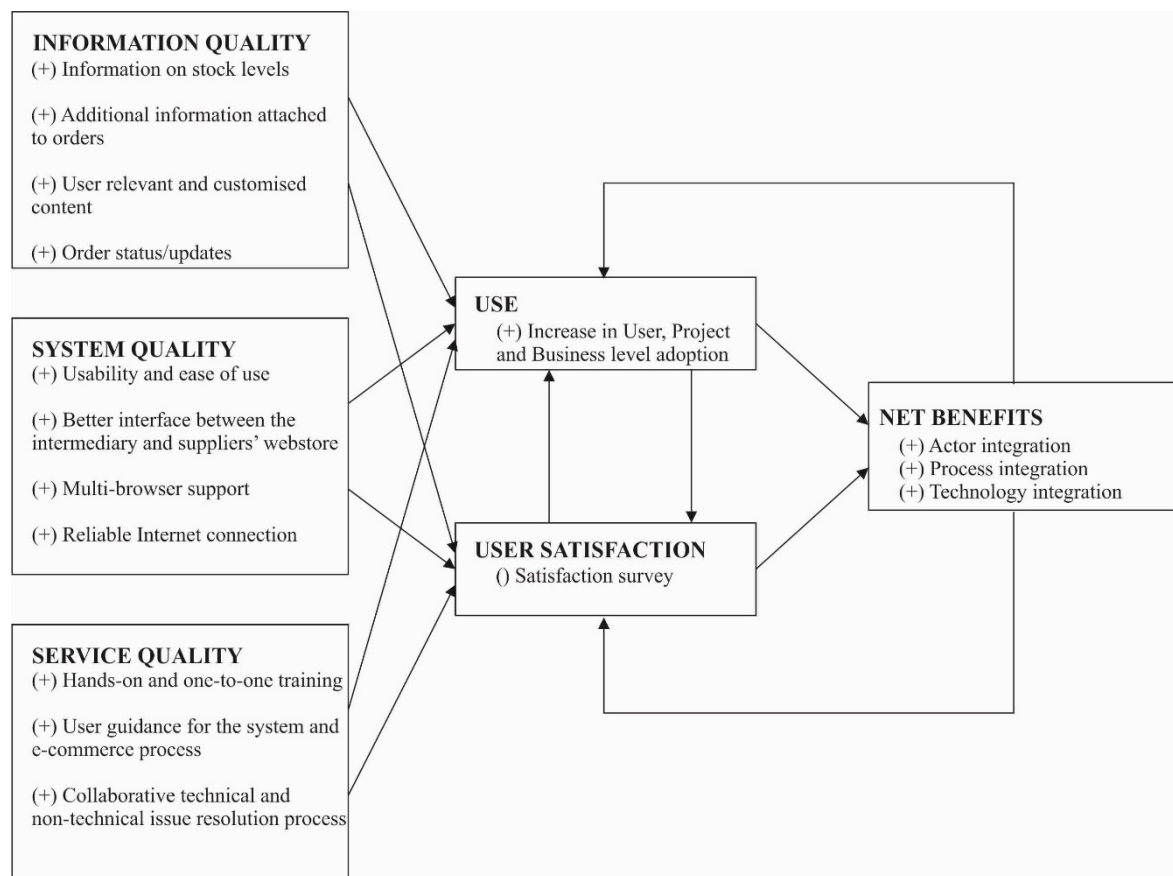


Figure 8: Factors which must be considered during e-Marketplace implementation (adapted from DeLone and McLean 2004).

customise its solutions for each user/project/business. Besides the importance of hands-on and one-to-one training and, guidance and self-learning materials, the technical support process forms an essential element for user satisfaction. It is therefore necessary to have a joint issue resolution mechanism between all the parties (that is the buyer firm, supplier and the intermediary B2B e-Marketplace technology provider) so that all technical and non-technical issues are resolved quickly and efficiently.

In terms of the benefits of implementation, akin to the economic, technical, and operational evaluation, the relational aspects of supplier integration must be weighed to ensure that only the value-adding suppliers are incorporated into the e-Marketplace. This requires careful analysis of supply chain relationships to determine whether the chosen suppliers are appropriate for supply chain integration strategy. It may be difficult to create and maintain similar levels of efficiency and synergy with each supplier connected to the B2B e-Marketplace if the end-users do not perceive suppliers as important for the supply chain operations of their projects and business units.

## 7 Limitations and Recommendations

The major weakness of this study lies in the single case-based research method which limits the generalisability of the findings. However, through the use of a previously tested and validated theoretical model (supported by multi-method strategy in data collection and analysis) the study was able to identify and categorise some of the important factors that influence the adoption and on-going use of B2B e-Marketplace systems which had been seldom examined in the prior



literature. Such information would be of high value for industry practitioners tasked with implementation; for example, they can learn from the challenges reported in the case study and prepare a risk plan to lessen their impact. Furthermore, the B2B e-Marketplace technology providers (the intermediary Hub Providers) can take on-board some of the suggestions as a guide in pursuit of improved system and service provision in the future.

In contrast with similar studies by Chung *et al.*, (2008) and Hjelt and Björk (2007) which employed the DM Model to explore the correlation between the DM Model variables and user adoption, this study was concerned with the traits of the B2B e-Marketplace system that users perceived as satisfactory or unsatisfactory. Therefore, how much the DM Model variables influenced the adoption or non-adoption could not be determined in the case study. In addition to this, the transactions conducted through the e-Marketplace needs to be compared with the off-line purchasing data to evaluate the adoption across the whole organisation. Although the Blanket Order data gave an indication of the potential e-Marketplace use, the absence of the supplier spend data limits the findings on the degree of usage. It must be acknowledged that the case study results are limited to the users' experiences with three suppliers connected to the e-Marketplace. Availability of more suppliers on-board the e-Marketplace might have produced different results.

Furthermore, what has been reported in this study is by no means the complete list of the challenges that plague the B2B e-Marketplace systems implementation. As the study topic has been quite neglected in the literature more in-depth research is required to contribute to knowledge on development and implementation of e-Marketplaces within the context of AEC firms and supply chains. A holistic understanding of the circumstances that determine the B2B e-Marketplace systems adoption and use would be particularly useful for academics and industry practitioners. While the DM Model is useful in describing the success and failure indicators in IS implementation projects it is worth recognising that the variables in the DM Model do not provide sufficient explanation alone and future studies rather need to be complemented with the adoption of other theoretical perspectives into its framework. For example, there are a host of other issues concerning business process reengineering, IS strategy, and organisational culture amongst many others, all of which must be further explored in future studies for a better understanding of the B2B e-Marketplace systems implementation projects.

## 8 Conclusion

The purpose of the research presented here was to explore the user adoption of a private B2B e-Marketplace system from the IS perspective with the aim of developing an understanding of the challenges that system users face during its on-going use. A longitudinal case study was conducted, which adopted a multi-level and multi-source data collection approach and followed a previously tested and validated theoretical model from the IS literature. The scope of the IOIS implementation was limited to a private e-Marketplace platform involving a third-party intermediary firm which provided the Cloud-based front-end interface and back-end integration of the ERP systems. The B2B e-Marketplace system studied in the case was live across eight business units and 42 projects of the case study organisation and had 135 users (buyers) assigned to the system.

As experienced in the case study, the diversity in usage and adoption is a real evidence of the degree and level of complexity that underlie the implementation of B2B e-Marketplace systems by the AEC firms. The case study findings show that the organic (non-mandatory) adoption of e-Marketplace systems can be very slow and different adoption rate can be expected even within the same user group and project types. Projects with a long duration and spend budget are more inclined to use the B2B e-Marketplace systems, whereas at the business level, the company turnover, contract size and commodity/product based purchasing influence the level of utilisation. It is worth to note; however, this finding is inferred from the case study

organisation's purchasing and procurement operations which is highly context specific, therefore should be interpreted with caution. At the user level, the roles which are tasked with the purchasing operations comprise the primary user base for conduct of commercial transactions. The perceived significance of suppliers for integration could be an important factor which can influence the benefits of implementation as well as the continuance use. Industry firms that intend to implement B2B e-Marketplace, or other IOIS alike, can benefit from the findings of this study by taking proactive measures to reduce the impact or the likelihood of similar challenges arising in their implementation project.

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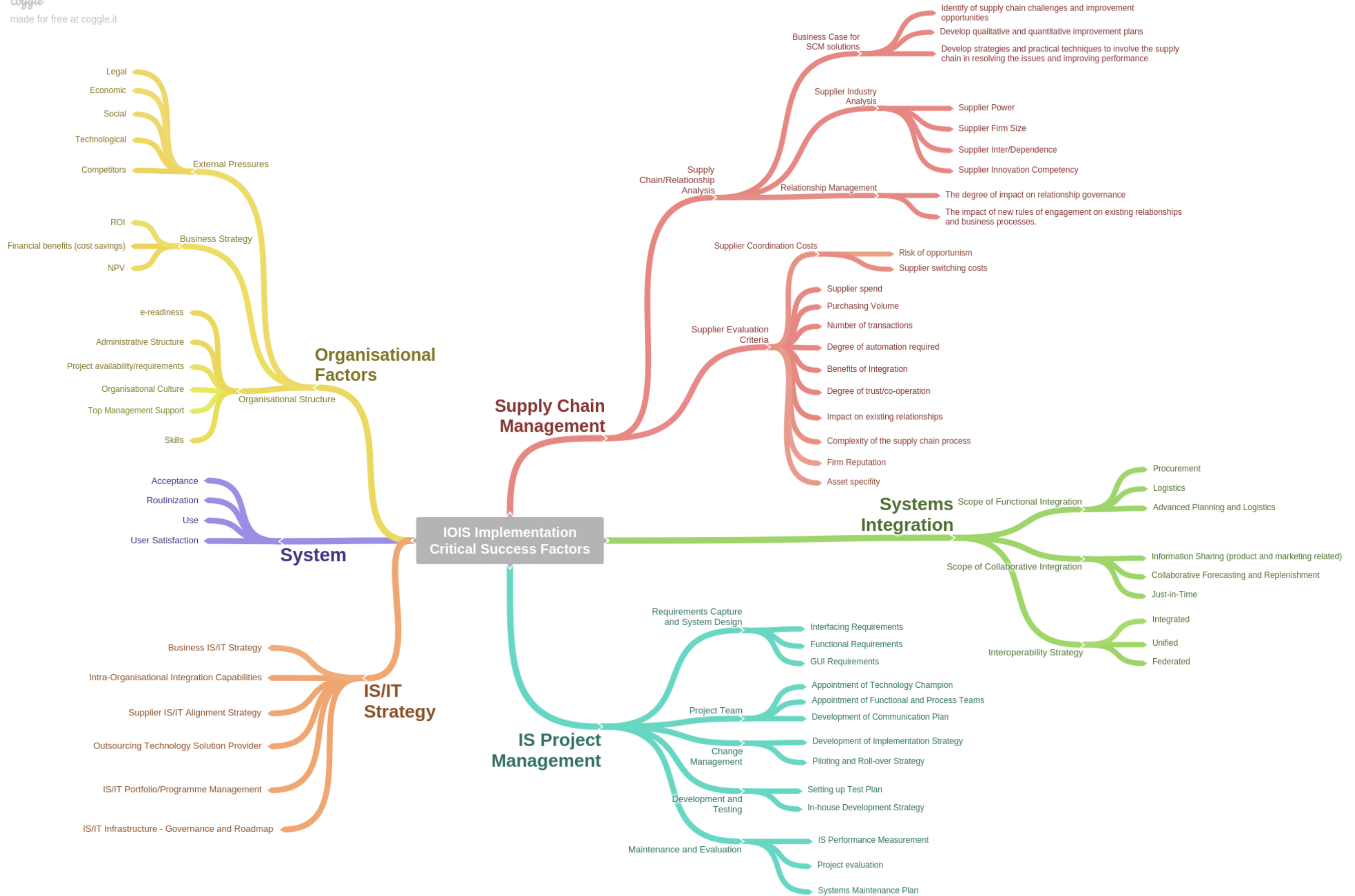
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## **Appendix G      IOIS Implementation Critical Success Factors Mindmap**

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## Appendix H Preliminary Studies and Training Undertaken

The below table lists the academic and industry-based training courses, workshops and events which were attended/completed during the course of the EngD.

#	Name	Targeted Skill	Type	Total Duration	Year
1	Procurement and Contract Procedure	P	Academic	48 hrs	2011/12
2	Management & Professional Development 1	PD	Academic	2 hrs	2011/12
3	Research and Communication	RS	Academic	48 hrs	2011/12
4	Lean and Agile Manufacturing	SCM	Academic	48 hrs	2011/12
5	ARCOM Conference	RS/PE	Conference	2 days	2012
6	EPOC Conference	RS/PE	Conference	2 days	2012
7	EngD Short Project	RS	Academic	2 hrs	2011/12
8	Postgraduate Research Project	RS	Academic	2 hrs	2011/12
9	Tools for Creative Thinking	RS	Academic	6 hrs	2011/12
10	Time and Self -Management	RS	Academic	3 hrs	2011/12
11	Building Capacity for Business Engagement with Impact- British Academy of Management	PD/PE	Industry	6 hrs	2012
12	Confident and Stress-free Minute Taking	RS	Academic/ Industry	6 hrs	2011/12
13	Academic Writing and Ultimate Publishing Workshop – London Centre for Social Studies	RS	Academic	4 hrs	2012/13
14	Construct-IT Seminar	T/PE	Seminar	8 hrs	2012
15	Social Network Analysis (e-Learning Course)	RS	Academic	16 hrs	2012/13
16	Project Management in the Real World	PD	Industry	8 hrs	2012/13
17	Management & Professional Development 2	PD	Academic	2 hrs	2012/13
18	CIOB Talk Construction	T/PE	Industry	4 hrs	2013
19	European Construction Institute Workshop on 'Harnessing the Power of Supply Chains'	P/PE	Workshop	1 day	2013
20	British Standards Institute seminar on BS11000: 'Bigger contracts, better results, satisfied customers'	P/PE	Seminar	6 hrs	2013
21	WSCP/NAWIC SIT (Science Innovation Technology) Talk on Supply Chain Management (Guest Speaker)	PE	Workshop	2.5 hrs	2013
22	COMIT Annual IT Conference	T/PE	Conference	6 hrs	2013
23	Supply Chain Summit/ Procurex	P	Industry	4 hrs	2014
24	"Collaborative Working and Procurement in Construction" Workshop	P/PE	Workshop	6 hrs	2014
25	Data in Construction - A G4C Constructing Excellence event	T/PE	Seminar	3 hrs	2014
26	"CIOB Bright Futures Challenge"	PE	Industry	18 hrs	2014
27	New EU Procurement Directive – A Supplier's Perspective	PM	Industry	8 hrs	2014
28	COMIT Annual IT Conference	T/PE	Conference	6 hrs	2014
29	Data Mining and Business Intelligence in Construction	T/PE	Seminar	4 hrs	2014
30	Big Data: Opportunities and Challenges in Construction (Co-Host, Presenter)	T/PE	Conference	8 hrs	2015
31	BRE Future Leaders Programme	PD	Workshop	8 hrs	2017

### Key:

**P**= Procurement, **PD**= Professional Development, **SCM**= Supply Chain Management, **RS**= Research Skills, **T**= Technology, **PE**= Public Engagement